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## **The Effect of Hot Water Extract of Pluchea Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles**

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### **Abstract**

The hot water extract of *Pluchea indica* Less leaf powder has antioxidant and antidiabetic activities because it contains phytochemical compounds, such as alkaloids, phenolics, flavonoids, sterols, tannins, phenol hydroquinone, and cardiac glycosides. Therefore, the hot water extract of pluchea leaf powder has potential to be utilized as a functional ingredient in food products. The use of hot water extract of pluchea leaf powder in jelly drinks, soybean milk, and buns is found to have effects on the physical, chemical and sensory properties of the products. This research was conducted to determine the effect of hot water extract of pluchea leaf powder on the physical, chemical and sensory properties of wet noodles. The experiment used a one-factor randomized design i.e., the concentration of hot water extract of pluchea leaf powder at the seventh level, namely i.e., 0, 5, 10, 15, 20, 25, and 30% (w/v). Parameters tested included physical properties (moisture content, swelling index, cooking loss, color, texture), chemical properties (bioactive content (total phenolic content (TPC) and total flavonoid content (TFC)), and antioxidant activity (AA) (DPPH scavenging activity and iron ion reducing power), and sensory properties (taste, aroma, color, texture, and overall acceptance). The results showed that the addition of hot water extract of pluchea leaf powder had significant effects on the texture, lightness, yellowness, bioactive content, AA, and sensory properties (taste, texture, color, and overall acceptance) of wet noodles, while it had not been significant influenced the redness, chroma, hue, moisture content, swelling index, cooking loss, and aroma). The wet noodles added with 10% (w/v) hot water extract of pluchea leaf powder was the best treatment based on the hedonic test result that resulted in the color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. From the overall results of the study, it is recommended that the making of wet noodles with the addition of hot water extract from pluchea leaf powder can be used at a concentration of 10% (w/v) with TPC, TFC, DPPH free radicals scavenging activity, and iron ion reducing power 82.84 mg GAE/kg dried samples, 62.44 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples, and 51.33 mg GAE/kg dried samples, respectively.

### **Key-words**

Chemical, *Pluchea indica* Less, physical, sensory, wet noodles

## Introduction

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food<sup>1,2</sup>. The potency of pluchea leaves is related to phytochemical compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone, alkaloid, lignans and saponins<sup>2,3,4,5</sup>. Furthermore, pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100g, fat 0.49 g/100g, insoluble dietary fiber 0.89 g/100g, soluble dietary fiber 0.45 g/100g, carbohydrate 8.65 g/100g, calcium 251 mg/100g,  $\beta$ -carotene 1.225  $\mu$ g/100g<sup>6</sup>.

Processing of pluchea leaves to be pluchea tea has been proven to exhibit antioxidant activity<sup>6,7,8</sup>, anti-diabetic activity<sup>9</sup>, anti-inflammatory activity<sup>7</sup>, anti-isolated human LDL oxidation activity<sup>10</sup>. Previous research uses hot water extract of pluchea leaf powder to make several food products to increase functional values, i.e., jelly drink<sup>11</sup>, soy milk<sup>12</sup> and steamed bun<sup>13</sup>. Using 1% (w/v) hot water extract of pluchea leaf powder can improve the physicochemical properties of jelly drink and increase panelists' acceptance of the product<sup>11</sup>. Soy milk with the addition of hot water extract from pluchea leaves increases the viscosity and total dissolved solids and decreases the panelist acceptance rate<sup>12</sup>. The addition of 6% (w/v) hot water extract from pluchea leaf powder on steamed bun is the best treatment with the lowest level of hardness<sup>13</sup>. All previous research has proven that the addition of hot water extract of pluchea leaves can increase the bioactive compound contents based on total phenol and total flavonoids, as well as increase antioxidant activity based on iron ion reducing power and DPPH free radical scavenging activity.



To the best of our knowledge, the study of the addition of hot water extract from pluchea tea powder in making wet noodles from wheat flour has not been conducted, as well as its impact on physicochemical and sensory properties of the noodles. Noodles are a popular food product that is widely consumed in the world. Indonesia is one of the countries with the largest noodle consumption after China<sup>14</sup>. Wet noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet noodles as an alternative to wet noodles, which contain higher protein, and the second popular food in ASEAN regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia<sup>16</sup>. The addition of other ingredients has been endeavored to enhance wet noodles' specific properties. Many researchers incorporated plant extracts or natural products to increase functional properties of wet noodles, such as red spinach<sup>17</sup>, green tea<sup>18,19</sup>, purple sweet potatoes leaves<sup>20</sup>, moringa leaves<sup>21</sup>, sea weed<sup>22</sup>, ash of rice straw and turmeric extract<sup>23</sup>, and betel leaf extract<sup>24</sup> that influenced physicochemical and sensory properties of the wet noodles. The anthocyanin of red spinach ethanolic extract increased hedonic score of wet noodles' flavor<sup>17</sup>. The addition of green tea improves the stability, elastic modulus and viscosity, maintains retrogradation and cooking loss, and results no significant effect of the mouthfeel and overall acceptance from panelist on the produced wet noodles<sup>18</sup>. Moreover, the addition of sweet potatoes leaf extract on wet noodles increases moisture content, protein value and ash concentration, and improves hedonic score of texture<sup>20</sup>. Moringa extract influences protein content and decrease panelist acceptance of color, aroma and taste of the wet noodles<sup>21</sup>. The use of seaweed to produce wet noodles influences moisture content, swelling index, absorption ability, elongation value and color<sup>22</sup>. The addition of ash from rice straw and turmeric extract influences the elasticity and organoleptic properties (color, taste, aroma and texture) of the wet noodles<sup>23</sup>. Betel leaf extract

used to make hokkien noodles improves texture and acceptance score of all sensory attributes<sup>24</sup>.

Bioactive compounds and nutritive value of pluchea leaf can be an alternative ingredient to improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea leaves is potential to be an antioxidant source in wet noodles and to increase the functional value. This research was conducted to determine the effect of hot water extract from pluchea leaf powder addition on the physical, chemical and sensory properties of wet noodles.

## **Materials and Methods**

### **Preparation of Hot Water Extract from Pluchea Leaf Powder**

The young pluchea leaves number 1-6 were picked from the shoots, sorted and washed. The selected pluchea leaves were dried at ambient temperature for 7 days to derive moisture content of  $10.00 \pm 0.04\%$  dry base<sup>25</sup>. Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at 120°C for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag for about 2 g/tea bag. Pluchea leaf powder in tea bag was extracted using hot water (95°C) for 5 min to get various extract concentrations; 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

### **Wet Noodles Processing**

About 70 mL of hot extract from pluchea leaf powder with various concentrations (0, 5, 10, 15, 20, 25 and 30% (w/v) (Table 1) was measured and manually mixed with egg, baking powder, salt and wheat flour for 5 min (Table 2). The mixture was kneaded to form a solid and homogenized dough using a mixer (Oxone Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to form noodle strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled water about 3 min in 300 mL water and coated with oil to prevent the noodles

from sticking to each other. Wet noodles made without any addition of hot water of pluchea leaf extract were prepared as control. Wet noodles used in bioactive compounds and antioxidant activity assay were not added with oil to prevent the noodles from sticking to one another. The final characteristics of wet noodles were having width and thickness of 0.45 cm and 0.295 cm, respectively.

### **Pluchea Wet Noodles Extraction**

About 100 g of wet noodles were dried using a freeze dryer at a pressure of 0.1 bar and temperature  $-60^{\circ}\text{C}$  for 28 hours to obtain dried noodles. Each dried sample was powdered using a chopper machine at the speed of 35 seconds, and then 20 g of powdered sample was added with 50 mL methanol using a shaking water bath at  $35^{\circ}\text{C}$ , 70 rpm for 1 hour<sup>26</sup>. The filtrate was separated by filtration using Whatman filter paper grade 40 and the residue was extracted again with the same procedure. The filtrate was collected and dried using rotary evaporator (Buchi Rotary Evaporator; Buchi Shanghai Ltd, China) at 200 bars,  $50^{\circ}\text{C}$  for 60 min until forming 3 mL of extract. The obtained extract was kept at  $0^{\circ}\text{C}$  before further analysis.

### **Moisture Content Assay**

Moisture content of wet noodles was determined by thermogravimetric method<sup>27</sup>. The assay of moisture content from wet noodles was done by heating the samples in a drying oven (Binder, Merck KGaA, Darmstadt, Germany). The principle of this method is evaporating the water in the material. The sample was heated and weighed until a constant weight was obtained which was assumed to be all evaporated water.





## Measurement of Swelling Index

The principle of swelling index testing is to determine the ability of noodles to absorb water during the boiling process<sup>16</sup>. The water absorption test is carried out to determine the ability of wet noodles to absorb water per unit time that can estimate the time needed to fully cook wet noodles. The amount of water absorbed by wet noodles can be determined from the weight difference between the noodles after and before being boiled divided by the weight of the noodles before boiling<sup>28</sup>.

## Determination of Cooking Loss

Cooking loss is one of the important quality parameters in wet noodles to determine the quality of wet noodles after cooking<sup>28</sup>. The cooking loss test for pluchea wet noodles was carried out to determine the number of solids that leached out from the wet noodle strands during the cooking process, namely the release of a small portion of starch from the wet noodle strands. A large cooking loss value affects the texture of wet noodles, which is easy to break and less slippery.

## Determination of Texture

The texture of wet noodles with pluchea extract addition was measured based on its hardness, adhesiveness, cohesiveness, elongation and elasticity. The texture was determined using TA-XT2 texture analyzer (Stable Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the Texture Exponent 32 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were analyzed with a compression test using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle strands with the length of 4 cm for each strand were laid side by side, touching each other, perpendicular to the 35 mm compression cylinder probe on a flat aluminium base. The

cylinder probe was arranged to be at 15 mm distance from the lower plate at the start of the compression test, and was forced down through the noodle strips at the speed of 2 mm s<sup>-1</sup> until it touched the flat base to compress 75% of the noodle thickness, and was drawn back to at the end of the test. The profile curve was determined using a texture analyzer software<sup>24,29</sup>. The hardness was determined as the maximum force per gram. The adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area was obtained from the compression test under the curve. Cohesiveness was analyzed based on the ratio between the area under the second peak and the area under the first peak<sup>24,29,30</sup>. The elongation and elasticity of the noodles were individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. Elongation was the maximum force to deform and break noodles by extension that was measured by a test speed of 3.0 mm s<sup>-1</sup>, with a 100 mm distance between two rollers. The elongation at breaking was calculated per gram. Elasticity was determined by formula (1)<sup>31,32</sup>:

$$\text{Elasticity} = \frac{Fx lo}{Ax to} \frac{1}{v} \quad (1)$$

where F is the tensile strength, lo is the original length of the noodles between the limit arms (mm), A is the original cross-sectional area of the noodle (mm<sup>2</sup>), v is the rate of movement of the upper arm (mm/s), and t is break up time of the noodles (s). The measurement of texture was recorded using the software and expressed as a graph.

### Color Measurement

The color of the noodle sheets was measured by a colorimeter (Minolta CR 10, Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab L\*, a\* and b\* values were analyzed based on Fadzil et al.,<sup>29</sup>,

method. The  $L^*$  value was stated as the position on the white/black axis, the  $a^*$  value as the position on the red/green axis, and the  $b^*$  value as the position on the yellow/blue axis.

### **Analysis of Total Phenol Content**

The total phenol content analysis is measured based on the reaction between phenolic compounds and folin ciocalteu/FC reagent (phosphomolybdic acid and phosphotungstic acid). FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups becomes a blue molybdenum-tungsten complex solution<sup>33</sup>. The intensity of the blue color was measured by a UV-Vis spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  760 nm. In the analysis, 7.5%  $\text{Na}_2\text{CO}_3$  solution was added to reach pH 10 that caused an electron transfer reaction (redox). The obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

### **Analysis of Total Flavonoid Content**

The flavonoid content in wet noodles was measured by the spectrophotometric method based on the reaction between flavonoids and  $\text{AlCl}_3$  to form a yellow complex solution. In the presence of NaOH solution, a pink color is formed which can be measured by spectrophotometer (Spectrophotometer UV- Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm<sup>33,34,35</sup>. The obtained data were expressed in mg of (+)-catechin equivalent (CE)/L sample.

### **Analysis of DPPH Free Radical Scavenging Activity**

DPPH (2,2-diphenyl-1-picrylhydrazyl) is a free radical that used to evaluate antioxidant activity. The principle of the DPPH method is to measure the absorbance of compounds that can react with DPPH<sup>36</sup>. Antioxidant compounds can donate hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced to yellow<sup>37</sup>. The color change was measured as an

absorbance at  $\lambda$  517 nm by spectrophotometer (Spectrophotometer UV Vis 1800, Shimadzu, Japan)<sup>38</sup>.

The data were expressed in mg gallic acid equivalent (GAE)/L sample.

### **Analysis of Iron Ion Reduction Power**

This method identifies the capacity of antioxidant components through increasing absorbance as a result of the reaction of antioxidant compounds with potassium ferricyanide, trichloroacetic acid, and ferric chloride to produce color complexes that can be measured spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm<sup>39</sup>. The principle of this testing is the ability antioxidants to reduce iron ions from potassium ferricyanide ( $\text{Fe}^{3+}$ ) to potassium ferrocyanide ( $\text{Fe}^{2+}$ ). Potassium ferrocyanide reacts with ferric chloride to form a ferric-ferrous complex. The color change that occurs is yellow to green<sup>40</sup>. The final data were expressed in mg gallic acid equivalent (GAE)/L sample.

### **Sensory Evaluation**

All samples of wet noodles were proceeded to hedonic test by involving 100 untrained panelists with an age range of 17 to 25 years. A hedonic test used in this research was the hedonic scoring method, where the panelists gave a preference score value of all samples<sup>41</sup>. The hedonic scores were transformed to numeric scale and analyzed using statistical analysis<sup>42</sup>. The numeric scale in the sensory analysis used a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The panelists were asked to score according to their level of preference for texture, taste, color, flavor and overall acceptability. All the samples were blind coded with 3 digits which differed from each other<sup>43</sup>.

## Statistical Analysis

The research design used in the physicochemical assay was a randomized block design (RBD) with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25%, and 30% (w/v). Each treatment was repeated four times in order to obtain 28 experiment units. The sensory test used a completely randomized design (CRD) on 100 untrained panelists with an age range of 17 to 25 years.

The data normal distribution and homogeneity were presented as the mean  $\pm$  SD of the triplicate determinations and were analyzed using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan Multiple Range Test) at  $p \leq 5\%$  to determine the level of treatment that gave significant different results. The best treatment of pluchea extract addition on wet noodles was determined using a spider web graph.

## Results and Discussion

Wet noodles added with hot extract of pluchea leaf powder were produced with aiming to increase the functional value of wet noodles. This is supported by several previous researches related to the potential value of water extract of pluchea leaf that exhibit a biological activity<sup>6,7,41</sup>. In this research, the cooking quality was observed after cooking wet noodles in 300 mL water/100g samples for 3 min in boiling water.

### Cooking Quality

Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at various concentrations (0, 5, 10, 15, 20, 25, and 30% (w/v)) was shown in Figure 1, Table 3 and Table 4. The addition of pluchea extract did not significantly influence the moisture content,

swelling index, cooking loss, chroma, and hue of the produced wet noodles based on the statistical analysis by ANOVA at  $p \leq 5\%$ . Moisture content is one of the chemical properties of a food product that determines the shelf life of food products because the moisture content measures the free water content and weakly bound water in foodstuffs<sup>44,45</sup>. This study identified that the moisture content of the cooked wet noodles ranged between 64-67% wb. A previous study showed that the moisture content of the cooked egg wet noodles was around 54-58% wb<sup>45</sup> and maximum of 65%<sup>20</sup>. Chairuni et al.,<sup>44</sup>, stated that the boiling process could cause a change in moisture content from around 35% to around 52%. The Indonesian National Standard,<sup>46</sup> stipulates that the moisture content of cooked wet noodles is a maximum of 65%. This means that only control noodles (without treatment) exhibited a moisture content similar to the previous information. The obtained data showed a trend that an increase in extract addition caused an increase in the moisture content of wet noodles, but statistical analysis at  $p \leq 5\%$  showed no significant difference. This phenomenon was in accordance with the experimental results of Juliana et al.,<sup>45</sup>, that the using of spenochlea leaf extract to making wet noodles, as well as Hasmawati et al.,<sup>20</sup>, that the supplementary of sweet potato leaf extract increased the moisture of fresh noodles. The moisture content of pluchea wet noodles was expected by an interaction between many components composing the dough that impacted to the swelling index and cooking loss. Mualim et al.,<sup>14</sup>, Bilina et al.,<sup>22</sup>, and Setiyoko et al.,<sup>28</sup>, informed that the presence of amino groups in protein and hydroxyl groups in amylose and amylopectin fractions in wheat flour as raw material for making dough determines the moisture content, swelling index and cooking loss of wet noodles. The contribution of glutenin and gliadin proteins in the formation of gluten networks determines the ability of noodles to absorb and retain water in the system. Gliadin acts as an adhesive that causes dough to be elastic, while glutenin

makes the dough to be firm and able to withstand CO<sub>2</sub> gas thus the dough can expand and form pores. Fadzil et al.,<sup>29</sup>, found that thermal treatment during the boiling process results in the denaturation of gluten and caused a monomer of proteins to determine other reactions at the disulfide or sulfhydryl chain. The existence of phenolic compounds from pluchea extract also increased the capacity of noodles to absorb water and determined water mobility. Widyawati et al.,<sup>41</sup>, also confirmed that hydrophilic compounds of proteins, carbohydrates, and polyphenolic components determine water mobility due to their ability to bind with water molecules through hydrogen bonding. Tuhumury et al.,<sup>47</sup>, informed that gluten formation can inhibit water absorption by starch granules so that can prevent gelatinization. Therefore, the addition of phenolic compounds from the hot extract of pluchea leaf powder can inhibit the formation of gluten so that it stimulates gelatinization of starch granules.

As a result, the impact of increased the moisture content during boiling had an effect on the value of the swelling index and cooking loss of the wet noodles. Widyawati et al.,<sup>41</sup>, said that the swelling index is the capability to absorb water which is dependent on the particle size, chemical composition, and moisture content. Gull et al.,<sup>48</sup>, also confirmed that the swelling index is an indicator to determine water absorption by starch and protein to make gelatinization and hydration. Setiyoko et al.,<sup>28</sup>, explained that cooking loss is the mass of noodle solids that come out of the noodle strands during the cooking process. Gull et al.,<sup>48</sup>, added that soluble starch and other soluble components leach out into the water during the cooking process, making the cooking water turned thicker. The moisture content results (64-67% wb) showed that the produced wet noodles exceeded the moisture content limit of wet noodles after cooking, which is between 54-58%<sup>44</sup>,

while the cooking loss value of wet noodles should not be more than 10%<sup>28</sup>. In this study, the cooking loss value was 3-4.2%. The cooking loss of samples during boiling noodles were caused the breaking of the bonding network that the polysaccharides are released and the gluten network breaks because of the addition of pluchea leaf extract. Widyawati et al.,<sup>41</sup>, supported that polyphenol can be bound with protein and starch with many non-covalent interactions, such as hydrophobic interaction, hydrogen bonding, electrostatic interaction, Van der Waals interaction, and  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch to undergo gelatinization and gliadin and glutelin from the protein of wheat flour to form gluten.

The swelling index value obtained from this research was around 56-68 %. Based on the previous research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.) fruit was around 51%<sup>49</sup>. This means that the addition of pluchea leaf extract in wet noodles also affects the ability of noodles to absorb water. Widyawati et al.,<sup>41</sup>, and Suriyaphan,<sup>6</sup>, informed that bioactive compounds in hot water extract of pluchea leaf tea include 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, 4,5-O-dicaffeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was higher than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from extract in absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch granules to absorb water so that the swelling index and cooking loss increased. Suriyaphan,<sup>6</sup>, informed that hot extract of pluchea leaf tea contains 1.79g/100g protein, 8.65g/100g carbohydrate, and fiber (0.45g/100g soluble and 0.89g/100g insoluble), these compounds can involve in increasing the swelling index from pluchea wet noodles.



Color is one of the physical characteristics possessed by wet noodles that becomes a benchmark for consumer acceptance. This research found that the addition of pluchea extract affected the color of wet noodles. The addition of pluchea leaf extract did not significantly affect the redness ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it affected the yellowness ( $b^*$ ) and lightness ( $L^*$ ) values. The use of hot water extract from pluchea leaf powder decreased the brightness of wet noodles significantly as the concentration of the extract increased. This is related to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to experience color changes. According to Widyawati et al.,<sup>8</sup>, tannins are water-soluble compounds that can give a brown color. Suriyaphan,<sup>6</sup> and Widyawati et al.,<sup>41</sup>, also stated that Khlu tea from pluchea leaves contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and  $6.39$  mg/100g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow color. Gull et al.,<sup>48</sup>, stated that this pigment was easily changed in the paste sample due to the swelling and discoloration of the pigment during cooking.

Thus, the addition of pluchea leaf extract significantly reduced the brightness of wet noodles, because brown-colored noodles were produced as the concentrations of added pluchea leaf extract increased. However, increasing the concentration of pluchea leaf extract had no effect on the redness, hue, and chroma values in statistical analysis (ANOVA) at  $p \leq 5\%$ . The results showed that the redness value of wet noodles ranged from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet noodles ranged from  $82.1 \pm 3.1$  to  $86.5 \pm 1.0$ . Based on this value, the color of wet noodles is in the yellow to the red color range<sup>50</sup>, thus the visible color of the wet noodle product was yellow to brown (Figure 1). Yellowness increased significantly with the addition of pluchea leaf extract and the value ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the presence of tannins and

chlorophyll compounds from pluchea leaf extract. The chroma value of wet noodles was obtained within the range of  $15.6 \pm 1.5$ – $19.8 \pm 3.4$ . This means that the hot water extract of pluchea leaf powder did not change the intensity of the brown color in the resulting wet noodles.

Texture analysis of pluchea wet noodles added with various concentrations of hot water extract from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness, elongation, and elasticity. Hardness is the maximum force given to a product until deformation<sup>51,52</sup>. From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher peak of graph shows the harder product<sup>30</sup>. Adhesiveness is force or tackiness that is required to pull the product from its surface, its value is obtained from the area between the first and second compressions<sup>53,54</sup>. Adhesiveness values show negative value; the bigger negative value means the product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and second compressions<sup>52,54</sup>. This is an indication of the internal forces that make up the product<sup>55</sup>. Elongation is the change in length of noodles when being exposed to a tensile force until the noodles break<sup>56</sup>. Elasticity is the time required for the product to withstand the load until it breaks. The more elastic a product, the longer the holding time. The data showed that the higher concentration of pluchea leaf powder within the hot water extract caused a significant increase in the hardness, stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati et al.,<sup>41</sup>, informed that the polyphenols contained in pluchea leaf extract can weakly interact either covalently or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups that are polar. Amoako and Akiwa,<sup>57</sup> and Zhu et al.,<sup>58</sup> have also proven that polyphenolic compounds can interact with carbohydrates through the

interaction of two hydrophobic and hydrophilic functional groups with amylose. Diez-Sánchez et al.,<sup>59</sup>, stated that polyphenolic compounds can interact with amylose and protein helical structures and largely determined by molecular weight, conformational mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and amylopectin can affect the gelatinization process in the amylose helical structure and interfere with the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss (>98%) and swelling index (56.2 -67.7%) data, it can be concluded that the interaction that occurs between the phenol group in pluchea leaf extract with amylose and protein was weak. The bioactive components of pluchea leaf extract are thought to affect the formation of disulfide cross-links (S-S) and turn into to form sulfhydryl groups (-SH) under the influence of heat. Ananingsih and Zhou,<sup>60</sup>, said that antioxidant compounds are a reducing agent that can have an impact on reducing S-S bonds and increasing the number of SH groups in the dough to produce a harder texture. According to Rahardjo *et al.* (2020), phenolic compounds are hydroxyl compounds that influence the strength of the dough, where the higher the component of phenol compounds will weaken the gluten matrix and the dough thus becoming unstable. The instability of the dough can cause the texture to become hard.

Many researchers also find that tannins and phenols influence the networking S-S bond in the dough of wet noodles. Wang *et al.* (2015) showed that tannins increase the relative amount of large, medium polymers in the gluten protein network so as to improve the dough quality. Zhang et

al.,<sup>61</sup>, said that these polymer compounds are the results of interactions or combinations of protein-tannin compounds that form bonds with the type of covalent bonds, hydrogen bonds, or ionic bonds. Rauf and Andini,<sup>62</sup>, also added that phenol compounds are able to reduce S-S bonds to SH bonds. SH is a type of thiol compound group, where the thiol group can influence the stickiness, viscosity, cohesiveness, elongation, and extensibility of the dough. Wang et al.,<sup>63</sup>, found the effect of phenolic compounds from green tea extract to increase the stickiness of wheat bread. The cohesiveness of the dough is formed due to a large number of thiol bonds formed, thus increasing the viscosity of the dough. The increased viscosity of the dough is thought to be due to the formation of polyphenolic compounds with thiol groups, as in the research of Ananingsih and Zhou,<sup>60</sup>, that the formation of catechin-thiol can increase the viscosity of the dough and increase the stability of the dough. Zhu et al.,<sup>64</sup>, declared that the addition of phenolic compounds from green tea was able to increase the PV (peak viscosity) of wheat flour. Wang et al.,<sup>65</sup>. also found that the cohesiveness of the dough is influenced by tannins, where tannins can produce micro-glutens so as to produce a compact dough and increase the gluten network. The addition of pluchea leaf extract in making wet noodles could influence the elongation of wet noodles due to the components of polyphenol compounds such as tannins that can reduce the number of free amino groups. This is supported by Zhang et al.,<sup>30</sup>, and Wang et al.,<sup>65</sup>, that support the formation of other types of covalent bonds, such as bonds between amino groups and hydroxyl groups, by forming hydrogen bonds between phenolic compounds and protein gluten so as to improve the quality of dough strength and dough extensibility.

### **Bioactive Compounds and Antioxidant Activity**

Wet noodles added with pluchea leaf powder were analyzed based on its bioactive

compounds and antioxidant activities. The analysis was carried out to determine the functional properties of wet noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles are presented in Table 5. The measured bioactive compounds (BC) included total phenol content (TPC) and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical scavenging activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed that there was a positive and strong correlation between TPC and DPPH ( $r=0.990$ ), TPC and FRAP ( $r=0.986$ ), TFC and DPPH ( $r=0.974$ ), and TFC and FRAP ( $r=0.991$ ). This means that the antioxidant activity of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah et al.,<sup>66</sup>, informed that the PC ( $r$ )  $> 0.699$  indicates the strength and linear correlation between antioxidant activity (AA) and TPC, and also shows a strong positive relationship but PC ( $r$ )  $< 0.699$  obtains a moderately positive relationship. If the  $r$  value of TFC and AA is lower than TPC and AA, it indicates that the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship which is expected because both classes all contributed to AA plants. Aryal et al.,<sup>67</sup>, and Muflihah et al.,<sup>66</sup>, informed that phenolic compounds are soluble natural antioxidants and potential donating electrons depend on their number and position of hydroxyl groups contributed to antioxidant action. Consequently, these groups are responsible to scavenge the free radicals that TPC of pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the stable purple-colored to the yellow-colored solution. Based on FRAP analysis, it was

showed that the bioactive compounds contained in pluchea wet noodles are a potential source of antioxidants because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive compounds contained in pluchea wet noodles can function as primary and secondary antioxidants. Research data showed that the cooking quality of wet noodles tends to increase along with the increase in the value of TPC, TFC, DPPH, and FRAP.

### **Sensory Evaluation**

Sensory pluchea wet noodles, namely color, aroma, taste, texture, and overall acceptance, were carried out using a hedonic test to determine the level of consumer preference for the product. This test was conducted to determine the quality differences between the products and to provide an assessment on certain properties<sup>42</sup>. The hedonic test itself is the most widely used test to measure the level of preference for production<sup>68</sup>. The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm 1.26$  (neutral-like). The statistical analysis showed that the higher concentration of pluchea extract addition caused lower color preference of wet noodles. The higher concentration of pluchea extract could reduce the level of preference for color because the color of the wet noodles was darker than control and turned to dark brown. This color change was due to the pluchea extract containing several components, including chlorophyll and tannins, which can alter the of wet noodles' color to be browner along with the increase in the concentration of pluchea extract. This result was in accordance to the results of color analysis performed using color reader where the pluchea wet noodles' brightness declined, yellowness increased, and the color intensity increased with an increased concentration of pluchea extract. The occurrence of this process is related to the

effect of light and heat on pluchea leaf powder which causes the degradation of chlorophyll into brown pheophytin due to drying, where the nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals<sup>69,70</sup>.

Aroma is one of the parameters in sensory evaluation using the sense of smell and is an indicator of the assessment of a product<sup>71</sup>. The results of the preference value for aroma were ranged from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet noodles reduced the panelists' preference for aroma due to the occurrence of distinct dry leaves (green) aroma. Lee et al.,<sup>72</sup>, informed that the unpleasant aroma on leaves comes from a group of aliphatic aldehyde compounds. The appearance of a distinctive leaf aroma in noodles is due to aromatic compounds. According to Martiyanti and Vita,<sup>73</sup>, aromatic compounds are chemical compounds that have an aroma or odor when the conditions are met, which is volatile, while Widyawati et al.,<sup>74</sup>, informed that pluchea leaves were detected to have 66 volatile compounds. The appearance of the aroma is due to the volatile compounds in the raw material reacting with water vapor when boiling the noodles. In addition, there is also an oxidation process of polyphenolic compounds such as catechins or tannins that can produce an aroma in pluchea wet noodles.

According to Martiyanti and Vita,<sup>3</sup>, taste attribute is one important sensory aspect in food products and has a great impact on the food selection by consumers. Tongue are able to detect basic tastes, namely sweet, salty, sour, and bitter, at different points. Lamusu,<sup>71</sup>, declared that taste is a component of flavor and an important criterion in assessing a product that is accepted by the tongue. The preference test of the taste of pluchea wet noodles resulted in values ranging from  $4.15 \pm 1.40$  to  $5.50 \pm 1.28$  (neutral-slightly like). The increase in concentrations of pluchea extract was

negatively correlated to the preference level of the pluchea wet noodles' taste assessed by the panelists. The statistical analysis results showed that the difference in the concentration of pluchea extract had a significant effect on the panelists' preference for the taste of pluchea wet noodles. The increased concentration of pluchea extract produced a distinctive taste on wet noodles, such as a bitter, bitter, and astringent tastes, due to the presence of compounds such as tannins and alkaloids from the pluchea leaves. Susetyarini,<sup>75</sup> said that pluchea leaves contain tannins (2.351%), and alkaloids (0.316%). According to Pertiwi,<sup>76</sup> tannin compounds dominate the bitter and astringent taste, while alkaloid compounds cause a bitter taste. The high level of taste preference for wet noodles was found in noodles with lower content of pluchea extract.

Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and swallowed) or touched with fingers<sup>77</sup>. Texture testing performed by the panelist is called mouthfeel testing. According to Martiyanti and Vita,<sup>73</sup> mouthfeel is the kinesthetic effect of chewing food in the mouth. In this study, the preference test results on the texture of pluchea wet noodles ranged from  $5.5 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and draining noodles. Subjective testing results based on sensory evaluation were in line with the objective testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to break, and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea wet noodles was influenced by the fiber and protein components. According to Shabrina,<sup>78</sup> the components of fiber, protein, and starch



compete to bind water. Texture changes are also influenced by the polyphenol compounds in the pluchea extract which is able to reduce S-S bonds to SH bonds, where the increase in SH (thiol) groups can give a hard, sticky, and compact texture<sup>62,63,65</sup>. Besides, a high concentration of tannins capable of binding to proteins to form complex compounds into tannins-proteins are also able to build noodles' texture.

The interaction between color, aroma, taste, and texture created an overall taste of the food product and was assessed as the overall preference. The highest value on the overall preference was derived from control wet noodles i.e., 6.63 (slightly like it), while the wet noodles added with 20% (w/v) concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to 10% (w/v) concentration with scores of 6.63 and 6.53, respectively. The area of the spider web chart for each treatment with the various concentrations of pluchea extract was seen in Figure 2. The best treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively.

The use of pluchea leaf extract in the making of wet noodles was able to increase the functional value of wet noodles, based on the levels of bioactive compounds and antioxidant activity without changing the quality of cooking, which includes water content, swelling index and cooking loss. Besides that, the use of pluchea leaf extract did not significantly change the color and color intensity of the resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet noodles produced were still acceptable to the panelists, the addition of

pluchea leaf extract as much as 10% (w/v) was the best treatment with an assessment that was almost close to the control wet noodles (without treatment).

## **Conclusion**

Wet noodles made by incorporating hot water extract of pluchea leaf powder underwent lightness, texture, bioactive compound content, antioxidant activity, and sensory properties changes. The higher concentration of pluchea extract addition caused the bigger lightness, hardness, adhesiveness, cohesiveness, elongation, and elasticity from pluchea wet noodles. The sensory properties of the produced wet noodles evaluated by hedonic test showed that wet noodles made with 10% (w/v) concentration of hot water extract from pluchea leaf powder resulted in the color, aroma, taste, and texture with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. The concentration was the best treatment of pluchea wet noodles with an area of spider web graph i.e. 66.37 cm<sup>2</sup>.

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## **Conflict of Interest**

The authors declare no conflict of interest.

## Notes on Appendices

TPC	Total phenol content
TFC	Total flavonoid content
DPPH	2,2-Diphenyl-1-picrylhydrazyl free radical
FRAP	Ferric reducing antioxidant power
AA	Antioxidant activity
PC	Person Correlation
LDL	Low Density Lipoprotein
w/v	Weight per volume
CRD	Completely randomized design
CE	Catechin equivalent
GAE	Gallic acid equivalent
BC	Bioactive compounds
ANOVA	Analysis of variance
UV-Vis	Ultra violet-visible

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# The Effect of Hot Water Extract of Pluchea Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

*By Food 3638*

## The Effect of Hot Water Extract of Pluchea Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

### Abstract

The hot water extract of *Pluchea indica* Less leaf powder has antioxidant and antidiabetic activities because it contains phytochemical compounds, such as alkaloids, phenolics, flavonoids, sterols, tannins, phenol hydroquinone, and cardiac glycosides. Therefore, the hot water extract of pluchea leaf powder has potential to be utilized as a functional ingredient in food products. The use of hot water extract of pluchea leaf powder in jelly drinks, soybean milk, and buns is found to have effects on the physical, chemical and sensory properties of the products. This research was conducted to determine the effect of hot water extract of pluchea leaf powder on the physical, chemical and sensory properties of wet noodles. The experiment used a one-factor randomized design i.e., the concentration of hot water extract of pluchea leaf powder at the seventh level, namely i.e., 0, 5, 10, 15, 20, 25, and 30% (w/v). Parameters tested included physical properties (moisture content, swelling index, cooking loss, color, texture), chemical properties (bioactive content (total phenolic content (TPC) and total flavonoid content (TFC)), antioxidant activity (AA) (DPPH scavenging activity and iron ion reducing power), and sensory properties (taste, aroma, color, texture, and overall acceptance). The results showed that the addition of hot water extract of pluchea leaf powder had significant effects on the texture, lightness, yellowness, bioactive content, AA, and sensory properties (taste, texture, color, and overall acceptance) of wet noodles, while it had not been significant influenced the redness, chroma, hue, moisture content, swelling index, cooking loss, and aroma). The wet noodles added with 10% (w/v) hot water extract of pluchea leaf powder was the best treatment based on the hedonic test result that resulted in the color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. From the overall results of the study, it is recommended that the making of wet noodles with the addition of hot water extract from pluchea leaf powder can be used at a concentration of 10% (w/v) with TPC, TFC, DPPH free radicals scavenging activity, and iron ion reducing power 82.84 mg GAE/kg dried samples, 62.44 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples, and 51.33 mg GAE/kg dried samples, respectively.

### Key-words

Chemical, *Pluchea indica* Less, physical, sensory, wet noodles

### Introduction



*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional

medicine and food<sup>1,2</sup>. The potency of pluchea leaves is related to phytochemical compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone, alkaloid, lignans and saponins<sup>2,3,4,5</sup>. Furthermore, pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100g, fat 0.49 g/100g, insoluble dietary fiber 0.89 g/100g, soluble dietary fiber 0.45 g/100g, carbohydrate 8.65 g/100g, calcium 251 mg/100g,  $\beta$ -carotene 1.225  $\mu$ g/100g<sup>6</sup>.

Processing of pluchea leaves to be pluchea tea has been proven to exhibit antioxidant activity<sup>6,7,8</sup>, anti-diabetic activity<sup>9</sup>, anti-inflammatory activity<sup>7</sup>, anti-isolated human LDL oxidation activity<sup>10</sup>. Previous research uses hot water extract of pluchea leaf powder to make several food products to increase functional values, i.e., jelly drink<sup>11</sup>, soy milk<sup>12</sup> and steamed bun<sup>13</sup>. Using 1% (w/v) hot water extract of pluchea leaf powder can improve the physicochemical properties of jelly drink and increase panelists' acceptance of the product<sup>11</sup>. Soy milk with the addition of hot water extract from pluchea leaves increases the viscosity and total dissolved solids and decreases the panelist acceptance rate<sup>12</sup>. The addition of 6% (w/v) hot water extract from pluchea leaf powder on steamed bun is the best treatment with the lowest level of hardness<sup>13</sup>. All previous research has proven that the addition of hot water extract of pluchea leaves can increase the bioactive compound contents based on total phenol and total flavonoids, as well as increase antioxidant activity based on iron ion reducing power and DPPH free radical scavenging activity.





in making wet noodles from wheat flour has not been conducted, as well as its impact on physicochemical and sensory properties of the noodles. Noodles are a popular food product that is widely consumed in the world. Indonesia is one of the countries with the largest noodle consumption after China<sup>14</sup>. Wet noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet noodles as an alternative to wet noodles, which contain higher protein, and the second popular food in ASEAN regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia<sup>16</sup>. The addition of other ingredients has been endeavored to enhance wet noodles' specific properties. Many researchers incorporated plant extracts or natural products to increase functional properties of wet noodles, such as red spinach<sup>17</sup>, green tea<sup>18,19</sup>, purple sweet potatoes leaves<sup>20</sup>, moringa leaves<sup>21</sup>, sea weed<sup>22</sup>, ash of rice straw and turmeric extract<sup>23</sup>, and betel leaf extract<sup>24</sup> that influenced physicochemical and sensory properties of the wet noodles. The anthocyanin of red spinach ethanolic extract increased hedonic score of wet noodles' flavor<sup>17</sup>. The addition of green tea improves the stability, elastic modulus and viscosity, maintains retrogradation and cooking loss, and results no significant effect of the mouthfeel and overall acceptance from panelist on the produced wet noodles<sup>18</sup>. Moreover, the addition of sweet potatoes leaf extract on wet noodles increases moisture content, protein value and ash concentration, and improves hedonic score of texture<sup>20</sup>. Moringa extract influences protein content and decrease panelist acceptance of color, aroma and taste of the wet noodles<sup>21</sup>. The use of seaweed to produce wet noodles influences moisture content, swelling index, absorption ability, elongation value and color<sup>22</sup>. The addition of ash from rice straw and turmeric extract influences the elasticity and organoleptic properties (color, taste, aroma and texture) of the wet noodles<sup>23</sup>. Betel leaf extract



used to make hokkien noodles improves texture and acceptance score of all sensory attributes<sup>14</sup>.

Bioactive compounds and nutritive value of pluchea leaf can be an alternative ingredient to improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea leaves is potential to be an antioxidant source in wet noodles and to increase the functional value. This research was conducted to determine the effect of hot water extract from pluchea leaf powder addition on the physical, chemical and sensory properties of wet noodles.

## Materials and Methods

### Preparation of Hot Water Extract from Pluchea Leaf Powder

The young pluchea leaves number 1-6 were picked from the shoots, sorted and washed. The selected pluchea leaves were dried at ambient temperature for 7 days to derive moisture content of  $10.00 \pm 0.04\%$  dry base<sup>25</sup>. Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at 120°C for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag for about 2 g/tea bag. Pluchea leaf powder in tea bag was extracted using hot water (95°C) for 5 min to get various extract concentrations; 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

### Wet Noodles Processing

About 70 mL of hot extract from pluchea leaf powder with various concentrations (0, 5, 10, 15, 20, 25 and 30% (w/v) (Table 1) was measured and manually mixed with egg, baking powder, salt and wheat flour for 5 min (Table 2). The mixture was kneaded to form a solid and homogenized dough using a mixer (Oxone Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to form noodle strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled water about 3 min in 300 mL water and coated with oil to prevent the noodles



from sticking to each other. Wet noodles made without any addition of hot water of pluchea leaf

extract were prepared as control. Wet noodles used in bioactive compounds and antioxidant activity assay were not added with oil to prevent the noodles from sticking to one another. The final characteristics of wet noodles were having width and thickness of 0.45 cm and 0.295 cm, respectively.

#### Pluchea Wet Noodles Extraction

About 100 g of wet noodles were dried using a freeze dryer at a pressure of 0.1 bar and temperature -60°C for 28 hours to obtain dried noodles. Each dried sample was powdered using a chopper machine at the speed of 35 seconds, and then 20 g of powdered sample was added with 50 mL methanol using a shaking water bath at 35°C, 70 rpm for 1 hour<sup>26</sup>. The filtrate was separated by filtration using Whatman filter paper grade 40 and the residue was extracted again with the same procedure. The filtrate was collected and dried using rotary evaporator (Buchi Rotary Evaporator; Buchi Shanghai Ltd, China) at 200 bars, 50°C for 60 min until forming 3 mL of extract. The obtained extract was kept at 0°C before further analysis.

#### Moisture Content Assay

Moisture content of wet noodles was determined by thermogravimetric method<sup>27</sup>. The assay of moisture content from wet noodles was done by heating the samples in a drying oven (Binder, Merck KGaA, Darmstadt, Germany). The principle of this method is evaporating the water in the material. The sample was heated and weighed until a constant weight was obtained which was assumed to be all evaporated water.

#### Measurement of Swelling Index



The principle of swelling index testing is to determine the ability of noodles to absorb water

during the boiling process<sup>16</sup>. The water absorption test is carried out to determine the ability of wet noodles to absorb water per unit time that can estimate the time needed to fully cook wet noodles.

The amount of water absorbed by wet noodles can be determined from the weight difference between the noodles after and before being boiled divided by the weight of the noodles before boiling<sup>28</sup>.

#### Determination of Cooking Loss

Cooking loss is one of the important quality parameters in wet noodles to determine the quality of wet noodles after cooking<sup>28</sup>. The cooking loss test for pluchea wet noodles was carried out to determine the number of solids that leached out from the wet noodle strands during the cooking process, namely the release of a small portion of starch from the wet noodle strands. A large cooking loss value affects the texture of wet noodles, which is easy to break and less slippery.

#### Determination of Texture

The texture of wet noodles with pluchea extract addition was measured based on its hardness, adhesiveness, cohesiveness, elongation and elasticity. The texture was determined using TA-XT2 texture analyzer (Stable Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the Texture Exponent 32 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were analyzed with a compression test using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle strands with the length of 4 cm for each strand were laid side by side, touching each other, perpendicular to the 35 mm compression cylinder probe on a flat aluminium base. The





cylinder probe was arranged to be at 15 mm distance from the lower plate at the start of the

compression test, and was forced down through the noodle strips at the speed of  $2 \text{ mm s}^{-1}$  until it touched the flat base to compress 75% of the noodle thickness, and was drawn back to at the end of the test. The profile curve was determined using a texture analyzer software<sup>24,29</sup>. The hardness was determined as the maximum force per gram. The adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area was obtained from the compression test under the curve. Cohesiveness was analyzed based on the ratio between the area under the second peak and the area under the first peak<sup>24,29,30</sup>. The elongation and elasticity of the noodles were individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. Elongation was the maximum force to deform and break noodles by extension that was measured by a test speed of  $3.0 \text{ mm s}^{-1}$ , with a 100 mm distance between two rollers. The elongation at breaking was calculated per gram. Elasticity was determined by formula (1)<sup>31,32</sup>:

$$\text{Elasticity} = \frac{Fx lo}{Ax to} \frac{1}{v} \quad (1)$$

where F is the tensile strength, lo is the original length of the noodles between the limit arms (mm), A is the original cross-sectional area of the noodle ( $\text{mm}^2$ ), v is the rate of movement of the upper arm (mm/s), and t is break up time of the noodles (s). The measurement of texture was recorded using the software and expressed as a graph.

#### Color Measurement

The color of the noodle sheets was measured by a colorimeter (Minolta CR 10, Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab  $L^*$ ,  $a^*$  and  $b^*$  values were analyzed based on Fadzil et al.,<sup>29</sup>



method. The L\* value was stated as the position on the white/black axis, the a\* value as the position

on the red/green axis, and the b\* value as the position on the yellow/blue axis.

#### Analysis of Total Phenol Content

The total phenol content analysis is measured based on the reaction between phenolic compounds and folin ciocalteu/FC reagent (phosphomolybdic acid and phosphotungstic acid). FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups becomes a blue molybdenum-tungsten complex solution<sup>33</sup>. The intensity of the blue color was measured by a UV-Vis spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  760 nm. In the analysis, 7.5% Na<sub>2</sub>CO<sub>3</sub> solution was added to reach pH 10 that caused an electron transfer reaction (redox). The obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

#### Analysis of Total Flavonoid Content

The flavonoid content in wet noodles was measured by the spectrophotometric method based on the reaction between flavonoids and AlCl<sub>3</sub> to form a yellow complex solution. In the presence of NaOH solution, a pink color is formed which can be measured by spectrophotometer (Spectrophotometer UV- Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm<sup>33,34,35</sup>. The obtained data were expressed in mg of (+)-catechin equivalent (CE)/L sample.

#### Analysis of DPPH Free Radical Scavenging Activity

DPPH (2,2-diphenyl-1-picrylhydrazyl) is a free radical that used to evaluate antioxidant activity. The principle of the DPPH method is to measure the absorbance of compounds that can react with DPPH<sup>36</sup>. Antioxidant compounds can donate hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced to yellow<sup>37</sup>. The color change was measured as an



The data were expressed in mg gallic acid equivalent (GAE)/L sample.

#### Analysis of Iron Ion Reduction Power

This method identifies the capacity of antioxidant components through increasing absorbance as a result of the reaction of antioxidant compounds with potassium ferricyanide, trichloroacetic acid, and ferric chloride to produce color complexes that can be measured spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm<sup>39</sup>. The principle of this testing is the ability antioxidants to reduce iron ions from potassium ferricyanide ( $\text{Fe}^{3+}$ ) to potassium ferrocyanide ( $\text{Fe}^{2+}$ ). Potassium ferrocyanide reacts with ferric chloride to form a ferric-ferrous complex. The color change that occurs is yellow to green<sup>40</sup>. The final data were expressed in mg gallic acid equivalent (GAE)/L sample.

#### Sensory Evaluation

All samples of wet noodles were proceeded to hedonic test by involving 100 untrained panelists with an age range of 17 to 25 years. A hedonic test used in this research was the hedonic scoring method, where the panelists gave a preference score value of all samples<sup>41</sup>. The hedonic scores were transformed to numeric scale and analyzed using statistical analysis<sup>42</sup>. The numeric scale in the sensory analysis used a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The panelists were asked to score according to their level of preference for texture, taste, color, flavor and overall acceptability. All the samples were blind coded with 3 digits which differed from each other<sup>43</sup>.



The research design used in the physicochemical assay was a randomized block design (RBD) with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25%, and 30% (w/v). Each treatment was repeated four times in order to obtain 28 experiment units. The sensory test used a completely randomized design (CRD) on 100 untrained panelists with an age range of 17 to 25 years.

The data normal distribution and homogeneity were presented as the mean  $\pm$  SD of the triplicate determinations and were analyzed using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan Multiple Range Test) at  $p \leq 5\%$  to determine the level of treatment that gave significant different results. The best treatment of pluchea extract addition on wet noodles was determined using a spider web graph.

## Results and Discussion

Wet noodles added with hot extract of pluchea leaf powder were produced with aiming to increase the functional value of wet noodles. This is supported by several previous researches related to the potential value of water extract of pluchea leaf that exhibit a biological activity<sup>6,7,41</sup>. In this research, the cooking quality was observed after cooking wet noodles in 300 mL water/100g samples for 3 min in boiling water.

## Cooking Quality

Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at various concentrations (0, 5, 10, 15, 20, 25, and 30% (w/v)) was shown in Figure 1, Table 3 and Table 4. The addition of pluchea extract did not significantly influence the moisture content,



swelling index, cooking loss, chroma, and hue of the produced wet noodles based on the statistical

analysis by ANOVA at  $p \leq 5\%$ . Moisture content is one of the chemical properties of a food product that determines the shelf life of food products because the moisture content measures the free water content and weakly bound water in foodstuffs<sup>44,45</sup>. This study identified that the moisture content of the cooked wet noodles ranged between 64-67% wb. A previous study showed that the moisture content of the cooked egg wet noodles was around 54-58% wb<sup>45</sup> and maximum of 65%<sup>20</sup>. Chairuni et al.,<sup>44</sup> stated that the boiling process could cause a change in moisture content from around 35% to around 52%. The Indonesian National Standard,<sup>46</sup> stipulates that the moisture content of cooked wet noodles is a maximum of 65%. This means that only control noodles (without treatment) exhibited a moisture content similar to the previous information. The obtained data showed a trend that an increase in extract addition caused an increase in the moisture content of wet noodles, but statistical analysis at  $p \leq 5\%$  showed no significant difference. This phenomenon was in accordance with the experimental results of Juliana et al.,<sup>45</sup> that the using of spenochlea leaf extract to making wet noodles, as well as Hasmawati et al.,<sup>20</sup> that the supplementary of sweet potato leaf extract increased the moisture of fresh noodles. The moisture content of pluchea wet noodles was expected by an interaction between many components composing the dough that impacted to the swelling index and cooking loss. Mualim et al.,<sup>14</sup> Bilina et al.,<sup>22</sup> and Setiyoko et al.,<sup>28</sup> informed that the presence of amino groups in protein and hydroxyl groups in amylose and amylopectin fractions in wheat flour as raw material for making dough determines the moisture content, swelling index and cooking loss of wet noodles. The contribution of glutelin and gliadin proteins in the formation of gluten networks determines the ability of noodles to absorb and retain water in the system. Gliadin acts as an adhesive that causes dough to be elastic, while glutenin





makes the dough to be firm and able to withstand CO<sub>2</sub> gas thus the dough can expand and form

pores. Fadzil et al.,<sup>29</sup>, found that thermal treatment during the boiling process results in the denaturation of gluten and caused a monomer of proteins to determine other reactions at the disulfide or sulfhydryl chain. The existence of phenolic compounds from pluchea extract also increased the capacity of noodles to absorb water and determined water mobility. Widyawati et al.,<sup>41</sup>, also confirmed that hydrophilic compounds of proteins, carbohydrates, and polyphenolic components determine water mobility due to their ability to bind with water molecules through hydrogen bonding. Tuhumury et al.,<sup>47</sup>, informed that gluten formation can inhibit water absorption by starch granules so that can prevent gelatinization. Therefore, the addition of phenolic compounds from the hot extract of pluchea leaf powder can inhibit the formation of gluten so that it stimulates gelatinization of starch granules.

As a result, the impact of increased the moisture content during boiling had an effect on the value of the swelling index and cooking loss of the wet noodles. Widyawati et al.,<sup>41</sup>, said that the swelling index is the capability to absorb water which is dependent on the particle size, chemical composition, and moisture content. Gull et al.,<sup>48</sup>, also confirmed that the swelling index is an indicator to determine water absorption by starch and protein to make gelatinization and hydration. Setiyoko et al.,<sup>28</sup>, explained that cooking loss is the mass of noodle solids that come out of the noodle strands during the cooking process. Gull et al.,<sup>48</sup>, added that soluble starch and other soluble components leach out into the water during the cooking process, making the cooking water turned thicker. The moisture content results (64-67% wb) showed that the produced wet noodles exceeded the moisture content limit of wet noodles after cooking, which is between 54-58%<sup>44</sup>,

while the cooking loss value of wet noodles should not be more than 10%<sup>28</sup>. In this study, the cooking

loss value was 3-4.2%. The cooking loss of samples during boiling noodles were caused the breaking of the bonding network that the polysaccharides are released and the gluten network breaks because of the addition of pluchea leaf extract. Widyawati et al.,<sup>41</sup>, supported that polyphenol can be bound with protein and starch with many non-covalent interactions, such as hydrophobic interaction, hydrogen bonding, electrostatic interaction, Van der Waals interaction, and  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch to undergo gelatinization and gliadin and glutenin from the protein of wheat flour to form gluten.

The swelling index value obtained from this research was around 56-68 %. Based on the previous research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.) fruit was around 51%<sup>49</sup>. This means that the addition of pluchea leaf extract in wet noodles also affects the ability of noodles to absorb water. Widyawati et al.,<sup>41</sup>, and Suriyaphan,<sup>6</sup>, informed that bioactive compounds in hot water extract of pluchea leaf tea include 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, 4,5-O-dicaffeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was higher than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from extract in absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch granules to absorb water so that the swelling index and cooking loss increased. Suriyaphan,<sup>6</sup>, informed that hot extract of pluchea leaf tea contains 1.79g/100g protein, 8.65g/100g carbohydrate, and fiber (0.45g/100g soluble and 0.89g/100g insoluble), these compounds can involve in increasing the swelling index from pluchea wet noodles.



Color is one of the physical characteristics possessed by wet noodles that becomes a

benchmark for consumer acceptance. This research found that the addition of pluchea extract affected the color of wet noodles. The addition of pluchea leaf extract did not significantly affect the redness ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it affected the yellowness ( $b^*$ ) and lightness ( $L^*$ ) values. The use of hot water extract from pluchea leaf powder decreased the brightness of wet noodles significantly as the concentration of the extract increased. This is related to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to experience color changes. According to Widyawati et al.,<sup>8</sup>, tannins are water-soluble compounds that can give a brown color. Suriyaphan,<sup>6</sup> and Widyawati et al.,<sup>41</sup>, also stated that Khlu tea from pluchea leaves contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and  $6.39$  mg/100g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow color. Gull et al.,<sup>48</sup>, stated that this pigment was easily changed in the paste sample due to the swelling and discoloration of the pigment during cooking.

Thus, the addition of pluchea leaf extract significantly reduced the brightness of wet noodles, because brown-colored noodles were produced as the concentrations of added pluchea leaf extract increased. However, increasing the concentration of pluchea leaf extract had no effect on the redness, hue, and chroma values in statistical analysis (ANOVA) at  $p \leq 5\%$ . The results showed that the redness value of wet noodles ranged from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet noodles ranged from  $82.1 \pm 3.1$  to  $86.5 \pm 1.0$ . Based on this value, the color of wet noodles is in the yellow to the red color range<sup>50</sup>, thus the visible color of the wet noodle product was yellow to brown (Figure 1). Yellowness increased significantly with the addition of pluchea leaf extract and the value ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the presence of tannins and





chlorophyll compounds from pluchea leaf extract. The chroma value of wet noodles was obtained

within the range of  $15.6 \pm 1.5$ – $19.8 \pm 3.4$ . This means that the hot water extract of pluchea leaf powder did not change the intensity of the brown color in the resulting wet noodles.

Texture analysis of pluchea wet noodles added with various concentrations of hot water extract from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness, elongation, and elasticity. Hardness is the maximum force given to a product until deformation<sup>51,52</sup>. From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher peak of graph shows the harder product<sup>30</sup>. Adhesiveness is force or tackiness that is required to pull the product from its surface, its value is obtained from the area between the first and second compressions<sup>53,54</sup>. Adhesiveness values show negative value; the bigger negative value means the product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and second compressions<sup>52,54</sup>. This is an indication of the internal forces that make up the product<sup>55</sup>. Elongation is the change in length of noodles when being exposed to a tensile force until the noodles break<sup>56</sup>. Elasticity is the time required for the product to withstand the load until it breaks. The more elastic a product, the longer the holding time. The data showed that the higher concentration of pluchea leaf powder within the hot water extract caused a significant increase in the hardness, stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati et al.,<sup>41</sup>, informed that the polyphenols contained in pluchea leaf extract can weakly interact either covalently or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups that are polar. Amoako and Akiwa,<sup>57</sup> and Zhu et al.,<sup>58</sup>, have also proven that polyphenolic compounds can interact with carbohydrates through the



interaction of two hydrophobic and hydrophilic functional groups with amylose. Diez-Sánchez et

al.<sup>59</sup>, stated that polyphenolic compounds can interact with amylose and protein helical structures and largely determined by molecular weight, conformational mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and amylopectin can affect the gelatinization process in the amylose helical structure and interfere with the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss (>98%) and swelling index (56.2 -67.7%) data, it can be concluded that the interaction that occurs between the phenol group in pluchea leaf extract with amylose and protein was weak. The bioactive components of pluchea leaf extract are thought to affect the formation of disulfide cross-links (S-S) and turn into to form sulfhydryl groups (-SH) under the influence of heat. Ananingsih and Zhou,<sup>60</sup>, said that antioxidant compounds are a reducing agent that can have an impact on reducing S-S bonds and increasing the number of SH groups in the dough to produce a harder texture. According to Rahardjo *et al.* (2020), phenolic compounds are hydroxyl compounds that influence the strength of the dough, where the higher the component of phenol compounds will weaken the gluten matrix and the dough thus becoming unstable. The instability of the dough can cause the texture to become hard.

Many researchers also find that tannins and phenols influence the networking S-S bond in the dough of wet noodles. Wang *et al.* (2015) showed that tannins increase the relative amount of large, medium polymers in the gluten protein network so as to improve the dough quality. Zhang et

al.,<sup>61</sup> said that these polymer compounds are the results of interactions or combinations of protein-

tannin compounds that form bonds with the type of covalent bonds, hydrogen bonds, or ionic bonds.

Rauf and Andini,<sup>62</sup> also added that phenol compounds are able to reduce S-S bonds to SH bonds. SH

is a type of thiol compound group, where the thiol group can influence the stickiness, viscosity,

cohesiveness, elongation, and extensibility of the dough. Wang et al.,<sup>63</sup> found the effect of phenolic

compounds from green tea extract to increase the stickiness of wheat bread. The cohesiveness of the

dough is formed due to a large number of thiol bonds formed, thus increasing the viscosity of the

dough. The increased viscosity of the dough is thought to be due to the formation of polyphenolic

compounds with thiol groups, as in the research of Ananingsih and Zhou,<sup>60</sup> that the formation of

catechin-thiol can increase the viscosity of the dough and increase the stability of the dough. Zhu et

al.,<sup>64</sup> declared that the addition of phenolic compounds from green tea was able to increase the PV

(peak viscosity) of wheat flour. Wang et al.,<sup>65</sup> also found that the cohesiveness of the dough is

influenced by tannins, where tannins can produce micro-glutens so as to produce a compact dough

and increase the gluten network. The addition of pluchea leaf extract in making wet noodles could

influence the elongation of wet noodles due to the components of polyphenol compounds such as

tannins that can reduce the number of free amino groups. This is supported by Zhang et al.,<sup>30</sup> and

Wang et al.,<sup>65</sup> that support the formation of other types of covalent bonds, such as bonds between

amino groups and hydroxyl groups, by forming hydrogen bonds between phenolic compounds and

protein gluten so as to improve the quality of dough strength and dough extensibility.

### Bioactive Compounds and Antioxidant Activity

Wet noodles added with pluchea leaf powder were analyzed based on its bioactive





compounds and antioxidant activities. The analysis was carried out to determine the functional

properties of wet noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles are presented in Table 5. The measured bioactive compounds (BC) included total phenol content (TPC) and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical scavenging activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed that there was a positive and strong correlation between TPC and DPPH ( $r=0.990$ ), TPC and FRAP ( $r=0.986$ ), TFC and DPPH ( $r=0.974$ ), and TFC and FRAP ( $r=0.991$ ). This means that the antioxidant activity of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah et al.,<sup>66</sup>, informed that the PC ( $r$ )  $> 0.699$  indicates the strength and linear correlation between antioxidant activity (AA) and TPC, and also shows a strong positive relationship but PC ( $r$ )  $< 0.699$  obtains a moderately positive relationship. If the  $r$  value of TFC and AA is lower than TPC and AA, it indicates that the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship which is expected because both classes all contributed to AA plants. Aryal et al.,<sup>67</sup>, and Muflihah et al.,<sup>66</sup>, informed that phenolic compounds are soluble natural antioxidants and potential donating electrons depend on their number and position of hydroxyl groups contributed to antioxidant action. Consequently, these groups are responsible to scavenge the free radicals that TPC of pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the stable purple-colored to the yellow-colored solution. Based on FRAP analysis, it was

showed that the bioactive compounds contained in pluchea wet noodles are a potential source of

antioxidants because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive compounds contained in pluchea wet noodles can function as primary and secondary antioxidants. Research data showed that the cooking quality of wet noodles tends to increase along with the increase in the value of TPC, TFC, DPPH, and FRAP.

### Sensory Evaluation

Sensory pluchea wet noodles, namely color, aroma, taste, texture, and overall acceptance, were carried out using a hedonic test to determine the level of consumer preference for the product. This test was conducted to determine the quality differences between the products and to provide an assessment on certain properties<sup>42</sup>. The hedonic test itself is the most widely used test to measure the level of preference for production<sup>68</sup>. The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm 1.26$  (neutral-like). The statistical analysis showed that the higher concentration of pluchea extract addition caused lower color preference of wet noodles. The higher concentration of pluchea extract could reduce the level of preference for color because the color of the wet noodles was darker than control and turned to dark brown. This color change was due to the pluchea extract containing several components, including chlorophyll and tannins, which can alter the of wet noodles' color to be browner along with the increase in the concentration of pluchea extract. This result was in accordance to the results of color analysis performed using color reader where the pluchea wet noodles' brightness declined, yellowness increased, and the color intensity increased with an increased concentration of pluchea extract. The occurrence of this process is related to the





effect of light and heat on pluchea leaf powder which causes the degradation of chlorophyll into

brown pheophytin due to drying, where the nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals<sup>69,70</sup>.

Aroma is one of the parameters in sensory evaluation using the sense of smell and is an indicator of the assessment of a product<sup>71</sup>. The results of the preference value for aroma were ranged from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet noodles reduced the panelists' preference for aroma due to the occurrence of distinct dry leaves (green) aroma. Lee et al.,<sup>72</sup>, informed that the unpleasant aroma on leaves comes from a group of aliphatic aldehyde compounds. The appearance of a distinctive leaf aroma in noodles is due to aromatic compounds. According to Martiyanti and Vita,<sup>73</sup>, aromatic compounds are chemical compounds that have an aroma or odor when the conditions are met, which is volatile, while Widiyawati et al.,<sup>74</sup>, informed that pluchea leaves were detected to have 66 volatile compounds. The appearance of the aroma is due to the volatile compounds in the raw material reacting with water vapor when boiling the noodles. In addition, there is also an oxidation process of polyphenolic compounds such as catechins or tannins that can produce an aroma in pluchea wet noodles.

According to Martiyanti and Vita,<sup>3</sup>, taste attribute is one important sensory aspect in food products and has a great impact on the food selection by consumers. Tongue are able to detect basic tastes, namely sweet, salty, sour, and bitter, at different points. Lamusu,<sup>71</sup>, declared that taste is a component of flavor and an important criterion in assessing a product that is accepted by the tongue. The preference test of the taste of pluchea wet noodles resulted in values ranging from  $4.15 \pm 1.40$  to  $5.50 \pm 1.28$  (neutral-slightly like). The increase in concentrations of pluchea extract was



negatively correlated to the preference level of the pluchea wet noodles' taste assessed by the panelists. The statistical analysis results showed that the difference in the concentration of pluchea extract had a significant effect on the panelists' preference for the taste of pluchea wet noodles. The increased concentration of pluchea extract produced a distinctive taste on wet noodles, such as a bitter, bitter, and astringent tastes, due to the presence of compounds such as tannins and alkaloids from the pluchea leaves. Susetyarini,<sup>75</sup> said that pluchea leaves contain tannins (2.351%), and alkaloids (0.316%). According to Pertiwi,<sup>76</sup> tannin compounds dominate the bitter and astringent taste, while alkaloid compounds cause a bitter taste. The high level of taste preference for wet noodles was found in noodles with lower content of pluchea extract.

Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and swallowed) or touched with fingers<sup>77</sup>. Texture testing performed by the panelist is called mouthfeel testing. According to Martiyanti and Vita,<sup>73</sup> mouthfeel is the kinesthetic effect of chewing food in the mouth. In this study, the preference test results on the texture of pluchea wet noodles ranged from  $5.5 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and draining noodles. Subjective testing results based on sensory evaluation were in line with the objective testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to break, and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea wet noodles was influenced by the fiber and protein components. According to Shabrina,<sup>78</sup> the components of fiber, protein, and starch



compete to bind water. Texture changes are also influenced by the polyphenol compounds in the

pluchea extract which is able to reduce S-S bonds to SH bonds, where the increase in SH (thiol) groups can give a hard, sticky, and compact texture<sup>62,63,65</sup>. Besides, a high concentration of tannins capable of binding to proteins to form complex compounds into tannins-proteins are also able to build noodles' texture.

The interaction between color, aroma, taste, and texture created an overall taste of the food product and was assessed as the overall preference. The highest value on the overall preference was derived from control wet noodles i.e., 6.63 (slightly like it), while the wet noodles added with 20% (w/v) concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to 10% (w/v) concentration with scores of 6.63 and 6.53, respectively. The area of the spider web chart for each treatment with the various concentrations of pluchea extract was seen in Figure 2. The best treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively.

The use of pluchea leaf extract in the making of wet noodles was able to increase the functional value of wet noodles, based on the levels of bioactive compounds and antioxidant activity without changing the quality of cooking, which includes water content, swelling index and cooking loss. Besides that, the use of pluchea leaf extract did not significantly change the color and color intensity of the resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet noodles produced were still acceptable to the panelists, the addition of





pluchea leaf extract as much as 10% (w/v) was the best treatment with an assessment that was almost close to the control wet noodles (without treatment).

## Conclusion

Wet noodles made by incorporating <sup>1</sup> hot water extract of pluchea leaf powder underwent lightness, texture, bioactive compound content, antioxidant activity, and sensory properties changes. The higher <sup>1</sup> concentration of pluchea extract addition caused the bigger lightness, hardness, adhesiveness, cohesiveness, elongation, and elasticity from pluchea <sup>1</sup> wet noodles. The sensory properties of the produced wet noodles evaluated by hedonic test showed that wet noodles made with 10% (w/v) concentration of <sup>2</sup> hot water extract from pluchea leaf powder resulted in the color, aroma, taste, and texture with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. The concentration was <sup>1</sup> the best treatment of pluchea wet noodles with an area of spider web graph i.e. 66.37 cm<sup>2</sup>.

# The Effect of Hot Water Extract of Pluchea Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

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## The Effect of Hot Water Extract of *Pluchea* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

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### Abstract

Powdered *Pluchea indica* Less leaves have been utilized as herbal tea, brewing of pluchea tea by hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional value and influence physic, chemical, and sensory characteristics of food. The study was done to aim the effect of various concentration of brewing from pluchea tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with concentration of brewing pluchea tea at the seventh level, i.e., 0, 5, 10, 15, 20, 25, and 30% (w/v). The physical properties was analyzed, including water content, swelling index, cooking loss, color, texture, chemical properties was measured, namely bioactive content (total phenolic content (TPC) and total flavonoid content (TFC)), and antioxidant activity (AA) (ability to scavenge DPPH free radical and iron ion reducing power), and sensory properties was determined, i.e., taste, texture, color, aroma, and overall acceptance. The addition of various concentration of extract gave significantly effects on parameters of physical, chemical, and sensory properties of noodles, except color (redness, chroma, and hue), cooking loss, water content, swelling index, and aroma. Using of 10% (w/v) brewing of pluchea tea resulted the best treatment obtained from the hedonic test, that afforded sensory properties, such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. Generally of this research can be concluded that the making of wet noodles with the addition of brewing of pluchea tea can be used at a concentration of 10% (w/v) with TPC, TFC, ability to scavenge DPPH free, and iron ion reducing power 82.84 mg GAE/kg dried samples, 62.44 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples, and 51.33 mg GAE/kg dried samples, respectively.

### Key-words

Chemical, *Pluchea indica* Less, physical, sensory, wet noodles

### Introduction

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food<sup>1,2</sup>. The potency of pluchea leaves is related to phytochemical compounds, such as

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41 tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone, alkaloid, lignans and  
42 saponins<sup>2,3,4,5</sup>. Furthermore, pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100g, fat  
43 0.49 g/100g, insoluble dietary fiber 0.89 g/100g, soluble dietary fiber 0.45 g/100g, carbohydrate 8.65  
44 g/100g, calcium 251 mg/100g,  $\beta$ -carotene 1.225  $\mu$ g/100g<sup>6</sup>.

45 Processing of pluchea leaves to be pluchea tea has been proven to exhibit antioxidant  
46 activity<sup>6,7,8</sup>, anti-diabetic activity<sup>9</sup>, anti-inflammatory activity<sup>7</sup>, anti-isolated human LDL oxidation  
47 activity<sup>10</sup>. Previous research uses brewing of pluchea leaf powder to make several food products to  
48 increase functional values, i.e., jelly drink<sup>11</sup>, soy milk<sup>12</sup> and steamed bun<sup>13</sup>. Using 1% (w/v) brewing of  
49 pluchea leaf powder can improve the physicochemical properties of jelly drink and increase panelists'  
50 acceptance of the product<sup>11</sup>. Soy milk with the addition of brewing from pluchea leaves increases the  
51 viscosity and total dissolved solids and decreases the panelist acceptance rate<sup>12</sup>. The addition of 6%  
52 (w/v) brewing from pluchea leaf powder on steamed bun is the best treatment with the lowest level  
53 of hardness<sup>13</sup>. All previous research has proven that the addition of brewing of pluchea leaves can  
54 increase the bioactive compound contents based on total phenol and total flavonoids, as well as  
55 increase antioxidant activity based on ferric reducing power and ability to scavenge DPPH free radical.

56 To the best of our knowledge, the study of the addition of steeping water of pluchea tea in  
57 making wet noodles from wheat flour has not been conducted, as well as its impact on physicochemical  
58 and organoleptic characteristics of the noodles. Noodles are a popular food product that is widely  
59 consumed in the world. Indonesia is one of the countries with the largest noodle consumption after  
60 China<sup>14</sup>. Wet noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet  
61 noodles as an alternative to wet noodles, which contain higher protein, and the second popular food

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62 in ASEAN regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia<sup>16</sup>.  
63 The addition of other ingredients has been endeavored to enhance wet noodles' specific properties.  
64 Many researchers incorporated plant extracts or natural products to increase functional properties of  
65 wet noodles, such as red spinach<sup>17</sup>, green tea<sup>18,19</sup>, purple sweet potatoes leaves<sup>20</sup>, moringa leaves<sup>21</sup>,  
66 sea weed<sup>22</sup>, ash of rice straw and turmeric extract<sup>23</sup>, and betel leaf extract<sup>24</sup> that influenced physical,  
67 chemical, and organoleptic properties of the wet noodles. The anthocyanin of red spinach ethanolic  
68 extract increased hedonic score of wet noodles' flavor<sup>17</sup>. The addition of green tea improves the  
69 stability, elastic modulus and viscosity, maintains retrogradation and cooking loss, and results no  
70 significant effect of the mouthfeel and overall acceptance from panelist on the produced wet  
71 noodles<sup>18</sup>. Moreover, the addition of sweet potatoes leaf extract on wet noodles increases moisture  
72 content, protein value and ash concentration, and improves hedonic score of texture<sup>20</sup>. Moringa  
73 extract influences protein content and decrease panelist acceptance of color, aroma and taste of the  
74 wet noodles<sup>21</sup>. The use of seaweed to produce wet noodles influences moisture content, swelling  
75 index, absorption ability, elongation value and color<sup>22</sup>. The addition of ash from rice straw and turmeric  
76 extract influences the elasticity and sensory characteristics (color, taste, aroma and texture) of the wet  
77 noodles<sup>23</sup>. Betel leaf extract used to make hokkien noodles improves texture and acceptance score of  
78 all sensory attributes<sup>24</sup>.

79 Bioactive compounds and nutritive value of pluchea leaf can be an alternative ingredient to  
80 improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea  
81 leaves is potential to be an antioxidant source in wet noodles and to increase the functional value. The

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82 study was done to aim the effect of various concentration of brewing from pluchea tea on the physical,  
83 chemical and sensory properties of wet noodles.

#### 84 **Materials and Methods**

85

#### 86 **Preparation of Hot Water Extract from Pluchea Leaf Powder**

87 The young pluchea leaves number 1-6 were picked from the shoots, sorted and washed. The  
88 selected pluchea leaves were dried at ambient temperature for 7 days to derive moisture content of  
89  $10.00 \pm 0.04\%$  dry base<sup>25</sup>. Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at  
90  $120^{\circ}\text{C}$  for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag  
91 for about 2 g/tea bag. Pluchea leaf powder in tea bag was extracted using hot water ( $95^{\circ}\text{C}$ ) for  
92 5 min to get various extract concentrations; 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

#### 93 **Wet Noodles Processing**

94 About 70 mL of hot extract from pluchea leaf powder with various concentrations (0, 5, 10, 15,  
95 20, 25 and 30% (w/v) (Table 1) was measured and manually mixed with egg, baking powder, salt and  
96 wheat flour for 5 min (Table 2). The mixture was kneaded to form a solid and homogenized dough using  
97 a mixer (Oxone Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to  
98 form noodle strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled  
99 water about 3 min in 300 mL water and coated with oil to prevent the noodles from sticking to each  
100 other. Wet noodles made without any addition of hot water of pluchea leaf extract were prepared as  
101 control. Wet noodles used in bioactive compounds and antioxidant activity assay were not added with  
102 oil to prevent the noodles from sticking to one another. The final characteristics of wet noodles were  
103 having width and thickness of 0.45 cm and 0.295 cm, respectively.

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**104 Pluchea Wet Noodles Extraction**

105 About 100 g of wet noodles were dried using a freeze dryer at a pressure of 0.1 bar and  
106 temperature -60°C for 28 hours to obtain dried noodles. Each dried of pluchea leaves were powdered  
107 using a chopper machine at the speed of 35 seconds. 20 g of powdered pluchea leaves were mixed by  
108 50 mL absolute methanol in a shaking water bath at 35°C, 70 rpm for 1 hour<sup>26</sup>. The filtration was done  
109 to separate filtrate by using Whatman filter paper grade 40 and the extraction of residue was done  
110 again with the same procedure. The collection of filtrates was done, then evaporation by rotary  
111 evaporator was done to get 3 mL of extract (Buchi Rotary Evaporator; Buchi Shanghai Ltd, China) at 200  
112 bars, 50°C for 60 min. The obtained extract was kept at 0°C before further analysis.

**113 Moisture Content Assay**

114 Moisture content or water content of wet noodles was determined by thermogravimetric  
115 method<sup>27</sup>. The assay of moisture content from wet noodles was done by heating the samples in a drying  
116 oven (Binder, Merck KGaA, Darmstadt, Germany). The principle of this method is evaporating the water  
117 in the material. The sample was heated and weighed until a constant weight was obtained which was  
118 assumed to be all evaporated water.

**119 Measurement of Swelling Index**

120 The principle of swelling index testing determines capability of noodles to swell during the  
121 boiling process<sup>16</sup>. The swelling index assay is done to determine the ability of wet noodles to absorb  
122 water per unit time that can estimate the time needed to fully cook wet noodles. The amount of water  
123 absorbed by wet noodles was measured from the weight difference of noodles after and before being  
124 boiled divided by the initial weight of the noodles<sup>28</sup>.

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**125 Determination of Cooking Loss**

126 Cooking loss is one of the necessary quality parameters in wet noodles to establish the quality  
127 of wet noodles after boiling<sup>28</sup>. The cooking loss assay for pluchea wet noodles was done to measure  
128 the number of solids that leached out from the wet noodle strands during the boiling process, namely  
129 the leak of a small portion of starch from the wet noodle strands. A large cooking loss value affects the  
130 texture of wet noodles, which is easy to break and less slippery.

**131 Determination of Texture**

132 The texture of wet noodles with pluchea extract addition was measured based on its hardness,  
133 adhesiveness, cohesiveness, elongation and elasticity. The texture was analyzed by TA-XT2 texture  
134 analyzer (Stable Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the  
135 Texture Exponent 32 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were  
136 analyzed with a compression assay using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle strands  
137 with the length of 4 cm for each strand were laid side by side, touching each other, perpendicular to  
138 the 35 mm compression cylinder probe on a flat aluminium base. The cylinder probe was arranged to  
139 be at 15 mm distance from the lower plate at the start of the compression test, and was forced down  
140 through the noodle strips at the speed of 2 mm s<sup>-1</sup> until it touched the flat base to compress 75% of  
141 the noodle thickness, and was drawn back to at the end of the test. The profile curve was determined  
142 using a texture analyzer software<sup>24,29</sup>. The hardness was determined as the maximum force per gram.  
143 The adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area  
144 was obtained from the compression test under the curve. Cohesiveness was analyzed based on the

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ratio between the area under the second peak and the area under the first peak<sup>24,29,30</sup>. The elongation and elasticity of the noodles were individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. Elongation was the maximum force to change of noodle form and break by extension that was analyzed by a test speed of 3.0 mm s<sup>-1</sup> between two rollers with a 100 mm distance. The elongation at breaking was calculated per gram. Elasticity was determined by formula (1)<sup>31,32</sup>:

$$\text{Elasticity} = \frac{Fx lo}{Ax to} \frac{1}{v} \quad (1)$$

where F is the tensile strength, lo is the original length of the noodles between the limit arms (mm), A is the original cross-sectional area of the noodle (mm<sup>2</sup>), v is the rate of movement of the upper arm (mm/s), and t is break up time of the noodles (s). The measurement of texture was detected by the software and expressed as a graph.

## Color Measurement

The color of the noodle sheets was determined by a colorimeter (Minolta CR 10, Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab L\*, a\* and b\* values were analyzed based on Fadzil et al.,<sup>29</sup>, method. The L\* value measured the position on the white/black axis, the a\* value as the position on the red/green axis, and the b\* value as the position on the yellow/blue axis.

## Analysis of Total Phenol Content

The total phenol content analysis is analyzed based on the reaction between phenolic compounds and folin ciocalteu/FC reagent (phosphomolybdic acid and phosphotungstic acid). FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups becomes a blue molybdenum-

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165 tungsten complex solution<sup>33</sup>. The intensity of the blue color was detected by a UV-Vis  
166 spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  760 nm. In the analysis,  
167 7.5% Na<sub>2</sub>CO<sub>3</sub> solution was added to reach pH 10 that caused an electron transfer reaction (redox). The  
168 obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

#### 169 **Analysis of Total Flavonoid Content**

170 The flavonoid content assay was done by the spectrophotometric method based on the  
171 reaction between flavonoids and AlCl<sub>3</sub> to form a yellow complex solution. In the presence of NaOH  
172 solution, a pink color is formed which can be detected by spectrophotometer (Spectrophotometer UV-  
173 Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm<sup>33,34,35</sup>. The obtained data were expressed in mg of (+)-catechin  
174 equivalent (CE)/L sample.

#### 175 **Analysis of DPPH Free Radical Scavenging Activity**

176 The ability of antioxidant compounds of extract to scavenge DPPH (2,2-diphenyl-1-  
177 picrylhydrazyl) free radical can be used to evaluate antioxidant activity. The principle of the DPPH  
178 method is to measure the absorbance of compounds that can react with DPPH<sup>36</sup>. Antioxidant  
179 compounds can donate hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced  
180 to yellow<sup>37</sup>. The color change was measured as an absorbance at  $\lambda$  517 nm by spectrophotometer  
181 (Spectrophotometer UV Vis 1800, Shimadzu, Japan)<sup>38</sup>. The data were expressed in mg gallic acid  
182 equivalent (GAE)/L dried noodles sample.

#### 183 **Analysis of Iron Ion Reduction Power**

184 This method identifies the capacity of antioxidant components through increasing absorbance  
185 as a result of the reaction of antioxidant compounds with potassium ferricyanide, trichloroacetic acid,

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and ferric chloride to produce color complexes that can be measured spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm<sup>39</sup>. The principle of this testing is the ability antioxidants to reduce iron ions from  $K_3Fe(CN)_6$  ( $Fe^{3+}$ ) to  $K_4Fe(CN)_6$  ( $Fe^{2+}$ ). Then, potassium ferrocyanide reacts with  $FeCl_3$  to form a  $Fe_4[Fe(CN)_6]_3$  complex. The color change that occurs is yellow to green<sup>40</sup>. The final data were stated in mg gallic acid equivalent (GAE)/L dried noodles.

### 191 **Sensory Evaluation**

All samples of wet noodles were proceeded to hedonic test by involving 100 untrained panelists with an age range of 17 to 25 years. A hedonic test used in this research was the hedonic scoring method, where the panelists gave a preference score value of all samples<sup>41</sup>. The hedonic scores were transformed to numeric scale and analyzed using statistical analysis<sup>42</sup>. The numeric scale in the sensory analysis used a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The panelists were asked to score according to their level of preference for texture, taste, color, flavor and overall acceptability. All the samples were blind coded with 3 digits which differed from each other<sup>43</sup>.

### 199 **Statistical Analysis**

The research design used in the physicochemical assay was a randomized block design (RBD) with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25, and 30% (w/v). Each treatment was repeated four times that obtained 28 experiment units. A completely randomized design (CRD) was used to evaluated sensory assay with 100 untrained panelists with an age range of 17 to 25 years.

The data normal distribution and homogeneity were stated as the mean  $\pm$  SD of the triplicate determinations and were determined using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc.,

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Chicago, IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan Multiple Range Test) at  $p \leq 5\%$  to determine the level of treatment that gave significant different results. The best treatment of pluchea extract addition on wet noodles was analyzed by a spider web graph.

## Results and Discussion

Wet noodles added with hot extract of pluchea leaf powder were produced with aiming to increase the functional value of wet noodles. This is supported by several previous researches related to the potential value of water extract of pluchea leaf that exhibit a biological activity<sup>6,7,41</sup>. In this research, the cooking quality was observed after cooking wet noodles in 300 mL water/100g samples for 3 min in boiling water.

## Cooking Quality

Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at various concentrations (0, 5, 10, 15, 20, 25, and 30% (w/v)) was shown in Figure 1, Table 3 and Table 4. The addition of pluchea extract no significantly influenced the water content, cooking loss, swelling index, chroma, and hue of the produced wet noodles using statistical analysis by ANOVA at  $p \leq 5\%$ . Water content is one of the chemical properties of a food product determined shelf life of food products, because the water content measures the free and weakly bound water in foodstuffs<sup>44,45</sup>. This study identified that the moisture content of the cooked wet noodles ranged between 64-67% wb. A previous study showed that the water content of the cooked egg wet noodles was around 54-58% wb<sup>45</sup> and maximum of 65%<sup>20</sup>. Chairuni et al.,<sup>44</sup> stated that the boiling process could cause a change in moisture content from around 35% to around 52%. The Indonesian National Standard,<sup>46</sup> stipulates

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228 that the moisture content of cooked wet noodles is a maximum of 65%. This means that only control  
229 noodles (without treatment) exhibited a moisture content similar to the previous information. The  
230 obtained data showed a trend that an extract addition caused an increase in the water content of wet  
231 noodles, but statistical analysis at  $p \leq 5\%$  showed no significant difference. This phenomenon was in  
232 accordance with the experimental results of Juliana et al.,<sup>45</sup>, that the using of spenochlea leaf extract  
233 to making wet noodles, as well as Hasmawati et al.,<sup>20</sup>, that the supplementary of sweet potato leaf  
234 extract increased the moisture of fresh noodles. The water content of pluchea wet noodles was  
235 expected by reaction between many components in the dough that impacted to the swelling index and  
236 cooking loss. Mualim et al.,<sup>14</sup>, Bilina et al.,<sup>22</sup>, and Setiyoko et al.,<sup>28</sup>, informed that the presence of amino  
237 groups in protein and hydroxyl groups in amylose and amylopectin fractions in wheat flour as raw  
238 material for making dough determines the moisture content, swelling index and cooking loss of wet  
239 noodles. The contribution of glutelin and gliadin proteins in wheat flour to form gluten networks  
240 determines the capability of noodles to swell and retain water in the system. Gliadin acts as an adhesive  
241 that causes dough to be elastic, while glutenin makes the dough to be firm and able to withstand CO<sub>2</sub>  
242 gas thus the dough can expand and form pores. Fadzil et al.,<sup>29</sup>, found that thermal treatment during  
243 the boiling process results in the denaturation of gluten and caused a monomer of proteins to  
244 determine other reactions at the disulfide or sulfhydryl chain. The existence of phenolic compounds  
245 from pluchea extract also increased the capacity of noodles to absorb water and determined water  
246 mobility. Widyawati et al.,<sup>41</sup>, also confirmed that hydrophilic compounds of proteins, carbohydrates,  
247 and polyphenolic components determine water mobility due to their ability to bind with water  
248 molecules through hydrogen bonding. Tuhumury et al.,<sup>47</sup>, informed that gluten formation can inhibit

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249 water absorption by starch granules so that can prevent gelatinization. Therefore, the addition of  
250 phenolic compounds from the hot extract of pluchea leaf powder can inhibit the formation of gluten  
251 so that it stimulates gelatinization of starch granules.

252 As a result, the impact of increased the moisture content during boiling had an effect on the  
253 value of the swelling index and cooking loss of the wet noodles. Widyawati et al.,<sup>41</sup>, said that the  
254 swelling index is the capability to trap water which is dependent on the chemical composition, particle  
255 size, and water content. Gull et al.,<sup>48</sup>, also confirmed that the swelling index is an indicator to determine  
256 water absorption by starch and protein to make gelatinization and hydration. Setiyoko et al.,<sup>28</sup>,  
257 explained that cooking loss is the mass of noodle solids that come out of the noodle strands for boiling.  
258 Gull et al.,<sup>48</sup>, added that soluble starch and other soluble components leach out into the water during  
259 the cooking process, making the cooking water turned thicker. The moisture content results (64-67%  
260 wb) showed that the produced wet noodles exceeded the moisture content limit of wet noodles after  
261 cooking, which is between 54-58%<sup>44</sup>, while the cooking loss value of wet noodles should not be more  
262 than 10%<sup>28</sup>. In this study, the cooking loss value was 3-4.2%. The cooking loss of samples during boiling  
263 noodles were caused the breaking of the bonding network that the polysaccharides are released and  
264 the gluten network breaks because of the addition of pluchea leaf extract. Widyawati et al.,<sup>41</sup>,  
265 supported that polyphenol can be bound with protein and starch with many non-covalent interactions,  
266 such as hydrogen bonding, electrostatic interaction, hydrophobic interaction, Van der Waals  
267 interaction, and  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch to  
268 undergo gelatinization and gliadin and glutelin from the protein of wheat flour to form gluten.

269 The swelling index value obtained from this research was around 56-68 %. Based on the

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previous research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.) fruit was around 51%<sup>49</sup>. This means that the addition of pluchea leaf extract in wet noodles also affects the ability of noodles to absorb water. Widyawati et al.,<sup>41</sup>, and Suriyaphan,<sup>6</sup>, informed that bioactive compounds in hot water extract of pluchea leaf tea include 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, 4,5-O-dicaffeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was higher than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from extract in absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch granules to absorb water so that the swelling index and cooking loss increased. Suriyaphan,<sup>6</sup>, informed that hot extract of pluchea leaf tea contains 1.79g/100g protein, 8.65g/100g carbohydrate, and fiber (0.45g/100g soluble and 0.89g/100g insoluble), these compounds can involve in increasing the swelling index from pluchea wet noodles.

Color is one of the physical characteristics possessed by wet noodles that becomes a benchmark for consumer acceptance. This research found that the color of wet noodles was influenced by the addition of pluchea extract. The addition of pluchea leaf extract no significant affected the redness ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it influenced the yellowness ( $b^*$ ) and lightness ( $L^*$ ) values. Using of pluchea leaf powder brewing decreased the brightness of wet noodles significantly, as the concentration of the extract increased. This is related to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to experience color changes. According to Widyawati et al.,<sup>8</sup>, tannins are water-soluble compounds that

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291 can give a brown color. Suriyaphan,<sup>6</sup> and Widyawati et al.,<sup>41</sup>, also stated that Khlu tea from pluchea  
292 leaves contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and  $6.39$   
293 mg/100g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow color.  
294 Gull et al.,<sup>48</sup>, stated that this pigment was easily changed in the paste sample due to the swelling and  
295 discoloration of the pigment during cooking.

296 Thus, the addition of hot water extract of pluchea leaf powder significantly reduced the  
297 brightness of wet noodles, because brown-colored noodles were produced as the concentrations of  
298 added pluchea leaf extract increased. However, increasing the concentration of this extract had no  
299 influenced on the redness, hue, and chroma values in ANOVA at  $p \leq 5\%$ . The results showed that the  
300 redness value of wet noodles revolved from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet  
301 noodles ranged from  $82.1 \pm 3.1$  to  $86.5 \pm 1.0$ . Based on this value, the color of wet noodles is in the yellow  
302 to the red color range<sup>50</sup>, thus the visible color of the wet noodle product was yellow to brown (Figure  
303 1). Yellowness increased significantly with the addition of pluchea leaf extract and the value ranged  
304 from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the availability of tannins and chlorophyll compounds  
305 from pluchea leaf extract. The chroma value of wet noodles was obtained within the range of  $15.6 \pm$   
306  $1.5 - 19.8 \pm 3.4$ . This means that the brewing of pluchea leaf powder did not change the intensity of the  
307 brown color in the resulting wet noodles.

308 Texture analysis of pluchea wet noodles added with various concentrations of hot water extract  
309 from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness,  
310 elongation, and elasticity. Hardness is the maximum force given to a product until deformation<sup>51,52</sup>.  
311 From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher

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312 peak of graph shows the harder product<sup>30</sup>. Adhesiveness is force or tackiness that is required to pull  
313 the product from its surface, its value is obtained from the area between the first and second  
314 compressions<sup>53,54</sup>. Adhesiveness values show negative value; the bigger negative value means the  
315 product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and  
316 second compressions<sup>52,54</sup>. This is an indication of the internal forces that make up the product<sup>55</sup>.  
317 Elongation is the change in length of noodles when being exposed to a tensile force until the noodles  
318 break<sup>56</sup>. Elasticity is the time required for the product to withstand the load until it breaks. The more  
319 elastic a product, the longer the holding time. The data showed that the higher concentration of  
320 pluchea leaf powder within the hot water extract caused a significant increase in the hardness,  
321 stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati et al.,<sup>41</sup>,  
322 informed that the polyphenols contained in pluchea leaf extract can weakly interact either covalently  
323 or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch  
324 and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups  
325 that are polar. Amoako and Akiwa,<sup>57</sup>, and Zhu et al.,<sup>58</sup>, have also proven that polyphenolic compounds  
326 can interact with carbohydrates through the interaction of two hydrophobic and hydrophilic functional  
327 groups with amylose. Diez-Sánchez et al.,<sup>59</sup>, stated that polyphenolic compounds can interact with  
328 amylose and protein helical structures and largely determined by molecular weight, conformational  
329 mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in  
330 protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and  
331 amylopectin can affect the gelatinization process in the amylose helical structure and interfere with  
332 the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network

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that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss (>98%) and swelling index (56.2 -67.7%) data, it can be concluded that the interaction that occurs between the phenol group in pluchea leaf extract with amylose and protein was weak. The bioactive components of pluchea leaf extract are thought to affect the formation of disulfide cross-links (S-S) and turn into to form sulfhydryl groups (-SH) under the influence of heat. Ananingsih and Zhou,<sup>60</sup>, said that antioxidant compounds are a reducing agent that can have an impact on reducing S-S bonds and increasing the number of SH groups in the dough to produce a harder texture. According to Rahardjo *et al.* (2020), phenolic compounds are hydroxyl compounds that influence the strength of the dough, where the higher the component of phenol compounds will weaken the gluten matrix and the dough thus becoming unstable. The instability of the dough can cause the texture to become hard.

Many researchers also find that tannins and phenols influence the networking S-S bond in the dough of wet noodles. Wang *et al.* (2015) showed that tannins increase the relative amount of large, medium polymers in the gluten protein network so as to improve the dough quality. Zhang *et al.*,<sup>61</sup>, said that these polymer compounds are the results of interactions or combinations of protein-tannin compounds that form bonds with the type of covalent bonds, hydrogen bonds, or ionic bonds. Rauf and Andini,<sup>62</sup>, also added that phenol compounds are able to reduce S-S bonds to SH bonds. SH is a type of thiol compound group, where the thiol group can influence the stickiness, viscosity, cohesiveness, elongation, and extensibility of the dough. Wang *et al.*,<sup>63</sup>, found the effect of phenolic compounds from green tea extract to increase the stickiness of wheat bread. The cohesiveness of the dough is formed due to a large number of thiol bonds formed, thus increasing the viscosity of the

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dough. The increased viscosity of the dough is thought to be due to the formation of polyphenolic compounds with thiol groups, as in the research of Ananingsih and Zhou,<sup>60</sup>, that the formation of catechin-thiol can increase the viscosity of the dough and increase the stability of the dough. Zhu et al.,<sup>64</sup>, declared that the addition of phenolic compounds from green tea was able to increase the PV (peak viscosity) of wheat flour. Wang et al.,<sup>65</sup>. also found that the cohesiveness of the dough is influenced by tannins, where tannins can produce micro-glutens so as to produce a compact dough and increase the gluten network. The addition of pluchea leaf extract in making wet noodles could influence the elongation of wet noodles due to the components of polyphenol compounds such as tannins that can reduce the number of free amino groups. This is supported by Zhang et al.,<sup>30</sup>, and Wang et al.,<sup>65</sup>, that support the formation of other types of covalent bonds, such as bonds between amino groups and hydroxyl groups, by forming hydrogen bonds between phenolic compounds and protein gluten so as to improve the quality of dough strength and dough extensibility.

#### **Bioactive Compounds and Antioxidant Activity**

Wet noodles added with pluchea leaf powder were analyzed based on its bioactive compounds and antioxidant activities. The analysis was conducted to determine the functional properties of wet noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles are presented in Table 5. The measured bioactive compounds (BC) included total phenol content (TPC) and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical scavenging activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a tendency

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for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed that there was a positive and strong correlation between TPC and DPPH ( $r=0.990$ ), TPC and FRAP ( $r=0.986$ ), TFC and DPPH ( $r=0.974$ ), and TFC and FRAP ( $r=0.991$ ). This means that the antioxidant activity of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah et al.,<sup>66</sup>, informed that the PC ( $r$ ) > 0.699 indicates the strength and linear correlation between antioxidant activity (AA) and TPC, and also shows a strong positive relationship but PC ( $r$ ) < 0.699 obtains a moderately positive relationship. If the  $r$  value of TFC and AA is lower than TPC and AA, it indicates that the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship which is expected because both classes all contributed to AA plants. Aryal et al.,<sup>67</sup>, and Muflihah et al.,<sup>66</sup>, informed that phenolic compounds are soluble natural antioxidants and potential donating electrons depend on their number and position of hydroxyl groups contributed to antioxidant action. Consequently, these groups are responsible to scavenge the free radicals that TPC of pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the stable purple-colored to the yellow-colored solution. Based on FRAP analysis, it was showed that the bioactive compounds contained in pluchea wet noodles are a potential source of antioxidants because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive compounds contained in pluchea wet noodles can function as primary and secondary antioxidants. Research data showed that the cooking quality of wet noodles tends to increase along with the increase in the value of TPC, TFC, DPPH, and FRAP.

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**396      Sensory Evaluation**

397            Sensory pluchea wet noodles, namely color, aroma, taste, texture, and overall acceptance,  
398      were carried out using a hedonic test to determine the level of consumer preference for the product.  
399      This test was conducted to determine the quality differences between the products and to provide an  
400      assessment on certain properties<sup>42</sup>. The hedonic test itself is the most widely used test to determine  
401      the level of preference for production<sup>68</sup>. The results of the sensory evaluation of pluchea wet noodles  
402      were presented in Table 6.

403            The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm 1.26$   
404      (neutral-like). The statistical analysis showed that the higher concentration of hot water extract  
405      addition decreased lower color preference of wet noodles. The higher concentration of pluchea extract  
406      could reduce the level of preference for color because the color of the wet noodles was darker than  
407      control and turned to dark brown. This color change was due to the pluchea extract containing several  
408      components, including chlorophyll and tannins, which can alter the of wet noodles' color to be  
409      browner along with the increase in the concentration of pluchea extract. This result was in accordance  
410      to the results of color analysis performed using color reader where the pluchea wet noodles' brightness  
411      declined, yellowness increased, and the color intensity increased with an increased concentration of  
412      pluchea extract. The occurrence of this process is related to the effect of light and heat on pluchea leaf  
413      powder which causes the degradation of chlorophyll into brown pheophytin due to drying, where the  
414      nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals<sup>69,70</sup>.

415            Aroma is one of the parameters in sensory evaluation using the sense of smell and is an  
416      indicator of the assessment of a product<sup>71</sup>. The results of the preference value for aroma were ranged

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417 from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet  
418 noodles reduced the preference score for aroma due to the occurrence of distinct dry leaves (green)  
419 aroma. Lee et al.,<sup>72</sup>, informed that the unpleasant aroma on leaves comes from a group of aliphatic  
420 aldehyde compounds. The appearance of a distinctive leaf aroma in noodles is due to aromatic  
421 compounds. According to Martiyanti and Vita,<sup>73</sup>, aromatic compounds are chemical compounds that  
422 have an aroma or odor when the conditions are met, which is volatile, while Widyawati et al.,<sup>74</sup>,  
423 informed that pluchea leaves were detected to have 66 volatile compounds. The appearance of the  
424 aroma is due to the volatile compounds in the raw material reacting with water vapor when boiling the  
425 noodles. In addition, there is also an oxidation process of polyphenolic compounds such as catechins  
426 or tannins that can produce an aroma in pluchea wet noodles.

427         According to Martiyanti and Vita,<sup>3</sup>, taste attribute is one important sensory aspect in food  
428 products and has a great impact on the food selection by consumers. Tongue are able to detect basic  
429 tastes, namely sweet, salty, sour, and bitter, at different points. Lamusu,<sup>71</sup>, declared that taste is a  
430 component of flavor and an important criterion in assessing a product that is accepted by the tongue.  
431 The preference test of the taste of pluchea wet noodles resulted in values ranging from  $4.15 \pm 1.40$  to  
432  $5.50 \pm 1.28$  (neutral-slightly like). The increase in concentrations of pluchea extract was negatively  
433 correlated to the preference level of the pluchea wet noodles' taste assessed by the panelists. The  
434 statistical analysis results showed that the difference in the concentration of the extract significant  
435 influenced on the preference score for the taste of pluchea wet noodles. The increased concentration  
436 of pluchea extract produced a distinctive taste on wet noodles, such as a bitter, bitter, and astringent  
437 tastes, due to the presence of compounds such as tannins and alkaloids from the pluchea leaves.

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438 Susetyarini,<sup>75</sup> said that pluchea leaves contain tannins (2.351%), and alkaloids (0.316%). According to  
439 Pertiwi,<sup>76</sup> tannin compounds dominate the bitter and astringent taste, while alkaloid compounds  
440 cause a bitter taste. The high level of taste preference for wet noodles was found in noodles with lower  
441 content of pluchea extract.

442 Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and  
443 swallowed) or touched with fingers<sup>77</sup>. Texture testing performed by the panelist is called mouthfeel  
444 testing. According to Martiyanti and Vita,<sup>73</sup> mouthfeel is the kinesthetic effect of chewing food in the  
445 mouth. In this study, the preference test results on the texture of pluchea wet noodles revolved from  
446  $5.5 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy and  
447 hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet noodles  
448 are influenced by polyphenolic compounds' contents, as well as several processing steps that can  
449 determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and draining  
450 noodles. Subjective testing results based on sensory evaluation were in line with the objective testing  
451 the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to break,  
452 and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea wet  
453 noodles was influenced by the fiber and protein components. According to Shabrina,<sup>78</sup>, the  
454 components of fiber, protein, and starch compete to bind water. Texture changes are also influenced  
455 by the polyphenol compositions in the pluchea extract which is able to reduce S-S bonds to SH bonds,  
456 where the increase in SH (thiol) groups can give a hard, sticky, and compact texture<sup>62,63,65</sup>. Besides, a  
457 high concentration of tannins capable of binding to proteins to form complex compounds into tannins-  
458 proteins are also able to build noodles' texture.

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459 The interaction between color, aroma, taste, and texture created an overall taste of the food  
460 product and was assessed as the overall preference. The highest value on the overall preference was  
461 derived from control wet noodles i.e., 6.63 (slightly like it), while the wet noodles added with 20% (w/v)  
462 concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The  
463 addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to  
464 10% (w/v) concentration with scores of 6.63 and 6.53, respectively. The area of the spider web chart  
465 for each treatment with the various concentrations of pluchea extract was seen in Figure 2. The best  
466 treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37  
467 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the  
468 scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like),  
469 respectively.

470 The use of pluchea leaf extract in the making of wet noodles was able to increase the functional  
471 value of wet noodles, based on the levels of bioactive compounds and antioxidant activity without  
472 changing the quality of cooking, which includes water content, swelling index and cooking loss. Besides  
473 that, the use of pluchea leaf extract did not significantly change the color and color intensity of the  
474 resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet  
475 noodles produced were still acceptable to the panelists, the addition of pluchea leaf extract as much  
476 as 10% (w/v) was the best treatment with an assessment that was almost close to the control wet  
477 noodles (without treatment).

## 478 Conclusion

479 Wet noodles made by incorporating hot water extract of pluchea leaf powder underwent

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480 lightness, texture, bioactive compound content, antioxidant activity, and sensory properties changes.  
481 The higher concentration of pluchea extract addition induced the bigger lightness, hardness,  
482 adhesiveness, cohesiveness, elongation, and elasticity from pluchea wet noodles. The sensory  
483 properties of the produced wet noodles evaluated by hedonic test showed that wet noodles made with  
484 10% (w/v) concentration of hot water extract from pluchea leaf powder obtained in the color, aroma,  
485 taste, and texture with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and  
486 6.53 (like), respectively. The concentration was the best treatment of pluchea wet noodles with an area  
487 of spider web graph i.e. 66.37 cm<sup>2</sup>.

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498 **Conflict of Interest**

499  
500 The authors declare no conflict of interest.

501 **Notes on Appendices**

TPC	Total phenol content
TFC	Total flavonoid content

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DPPH	2,2-Diphenyl-1-picrylhydrazyl free radical
FRAP	Ferric reducing antioxidant power
AA	Antioxidant activity
PC	Person Correlation
LDL	Low Density Lipoprotein
w/v	Weight per volume
CRD	Completely randomized design
CE	Catechin equivalent
GAE	Gallic acid equivalent
BC	Bioactive compounds
ANOVA	Analysis of variance
UV-Vis	Ultra violet-visible

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755

756 Table 1. The formula of hot water extract of pluchea leaf tea

Materials	Concentration of hot water extract of pluchea leaf tea (% w/v)						
	0	5	10	15	20	25	30
Pluchea leaf tea (g)	0	10	20	30	40	50	60
Hot water (mL)	200	200	200	200	200	200	200

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759 **Table 2.** Formula of pluchea wet noodles

Materials	Unit	Quantity
Wheat flour	g	200
Egg	g	40
Salt	g	4
Baking powder	g	2
Hot water extract	mL	70
Tapioca flour	g	10
TOTAL	g	326

760 Note: The formula of general wet noodles

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**Table 3.** Color, moisture content, swelling index, and cooking loss of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Color					Moisture content (% wb)	Swelling index (%)	Cooking loss (%)
	L*	a*	b*	C	h			
0	67.1 ± 1.8 <sup>a</sup>	0.97±0.30	16.18±0.62 <sup>ab</sup>	16.2 ± 0.6	86.5 ± 1.0	63.90±1.51	56.2±17.4	3.40±1.31
5	59.5 ± 2.7 <sup>b</sup>	2.18±0.93	15.47±1.46 <sup>a</sup>	15.6 ± 1.5	82.1 ± 3.1	65.08±4.33	62.4±4.7	3.33±1.26
10	59.0 ± 1.8 <sup>b</sup>	1.95±1.66	16.76±2.33 <sup>abc</sup>	17.1 ± 2.2	83.3 ± 5.4	64.97±3.89	61.5±7.5	3.00±1.16
15	58.4 ± 2.2 <sup>b</sup>	1.69±1.48	19.72±3.50 <sup>c</sup>	19.8 ± 3.4	84.7 ± 4.6	65.56±2.18	63.1±6.3	3.31±0.92
20	56.5 ± 2.4 <sup>b</sup>	1.97±1.24	19.09±2.97 <sup>bc</sup>	19.2 ± 2.9	83.6 ± 4.3	66.81±1.81	67.7±5.9	4.06±0.51
25	59.1 ± 2.5 <sup>b</sup>	1.95±1.44	19.55±2.97 <sup>c</sup>	19.6 ± 2.9	83.8 ± 4.0	66.04±0.85	64.5±10.3	3.93±1.37
30	57.1 ± 2.1 <sup>b</sup>	2.09±1.51	18.08±4.94 <sup>abc</sup>	18.3 ± 4.8	82.5 ± 5.2	66.65±2.16	64.0±5.3	4.23±1.34

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Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p < 5\%$

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775 **Table 4.** Texture of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Texture				
	Hardness (N)	Adhesiveness (g sec)	Cohesiveness	Elongation (%)	Elasticity (Pa)
0	135.8±5.9 <sup>a</sup>	-2.7 ±2.3 <sup>d</sup>	0.75±0.01 <sup>a</sup>	86.9±0.9 <sup>a</sup>	25336.7±104.2 <sup>a</sup>
5	120.1±2.1 <sup>a</sup>	-3.4±0.6 <sup>cd</sup>	0.68±0.00 <sup>b</sup>	97.3±1.6 <sup>b</sup>	25898.3±760.9 <sup>b</sup>
10	134.9±1.8 <sup>a</sup>	-3.9±0.7 <sup>bc</sup>	0.74±0.00 <sup>c</sup>	162.1±1.5 <sup>c</sup>	25807.7±761.9 <sup>b</sup>
15	180.5±5.1 <sup>b</sup>	-4.9±0.5 <sup>b</sup>	0.74±0.01 <sup>c</sup>	164.7±0.6 <sup>c</sup>	26971.6±516.7 <sup>b</sup>
20	195.1±14.1 <sup>b</sup>	-5.0±1.3 <sup>ab</sup>	0.75±0.01 <sup>cd</sup>	221.6±1.6 <sup>d</sup>	27474.4±453.8 <sup>b</sup>
25	244.6±8.8 <sup>c</sup>	-6.0±0.3 <sup>a</sup>	0.75±0.00 <sup>cd</sup>	230.7±0.7 <sup>e</sup>	27367.1±287.5 <sup>b</sup>
30	282.8±28.3 <sup>d</sup>	-6.1±0.2 <sup>a</sup>	0.79±0.01 <sup>d</sup>	255.4±0.4 <sup>f</sup>	26687.5±449.2 <sup>b</sup>

776 Note: the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in

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777 the same column are significantly different,  $p < 5\%$

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**Table 5.** Total phenol content, total flavonoid content, the DPPH free radical scavenging activity, and iron ion reducing power of the pluchea wet noodles.

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	TPC	TFC	DPPH (mg	FRAP
	(mg GAE/kg	(mg CE/kg	GAE/kg Dried	(mg GAE/kg
	Dried	Dried	Noodles)	Dried
	Noodles)	Noodles)		noodles)
0	39.26±0.66 <sup>a</sup>	32.36±1.47 <sup>a</sup>	96.75±4.26 <sup>a</sup>	25.96±0.25 <sup>a</sup>
5	61.09±3.80 <sup>b</sup>	46.31±2.15 <sup>b</sup>	121.36±3.58 <sup>b</sup>	34.50±1.71 <sup>b</sup>
10	82.84±3.11 <sup>c</sup>	62.44±0.55 <sup>c</sup>	130.68±4.82 <sup>c</sup>	51.33±2.19 <sup>c</sup>
15	101.48±2.16 <sup>d</sup>	84.67±1.22 <sup>d</sup>	142.48±2.14 <sup>d</sup>	58.69±2.14 <sup>d</sup>
20	114.94±4.20 <sup>e</sup>	100.14±1.50 <sup>e</sup>	148.84±3.20 <sup>e</sup>	67.26±0.06 <sup>e</sup>
25	128.06±1.38 <sup>f</sup>	107.93±0.89 <sup>f</sup>	157.51±7.69 <sup>f</sup>	69.53±1.06 <sup>f</sup>
30	136.35±1.16 <sup>g</sup>	131.69±1.56 <sup>g</sup>	166.97±1.53 <sup>g</sup>	84.98±0.11 <sup>g</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p < 5\%$ .





**Table 6.** Effect of hot water extract from pluchea leaf powder to preferences for color, aroma, taste, texture, and overall acceptance of wet noodles at various concentrations

Concentration of Hot		Hedonic Score				
Extract from Pluchea Leaf Powder (% w/v)						Overall
	Color	Aroma	Taste	Texture		acceptance
0	6.19±1.25 <sup>d</sup>	5.52±1.08	5.50±1.18 <sup>c</sup>	6.20±1.13 <sup>b</sup>		6.63±1.49 <sup>c</sup>
5	5.62±1.28 <sup>c</sup>	5.52±0.83	5.51±1.29 <sup>c</sup>	6.37±1.14 <sup>bc</sup>		6.40±1.52 <sup>c</sup>
10	5.62±1.21 <sup>c</sup>	5.45±0.85	5.46±1.12 <sup>c</sup>	6.53±1.14 <sup>c</sup>		6.53±1.64 <sup>c</sup>
15	5.14±1.25 <sup>b</sup>	4.81±1.04	4.61±1.11 <sup>b</sup>	6.13±1.09 <sup>b</sup>		5.78±1.67 <sup>b</sup>
20	4.91±1.32 <sup>b</sup>	4.54±1.18	4.47±1.15 <sup>ab</sup>	5.80±1.06 <sup>a</sup>		5.17±1.70 <sup>a</sup>
25	4.54±1.40 <sup>a</sup>	4.26±1.23	4.20±1.24 <sup>a</sup>	5.50±1.04 <sup>a</sup>		5.23±1.75 <sup>a</sup>
30	4.47±1.33 <sup>a</sup>	4.05±1.34	4.15±1.40 <sup>a</sup>	5.59±1.05 <sup>a</sup>		5.37±1.91 <sup>a</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p < 5\%$ .



Figure 1. The appearance of wet noodles with hot water extract of pluchea leaf powder addition at various concentrations; a.0%; b. 5%; c. 10%; d. 15%; e. 20%; f. 25%; and g. 30% w/v

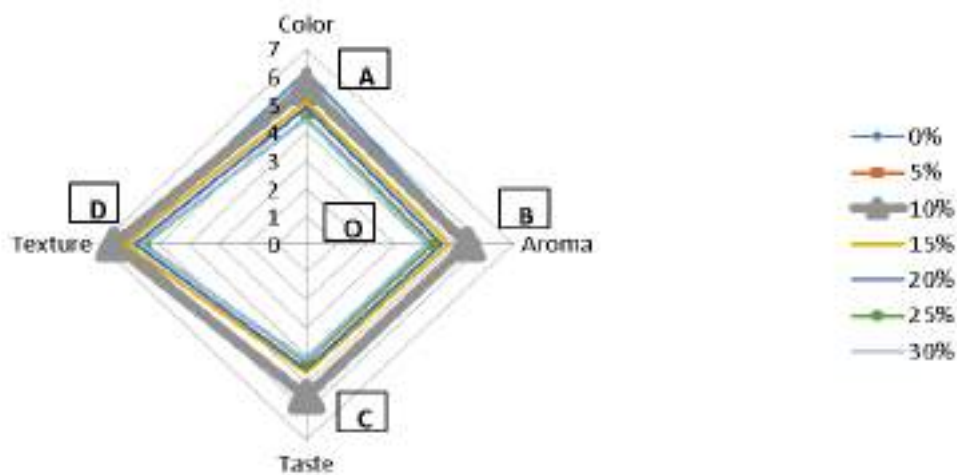


Figure 2. Spider web graph of sensory evaluation on wet noodles at various concentrations of hot water extract from pluchea leaf powder

### CERTIFICATE

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Syllvia Santalova Santoso	Food Technology Study Program, Faculty of Agricultural Technology, Widya Mandala Surabaya Catholic University of Surabaya	-	Syllvia Santalova Santoso

Explanation about similarity with  
[pubmed.ncbi.nlm.nih.gov/36014298/](https://pubmed.ncbi.nlm.nih.gov/36014298/) [pubmed.ncbi.nlm.nih.gov/36014298/](https://pubmed.ncbi.nlm.nih.gov/36014298/)

My manuscript is entitled the effect of hot water extract of pluchea leaf powder on the physical, chemical and sensory properties of wet noodles utilizes pluchea leaves as an ingredient used in making wet noodles and has similarities with previous publications because there are no citations outside of which discuss the active components of pluchea and their applications in the development of food products. Therefore the similarity is limited to information about the development of the use of hot pluchea leaf extract and its active components which will certainly affect the physical, chemical and sensory properties of the subject matter to be studied in this manuscript. Additionally the publications we cite are my other research projects funded by different grants.



Paini Sri Widyawati <paini@ukwms.ac.id>

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## Re: Manuscript submission for Current Research in Nutrition and Food Science Journal

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**Managing Editor** <info@foodandnutritionjournal.org>

Mon, Feb 20, 2023 at 6:29 PM

To: Paini Sri Widyawati <paini@ukwms.ac.id>

Dear Dr Paini,

Thank you for your email.

We will do the needful and update you soon accordingly.

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Paini Sri Widyawati <paini@ukwms.ac.id>

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## Re: Manuscript submission for Current Research in Nutrition and Food Science Journal

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**Paini Sri Widyawati** <paini@ukwms.ac.id>

Tue, Feb 21, 2023 at 8:38 AM

To: Managing Editor <info@foodandnutritionjournal.org>

Dear Ms Yahna Ahmed  
Thanks a lot.

Regards

Paini SW

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3. Second revision: Reject Unconditionally (9 -3-2023 until 27-3-2023)

-Correspondence

-Review Report Form

-Reviewer Comment

-Revision Document

-Author Response to Reviewer's Comments

-



Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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## Review report of article - 3638

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**Managing Editor** <info@foodandnutritionjournal.org>

Thu, Mar 9, 2023 at 5:25 PM

To: Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

Dear Dr Paini,

Attached are the review reports of your article.

kindly go through the review report and send us the final highlighted revised manuscript along with the author response form addressing the reviewer comments separately.

Kindly do the requested changes at your earliest convenience as this will help us to move forward with the publication process in a timely manner.

Kindly acknowledge the receipt of this email.

Looking forward to hearing from you soon

Best Regards

Yanha Ahmed

Editorial Assistant

Current Research in Nutrition and Food Science

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### Current Research in Nutrition and Food Science – Review Form

Title: **The Effect of Hot Water Extract of Pluchea Leaf Powder on the Physical, Chemical, and Sensory Properties of Wet Noodles**

Conflict of Interest: No

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Is the paper readable and appropriately presented? ☐ NO

English language level: is the English language comprehensive and flawless? ☐ Yes

Are there any grammatical or spelling mistakes? ☐ Yes

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Are appropriate legends provided with tables/ figures? ☐ Yes

Does the paper contain appropriate referencing? ☐ Yes

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NOT TOO much

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Does the paper compliant with the aims and scope of the journal it is submitted to? ☐ Yes

Does the paper meet ethical requirements? ☐ Yes

Does the paper include animal or human study? If yes, was ethical committee approval details provided in the paper? ☐ No

Is this a human intervention study? Was consent taken before the study? ☐ Yes ☐ No ☐ Not Applicable

Is the statistical analysis sound and justified? (Does it require expert statistical review?) ☐ Yes

Other Comments?

Title should be changed.

The conclusion is not clear.

What is the importance of this research on food industry.

Abstract is not clear.

GC-MS ,FTIR should be performed.

**Give your comments on the following section of the article:**

<p><b>Abstract –</b></p> <p>The abstract is expected to briefly summarize each of the IMRaD (introduction, methodology, results, and discussion) components of the research paper.</p> <ul style="list-style-type: none"> <li>• Why was the study performed?</li> <li>• What and how was it done?</li> <li>• What was found?</li> <li>• What is the impact of the study?</li> </ul>	<p>the effect of various concentrations of brewing from pluchea tea on the physical, chemical, and sensory properties of wet noodles.</p> <p>1st Hot Water Extract was prepared from Pluchea Leaf Powder and after that wet noodles enriched with pluchea was formed.</p> <p>The conclusion was not clear. Not clear</p>
<b>Introduction</b>	Some grammatical changes are there.
<b>Methodology</b>	GC-MS,FTIR should be performed
<b>Results and Discussion</b>	Some grammatical changes are there.
<b>References</b>	correct

**Rating (1 to 5) 5: Excellent, 1: Poor**

Originality / Novelty	3
Depth of research	2
Technical quality	2

**Recommendation:**

☐ Reject in current form, but allow resubmission after revision as per my accompanying comments



## The Effect of Hot Water Extract of Pluchea Leaf Powder on the Physical, Chemical, and Sensory Properties of Wet Noodles

### Abstract

Powdered *Pluchea indica* Less leaves have been utilized as herbal tea, brewing of pluchea tea in ~~by~~ hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional value and influence physical, chemical, and sensory characteristics of food. The study was done to aim for the effect of various concentrations of brewing from pluchea tea on the physical, chemical, and sensory properties of wet noodles. A one-factor randomized design was applied with the concentration of brewing pluchea tea at the seventh level, i.e., 0, 5, 10, 15, 20, 25, and 30% (w/v). The physical properties ~~was-were~~ analyzed, including water content, swelling index, cooking loss, color, texture, chemical properties ~~was-were~~ measured, namely bioactive content (total phenolic content (TPC) and total flavonoid content (TFC)), and antioxidant activity (AA) (ability to scavenge DPPH free radical and iron ion reducing power), and sensory properties was determined, i.e., taste, texture, color, aroma, and overall acceptance. The addition of various concentration of extract gave significantly effects on parameters of physical, chemical, and sensory properties of noodles, except color (redness, chroma, and hue), cooking loss, water content, swelling index, and aroma. Using of 10% (w/v) brewing of pluchea tea resulted the best treatment obtained from the hedonic test, ~~that~~ which afforded sensory properties, such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. Generally of this research can be concluded that the making of wet noodles with the addition of brewing of pluchea tea can be used at a concentration of 10% (w/v) with TPC, TFC, ability to scavenge DPPH free, and iron ion reducing power 82.84 mg GAE/kg dried samples, 62.44 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples, and 51.33 mg GAE/kg dried samples, respectively.

### Key-words

Chemical, *Pluchea indica* Less, physical, sensory, wet noodles

### Introduction

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food<sup>1,2</sup>. The potency of pluchea leaves is related to phytochemical compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone, alkaloid, lignans and saponins<sup>2,3,4,5</sup>. Furthermore, pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100g, fat

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38 0.49 g/100g, insoluble dietary fiber 0.89 g/100g, soluble dietary fiber 0.45 g/100g, carbohydrate 8.65  
39 g/100g, calcium 251 mg/100g,  $\beta$ -carotene 1.225  $\mu$ g/100g<sup>6</sup>.

40 Processing of pluchea leaves to be pluchea tea has been proven to exhibit antioxidant  
41 activity<sup>6,7,8</sup>, anti-diabetic activity<sup>9</sup>, anti-inflammatory activity<sup>7</sup>, anti-isolated human LDL oxidation  
42 activity<sup>10</sup>. Previous research uses brewing of pluchea leaf powder to make several food products to  
43 increase functional values, i.e., jelly drink<sup>11</sup>, soy milk<sup>12</sup> and steamed bun<sup>13</sup>. Using 1% (w/v) brewing of  
44 pluchea leaf powder can improve the physicochemical properties of jelly drink and increase panelists'  
45 acceptance of the product<sup>11</sup>. Soy milk with the addition of brewing from pluchea leaves increases the  
46 viscosity and total dissolved solids and decreases the panelist acceptance rate<sup>12</sup>. The addition of 6%  
47 (w/v) brewing from pluchea leaf powder on steamed bun is the best treatment with the lowest level  
48 of hardness<sup>13</sup>. All previous research has proven that the addition of brewing of pluchea leaves can  
49 increase the bioactive compound contents based on total phenol and total flavonoids, as well as  
50 increase antioxidant activity based on ferric reducing power and ability to scavenge DPPH free  
51 radical. To the best of our knowledge, the study of the addition of steeping water of pluchea tea in  
52 making wet noodles from wheat flour has not been conducted, as well as its impact on  
53 physicochemical and organoleptic characteristics of the noodles. Noodles are a popular food product  
54 that is widely consumed in the world. Indonesia is one of the countries with the largest noodle  
55 consumption after China<sup>14</sup>. Wet noodles usually contain lower protein and higher carbohydrate<sup>15</sup>  
56 than that of egg wet noodles as an alternative to wet noodles, which contain higher protein, and the  
57 second popular food in ASEAN regions including Thailand, Vietnam, Laos, Myanmar, Malaysia,  
58 Singapore and Indonesia<sup>16</sup>. The addition of other ingredients has been endeavored to enhance wet

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noodles' specific properties. Many researchers incorporated plant extracts or natural products to increase functional properties of wet noodles, such as red spinach<sup>17</sup>, green tea<sup>18,19</sup>, purple sweet potatoes leaves<sup>20</sup>, moringa leaves<sup>21</sup>, sea weed<sup>22</sup>, ash of rice straw and turmeric extract<sup>23</sup>, and betel leaf extract<sup>24</sup> that influenced physical, chemical, and organoleptic properties of the wet noodles. The anthocyanin of red spinach ethanolic extract increased hedonic score of wet noodles' flavor<sup>17</sup>. The addition of green tea improves the stability, elastic modulus and viscosity, maintains retrogradation and cooking loss, and results no significant effect of the mouthfeel and overall acceptance from panelist on the produced wet noodles<sup>18</sup>. Moreover, the addition of sweet potatoes leaf extract on wet noodles increases moisture content, protein value and ash concentration, and improves hedonic score of texture<sup>20</sup>. Moringa extract influences protein content and decrease panelist acceptance of color, aroma and taste of the wet noodles<sup>21</sup>. The use of seaweed to produce wet noodles influences moisture content, swelling index, absorption ability, elongation value and color<sup>22</sup>. The addition of ash from rice straw and turmeric extract influences the elasticity and sensory characteristics (color, taste, aroma and texture) of the wet noodles<sup>23</sup>. Betel leaf extract used to make hokkien noodles improves texture and acceptance score of all sensory attributes<sup>24</sup>.

Bioactive compounds and nutritive value of pluchea leaf can be an alternative ingredient to improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea leaves ~~is~~ can potential to be an antioxidant source in wet noodles and ~~to~~ increase the functional value. The study was done to aim for the effect of various concentrations of brewing from pluchea tea on the physical, chemical, and sensory properties of wet noodles.

#### Materials and Methods

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**81 Preparation of Hot Water Extract from Pluchea Leaf Powder**

82 The young pluchea leaves ~~number~~ 1-6 were picked from the shoots, sorted, and washed. The  
83 selected pluchea leaves were dried at ambient temperature for 7 days to derive moisture content of  
84  $10.00 \pm 0.04\%$  dry base<sup>25</sup>. Dried pluchea leaves were powdered to the size of 45 mesh and sterilized  
85 at 120°C for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea  
86 bag for about 2 g/tea bag. Pluchea leaf powder in tea bag was extracted using hot water  
87 (95°C) for 5 min to get various extract concentrations; 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively  
88 (Table 1).

**89 Wet Noodles Processing**

90 About 70 mL of hot extract from pluchea leaf powder with various concentrations (0, 5, 10,  
91 15, 20, 25 and 30% (w/v) (Table 1) was measured and manually mixed with egg, baking powder, salt  
92 and wheat flour for 5 min (Table 2). The mixture was kneaded to form a solid and homogenized  
93 dough using a mixer (Oxone Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was  
94 extruded to form noodle strands (Oxone Noodle Machine OX 355). The wet noodle strands were  
95 parboiled in boiled water about 3 min in 300 mL water and coated with oil to prevent the noodles  
96 from sticking to each other. Wet noodles made without any addition of hot water of pluchea leaf  
97 extract were prepared as control. Wet noodles used in bioactive compounds and antioxidant activity  
98 assay were not added with oil to prevent the noodles from sticking to one another. The final  
99 characteristics of wet noodles were having width and thickness of 0.45 cm and 0.295 cm,  
100 respectively.

**101 Pluchea Wet Noodles Extraction**

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About 100 g of wet noodles were dried using a freeze dryer at a pressure of 0.1 bar and temperature -60°C for 28 hours to obtain dried noodles. Each dried of pluchea leaves were powdered using a chopper machine at the speed of 35 seconds. 20 g of powdered pluchea leaves were mixed by 50 mL absolute methanol in a shaking water bath at 35°C, 70 rpm for 1 hour<sup>26</sup>. The filtration was done to separate filtrate ~~by~~ using Whatman filter paper grade 40 and the ~~extraction-of~~ residue extraction was done again with the same procedure. The collection of filtrates was done, then evaporation by rotary evaporator was done to get 3 mL of extract (Buchi Rotary Evaporator; Buchi Shanghai Ltd, China) at 200 bars, 50°C for 60 min.—The obtained extract was kept at 0°C before further analysis.

#### Moisture Content Assay

Moisture content or water content of wet noodles was determined by thermogravimetric method<sup>27</sup>. The assay of moisture content from wet noodles was done by heating the samples in a drying oven (Binder, Merck KGaA, Darmstadt, Germany). The principle of this method is evaporating the water in the material. The sample was heated and weighed until a constant weight was obtained ~~which was~~ assumed to be all evaporated water.

#### Measurement of Swelling Index

The principle of swelling index testing determines capability of noodles to swell during the boiling process<sup>16</sup>. The swelling index assay is done to determine the ability of wet noodles to absorb water per unit of time ~~that-which~~ can estimate the time needed to fully cook wet noodles. The amount of water absorbed by wet noodles was measured from the weight difference of noodles after and before being boiled divided by the initial weight of the noodles<sup>28</sup>.

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123 **Determination of Cooking Loss**

124 Cooking loss is one of the necessary quality parameters in wet noodles to establish the quality  
125 of wet noodles after boiling<sup>28</sup>. The cooking loss assay for pluchea wet noodles was done to measure  
126 the number of solids that leached out from the wet noodle strands during the boiling process, namely  
127 the leak of a small portion of starch from the wet noodle strands. A large cooking loss value affects  
128 the texture of wet noodles, which is easy to break and less slippery.

129 **Determination of Texture**

130 The texture of wet noodles with pluchea extract addition was measured based on its  
131 hardness, adhesiveness, cohesiveness, elongation and elasticity. The texture was analyzed by TA-XT2  
132 texture analyzer (Stable Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with  
133 the Texture Exponent 32 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness  
134 were analyzed with a compression assay using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle  
135 strands with the length of 4 cm for each strand were laid side by side, touching each other,  
136 perpendicular to the 35 mm compression cylinder probe on a flat aluminium base. The cylinder  
137 probe was arranged to be at 15 mm distance from the lower plate at the start of the compression  
138 test, and was forced down through the noodle strips at the speed of 2 mm s<sup>-1</sup> until it touched the  
139 flat base to compress 75% of the noodle thickness, and was drawn back to at the end of the test.  
140 The profile curve was determined using a texture analyzer software<sup>24,29</sup>. The hardness was  
141 determined as the maximum force per gram. The adhesiveness was evaluated when the probe was  
142 drawn at the end of the test, a negative area was obtained from the compression test under the  
143 curve. Cohesiveness was analyzed based on the

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ratio between the area under the second peak and the area under the first peak<sup>24,29,30</sup>. The elongation and elasticity of the noodles were individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. Elongation was the maximum force to change of noodle form and break by extension that was analyzed by a test speed of 3.0 mm s<sup>-1</sup> between two rollers with a 100 mm distance. The elongation at breaking was calculated per gram. Elasticity was determined by formula (1)<sup>31,32</sup>:

$$\text{Elasticity} = \frac{Fx}{Ax} \frac{l_0}{t_0} \frac{1}{v} \quad (1)$$

where F is the tensile strength, l<sub>0</sub> is the original length of the noodles between the limit arms (mm), A is the original cross-sectional area of the noodle (mm<sup>2</sup>), v is the rate of movement of the upper arm (mm/s), and t is break up time of the noodles (s). The measurement of texture was detected by the software and expressed as a graph.

#### Color Measurement

The color of the noodle sheets was determined by a colorimeter (Minolta CR 10, Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab L\*, a\* and b\* values were analyzed based on Fadzil et al.,<sup>29</sup>, method. The L\* value measured the position on the white/black axis, the a\* value as the position on the red/green axis, and the b\* value as the position on the yellow/blue axis.

#### Analysis of Total Phenol Content

The total phenol content analysis ~~was~~ analyzed based on the reaction between phenolic compounds and folin ciocalteu/FC reagent (phosphomolybdic acid and phosphotungstic acid). FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups becomes a blue molybdenum-

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tungsten complex solution<sup>33</sup>. The intensity of the blue color was detected by a UV-Vis spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  760 nm. In the analysis, 7.5% Na<sub>2</sub>CO<sub>3</sub> solution was added to reach pH 10 that caused an electron transfer reaction (redox). The obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

#### Analysis of Total Flavonoid Content

The flavonoid content assay was done by the spectrophotometric method based on the reaction between flavonoids and AlCl<sub>3</sub> to form a yellow complex solution. In the presence of NaOH solution, a pink color is formed which can be detected by spectrophotometer (Spectrophotometer UV- Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm<sup>33,34,35</sup>. The obtained data were expressed in mg of (+)-catechin equivalent (CE)/L sample.

#### Analysis of DPPH Free Radical Scavenging Activity

The ability of antioxidant compounds of extract to scavenge DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical can be used to evaluate antioxidant activity. The principle of the DPPH method is to measure the absorbance of compounds that can react with DPPH<sup>36</sup>. Antioxidant compounds can donate hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced to yellow<sup>37</sup>. The color change was measured as an absorbance at  $\lambda$  517 nm by spectrophotometer (Spectrophotometer UV Vis 1800, Shimadzu, Japan)<sup>38</sup>. The data were expressed in mg gallic acid equivalent (GAE)/L dried noodles sample.

#### Analysis of Iron Ion Reduction Power

This method identifies the capacity of antioxidant components through increasing absorbance as a result of the reaction of antioxidant compounds with potassium ferricyanide, trichloroacetic acid,

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and ferric chloride to produce color complexes that can be measured spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm<sup>39</sup>. The principle of this testing is the ability antioxidants to reduce iron ions from  $K_3Fe(CN)_6$  ( $Fe^{3+}$ ) to  $K_4Fe(CN)_6$  ( $Fe^{2+}$ ). Then, potassium ferrocyanide reacts with  $FeCl_3$  to form a  $Fe_4[Fe(CN)_6]_3$  complex. The color change that occurs is yellow to green<sup>40</sup>. The final data were stated in mg gallic acid equivalent (GAE)/L dried noodles.

#### Sensory Evaluation

All samples of wet noodles were proceeded to hedonic test by involving 100 untrained panelists with an age range of 17 to 25 years. A hedonic test used in this research was the hedonic scoring method, where the panelists gave a preference score value of all samples<sup>41</sup>. The hedonic scores were transformed to numeric scale and analyzed using statistical analysis<sup>42</sup>. The numeric scale in the sensory analysis used a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The panelists were asked to score according to their level of preference for texture, taste, color, flavor and overall acceptability. All the samples were blind coded with 3 digits which differed from each other<sup>43</sup>.

#### Statistical Analysis

The research design used in the physicochemical assay was a randomized block design (RBD) with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25, and 30% (w/v). Each treatment was repeated four times that obtained 28 experiment units. A completely randomized design (CRD) was used to evaluated sensory assay with 100 untrained panelists with an age range of sensory assay with 100 untrained panelists aged 17 to 25 years.

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The ~~data~~ normal distribution and homogeneity data were stated as the mean  $\pm$  SD of the triplicate determinations and were determined using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan Multiple Range Test) at  $p \leq 5\%$  to determine ~~the level of treatment that gave significant treatment level that gave significant~~ different results. The best treatment of pluchea extract addition on wet noodles was analyzed by a spider web graph.

## Results and Discussion

Wet noodles added with hot extract of pluchea leaf powder were produced with aiming to increase the functional value of wet noodles. This is supported by several previous researches related to the potential value of water extract of pluchea leaf that exhibit a biological activity<sup>6,7,41</sup>. In this research, the cooking quality was observed after cooking wet noodles in 300 mL water/100g samples for 3 min in boiling water.

### Cooking Quality

Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at various concentrations (0, 5, 10, 15, 20, 25, and 30% (w/v)) was shown in Figure 1, Table 3 and Table 4. The addition of pluchea extract no significantly influenced the water content, cooking loss, swelling index, chroma, and hue of the produced wet noodles using statistical analysis by ANOVA at  $p \leq 5\%$ . Water content is one of the chemical properties of a food product determined shelf life of food products, because the water content measures the free and weakly bound water in foodstuffs<sup>44,45</sup>. This study identified that the moisture content of the cooked wet noodles ranged between 64-67% wb.—A previous study showed that the water content of the cooked egg wet

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noodles was around 54-58% wb<sup>45</sup> and maximum of 65%<sup>20</sup>. Chairuni et al.,<sup>44</sup>, stated that the boiling process could cause a change in moisture content from around 35% to around 52%. The Indonesian National Standard,<sup>46</sup>, stipulates that the moisture content of cooked wet noodles is a maximum of 65%. This means that only control noodles (without treatment) exhibited a moisture content similar to the previous information. The obtained data showed a trend that an extract addition caused an increase in the water content of wet noodles, but statistical analysis at  $p \leq 5\%$  showed no significant difference. This phenomenon was in accordance with the experimental results of Juliana et al.,<sup>45</sup>, that the using of spenochlea leaf extract to making wet noodles, as well as Hasmawati et al.,<sup>20</sup>, that the supplementary of sweet potato leaf extract increased the moisture of fresh noodles. The water content of pluchea wet noodles was expected by reaction between many components in the dough that impacted to the swelling index and cooking loss. Mualim et al.,<sup>14</sup>, Bilina et al.,<sup>22</sup>, and Setiyoko et al.,<sup>28</sup>, informed that the presence of amino groups in protein and hydroxyl groups in amylose and amylopectin fractions in wheat flour as raw material for making dough determines the moisture content, swelling index and cooking loss of wet noodles. The contribution of glutelin and gliadin proteins in wheat flour to form gluten networks determines the capability of noodles to swell and retain water in the system. Gliadin acts as an adhesive that causes dough to be elastic, while glutenin makes the dough to be firm and able to withstand CO<sub>2</sub> gas thus the dough can expand and form pores. Fadzil et al.,<sup>29</sup>, found that thermal treatment during the boiling process results in the denaturation of gluten and caused a monomer of proteins to determine other reactions at the disulfide or sulfhydryl chain. The existence of phenolic compounds from pluchea extract also increased the capacity of noodles to absorb water and determined water mobility. Widyawati et

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al.<sup>41</sup>, also confirmed that hydrophilic compounds of proteins, carbohydrates, and polyphenolic components determine water mobility due to their ability to bind with water molecules through hydrogen bonding. Tuhumury et al.<sup>47</sup>, informed that gluten formation can inhibit water absorption by starch granules so that can prevent gelatinization. Therefore, the addition of phenolic compounds from the hot extract of pluchea leaf powder can inhibit the formation of gluten so that it stimulates gelatinization of starch granules.

As a result, the impact of increased the moisture content during boiling had an effect on the value of the swelling index and cooking loss of the wet noodles. Widyawati et al.<sup>41</sup>, said that the swelling index is the capability to trap water which is dependent on the chemical composition, particle size, and water content. Gull et al.<sup>48</sup>, also confirmed that the swelling index is an indicator to determine water absorption by starch and protein to make gelatinization and hydration. Setiyoko et al.<sup>28</sup>, explained that cooking loss is the mass of noodle solids that come out of the noodle strands for boiling. Gull et al.<sup>48</sup>, added that soluble starch and other soluble components leach out into the water during the cooking process, making the cooking water turned thicker. The moisture content results (64-67% wb) showed that the produced wet noodles exceeded the moisture content limit of wet noodles after cooking, which is between 54-58%<sup>44</sup>, while the cooking loss value of wet noodles should not be more than 10%<sup>28</sup>. In this study, the cooking loss value was 3-4.2%. The cooking loss of samples during boiling noodles were caused the breaking of the bonding network that the polysaccharides are released and the gluten network breaks because of the addition of pluchea leaf extract. Widyawati et al.<sup>41</sup>, supported that polyphenol can be bound with protein and starch with many non-covalent interactions, such as hydrogen bonding, electrostatic interaction, hydrophobic

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269 interaction, Van der Waals interaction, and  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and  
270 amylopectin from starch to undergo gelatinization and gliadin and glutelin from the protein of wheat  
271 flour to form gluten.

272 The swelling index value obtained from this research was around 56-68 %. Based on the  
273 previous research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.)  
274 fruit was around 51%<sup>49</sup>. This means that the addition of pluchea leaf extract in wet noodles also  
275 affects the ability of noodles to absorb water. Widyawati et al.,<sup>41</sup>, and Suriyaphan,<sup>6</sup>, informed that  
276 bioactive compounds in hot water extract of pluchea leaf tea include 3-O-caffeoylquinic acid, 4-O-  
277 caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid,  
278 4,5-O-dicaffeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total  
279 anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was  
280 higher than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from  
281 extract in absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch  
282 granules to absorb water so that the swelling index and cooking loss increased. Suriyaphan,<sup>6</sup>,  
283 informed that hot extract of pluchea leaf tea contains 1.79g/100g protein, 8.65g/100g carbohydrate,  
284 and fiber (0.45g/100g soluble and 0.89g/100g insoluble), these compounds can involve in increasing  
285 the swelling index from pluchea wet noodles.

286 Color is one of the physical characteristics possessed by wet noodles that becomes a  
287 benchmark for consumer acceptance. This research found that the color of wet noodles was  
288 influenced by the addition of pluchea extract. The addition of pluchea leaf extract no significant  
289 affected the redness ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it influenced the

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290 yellowness ( $b^*$ ) and lightness ( $L^*$ ) values. Using of pluchea leaf powder brewing decreased the  
291 brightness of wet noodles significantly, as the concentration of the extract increased. This is related  
292 to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that  
293 cause the wet noodles to experience color changes. According to Widyawati et al.<sup>8</sup>, tannins are  
294 water-soluble compounds that can give a brown color. Suriyaphan,<sup>6</sup> and Widyawati et al.,<sup>41</sup> also  
295 stated that Khlu tea from pluchea leaves contained  $\beta$ -carotene, total carotenoids, and total  
296 flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and  $6.39$  mg/100g fresh weight, respectively. This pigment is a  
297 water-soluble pigment that gives a yellow color. Gull et al.,<sup>48</sup>, stated that this pigment was easily  
298 changed in the paste sample due to the swelling and discoloration of the pigment during cooking.

299 Thus, the addition of hot water extract of pluchea leaf powder significantly reduced the  
300 brightness of wet noodles, because brown-colored noodles were produced as the concentrations of  
301 added pluchea leaf extract increased. However, increasing the concentration of this extract had no  
302 influenced on the redness, hue, and chroma values in ANOVA at  $p \leq 5\%$ . The results showed that the  
303 redness value of wet noodles revolved from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet  
304 noodles ranged from  $82.1 \pm 3.1$  to  $86.5 \pm 1.0$ . Based on this value, the color of wet noodles is in the  
305 yellow to the red color range<sup>50</sup>, thus the visible color of the wet noodle product was yellow to brown  
306 (Figure 1). Yellowness increased significantly with the addition of pluchea leaf extract and the value  
307 ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the availability of tannins and chlorophyll  
308 compounds from pluchea leaf extract. The chroma value of wet noodles was obtained within the  
309 range of  $15.6 \pm 1.5$ – $19.8 \pm 3.4$ . This means that the brewing of pluchea leaf powder did not change  
310 the intensity of the brown color in the resulting wet noodles.

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311 Texture analysis of pluchea wet noodles added with various concentrations of hot water  
312 extract from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness,  
313 cohesiveness, elongation, and elasticity. Hardness is the maximum force given to a product until  
314 deformation<sup>51,52</sup>. From the texture analyzer graph, hardness is measured from the highest height of  
315 the peak. The higher peak of graph shows the harder product<sup>30</sup>. Adhesiveness is force or tackiness  
316 that is required to pull the product from its surface, its value is obtained from the area between the  
317 first and second compressions<sup>53,54</sup>. Adhesiveness values show negative value; the bigger negative  
318 value means the product is stickier. Cohesiveness or compactness is the ratio of the positive force  
319 area to the first and second compressions<sup>52,54</sup>. This is an indication of the internal forces that make  
320 up the product<sup>55</sup>. Elongation is the change in length of noodles when being exposed to a tensile force  
321 until the noodles break<sup>56</sup>. Elasticity is the time required for the product to withstand the load until it  
322 breaks. The more elastic a product, the longer the holding time. The data showed that the higher  
323 concentration of pluchea leaf powder within the hot water extract caused a significant increase in the  
324 hardness, stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati  
325 et al.,<sup>41</sup>, informed that the polyphenols contained in pluchea leaf extract can weakly interact either  
326 covalently or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions)  
327 with starch and protein. Phenolic compounds can be dissolved in water because they have several  
328 hydroxyl groups that are polar. Amoako and Akiwa,<sup>57</sup>, and Zhu et al.,<sup>58</sup>, have also proven that  
329 polyphenolic compounds can interact with carbohydrates through the interaction of two  
330 hydrophobic and hydrophilic functional groups with amylose. Diez-Sánchez et al.,<sup>59</sup>, stated that  
331 polyphenolic compounds can interact with amylose and protein helical structures and largely

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determined by molecular weight, conformational mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and amylopectin can affect the gelatinization process in the amylose helical structure and interfere with the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss (>98%) and swelling index (56.2 -67.7%) data, it can be concluded that the interaction that occurs between the phenol group in pluchea leaf extract with amylose and protein was weak. The bioactive components of pluchea leaf extract are thought to affect the formation of disulfide cross-links (S-S) and turn into to form sulfhydryl groups (-SH) under the influence of heat. Ananingsih and Zhou,<sup>60</sup>, said that antioxidant compounds are a reducing agent that can have an impact on reducing S-S bonds and increasing the number of SH groups in the dough to produce a harder texture. According to Rahardjo *et al.* (2020), phenolic compounds are hydroxyl compounds that influence the strength of the dough, where the higher the component of phenol compounds will weaken the gluten matrix and the dough thus becoming unstable. The instability of the dough can cause the texture to become hard.

Many researchers also find that tannins and phenols influence the networking S-S bond in the dough of wet noodles. Wang *et al.* (2015) showed that tannins increase the relative amount of large, medium polymers in the gluten protein network so as to improve the dough quality. Zhang *et al.*,<sup>61</sup>, said that these polymer compounds are the results of interactions or combinations of protein-tannin

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353 compounds that form bonds with the type of covalent bonds, hydrogen bonds, or ionic bonds. Rauf  
354 and Andini,<sup>62</sup>, also added that phenol compounds ~~are able to~~can reduce S-S bonds to SH bonds. SH is  
355 a type of thiol compound group, where the thiol group can influence the stickiness, viscosity,  
356 cohesiveness, elongation, and extensibility of the dough. Wang et al.,<sup>63</sup>, found the effect of phenolic  
357 compounds from green tea extract to increase the stickiness of wheat bread. The cohesiveness of the  
358 dough is formed due to a large number of thiol bonds formed, thus increasing the viscosity of the  
359 dough. The increased viscosity of the dough is thought to be due to the formation of polyphenolic  
360 compounds with thiol groups, as in the research of Ananingsih and Zhou,<sup>60</sup>, that the formation of  
361 catechin-thiol can increase the viscosity of the dough and increase the stability of the dough. Zhu et  
362 al.,<sup>64</sup>, declared that the addition of phenolic compounds from green tea was able to increase the PV  
363 (peak viscosity) of wheat flour. Wang et al.,<sup>65</sup>. also found that the cohesiveness of the dough is  
364 influenced by tannins, where tannins can produce micro-glutens ~~so as to~~ produce a compact dough  
365 and increase the gluten network. The addition of pluchea leaf extract in making wet noodles could  
366 influence the elongation of wet noodles due to the components of polyphenol compounds such as  
367 tannins that can reduce the number of free amino groups. This is supported by Zhang et al.,<sup>30</sup>, and  
368 Wang et al.,<sup>65</sup>, that support the formation of other types of covalent bonds, such as bonds between  
369 amino groups and hydroxyl groups, by forming hydrogen bonds between phenolic compounds and  
370 protein gluten so as to improve the quality of dough strength and dough extensibility.

#### 371 Bioactive Compounds and Antioxidant Activity

372 Wet noodles added with pluchea leaf powder were analyzed based on its bioactive  
373 compounds and antioxidant activities. The analysis was conducted to determine the functional

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properties of wet noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles are presented in Table 5. The measured bioactive compounds (BC) included total phenol content (TPC) and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical scavenging activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed that there was a positive and strong correlation between TPC and DPPH ( $r=0.990$ ), TPC and FRAP ( $r=0.986$ ), TFC and DPPH ( $r=0.974$ ), and TFC and FRAP ( $r=0.991$ ). This means that the antioxidant activity of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah et al.,<sup>66</sup> informed that the PC ( $r$ ) > 0.699 indicates the strength and linear correlation between antioxidant activity (AA) and TPC, and also shows a strong positive relationship but PC ( $r$ ) < 0.699 obtains a moderately positive relationship. If the  $r$  value of TFC and AA is lower than TPC and AA, it indicates that the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship which is expected because both classes all contributed to AA plants. Aryal et al.,<sup>67</sup> and Muflihah et al.,<sup>66</sup> informed that phenolic compounds are soluble natural antioxidants and potential donating electrons depend on their number and position of hydroxyl groups contributed to antioxidant action. Consequently, these groups are responsible to scavenge the free radicals that TPC of pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the stable purple-colored to the yellow-colored solution. Based on FRAP analysis, it was showed that

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the bioactive compounds contained in pluchea wet noodles are a potential source of antioxidants because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive compounds contained in pluchea wet noodles can function as primary and secondary antioxidants. Research data showed that the cooking quality of wet noodles tends to increase along with the increase in the value of TPC, TFC, DPPH, and FRAP.

400

401

#### 402 Sensory Evaluation

403 Sensory pluchea wet noodles, namely color, aroma, taste, texture, and overall acceptance, were carried out using a hedonic test to determine the level of consumer preference for the product. This test was conducted to determine the quality differences between the products and to provide an assessment on certain properties<sup>42</sup>. The hedonic test itself is the most widely used test to determine the level of preference for production<sup>68</sup>. The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

409 The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to 410  $6.19 \pm 1.26$  (neutral-like). The statistical analysis showed that the higher concentration of hot water 411 extract addition decreased lower color preference of wet noodles. The higher concentration of 412 pluchea extract could reduce the level of preference for color because the color of the wet noodles 413 was darker than control and turned to dark brown. This color change was due to the pluchea extract 414 containing several components, including chlorophyll and tannins, which can alter the of wet 415 noodles' color to be browner along with the increase in the concentration of pluchea extract. This

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416 result was in accordance to the ~~results-effects~~ of color analysis performed using color reader where  
417 the pluchea wet noodles' brightness declined, yellowness increased, and the color intensity increased  
418 with an increased concentration of pluchea extract. The occurrence of this process is related to the  
419 effect of light and heat on pluchea leaf powder which causes the degradation of chlorophyll into  
420 brown pheophytin due to drying, where the nature of chlorophyll itself is sensitive to light, heat,  
421 oxygen, and chemicals<sup>69,70</sup>.

422 Aroma is one of the parameters in sensory evaluation using the sense of smell and is an  
423 indicator of the assessment of a product<sup>71</sup>. The results of the preference value for aroma were  
424 ranged from 4.05±1.34 to 5.52±1.23 (neutral-slightly like). Higher concentration of pluchea extract in  
425 wet noodles reduced the preference score for aroma due to ~~the occurrence of~~ distinct dry leaves  
426 (green) aroma. Lee et al.,<sup>72</sup>, informed that the unpleasant aroma on leaves comes from a group of  
427 aliphatic aldehyde compounds. The appearance of a distinctive leaf aroma in noodles is due to  
428 aromatic compounds. According to Martiyanti and Vita,<sup>73</sup>, aromatic compounds are chemical  
429 compounds that have an aroma or odor when the conditions are met, which is volatile, while  
430 Widyawati et al.,<sup>74</sup>, informed that pluchea leaves were detected to have 66 volatile compounds. The  
431 appearance of the aroma is due to the volatile compounds in the raw material reacting with water  
432 vapor when boiling the noodles. In addition, there is also an oxidation process of polyphenolic  
433 compounds such as catechins or tannins that can produce an aroma in pluchea wet noodles.

434 According to Martiyanti and Vita,<sup>3</sup>, taste attribute is one important sensory aspect in food  
435 products and has a great impact on the food selection by consumers. Tongue are able to detect basic  
436 tastes, namely sweet, salty, sour, and bitter, at different points. Lamusu,<sup>71</sup>, declared that taste is a

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component of flavor and an important criterion in assessing a product that is accepted by the tongue. The preference test of the taste of pluchea wet noodles resulted in values ranging from  $4.15 \pm 1.40$  to  $5.50 \pm 1.28$  (neutral-slightly like). The increase in concentrations of pluchea extract was negatively correlated to the preference level of the pluchea wet noodles' taste assessed by the panelists. The statistical analysis results showed that the difference in the concentration of the extract significant influenced on the preference score for the taste of pluchea wet noodles. The increased concentration of pluchea extract produced a distinctive taste on wet noodles, such as a bitter, bitter, and astringent tastes, due to the presence of compounds such as tannins and alkaloids from the pluchea leaves. Susetyarini,<sup>75</sup> said that pluchea leaves contain tannins (2.351%), and alkaloids (0.316%). According to Pertiwi,<sup>76</sup> tannin compounds dominate the bitter and astringent taste, while alkaloid compounds cause a bitter taste. The high level of taste preference for wet noodles was found in noodles with lower content of pluchea extract.

Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and swallowed) or touched with fingers<sup>77</sup>. Texture testing performed by the panelist is called mouthfeel testing. According to Martiyanti and Vita,<sup>73</sup> mouthfeel is the kinesthetic effect of chewing food in the mouth. In this study, the preference test results on the texture of pluchea wet noodles revolved from  $5.5 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and draining noodles. Subjective testing results based on sensory evaluation were in line with the

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objective testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to break, and tough were not preferred by the panelists. Therefore, ~~mentioned final texture of pluchea wet noodles was influenced by the fiber and protein components~~ the fiber and protein components influenced the final texture of pluchea wet noodles. According to Shabrina,<sup>78</sup>, the components of fiber, protein, and starch compete to bind water. Texture changes are also influenced by the polyphenol compositions in the pluchea extract which is able to reduce S-S bonds to SH bonds, where the increase in SH (thiol) groups can give a hard, sticky, and compact texture<sup>62,63,65</sup>. Besides, a high concentration of tannins capable of binding to proteins to form complex compounds into tannins-proteins are also able to build noodles' texture.

The interaction between color, aroma, taste, and texture created an overall taste of the food product and was assessed as the overall preference. The highest value on the overall preference was derived from control wet noodles i.e., 6.63 (slightly like it), while the wet noodles added with 20% (w/v) concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to 10% (w/v) concentration with scores of 6.63 and 6.53, respectively. The area of the spider web chart for each treatment with the various concentrations of pluchea extract was seen in Figure 2. The best treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively.

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478 The use of pluchea leaf extract in the making of wet noodles was able to increase the  
479 functional value of wet noodles, based on the levels of bioactive compounds and antioxidant activity  
480 without changing the quality of cooking, which includes water content, swelling index and cooking  
481 loss. Besides that, the use of pluchea leaf extract did not significantly change the color and color  
482 intensity of the resulting wet noodles, only slightly decreased the brightness level of the noodles.  
483 However, the wet noodles produced were still acceptable to the panelists, the addition of pluchea  
484 leaf extract as much as 10% (w/v) was the best treatment with an assessment that was almost close  
485 to the control wet noodles (without treatment).

#### 486 Conclusion

487 Wet noodles made by incorporating hot water extract of pluchea leaf powder underwent  
488 lightness, texture, bioactive compound content, antioxidant activity, and sensory properties changes.  
489 The higher concentration of pluchea extract addition induced the bigger lightness, hardness,  
490 adhesiveness, cohesiveness, elongation, and elasticity from pluchea wet noodles. The sensory  
491 properties of the produced wet noodles evaluated by hedonic test showed that wet noodles made  
492 with 10% (w/v) concentration of hot water extract from pluchea leaf powder obtained in the color,  
493 aroma, taste, and texture with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat  
494 like), and 6.53 (like), respectively. The concentration was the best treatment of pluchea wet noodles  
495 with an area of spider web graph i.e. 66.37 cm<sup>2</sup>.

#### 496 Notes on Appendices

TPC	Total phenol content
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TFC	Total flavonoid content
DPPH	2,2-Diphenyl-1-picrylhydrazyl free radical
FRAP	Ferric reducing antioxidant power
AA	Antioxidant activity
PC	Person Correlation
LDL	Low Density Lipoprotein
w/v	Weight per volume
CRD	Completely randomized design
CE	Catechin equivalent
GAE	Gallic acid equivalent
BC	Bioactive compounds
ANOVA	Analysis of variance
UV-Vis	Ultra violet-visible

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753 Table 1. The formula of hot water extract of pluchea leaf tea

Materials	Concentration of hot water extract of pluchea leaf tea (% w/v)						
	0	5	10	15	20	25	30
Pluchea leaf tea (g)	0	10	20	30	40	50	60
Hot water (mL)	200	200	200	200	200	200	200

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756 **Table 2.** Formula of pluchea wet noodles

Materials	Unit	Quantity
Wheat flour	g	200
Egg	g	40
Salt	g	4
Baking powder	g	2
Hot water extract	mL	70
Tapioca flour	g	10
TOTAL	g	326

757 Note: The formula of general wet noodles

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759 **Table 3.** Color, moisture content, swelling index, and cooking loss of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Color					Moisture content (% wb)	Swelling index (%)	Cooking loss (%)
	L*	a*	b*	C	h			
0	67.1 ± 1.8 <sup>a</sup>	0.97±0.30	16.18±0.62 <sup>ab</sup>	16.2 ± 0.6	86.5 ± 1.0	63.90±1.51	56.2±17.4	3.40±1.31
5	59.5 ± 2.7 <sup>b</sup>	2.18±0.93	15.47±1.46 <sup>a</sup>	15.6 ± 1.5	82.1 ± 3.1	65.08±4.33	62.4±4.7	3.33±1.26
10	59.0 ± 1.8 <sup>b</sup>	1.95±1.66	16.76±2.33 <sup>abc</sup>	17.1 ± 2.2	83.3 ± 5.4	64.97±3.89	61.5±7.5	3.00±1.16
15	58.4 ± 2.2 <sup>b</sup>	1.69±1.48	19.72±3.50 <sup>c</sup>	19.8 ± 3.4	84.7 ± 4.6	65.56±2.18	63.1±6.3	3.31±0.92
20	56.5 ± 2.4 <sup>b</sup>	1.97±1.24	19.09±2.97 <sup>bc</sup>	19.2 ± 2.9	83.6 ± 4.3	66.81±1.81	67.7±5.9	4.06±0.51
25	59.1 ± 2.5 <sup>b</sup>	1.95±1.44	19.55±2.97 <sup>c</sup>	19.6 ± 2.9	83.8 ± 4.0	66.04±0.85	64.5±10.3	3.93±1.37
30	57.1 ± 2.1 <sup>b</sup>	2.09±1.51	18.08±4.94 <sup>abc</sup>	18.3 ± 4.8	82.5 ± 5.2	66.65±2.16	64.0±5.3	4.23±1.34

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Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p < 5\%$

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772 **Table 4.** Texture of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Texture				
	Hardness (N)	Adhesiveness (g sec)	Cohesiveness	Elongation (%)	Elasticity (Pa)
0	135.8±5.9 <sup>a</sup>	-2.7 ±2.3 <sup>d</sup>	0.75±0.01 <sup>a</sup>	86.9±0.9 <sup>a</sup>	25336.7±104.2 <sup>a</sup>
5	120.1±2.1 <sup>a</sup>	-3.4±0.6 <sup>cd</sup>	0.68±0.00 <sup>b</sup>	97.3±1.6 <sup>b</sup>	25898.3±760.9 <sup>b</sup>
10	134.9±1.8 <sup>a</sup>	-3.9±0.7 <sup>bc</sup>	0.74±0.00 <sup>c</sup>	162.1±1.5 <sup>c</sup>	25807.7±761.9 <sup>b</sup>
15	180.5±5.1 <sup>b</sup>	-4.9±0.5 <sup>b</sup>	0.74±0.01 <sup>c</sup>	164.7±0.6 <sup>c</sup>	26971.6±516.7 <sup>b</sup>
20	195.1±14.1 <sup>b</sup>	-5.0±1.3 <sup>ab</sup>	0.75±0.01 <sup>cd</sup>	221.6±1.6 <sup>d</sup>	27474.4±453.8 <sup>b</sup>
25	244.6±8.8 <sup>c</sup>	-6.0±0.3 <sup>a</sup>	0.75±0.00 <sup>cd</sup>	230.7±0.7 <sup>e</sup>	27367.1±287.5 <sup>b</sup>
30	282.8±28.3 <sup>d</sup>	-6.1±0.2 <sup>a</sup>	0.79±0.01 <sup>d</sup>	255.4±0.4 <sup>f</sup>	26687.5±449.2 <sup>b</sup>

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773            Note: the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in  
774            the same column are significantly different,  $p < 5\%$

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**Table 5.** Total phenol content, total flavonoid content, the DPPH free radical scavenging activity, and iron ion reducing power of the pluchea wet noodles.

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	TPC (mg GAE/kg Dried Noodles)	TFC	DPPH (mg	FRAP
		(mg CE/kg	GAE/kg Dried	(mg GAE/kg
		Dried	Noodles)	Dried
		Noodles)		noodles)
0	39.26±0.66 <sup>a</sup>	32.36±1.47 <sup>a</sup>	96.75±4.26 <sup>a</sup>	25.96±0.25 <sup>a</sup>
5	61.09±3.80 <sup>b</sup>	46.31±2.15 <sup>b</sup>	121.36±3.58 <sup>b</sup>	34.50±1.71 <sup>b</sup>
10	82.84±3.11 <sup>c</sup>	62.44±0.55 <sup>c</sup>	130.68±4.82 <sup>c</sup>	51.33±2.19 <sup>c</sup>
15	101.48±2.16 <sup>d</sup>	84.67±1.22 <sup>d</sup>	142.48±2.14 <sup>d</sup>	58.69±2.14 <sup>d</sup>
20	114.94±4.20 <sup>e</sup>	100.14±1.50 <sup>e</sup>	148.84±3.20 <sup>e</sup>	67.26±0.06 <sup>e</sup>
25	128.06±1.38 <sup>f</sup>	107.93±0.89 <sup>f</sup>	157.51±7.69 <sup>f</sup>	69.53±1.06 <sup>f</sup>
30	136.35±1.16 <sup>g</sup>	131.69±1.56 <sup>g</sup>	166.97±1.53 <sup>g</sup>	84.98±0.11 <sup>g</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p < 5\%$ .

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**Table 6.** Effect of hot water extract from pluchea leaf powder to preferences for color, aroma, taste, texture, and overall acceptance of wet noodles at various concentrations

Concentration of Hot		Hedonic Score			
Extract from Pluchea					Overall
Leaf Powder (% w/v)	Color	Aroma	Taste	Texture	acceptance
0	6.19±1.25 <sup>d</sup>	5.52±1.08	5.50±1.18 <sup>c</sup>	6.20±1.13 <sup>b</sup>	6.63±1.49 <sup>c</sup>
5	5.62±1.28 <sup>c</sup>	5.52±0.83	5.51±1.29 <sup>c</sup>	6.37±1.14 <sup>bc</sup>	6.40±1.52 <sup>c</sup>
10	5.62±1.21 <sup>c</sup>	5.45±0.85	5.46±1.12 <sup>c</sup>	6.53±1.14 <sup>c</sup>	6.53±1.64 <sup>c</sup>
15	5.14±1.25 <sup>b</sup>	4.81±1.04	4.61±1.11 <sup>b</sup>	6.13±1.09 <sup>b</sup>	5.78±1.67 <sup>b</sup>
20	4.91±1.32 <sup>b</sup>	4.54±1.18	4.47±1.15 <sup>ab</sup>	5.80±1.06 <sup>a</sup>	5.17±1.70 <sup>a</sup>
25	4.54±1.40 <sup>a</sup>	4.26±1.23	4.20±1.24 <sup>a</sup>	5.50±1.04 <sup>a</sup>	5.23±1.75 <sup>a</sup>
30	4.47±1.33 <sup>a</sup>	4.05±1.34	4.15±1.40 <sup>a</sup>	5.59±1.05 <sup>a</sup>	5.37±1.91 <sup>a</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p < 5\%$ .

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Figure 1. The appearance of wet noodles with hot water extract of pluchea leaf powder addition at various concentrations; a.0%; b. 5%; c. 10%; d. 15%; e. 20%; f. 25%; and g. 30% w/v

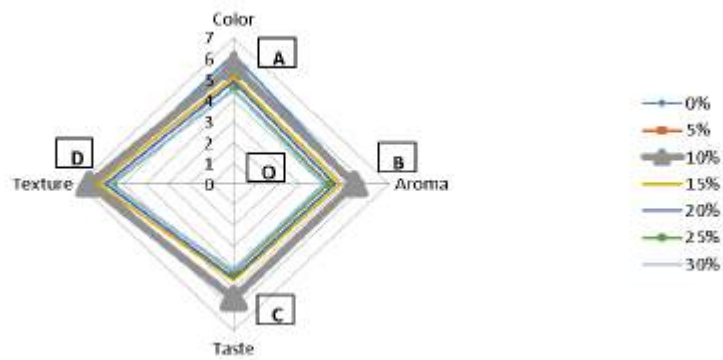


Figure 2. Spider web graph of sensory evaluation on wet noodles at various concentrations of hot water extract from pluchea leaf powder

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# **The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles**

## **Abstract**

Powdered *Pluchea indica* Less leaves have been utilized as herbal tea, brewing of pluchea tea by hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional value and influence physic, chemical, and sensory characteristics of food. The study was done to assess the effect of various concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with pluchea tea at concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v). Physical properties analyzed included water content, swelling index, cooking loss, color and texture. Chemical properties measured were bioactive contents of total phenolic content, total flavonoid content, and antioxidant ability to scavenge DPPH free radicals and to reduce iron ions. Sensory properties determined were taste, texture, color, aroma and overall acceptance. The addition of various concentrations of extract gave significantly effects on parameters of physical, chemical and sensory properties of noodles, except color (redness, chroma and hue), cooking loss, water content, swelling index and aroma. Using of 10% (w/v) of pluchea tea resulted in the best sensory properties such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. Generally, the study concluded that wet noodles can be made by adding pluchea tea at 10% (w/v). Dried samples TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg, 62.44 mg CE/kg, 130.68 mg GAE/kg and 51.33 mg GAE/kg, respectively.

## **Key-words**

Chemical, *Pluchea indica* Less, physical, sensory, wet noodles

## **Introduction**

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food<sup>1,2</sup>. The potency of pluchea leaves is related to phytochemical compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone, alkaloid, lignans and saponins<sup>2,3,4,5</sup>. Furthermore, pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100g, fat 0.49 g/100g, insoluble dietary fiber 0.89 g/100g, soluble dietary fiber 0.45 g/100g, carbohydrate 8.65 g/100g, calcium 251 mg/100g,  $\beta$ -carotene 1.225  $\mu$ g/100g<sup>6</sup>.

37 Processing of pluchea leaves to be pluchea tea has been proven to exhibit antioxidant  
38 activity<sup>6,7,8</sup>, anti-diabetic activity<sup>9</sup>, anti-inflammatory activity<sup>7</sup>, anti-isolated human LDL oxidation  
39 activity<sup>10</sup>. Previous research uses brewing of pluchea leaf powder to make several food products to  
40 increase functional values, i.e., jelly drink<sup>11</sup>, soy milk<sup>12</sup> and steamed bun<sup>13</sup>. Using 1% (w/v) brewing of  
41 pluchea leaf powder can improve the physicochemical properties of jelly drink and increase panelists'  
42 acceptance of the product<sup>11</sup>. Soy milk with the addition of brewing from pluchea leaves increases the  
43 viscosity and total dissolved solids and decreases the panelist acceptance rate<sup>12</sup>. The addition of 6%  
44 (w/v) brewing from pluchea leaf powder on steamed bun is the best treatment with the lowest level  
45 of hardness<sup>13</sup>. All previous research has proven that the addition of brewing of pluchea leaves can  
46 increase the bioactive compound contents based on total phenol and total flavonoids, as well as  
47 increase antioxidant activity based on ferric reducing power and ability to scavenge DPPH free radical.

48 To the best of our knowledge, the study of the addition of steeping water of pluchea tea in  
49 making wet noodles from wheat flour has not been conducted, as well as its impact on physicochemical  
50 and organoleptic characteristics of the noodles. Noodles are a popular food product that is widely  
51 consumed in the world. Indonesia is one of the countries with the largest noodle consumption after  
52 China<sup>14</sup>. Wet noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet  
53 noodles as an alternative to wet noodles, which contain higher protein, and the second popular food  
54 in ASEAN regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia<sup>16</sup>.  
55 The addition of other ingredients has been endeavored to enhance wet noodles' specific properties.  
56 Many researchers incorporated plant extracts or natural products to increase functional properties of  
57 wet noodles, such as red spinach<sup>17</sup>, green tea<sup>18,19</sup>, purple sweet potatoes leaves<sup>20</sup>, moringa leaves<sup>21</sup>,

58 sea weed<sup>22</sup>, ash of rice straw and turmeric extract<sup>23</sup>, and betel leaf extract<sup>24</sup> that influenced physical,  
59 chemical, and organoleptic properties of the wet noodles. The anthocyanin of red spinach ethanolic  
60 extract increased hedonic score of wet noodles' flavor<sup>17</sup>. The addition of green tea improves the  
61 stability, elastic modulus and viscosity, maintains retrogradation and cooking loss, and results no  
62 significant effect of the mouthfeel and overall acceptance from panelist on the produced wet  
63 noodles<sup>18</sup>. Moreover, the addition of sweet potatoes leaf extract on wet noodles increases moisture  
64 content, protein value and ash concentration, and improves hedonic score of texture<sup>20</sup>. Moringa  
65 extract influences protein content and decrease panelist acceptance of color, aroma and taste of the  
66 wet noodles<sup>21</sup>. The use of seaweed to produce wet noodles influences moisture content, swelling  
67 index, absorption ability, elongation value and color<sup>22</sup>. The addition of ash from rice straw and turmeric  
68 extract influences the elasticity and sensory characteristics (color, taste, aroma and texture) of the wet  
69 noodles<sup>23</sup>. Betel leaf extract used to make hokkien noodles improves texture and acceptance score of  
70 all sensory attributes<sup>24</sup>.

71 Bioactive compounds and nutritive value of pluchea leaf can be an alternative ingredient to  
72 improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea  
73 leaves is potential to be an antioxidant source in wet noodles and to increase the functional value. The  
74 study was done to aim the effect of various concentration of brewing from pluchea tea on the physical,  
75 chemical and sensory properties of wet noodles.

## 76 **Materials and Methods**

### 77 **Preparation of Hot Water Extract from Pluchea Leaf Powder**

79           The young pluchea leaves number 1-6 were picked from the shoots, sorted and washed. The  
80   selected pluchea leaves were dried at ambient temperature for 7 days to derive moisture content of  
81    $10.00 \pm 0.04\%$  dry base<sup>25</sup>. Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at  
82    $120^{\circ}\text{C}$  for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag  
83   for about 2 g/tea bag. Pluchea leaf powder in tea bags was extracted using hot water ( $95^{\circ}\text{C}$ ) for 5  
84   min to get various extract concentrations; 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

#### 85   **Wet Noodles Processing**

86           About 70 mL of hot extract from pluchea leaf powder with various concentrations (0, 5, 10, 15,  
87   20, 25 and 30% (w/v) (Table 1) was measured and manually mixed with egg, baking powder, salt and  
88   wheat flour for 5 min (Table 2). The mixture was kneaded to form a solid and homogenized dough using  
89   a mixer (Oxone Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to  
90   form noodle strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled  
91   water about 3 min in 300 mL water and coated with oil to prevent the noodles from sticking to each  
92   other. Wet noodles made without any addition of hot water of pluchea leaf extract were prepared as  
93   control. Wet noodles used in bioactive compounds and antioxidant activity assay were not added with  
94   oil to prevent the noodles from sticking to one another. The final characteristics of wet noodles were  
95   having width and thickness of 0.45 cm and 0.295 cm, respectively.

#### 96   **Pluchea Wet Noodles Extraction**

97           About 100 g of wet noodles were dried using a freeze dryer at a pressure of 0.1 bar and  
98   temperature  $-60^{\circ}\text{C}$  for 28 hours to obtain dried noodles. Each dried of pluchea leaves were powdered  
99   using a chopper machine at the speed of 35 seconds. 20 g of powdered pluchea leaves were mixed by

100 50 mL absolute methanol in a shaking water bath at 35°C, 70 rpm for 1 hour<sup>26</sup>. The filtration was done  
101 to separate filtrate by using Whatman filter paper grade 40 and the extraction of residue was done  
102 again with the same procedure. The collection of filtrates was done, then evaporation by rotary  
103 evaporator was done to get 3 mL of extract (Buchi Rotary Evaporator; Buchi Shanghai Ltd, China) at 200  
104 bars, 50°C for 60 min. The obtained extract was kept at 0°C before further analysis.

#### 105 **Moisture Content Assay**

106 Moisture content or water content of wet noodles was determined by thermogravimetric  
107 method<sup>27</sup>. The assay of moisture content from wet noodles was done by heating the samples in a drying  
108 oven (Binder, Merck KGaA, Darmstadt, Germany). The principle of this method is evaporating the water  
109 in the material. The sample was heated and weighed until a constant weight was obtained which was  
110 assumed to be all evaporated water.

#### 111 **Measurement of Swelling Index**

112 The principle of swelling index testing determines capability of noodles to swell during the  
113 boiling process<sup>16</sup>. The swelling index assay is done to determine the ability of wet noodles to absorb  
114 water per unit time that can estimate the time needed to fully cook wet noodles. The amount of water  
115 absorbed by wet noodles was measured from the weight difference of noodles after and before being  
116 boiled divided by the initial weight of the noodles<sup>28</sup>.

#### 117 **Determination of Cooking Loss**

118 Cooking loss is one of the necessary quality parameters in wet noodles to establish the quality  
119 of wet noodles after boiling<sup>28</sup>. The cooking loss assay for pluchea wet noodles was done to measure  
120 the number of solids that leached out from the wet noodle strands during the boiling process, namely

121 the leak of a small portion of starch from the wet noodle strands. A large cooking loss value affects the  
122 texture of wet noodles, which is easy to break and less slippery.

### 123 **Determination of Texture**

124 The texture of wet noodles with pluchea extract addition was measured based on its hardness,  
125 adhesiveness, cohesiveness, elongation and elasticity. The texture was analyzed by TA-XT2 texture  
126 analyzer (Stable Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the  
127 Texture Exponent 32 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were  
128 analyzed with a compression assay using  $2 \text{ mm s}^{-1}$  test speed and 75% strain. Five long noodle strands  
129 with the length of 4 cm for each strand were laid side by side, touching each other, perpendicular to  
130 the 35 mm compression cylinder probe on a flat aluminium base. The cylinder probe was arranged to  
131 be at 15 mm distance from the lower plate at the start of the compression test, and was forced down  
132 through the noodle strips at the speed of  $2 \text{ mm s}^{-1}$  until it touched the flat base to compress 75% of  
133 the noodle thickness, and was drawn back to at the end of the test. The profile curve was determined  
134 using a texture analyzer software<sup>24,29</sup>. The hardness was determined as the maximum force per gram.  
135 The adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area  
136 was obtained from the compression test under the curve. Cohesiveness was analyzed based on the  
137 ratio between the area under the second peak and the area under the first peak<sup>24,29,30</sup>. The elongation  
138 and elasticity of the noodles were individually tested by putting one end into the lower roller arm slot  
139 and sufficiently winding the loosened arm to fasten the noodle end. Elongation was the maximum  
140 force to change of noodle form and break by extension that was analyzed by a test speed of  $3.0 \text{ mm}$



s<sup>-1</sup> between two rollers with a 100 mm distance. The elongation at breaking was calculated per gram.

Elasticity was determined by formula (1)<sup>31,32</sup>:

$$\text{Elasticity} = \frac{Fx lo}{Ax to} \frac{1}{v} \quad (1)$$

where F is the tensile strength, lo is the original length of the noodles between the limit arms (mm), A is the original cross-sectional area of the noodle (mm<sup>2</sup>), v is the rate of movement of the upper arm (mm/s), and t is break up time of the noodles (s). The measurement of texture was detected by the software and expressed as a graph.

#### Color Measurement

The color of the noodle sheets was determined by a colorimeter (Minolta CR 10, Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab L\*, a\* and b\* values were analyzed based on Fadzil et al.<sup>29</sup> method. The L\* value measured the position on the white/black axis, the a\* value as the position on the red/green axis, and the b\* value as the position on the yellow/blue axis.

#### Analysis of Total Phenolic Content

The total phenolic content analysis was analyzed based on the reaction between phenolic compounds and Folin Ciocalteu (FC) reagent or phosphomolybdic acid and phosphotungstic acid. FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups becomes a blue molybdenum-tungsten complex solution<sup>33</sup>. The intensity of the blue color was detected by a UV-Vis spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 760 nm. In the analysis, 7.5% Na<sub>2</sub>CO<sub>3</sub> solution was added to reach pH 10 that caused an electron transfer reaction (redox). The obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

#### Analysis of Total Flavonoid Content

The flavonoid content assay was done by the spectrophotometric method based on the reaction between flavonoids and  $\text{AlCl}_3$  to form a yellow complex solution. In the presence of NaOH solution, a pink color is formed which can be detected by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm<sup>33,34,35</sup>. The obtained data were expressed in mg of (+)-catechin equivalent (CE)/L sample.

#### **Analysis of DPPH Free Radical Scavenging Activity**

The ability of antioxidant compounds of extract to scavenge DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical can be used to evaluate antioxidant activity. The principle of the DPPH method is to measure the absorbance of compounds that can react with DPPH<sup>36</sup>. Antioxidant compounds can donate hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced to yellow<sup>37</sup>. The color change was measured as an absorbance at  $\lambda$  517 nm by spectrophotometer (Spectrophotometer UV Vis 1800, Shimadzu, Japan)<sup>38</sup>. The data were expressed in mg gallic acid equivalent (GAE)/L dried noodles sample.

#### **Analysis of Iron Ion Reduction Power**

This method identifies the capacity of antioxidant components through increasing absorbance as a result of the reaction of antioxidant compounds with potassium ferricyanide, trichloroacetic acid, and ferric chloride to produce color complexes that can be measured spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm<sup>39</sup>. The principle of this testing is the ability antioxidants to reduce iron ions from  $\text{K}_3\text{Fe}(\text{CN})_6$  ( $\text{Fe}^{3+}$ ) to  $\text{K}_4\text{Fe}(\text{CN})_6$  ( $\text{Fe}^{2+}$ ). Then, potassium ferrocyanide reacts with  $\text{FeCl}_3$  to form a  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$  complex. The color change that occurs is yellow to green<sup>40</sup>. The final data were stated in mg gallic acid equivalent (GAE)/L dried noodles.

**183    Sensory Evaluation**

184            All samples of wet noodles were proceeded to hedonic test by involving 100 untrained panelists  
185    with an age range of 17 to 25 years. A hedonic test used in this research was the hedonic scoring  
186    method, where the panelists gave a preference score value of all samples<sup>41</sup>. The hedonic scores were  
187    transformed to numeric scale and analyzed using statistical analysis<sup>42</sup>. The numeric scale in the sensory  
188    analysis used a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The  
189    panelists were asked to score according to their level of preference for texture, taste, color, flavor and  
190    overall acceptability. All the samples were blind coded with 3 digits which differed from each other<sup>43</sup>.

**191    Statistical Analysis**

192            The research design used in the physicochemical assay was a randomized block design (RBD)  
193    with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that  
194    consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25, and 30% (w/v). Each treatment was repeated four  
195    times that obtained 28 experiment units. A completely randomized design (CRD) was used to evaluated  
196    sensory assay with 100 untrained panelists with an age range of 17 to 25 years.

197            The data normal distribution and homogeneity were stated as the mean  $\pm$  SD of the triplicate  
198    determinations and were determined using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc.,  
199    Chicago, IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan  
200    Multiple Range Test) at  $p \leq 5\%$  to determine the level of treatment that gave significant different  
201    results. The best treatment of pluchea extract addition on wet noodles was analyzed by a spider web  
202    graph.

203

## 204 **Results and Discussion**

205           Wet noodles added with hot extract of pluchea leaf powder were produced with aiming to  
206 increase the functional value of wet noodles. This is supported by several previous researches related  
207 to the potential value of water extract of pluchea leaf that exhibit a biological activity<sup>6,7,41</sup>. In this  
208 research, the cooking quality was observed after cooking wet noodles in 300 mL water/100g samples  
209 for 3 min in boiling water.

## 210 **Cooking Quality**

211           Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at 0, 5,  
212 10, 15, 20, 25, and 30% (w/v) was shown in Figure 1, Table 3 and Table 4. The addition of pluchea  
213 extract no significantly influenced the water content, cooking loss, swelling index, chroma, and hue of  
214 the produced wet noodles using statistical analysis by ANOVA at  $p \leq 5\%$ . Water content is one of the  
215 chemical properties of a food product determined shelf life of food products, because the water  
216 content measures the free and weakly bound water in foodstuffs<sup>44,45</sup>. This study identified that the  
217 moisture content of the cooked wet noodles ranged between 64-67% wb. A previous study showed  
218 that the water content of the cooked egg wet noodles was around 54-58% wb<sup>45</sup> and maximum of  
219 65%<sup>20</sup>. Chairuni et al.,<sup>44</sup> stated that the boiling process could cause a change in moisture content from  
220 around 35% to around 52%. The Indonesian National Standard,<sup>46</sup> stipulates that the moisture content  
221 of cooked wet noodles is a maximum of 65%. This means that only control noodles (without treatment)  
222 exhibited a moisture content similar to the previous information. The obtained data showed a trend  
223 that an extract addition caused an increase in the water content of wet noodles, but statistical analysis  
224 at  $p \leq 5\%$  showed no significant difference. This phenomenon was in accordance with the experimental

225 results of Juliana et al.<sup>45</sup>, that the using of spenochlea leaf extract to making wet noodles, as well as  
 226 Hasmawati et al.<sup>20</sup>, that the supplementary of sweet potato leaf extract increased the moisture of fresh  
 227 noodles. The water content of pluchea wet noodles was expected by reaction between many  
 228 components in the dough that impacted to the swelling index and cooking loss. Mualim et al.<sup>14</sup>, Bilina  
 229 et al.<sup>22</sup>, and Setiyoko et al.<sup>28</sup>, informed that the presence of amino groups in protein and hydroxyl  
 230 groups in amylose and amylopectin fractions in wheat flour as raw material for making dough  
 231 determines the moisture content, swelling index and cooking loss of wet noodles. The contribution of  
 232 glutelin and gliadin proteins in wheat flour to form gluten networks determines the capability of  
 233 noodles to swell and retain water in the system. Gliadin acts as an adhesive that causes dough to be  
 234 elastic, while glutenin makes the dough to be firm and able to withstand CO<sub>2</sub> gas thus the dough can  
 235 expand and form pores. Fadzil et al.,<sup>29</sup>, found that thermal treatment during the boiling process results  
 236 in the denaturation of gluten and caused a monomer of proteins to determine other reactions at the  
 237 disulfide or sulfhydryl chain. The existence of phenolic compounds from pluchea extract also increased  
 238 the capacity of noodles to absorb water and determined water mobility. Widyawati et al.,<sup>41</sup>, also  
 239 confirmed that hydrophilic compounds of proteins, carbohydrates, and polyphenolic components  
 240 determine water mobility due to their ability to bind with water molecules through hydrogen bonding.  
 241 Tuhumury et al.,<sup>47</sup>, informed that gluten formation can inhibit water absorption by starch granules so  
 242 that can prevent gelatinization. Therefore, the addition of phenolic compounds from the hot extract of  
 243 pluchea leaf powder can inhibit the formation of gluten so that it stimulates gelatinization of starch  
 244 granules.

245

246 As a result, the impact of increased the moisture content during boiling had an effect on the  
247 value of the swelling index and cooking loss of the wet noodles. Widyawati et al.,<sup>41</sup>, said that the  
248 swelling index is the capability to trap water which is dependent on the chemical composition, particle  
249 size, and water content. Gull et al.,<sup>48</sup>, also confirmed that the swelling index is an indicator to determine  
250 water absorption by starch and protein to make gelatinization and hydration. Setiyoko et al.,<sup>28</sup>,  
251 explained that cooking loss is the mass of noodle solids that come out of the noodle strands for boiling.  
252 Gull et al.,<sup>48</sup>, added that soluble starch and other soluble components leach out into the water during  
253 the cooking process, making the cooking water turned thicker. The moisture content results (64-67%  
254 wb) showed that the produced wet noodles exceeded the moisture content limit of wet noodles after  
255 cooking, which is between 54-58%<sup>44</sup>, while the cooking loss value of wet noodles should not be more  
256 than 10%<sup>28</sup>. In this study, the cooking loss value was 3-4.2%. The cooking loss of samples during boiling  
257 noodles were caused the breaking of the bonding network that the polysaccharides are released and  
258 the gluten network breaks because of the addition of pluchea leaf extract. Widyawati et al.<sup>41</sup>,  
259 supported that polyphenol can be bound with protein and starch with many non-covalent interactions,  
260 such as hydrogen bonding, electrostatic interaction, hydrophobic interaction, Van der Waals  
261 interaction, and  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch to  
262 undergo gelatinization and gliadin and glutelin from the protein of wheat flour to form gluten.

263 The swelling index value obtained from this research was around 56-68 %. Based on the  
264 previous research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.)  
265 fruit was around 51%<sup>49</sup>. This means that the addition of pluchea leaf extract in wet noodles also affects  
266 the ability of noodles to absorb water. Widyawati et al.<sup>41</sup>, and Suriyaphan<sup>6</sup>, informed that bioactive

compounds in hot water extract of pluchea leaf tea include 3-*O*-caffeoylquinic acid, 4-*O*-caffeoylquinic acid, 5-*O*-caffeoylquinic acid, 3,4-*O*-dicafeoylquinic acid, 3,5-*O*-dicafeoylquinic acid, 4,5-*O*-dicafeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was higher than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from extract in absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch granules to absorb water so that the swelling index and cooking loss increased. Suriyaphan,<sup>6</sup> informed that hot extract of pluchea leaf tea contains 1.79 g/100 g protein, 8.65 g/100 g carbohydrate, and fiber (0.45 g/100 g soluble and 0.89 g/100 g insoluble), these compounds can involve in increasing the swelling index from pluchea wet noodles.

Color is one of the physical characteristics possessed by wet noodles that becomes a benchmark for consumer acceptance. This research found that the color of wet noodles was influenced by the addition of pluchea extract. The addition of pluchea leaf extract no significant affected the redness ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it influenced the yellowness ( $b^*$ ) and lightness ( $L^*$ ) values. Using of pluchea leaf powder brewing decreased the brightness of wet noodles significantly, as the concentration of the extract increased. This is related to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to experience color changes. According to Widyawati et al.<sup>8</sup>, tannins are water-soluble compounds that can give a brown color. Suriyaphan,<sup>6</sup> and Widyawati et al.<sup>41</sup>, also stated that Khlu tea from pluchea leaves contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and 6.39 mg/100 g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow



288 color. Gull et al.<sup>48</sup>, stated that this pigment was easily changed in the paste sample due to the swelling  
289 and discoloration of the pigment during cooking.

290 Thus, the addition of hot water extract of pluchea leaf powder significantly reduced the  
291 brightness of wet noodles, because brown-colored noodles were produced as the concentrations of  
292 added pluchea leaf extract increased. However, increasing the concentration of this extract had no  
293 influenced on the redness, hue, and chroma values in ANOVA at  $p \leq 5\%$ . The results showed that the  
294 redness value of wet noodles revolved from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet  
295 noodles ranged from  $82.1 \pm 3.1$  to  $86.5 \pm 1.0$ . Based on this value, the color of wet noodles is in the  
296 yellow to the red color range<sup>50</sup>, thus the visible color of the wet noodle product was yellow to brown  
297 (Figure 1). Yellowness increased significantly with the addition of pluchea leaf extract and the value  
298 ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the availability of tannins and chlorophyll  
299 compounds from pluchea leaf extract. The chroma value of wet noodles was obtained within the range  
300 of  $15.6 \pm 1.5$  to  $19.8 \pm 3.4$ . This means that the brewing of pluchea leaf powder did not change the  
301 intensity of the brown color in the resulting wet noodles.

302 Texture analysis of pluchea wet noodles added with various concentrations of hot water extract  
303 from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness,  
304 elongation, and elasticity. Hardness is the maximum force given to a product until deformation<sup>51,52</sup>.  
305 From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher  
306 peak of graph shows the harder product<sup>30</sup>. Adhesiveness is force or tackiness that is required to pull  
307 the product from its surface, its value is obtained from the area between the first and second  
308 compressions<sup>53,54</sup>. Adhesiveness values show negative value; the bigger negative value means the

product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and second compressions<sup>52,54</sup>. This is an indication of the internal forces that make up the product<sup>55</sup>. Elongation is the change in length of noodles when being exposed to a tensile force until the noodles break<sup>56</sup>. Elasticity is the time required for the product to withstand the load until it breaks. The more elastic a product, the longer the holding time. The data showed that the higher concentration of pluchea leaf powder within the hot water extract caused a significant increase in the hardness, stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati et al.<sup>41</sup> informed that the polyphenols contained in pluchea leaf extract can weakly interact either covalently or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups that are polar. Amoako and Akiwa,<sup>57</sup> and Zhu et al.<sup>58</sup>, have also proven that polyphenolic compounds can interact with carbohydrates through the interaction of two hydrophobic and hydrophilic functional groups with amylose. Diez-Sánchez et al.<sup>59</sup> stated that polyphenolic compounds can interact with amylose and protein helical structures and largely determined by molecular weight, conformational mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and amylopectin can affect the gelatinization process in the amylose helical structure and interfere with the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss (> 98%) and swelling index (56.2 to 67.7%) data, it can be concluded that the

330 interaction that occurs between the phenol group in pluchea leaf extract with amylose and protein was  
331 weak. The bioactive components of pluchea leaf extract are thought to affect the formation of disulfide  
332 cross-links (S-S) and turn into to form sulfhydryl groups (-SH) under the influence of heat. Ananingsih  
333 and Zhou<sup>60</sup> said that antioxidant compounds are a reducing agent that can have an impact on reducing  
334 S-S bonds and increasing the number of SH groups in the dough to produce a harder texture. According  
335 to Rahardjo *et al.*<sup>53</sup>, phenolic compounds are hydroxyl compounds that influence the strength of the  
336 dough, where the higher the component of phenol compounds will weaken the gluten matrix and the  
337 dough thus becoming unstable. The instability of the dough can cause the texture to become hard.

338 Many researchers also find that tannins and phenols influence the networking S-S bond in the  
339 dough of wet noodles. Wang *et al.* (2015) showed that tannins increase the relative amount of large,  
340 medium polymers in the gluten protein network so as to improve the dough quality. Zhang *et al.*<sup>61</sup> said  
341 that these polymer compounds are the results of interactions or combinations of protein-tannin  
342 compounds that form bonds with the type of covalent bonds, hydrogen bonds, or ionic bonds. Rauf  
343 and Andini<sup>62</sup> also added that phenol compounds are able to reduce S-S bonds to SH bonds. SH is a type  
344 of thiol compound group, where the thiol group can influence the stickiness, viscosity, cohesiveness,  
345 elongation, and extensibility of the dough. Wang *et al.*<sup>63</sup> found the effect of phenolic compounds from  
346 green tea extract to increase the stickiness of wheat bread. The cohesiveness of the dough is formed  
347 due to a large number of thiol bonds formed, thus increasing the viscosity of the dough. The increased  
348 viscosity of the dough is thought to be due to the formation of polyphenolic compounds with thiol  
349 groups, as in the research of Ananingsih and Zhou<sup>60</sup> that the formation of catechin-thiol can increase  
350 the viscosity of the dough and increase the stability of the dough. Zhu *et al.*,<sup>64</sup> declared that the

addition of phenolic compounds from green tea was able to increase the PV (peak viscosity) of wheat flour. Wang *et al.*<sup>65</sup> also found that the cohesiveness of the dough is influenced by tannins, where tannins can produce micro-glutens so as to produce a compact dough and increase the gluten network. The addition of pluchea leaf extract in making wet noodles could influence the elongation of wet noodles due to the components of polyphenol compounds such as tannins that can reduce the number of free amino groups. This is supported by Zhang *et al.*<sup>30</sup> and Wang *et al.*<sup>65</sup> that support the formation of other types of covalent bonds, such as bonds between amino groups and hydroxyl groups, by forming hydrogen bonds between phenolic compounds and protein gluten so as to improve the quality of dough strength and dough extensibility.

#### **Bioactive Compounds and Antioxidant Activity**

Wet noodles added with pluchea leaf powder were analyzed based on its bioactive compounds and antioxidant activities. The analysis was conducted to determine the functional properties of wet noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles are presented in Table 5. The measured bioactive compounds (BC) included total phenol content (TPC) and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical scavenging activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed that there was a positive and strong correlation between TPC and DPPH ( $r=0.990$ ), TPC and FRAP ( $r=0.986$ ), TFC and DPPH ( $r=0.974$ ), and TFC and FRAP ( $r=0.991$ ). This means that the antioxidant activity of wet

pluchea noodles was strongly influenced by TPC and TFC. Muflihah et al.<sup>66</sup> informed that the PC ( $r$ ) > 0.699 indicates the strength and linear correlation between antioxidant activity (AA) and TPC, and also shows a strong positive relationship but PC ( $r$ ) < 0.699 obtains a moderately positive relationship. If the  $r$  value of TFC and AA is lower than TPC and AA, it indicates that the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship which is expected because both classes all contributed to AA plants. Aryal et al.<sup>67</sup> and Muflihah et al.<sup>66</sup> informed that phenolic compounds are soluble natural antioxidants and potential donating electrons depend on their number and position of hydroxyl groups contributed to antioxidant action. Consequently, these groups are responsible to scavenge the free radicals that TPC of pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the stable purple-colored to the yellow-colored solution. Based on FRAP analysis, it was showed that the bioactive compounds contained in pluchea wet noodles are a potential source of antioxidants because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive compounds contained in pluchea wet noodles can function as primary and secondary antioxidants. Research data showed that the cooking quality of wet noodles tends to increase along with the increase in the value of TPC, TFC, DPPH, and FRAP.

388

### 389 **Sensory Evaluation**

Sensory pluchea wet noodles, namely color, aroma, taste, texture, and overall acceptance, were carried out using a hedonic test to determine the level of consumer preference for the product. This test was conducted to determine the quality differences between the products and to provide an

assessment on certain properties<sup>42</sup>. The hedonic test itself is the most widely used test to determine the level of preference for production<sup>68</sup>. The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm 1.26$  (neutral-like). The statistical analysis showed that the higher concentration of hot water extract addition decreased lower color preference of wet noodles. The higher concentration of pluchea extract could reduce the level of preference for color because the color of the wet noodles was darker than control and turned to dark brown. This color change was due to the pluchea extract containing several components, including chlorophyll and tannins, which can alter the of wet noodles' color to be browner along with the increase in the concentration of pluchea extract. This result was in accordance to the results of color analysis performed using color reader where the pluchea wet noodles' brightness declined, yellowness increased, and the color intensity increased with an increased concentration of pluchea extract. The occurrence of this process is related to the effect of light and heat on pluchea leaf powder which causes the degradation of chlorophyll into brown pheophytin due to drying, where the nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals<sup>69,70</sup>.

Aroma is one of the parameters in sensory evaluation using the sense of smell and is an indicator of the assessment of a product<sup>71</sup>. The results of the preference value for aroma were ranged from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet noodles reduced the preference score for aroma due to the occurrence of distinct dry leaves (green) aroma. Lee et al.<sup>72</sup> informed that the unpleasant aroma on leaves comes from a group of aliphatic aldehyde compounds. The appearance of a distinctive leaf aroma in noodles is due to aromatic

414 compounds. According to Martiyanti and Vita<sup>73</sup> aromatic compounds are chemical compounds that  
415 have an aroma or odor when the conditions are met, which is volatile, while Widyawati et al.<sup>74</sup>  
416 informed that pluchea leaves were detected to have 66 volatile compounds. The appearance of the  
417 aroma is due to the volatile compounds in the raw material reacting with water vapor when boiling the  
418 noodles. In addition, there is also an oxidation process of polyphenolic compounds such as catechins  
419 or tannins that can produce an aroma in pluchea wet noodles.

420 According to Martiyanti and Vita<sup>3</sup> taste attribute is one important sensory aspect in food  
421 products and has a great impact on the food selection by consumers. Tongue **is** able to detect basic  
422 tastes, namely sweet, salty, sour, and bitter, at different points. Lamusu<sup>71</sup> declared that taste is a  
423 component of flavor and an important criterion in assessing a product that is accepted by the tongue.  
424 The preference test of the taste of pluchea wet noodles resulted in values ranging from **4.15 ± 1.40 to**  
425 **5.50 ± 1.28** (neutral-slightly like). The increase in concentrations of pluchea extract was negatively  
426 correlated to the preference level of **the taste of** pluchea wet **noodles** assessed by the panelists. The  
427 statistical analysis results showed that the difference in the concentration of the extract significant  
428 influenced on the preference score for the taste of pluchea wet noodles. The increased concentration  
429 of pluchea extract produced a distinctive taste on wet noodles, such as a bitter, bitter, and astringent  
430 tastes, due to the presence of compounds such as tannins and alkaloids from the pluchea leaves.  
431 Susetyarini<sup>75</sup> said that pluchea leaves contain tannins (2.351%), and alkaloids (0.316%). According to  
432 Pertiwi<sup>76</sup>, tannin compounds dominate the bitter and astringent taste, while alkaloid compounds cause  
433 a bitter taste. The high level of taste preference for wet noodles was found in noodles with lower  
434 content of pluchea extract.



435 Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and  
436 swallowed) or touched with fingers<sup>77</sup>. Texture testing performed by the panelist is called mouthfeel  
437 testing. According to Martiyanti and Vita<sup>73</sup>, mouthfeel is the kinesthetic effect of chewing food in the  
438 mouth. In this study, the preference test results on the texture of pluchea wet noodles revolved from  
439  $5.5 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy  
440 and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet  
441 noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that  
442 can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and  
443 draining noodles. Subjective testing results based on sensory evaluation were in line with the objective  
444 testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to  
445 break, and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea  
446 wet noodles was influenced by the fiber and protein components. According to Shabrina,<sup>78</sup>, the  
447 components of fiber, protein, and starch compete to bind water. Texture changes are also influenced  
448 by the polyphenol compositions in the pluchea extract which is able to reduce S-S bonds to SH bonds,  
449 where the increase in SH (thiol) groups can give a hard, sticky, and compact texture<sup>62,63,65</sup>. Besides, a  
450 high concentration of tannins capable of binding to proteins to form complex compounds into tannins-  
451 proteins are also able to build noodles' texture.

452 The interaction between color, aroma, taste, and texture created an overall taste of the food  
453 product and was assessed as the overall preference. The highest value on the overall preference was  
454 derived from control wet noodles i.e., 6.63 (slightly like it), while the wet noodles added with 20% (w/v)  
455 concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The

addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to 10% (w/v) concentration with scores of 6.63 and 6.53, respectively. The area of the spider web chart for each treatment with the various concentrations of pluchea extract was seen in Figure 2. The best treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively.

The use of pluchea leaf extract in the making of wet noodles was able to increase the functional value of wet noodles, based on the levels of bioactive compounds and antioxidant activity without changing the quality of cooking, which includes water content, swelling index and cooking loss. Besides that, the use of pluchea leaf extract did not significantly change the color and color intensity of the resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet noodles produced were still acceptable to the panelists, the addition of pluchea leaf extract as much as 10% (w/v) was the best treatment with an assessment that was almost close to the control wet noodles (without treatment).

## Conclusion

Wet noodles made by incorporating hot water extract of pluchea leaf powder underwent lightness, texture, bioactive compound content, antioxidant activity, and sensory properties changes. The higher concentration of pluchea extract addition induced the bigger lightness, hardness, adhesiveness, cohesiveness, elongation, and elasticity from pluchea wet noodles. The sensory properties of the produced wet noodles evaluated by hedonic test showed that wet noodles made with

477 10% (w/v) concentration of hot water extract from pluchea leaf powder obtained in the color, aroma,  
478 taste, and texture with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and  
479 6.53 (like), respectively. The concentration was the best treatment of pluchea wet noodles with an area  
480 of spider web graph i.e., 66.37 cm<sup>2</sup>.

481

482 **Notes on Appendices**

TPC	Total phenol content
TFC	Total flavonoid content
DPPH	2,2-Diphenyl-1-picrylhydrazyl free radical
FRAP	Ferric reducing antioxidant power
AA	Antioxidant activity
PC	Person Correlation
LDL	Low Density Lipoprotein
w/v	Weight per volume
CRD	Completely randomized design
CE	Catechin equivalent
GAE	Gallic acid equivalent
BC	Bioactive compounds
ANOVA	Analysis of variance
UV-Vis	Ultra violet-visible

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- 721 78. Shabrina N. The Effect of Substitution of Wheat Flour with Koro Sword Bean Flour (*Canalia*  
722 *Ensiformis* L) and Fermentation Time on The Characteristics of White Bread. [Undergraduate  
723 thesis]. Bandung: Indonesia University of Pasundan. 2017. <http://repository.unpas.ac.id/28532/>  
724

725 Table 1. Information of hot water extract of pluchea tea

Materials	Concentration of hot water extract of pluchea leaf tea (% w/v)						
	0	5	10	15	20	25	30
Pluchea leaf tea (g)	0	10	20	30	40	50	60
Hot water (mL)	200	200	200	200	200	200	200

726

727

728 **Table 2. Ingredients** of pluchea wet noodles

Materials	Unit	Quantity
Wheat flour	g	200
Egg	g	40
Salt	g	4
Baking powder	g	2
Hot water extract	mL	70
Tapioca flour	g	10
TOTAL	g	326

729

**Table 3.** Color, moisture content, swelling index, and cooking loss of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Color					Moisture content (% wb)	Swelling index (%)	Cooking loss (%)
	L*	a*	b*	C	h			
0	67.1 ± 1.8 <sup>a</sup>	0.97±0.30	16.18±0.62 <sup>ab</sup>	16.2 ± 0.6	86.5 ± 1.0	63.90±1.51	56.2±17.4	3.40±1.31
5	59.5 ± 2.7 <sup>b</sup>	2.18±0.93	15.47±1.46 <sup>a</sup>	15.6 ± 1.5	82.1 ± 3.1	65.08±4.33	62.4±4.7	3.33±1.26
10	59.0 ± 1.8 <sup>b</sup>	1.95±1.66	16.76±2.33 <sup>abc</sup>	17.1 ± 2.2	83.3 ± 5.4	64.97±3.89	61.5±7.5	3.00±1.16
15	58.4 ± 2.2 <sup>b</sup>	1.69±1.48	19.72±3.50 <sup>c</sup>	19.8 ± 3.4	84.7 ± 4.6	65.56±2.18	63.1±6.3	3.31±0.92
20	56.5 ± 2.4 <sup>b</sup>	1.97±1.24	19.09±2.97 <sup>bc</sup>	19.2 ± 2.9	83.6 ± 4.3	66.81±1.81	67.7±5.9	4.06±0.51
25	59.1 ± 2.5 <sup>b</sup>	1.95±1.44	19.55±2.97 <sup>c</sup>	19.6 ± 2.9	83.8 ± 4.0	66.04±0.85	64.5±10.3	3.93±1.37
30	57.1 ± 2.1 <sup>b</sup>	2.09±1.51	18.08±4.94 <sup>abc</sup>	18.3 ± 4.8	82.5 ± 5.2	66.65±2.16	64.0±5.3	4.23±1.34

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different, p<5%

734 **Table 4.** Texture of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Texture				
	Hardness (N)	Adhesiveness (g sec)	Cohesiveness	Elongation (%)	Elasticity (Pa)
0	135.8±5.9 <sup>a</sup>	-2.7 ±2.3 <sup>d</sup>	0.75±0.01 <sup>a</sup>	86.9±0.9 <sup>a</sup>	25336.7±104.2 <sup>a</sup>
5	120.1±2.1 <sup>a</sup>	-3.4±0.6 <sup>cd</sup>	0.68±0.00 <sup>b</sup>	97.3±1.6 <sup>b</sup>	25898.3±760.9 <sup>b</sup>
10	134.9±1.8 <sup>a</sup>	-3.9±0.7 <sup>bc</sup>	0.74±0.00 <sup>c</sup>	162.1±1.5 <sup>c</sup>	25807.7±761.9 <sup>b</sup>
15	180.5±5.1 <sup>b</sup>	-4.9±0.5 <sup>b</sup>	0.74±0.01 <sup>c</sup>	164.7±0.6 <sup>c</sup>	26971.6±516.7 <sup>b</sup>
20	195.1±14.1 <sup>b</sup>	-5.0±1.3 <sup>ab</sup>	0.75±0.01 <sup>cd</sup>	221.6±1.6 <sup>d</sup>	27474.4±453.8 <sup>b</sup>
25	244.6±8.8 <sup>c</sup>	-6.0±0.3 <sup>a</sup>	0.75±0.00 <sup>cd</sup>	230.7±0.7 <sup>e</sup>	27367.1±287.5 <sup>b</sup>
30	282.8±28.3 <sup>d</sup>	-6.1±0.2 <sup>a</sup>	0.79±0.01 <sup>d</sup>	255.4±0.4 <sup>f</sup>	26687.5±449.2 <sup>b</sup>

735 Note: the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in  
736 the same column are significantly different, p<5%



**Table 5.** Total phenol content, total flavonoid content, the DPPH free radical scavenging activity, and iron ion reducing power of the pluchea wet noodles.

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	TPC (mg GAE/kg Dried Noodles)	TFC (mg CE/kg Dried Noodles)	DPPH (mg GAE/kg Dried Noodles)	FRAP (mg GAE/kg Dried noodles)
0	39.26±0.66 <sup>a</sup>	32.36±1.47 <sup>a</sup>	96.75±4.26 <sup>a</sup>	25.96±0.25 <sup>a</sup>
5	61.09±3.80 <sup>b</sup>	46.31±2.15 <sup>b</sup>	121.36±3.58 <sup>b</sup>	34.50±1.71 <sup>b</sup>
10	82.84±3.11 <sup>c</sup>	62.44±0.55 <sup>c</sup>	130.68±4.82 <sup>c</sup>	51.33±2.19 <sup>c</sup>
15	101.48±2.16 <sup>d</sup>	84.67±1.22 <sup>d</sup>	142.48±2.14 <sup>d</sup>	58.69±2.14 <sup>d</sup>
20	114.94±4.20 <sup>e</sup>	100.14±1.50 <sup>e</sup>	148.84±3.20 <sup>e</sup>	67.26±0.06 <sup>e</sup>
25	128.06±1.38 <sup>f</sup>	107.93±0.89 <sup>f</sup>	157.51±7.69 <sup>f</sup>	69.53±1.06 <sup>f</sup>
30	136.35±1.16 <sup>g</sup>	131.69±1.56 <sup>g</sup>	166.97±1.53 <sup>g</sup>	84.98±0.11 <sup>g</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p < 5\%$ .



**Table 6.** Effect of hot water extract from pluchea leaf powder to preferences for color, aroma, taste, texture, and overall acceptance of wet noodles at various concentrations

Concentration of Hot		Hedonic Score			
Extract from Pluchea Leaf Powder (% w/v)	Color	Aroma	Taste	Texture	Overall
					acceptance
0	6.19±1.25 <sup>d</sup>	5.52±1.08	5.50±1.18 <sup>c</sup>	6.20±1.13 <sup>b</sup>	6.63±1.49 <sup>c</sup>
5	5.62±1.28 <sup>c</sup>	5.52±0.83	5.51±1.29 <sup>c</sup>	6.37±1.14 <sup>bc</sup>	6.40±1.52 <sup>c</sup>
10	5.62±1.21 <sup>c</sup>	5.45±0.85	5.46±1.12 <sup>c</sup>	6.53±1.14 <sup>c</sup>	6.53±1.64 <sup>c</sup>
15	5.14±1.25 <sup>b</sup>	4.81±1.04	4.61±1.11 <sup>b</sup>	6.13±1.09 <sup>b</sup>	5.78±1.67 <sup>b</sup>
20	4.91±1.32 <sup>b</sup>	4.54±1.18	4.47±1.15 <sup>ab</sup>	5.80±1.06 <sup>a</sup>	5.17±1.70 <sup>a</sup>
25	4.54±1.40 <sup>a</sup>	4.26±1.23	4.20±1.24 <sup>a</sup>	5.50±1.04 <sup>a</sup>	5.23±1.75 <sup>a</sup>
30	4.47±1.33 <sup>a</sup>	4.05±1.34	4.15±1.40 <sup>a</sup>	5.59±1.05 <sup>a</sup>	5.37±1.91 <sup>a</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p < 5\%$ .





Figure 1. Wet noodles with hot water extract of pluchea leaf powder at concentrations (clockwise from bottom right) a. 0%; b. 5%; c. 10%; d. 15%; e. 20%; f. 25%; and g. 30% w/v



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## Review report of article - 3638

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**Managing Editor** <info@foodandnutritionjournal.org>

Mon, Mar 13, 2023 at 1:58 PM

To: Paini Sri Widyawati <paini@ukwms.ac.id>

Dear Dr Paini,

Hope this email finds you well.

The deadline to submit a revised manuscript is the 16th of March as we are closing our issue by the end of march so that we will move forward with the publication process in a timely manner.

Kindly do the requested changes at your earliest convenience.

We will be looking forward to your response.

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Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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## Review report of article - 3638

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**Paini Sri Widyawati** <paini@ukwms.ac.id>

Wed, Mar 15, 2023 at 3:40 AM

To: Managing Editor &lt;info@foodandnutritionjournal.org&gt;

Dear Ms. Yanha Ahmed

I have revised my manuscript and sent it back. Thanks for attention

Regards

Paini Sri W

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### 3 attachments

**Response Form 1 (15-03-2023).docx**  
52K**Response Form 2 (15-03-2023).docx**  
51K**Revise of this manuscript based on reviewer comments.docx**  
744K

## Author's Response to Reviewer's Comments

Reviewer number 1

Paper title: **The Effect of Hot Water Extract of Pluchea Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles**

Title	Reviewer's Comments	Author's Response
<p>Abstract Should be more scientifically written, English has to be improved throughout the manuscript. References must be uniform.</p>		<p>Abstract has been revised To be .....</p> <p>Powdered <i>Pluchea indica</i> Less leaves have been utilized as herbal tea, brewing of pluchea tea in hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional value and influence physic, chemical, and sensory characteristics of food. The study was done to assess the effect of various concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with pluchea tea at concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v). Physical properties analyzed included water content, swelling index, cooking loss, color and texture. Chemical properties measured were bioactive contents of total phenolic content, total flavonoid content, and antioxidant ability to scavenge DPPH free radicals and to reduce iron ions. Sensory</p>



		<p>properties determined <b>were</b> taste, texture, color, aroma and overall acceptance. The addition of various <b>concentrations</b> of extract gave significantly effects on parameters of physical, chemical and sensory properties of noodles, except color (redness, chroma and hue), cooking loss, water content, swelling index and aroma. Using of 10% (w/v) of pluchea tea resulted <b>in</b> the best sensory properties such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. <b>Generally, the study concluded</b> that wet noodles <b>can be made by adding pluchea tea at 10% (w/v)</b>. <b>Dried samples</b> TPC, TFC, <b>DPPH free radical scavenging</b> and iron ion reducing power <b>were</b> 82.84 mg GAE/kg, 62.44 mg CE/kg, 130.68 mg GAE/kg and 51.33 mg GAE/kg, respectively.</p>
Keywords		-
Introduction		Some grammatical has been revised
Methodology		GC-MS and FTIR analysis are not done that we were not stated
Results		Some grammatical has been revised
Discussion		Some grammatical has been revised
Conclusion		<p>Conclusion has been revised To be .....</p> <p>Addition of hot water extract of pluchea leaf powder influenced physical, chemical and sensory properties of wet noodles. Lightness, texture, bioactive compound content, antioxidant activity, and sensory properties of samples underwent significant difference. The higher concentration of pluchea extract caused the bigger these parameters of pluchea wet</p>



		noodles. Using 10% (w/v) of hot water extract from pluchea leaf powder was the best treatment with color, aroma, taste, and texture scores 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. Utilization of hot water extract of pluchea leaf powder at 10% (w/v) resulted wet noodle functional with TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg dried samples, 62.44 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples and 51.33 mg GAE/kg dried samples, respectively.
References (Appropriateness)		References have been revised
Title		Title has been revised To be ..... The Effect of Hot Water Extract of <i>Pluchea indica</i> Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

## Author's Response to Reviewer's Comments

Reviewer number 2

Paper title: **The Effect of Hot Water Extract of Pluchea Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles**

Title	Reviewer's Comments	Author's Response
Abstract Should be more scientifically written, English has to be improved throughout the manuscript. References must be uniform.		<p>Abstract has been revised</p> <p>To be .....</p> <p>Powdered <i>Pluchea indica</i> Less leaves have been utilized as herbal tea, brewing of pluchea tea in hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional value and influence physic, chemical, and sensory characteristics of food. The study was done to assess the effect of various concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with pluchea tea at concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v). Physical properties analyzed included water content, swelling index, cooking loss, color and texture. Chemical properties measured were bioactive contents of total phenolic content, total flavonoid content, and antioxidant ability to scavenge DPPH free radicals and to reduce iron ions. Sensory properties determined were taste, texture, color, aroma and overall acceptance. The</p>





		addition of various <b>concentrations</b> of extract gave significantly effects on parameters of physical, chemical and sensory properties of noodles, except color (redness, chroma and hue), cooking loss, water content, swelling index and aroma. Using of 10% (w/v) of pluchea tea resulted <b>in</b> the best sensory properties such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. <b>Generally, the study concluded</b> that wet noodles <b>can be made by adding pluchea tea at 10% (w/v)</b> . <b>Dried samples</b> TPC, TFC, <b>DPPH free radical scavenging</b> and iron ion reducing power <b>were</b> 82.84 mg GAE/kg, 62.44 mg CE/kg, 130.68 mg GAE/kg and 51.33 mg GAE/kg, respectively.
Keywords		-
Introduction		Some grammatical has been revised I have added information related botany of <i>Pluchea indica</i> Less of Chan et al. 2022 To be..... Chan et al. <sup>1</sup> also informed that <i>Pluchea indica</i> Less leaves compose caffeoylquinic acids, phenolic acids, flavonoids and thiophenes which these compounds are potential as antioxidant activity.
Methodology		Some grammatical has been revised
Results		Some grammatical has been revised
Discussion		Some grammatical has been revised
Conclusion		Conclusion has been revised To be ..... Addition of hot water extract of pluchea leaf powder influenced physical, chemical and sensory properties of wet noodles. Lightness, texture, bioactive compound content,



		antioxidant activity, and sensory properties of samples underwent significant difference. The higher concentration of pluchea extract caused the bigger these parameters of pluchea wet noodles. Using 10% (w/v) of hot water extract from pluchea leaf powder was the best treatment with color, aroma, taste, and texture scores 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. Utilization of hot water extract of pluchea leaf powder at 10% (w/v) resulted wet noodle functional with TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg dried samples, 62.44 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples and 51.33 mg GAE/kg dried samples, respectively.
References (Appropriateness)		References have been revised
Title		Title has been revised To be ..... The Effect of Hot Water Extract of <i>Pluchea indica</i> Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

## The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

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Corresponding Author Email: paini@ukwms.ac.id

### Abstract

Powdered *Pluchea indica* Less leaves have been utilized as herbal tea, brewing of pluchea tea in hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional value and influence physic, chemical, and sensory characteristics of food. The study was done to assess the effect of various concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with pluchea tea at concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v). Physical properties analyzed included water content, swelling index, cooking loss, color and texture. Chemical properties measured were bioactive contents of total phenolic content, total flavonoid content, and antioxidant ability to scavenge DPPH free radicals and to reduce iron ions. Sensory properties determined were taste, texture, color, aroma and overall acceptance. The addition of various concentrations of extract gave significantly effects on parameters of physical, chemical and sensory properties of noodles, except color (redness, chroma and hue), cooking loss, water content, swelling index and aroma. Using of 10% (w/v) of pluchea tea resulted in the best sensory properties such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. Generally, the study concluded that wet noodles can be made by adding pluchea tea at 10% (w/v). Dried samples TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg, 62.44 mg CE/kg, 130.68 mg GAE/kg and 51.33 mg GAE/kg, respectively.

### Key-words

Chemical, *Pluchea indica* Less, physical, sensory, wet noodles

### Introduction

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food<sup>1,2</sup>. The potency of pluchea leaves is related to phytochemical

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40 compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone,  
41 alkaloid, lignans and saponins<sup>2,3,4,5</sup>. Chan et al.<sup>1</sup> also informed that *Pluchea indica* Less leaves compose  
42 caffeoylquinic acids, phenolic acids, flavonoids and thiophenes which these compounds are potential as  
43 antioxidant activity. Furthermore, pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100 g,  
44 fat 0.49 g/100 g, insoluble dietary fiber 0.89 g/100 g, soluble dietary fiber 0.45 g/100 g, carbohydrate  
45 8.65 g/100 g, calcium 251 mg/100 g,  $\beta$ -carotene 1.225  $\mu$ g/100 g<sup>6</sup>.

46 Processing of pluchea leaves to be pluchea tea has been proven to exhibit antioxidant  
47 activity<sup>6,7,8</sup>, anti-diabetic activity<sup>9</sup>, anti-inflammatory activity<sup>7</sup>, anti-isolated human LDL oxidation  
48 activity<sup>10</sup>. Previous research uses brewing of pluchea leaf powder to make several food products to  
49 increase functional values, i.e., jelly drink<sup>11</sup>, soy milk<sup>12</sup> and steamed bun<sup>13</sup>. Using 1% (w/v) brewing of  
50 pluchea leaf powder can improve the physicochemical properties of jelly drink and increase panelists'  
51 acceptance of the product<sup>11</sup>. Soy milk with the addition of brewing from pluchea leaves increases the  
52 viscosity and total dissolved solids and decreases the panelist acceptance rate<sup>12</sup>. The addition of 6%  
53 (w/v) brewing from pluchea leaf powder on steamed bun is the best treatment with the lowest level  
54 of hardness<sup>13</sup>. All previous research has proven that the addition of brewing of pluchea leaves can  
55 increase the bioactive compound contents based on total phenol and total flavonoids, as well as  
56 increase antioxidant activity based on ferric reducing power and ability to scavenge DPPH free radical.

57 To the best of our knowledge, the study of the addition of steeping water of pluchea tea in  
58 making wet noodles from wheat flour has not been conducted, as well as its impact on physicochemical  
59 and organoleptic characteristics of the noodles. Noodles are a popular food product that is widely  
60 consumed in the world. Indonesia is one of the countries with the largest noodle consumption after

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61 China<sup>14</sup>. Wet noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet  
62 noodles as an alternative to wet noodles, which contain higher protein, and the second popular food  
63 in ASEAN regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia<sup>16</sup>.  
64 The addition of other ingredients has been endeavored to enhance wet noodles' specific properties.  
65 Many researchers incorporated plant extracts or natural products to increase functional properties of  
66 wet noodles, such as red spinach<sup>17</sup>, green tea<sup>18,19</sup>, purple sweet potatoes leaves<sup>20</sup>, moringa leaves<sup>21</sup>,  
67 sea weed<sup>22</sup>, ash of rice straw and turmeric extract<sup>23</sup>, and betel leaf extract<sup>24</sup> that influenced physical,  
68 chemical, and organoleptic properties of the wet noodles. The anthocyanin of red spinach ethanolic  
69 extract increased hedonic score of wet noodles' flavor<sup>17</sup>. The addition of green tea improves the  
70 stability, elastic modulus and viscosity, maintains retrogradation and cooking loss, and results no  
71 significant effect of the mouthfeel and overall acceptance from panelist on the produced wet  
72 noodles<sup>18</sup>. Moreover, the addition of sweet potatoes leaf extract on wet noodles increases moisture  
73 content, protein value and ash concentration, and improves hedonic score of texture<sup>20</sup>. Moringa  
74 extract influences protein content and decrease panelist acceptance of color, aroma and taste of the  
75 wet noodles<sup>21</sup>. The use of seaweed to produce wet noodles influences moisture content, swelling  
76 index, absorption ability, elongation value and color<sup>22</sup>. The addition of ash from rice straw and turmeric  
77 extract influences the elasticity and sensory characteristics (color, taste, aroma and texture) of the wet  
78 noodles<sup>23</sup>. Betel leaf extract used to make hokkien noodles improves texture and acceptance score of  
79 all sensory attributes<sup>24</sup>.

80 Bioactive compounds and nutritive value of pluchea leaf can be an alternative ingredient to  
81 improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea

82 leaves can potential an antioxidant source in wet noodles and increase the functional value. The study  
83 was done to assess the effect of various concentration of brewing from pluchea tea on the physical,  
84 chemical and sensory properties of wet noodles.

## 85 Materials and Methods

### 86 Preparation of Hot Water Extract from Pluchea Leaf Powder

87 The young pluchea leaves 1-6 were picked from the shoots, sorted and washed. The selected  
88 pluchea leaves were dried at ambient temperature for 7 days to derive moisture content of 10.00 ±  
89 0.04% dry base<sup>25</sup>. Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at 120°C  
90 for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag for  
91 about 2 g/tea bag. Pluchea leaf powder in tea bags was extracted using hot water (95°C) for 5 min to  
92 get various extract concentrations; 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

### 94 Wet Noodles Processing

95 About 70 mL of hot extract from pluchea leaf powder with various concentrations (0, 5, 10, 15,  
96 20, 25 and 30% (w/v) (Table 1) was measured and manually mixed with egg, baking powder, salt and  
97 wheat flour for 5 min (Table 2). The mixture was kneaded to form a solid and homogenized dough using  
98 a mixer (Oxone Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to  
99 form noodle strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled  
100 water about 3 min in 300 mL water and coated with oil to prevent the noodles from sticking to each  
101 other. Wet noodles made without any addition of hot water of pluchea leaf extract were prepared as  
102 control. Wet noodles used in bioactive compounds and antioxidant activity assay were not added with  
103 oil to prevent the noodles from sticking to one another. The final characteristics of wet noodles were

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104 having width and thickness of 0.45 cm and 0.295 cm, respectively.

#### 105 **Pluchea Wet Noodles Extraction**

106 About 100 g of wet noodles were dried using a freeze dryer at a pressure of 0.1 bar and  
107 temperature -60°C for 28 hours to obtain dried noodles. Each dried of pluchea leaves were powdered  
108 using a chopper machine at the speed of 35 seconds. 20 g of powdered pluchea leaves were mixed by  
109 50 mL absolute methanol in a shaking water bath at 35°C, 70 rpm for 1 hour<sup>26</sup>. The filtration was done  
110 to separate filtrate using Whatman filter paper grade 40 and the residue extraction was done again  
111 with the same procedure. The collection of filtrates was done, then evaporation by rotary evaporator  
112 was done to get 3 mL of extract (Buchi Rotary Evaporator; Buchi Shanghai Ltd, China) at 200 bars, 50°C  
113 for 60 min. The obtained extract was kept at 0°C before further analysis.

#### 114 **Moisture Content Assay**

115 Moisture content or water content of wet noodles was determined by thermogravimetric  
116 method<sup>27</sup>. The assay of moisture content from wet noodles was done by heating the samples in a drying  
117 oven (Binder, Merck KGaA, Darmstadt, Germany). The principle of this method is evaporating the water  
118 in the material. The sample was heated and weighed until a constant weight was obtained assumed to  
119 be all evaporated water.

#### 120 **Measurement of Swelling Index**

121 The principle of swelling index testing determines capability of noodles to swell during the  
122 boiling process<sup>16</sup>. The swelling index assay is done to determine the ability of wet noodles to absorb  
123 water per unit of time which can estimate the time needed to fully cook wet noodles. The amount of

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124 water absorbed by wet noodles was measured from the weight difference of noodles after and before  
125 being boiled divided by the initial weight of the noodles<sup>28</sup>.

#### 126 **Determination of Cooking Loss**

127 Cooking loss is one of the necessary quality parameters in wet noodles to establish the quality  
128 of wet noodles after boiling<sup>28</sup>. The cooking loss assay for pluchea wet noodles was done to measure  
129 the number of solids that leached out from the wet noodle strands during the boiling process, namely  
130 the leak of a small portion of starch from the wet noodle strands. A large cooking loss value affects the  
131 texture of wet noodles, which is easy to break and less slippery.

#### 132 **Determination of Texture**

133 The texture of wet noodles with pluchea extract addition was measured based on its hardness,  
134 adhesiveness, cohesiveness, elongation and elasticity. The texture was analyzed by TA-XT2 texture  
135 analyzer (Stable Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the  
136 Texture Exponent 32 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were  
137 analyzed with a compression assay using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle strands  
138 with the length of 4 cm for each strand were laid side by side, touching each other, perpendicular to  
139 the 35 mm compression cylinder probe on a flat aluminium base. The cylinder probe was arranged to  
140 be at 15 mm distance from the lower plate at the start of the compression test, and was forced down  
141 through the noodle strips at the speed of 2 mm s<sup>-1</sup> until it touched the flat base to compress 75% of  
142 the noodle thickness, and was drawn back to at the end of the test. The profile curve was determined  
143 using a texture analyzer software<sup>24,29</sup>. The hardness was determined as the maximum force per gram.



144 The adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area  
145 was obtained from the compression test under the curve. Cohesiveness was analyzed based on the  
146 ratio between the area under the second peak and the first peak<sup>24,29,30</sup>. The elongation and elasticity  
147 of the noodles were individually tested by putting one end into the lower roller arm slot and  
148 sufficiently winding the loosened arm to fasten the noodle end. Elongation was the maximum force  
149 to change of noodle form and break by extension that was analyzed by a test speed of 3.0 mm s<sup>-1</sup>  
150 between two rollers with a 100 mm distance. The elongation at breaking was calculated per gram.  
151 Elasticity was determined by formula (1)<sup>31,32</sup>:

$$152 \quad \text{Elasticity} = \frac{Fx}{Ax} \frac{l_0}{t_0} \frac{1}{v} \quad (1)$$

153 where F is the tensile strength,  $l_0$  is the original length of the noodles between the limit arms (mm), A  
154 is the original cross-sectional area of the noodle (mm<sup>2</sup>), v is the rate of movement of the upper arm  
155 (mm/s), and t is break up time of the noodles (s). The measurement of texture was detected by the  
156 software and expressed as a graph.

#### 157 Color Measurement

158 The color of the noodle sheets was determined by a colorimeter (Minolta CR 10, Minolta Co.  
159 Ltd., Osaka, Japan), and the CIE-Lab L\*, a\* and b\* values were analyzed based on Fadzil et al.<sup>29</sup> method.  
160 The L\* value measured the position on the white/black axis, the a\* value as the position on the  
161 red/green axis, and the b\* value as the position on the yellow/blue axis.

#### 162 Analysis of Total Phenolic Content

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163 The total phenolic content analysis was analyzed based on the reaction between phenolic  
164 compounds and Folin Ciocalteu (FC) reagent or phosphomolybdic acid and phosphotungstic acid. FC  
165 reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups becomes a blue molybdenum-  
166 tungsten complex solution<sup>33</sup>. The intensity of the blue color was detected by a UV-Vis  
167 spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  760 nm. In the analysis,  
168 7.5% Na<sub>2</sub>CO<sub>3</sub> solution was added to reach pH 10 that caused an electron transfer reaction (redox). The  
169 obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

170

#### 171 Analysis of Total Flavonoid Content

172 The flavonoid content assay was done by the spectrophotometric method based on the  
173 reaction between flavonoids and AlCl<sub>3</sub> to form a yellow complex solution. In the presence of NaOH  
174 solution, a pink color is formed which can be detected by spectrophotometer (Spectrophotometer UV-  
175 Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm<sup>33,34,35</sup>. The obtained data were expressed in mg of (+)-catechin  
176 equivalent (CE)/L sample.

#### 177 Analysis of DPPH Free Radical Scavenging Activity

178 The ability of antioxidant compounds of extract to scavenge DPPH (2,2-diphenyl-1-  
179 picrylhydrazyl) free radical can be used to evaluate antioxidant activity. The principle of the DPPH  
180 method is to measure the absorbance of compounds that can react with DPPH<sup>36</sup>. Antioxidant  
181 compounds can donate hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced  
182 to yellow<sup>37</sup>. The color change was measured as an absorbance at  $\lambda$  517 nm by spectrophotometer

(Spectrophotometer UV Vis 1800, Shimadzu, Japan)<sup>38</sup>. The data were expressed in mg gallic acid equivalent (GAE)/L dried noodles sample.

#### Analysis of Iron Ion Reduction Power

This method identifies the capacity of antioxidant components through increasing absorbance as a result of the reaction of antioxidant compounds with potassium ferricyanide, trichloroacetic acid, and ferric chloride to produce color complexes that can be measured spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm<sup>39</sup>. The principle of this testing is the ability antioxidants to reduce iron ions from  $K_3Fe(CN)_6$  ( $Fe^{3+}$ ) to  $K_4Fe(CN)_6$  ( $Fe^{2+}$ ). Then, potassium ferrocyanide reacts with  $FeCl_3$  to form a  $Fe_4[Fe(CN)_6]_3$  complex. The color change that occurs is yellow to green<sup>40</sup>. The final data were stated in mg gallic acid equivalent (GAE)/L dried noodles.

#### Sensory Evaluation

All samples of wet noodles were proceeded to hedonic test by involving 100 untrained panelists with an age range of 17 to 25 years. A hedonic test used in this research was the hedonic scoring method, where the panelists gave a preference score value of all samples<sup>41</sup>. The hedonic scores were transformed to numeric scale and analyzed using statistical analysis<sup>42</sup>. The numeric scale in the sensory analysis used a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The panelists were asked to score according to their level of preference for texture, taste, color, flavor and overall acceptability. All the samples were blind coded with 3 digits which differed from each other<sup>43</sup>.

#### Statistical Analysis

The research design used in the physicochemical assay was a randomized block design (RBD) with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that

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204 consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25, and 30% (w/v). Each treatment was repeated four  
205 times that obtained 28 experiment units. A completely randomized design (CRD) was used to evaluate  
206 sensory assay with 100 untrained panelists with an aged 17 to 25 years.  
207 The normal distribution and homogeneity data were stated as the mean  $\pm$  SD of the triplicate  
208 determinations and were determined using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc.,  
209 Chicago, IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan  
210 Multiple Range Test) at  $p \leq 5\%$  to determine treatment level that gave significant different results. The  
211 best treatment of pluchea extract addition on wet noodles was analyzed by a spider web graph.

## 212 Results and Discussion

213 Wet noodles added with hot extract of pluchea leaf powder were produced with aiming to  
214 increase the functional value of wet noodles. This is supported by several previous researches related  
215 to the potential value of water extract of pluchea leaf that exhibit a biological activity<sup>6,7,41</sup>. In this  
216 research, the cooking quality was observed after cooking wet noodles in 300 mL water/100 g samples  
217 for 3 min in boiling water.

## 218 Cooking Quality

219 Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at 0, 5,  
220 10, 15, 20, 25, and 30% (w/v) was shown in Figure 1, Table 3 and Table 4. The addition of pluchea  
221 extract no significantly influenced the water content, cooking loss, swelling index, chroma, and hue of  
222 the produced wet noodles using statistical analysis by ANOVA at  $p \leq 5\%$ . Water content is one of the  
223 chemical properties of a food product determined shelf life of food products, because the water  
224 content measures the free and weakly bound water in foodstuffs<sup>44,45</sup>. This study identified that the

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225 moisture content of the cooked wet noodles ranged between 64-67% wb. Previous study showed that  
226 the water content of the cooked egg wet noodles was around 54-58% wb<sup>45</sup> and maximum of 65%<sup>20</sup>.  
227 Chairuni et al.<sup>44</sup> stated that the boiling process could cause a change in moisture content from around  
228 35% to around 52%. The Indonesian National Standard<sup>46</sup> stipulates that the moisture content of cooked  
229 wet noodles is a maximum of 65%. This means that only control noodles (without treatment) exhibited  
230 a moisture content similar to the previous information. The obtained data showed a trend that an  
231 extract addition caused an increase in the water content of wet noodles, but statistical analysis at  $p \leq$   
232 5% showed no significant difference. This phenomenon was in accordance with the experimental  
233 results of Juliana et al.<sup>45</sup> that the using of spenochlea leaf extract to making wet noodles, as well as  
234 Hasmawati et al.<sup>20</sup> that the supplementary of sweet potato leaf extract increased the moisture of fresh  
235 noodles. The water content of pluchea wet noodles was expected by reaction between many  
236 components in the dough that impacted to the swelling index and cooking loss. Mualim et al.<sup>14</sup>, Bilina  
237 et al.<sup>22</sup> and Setiyoko et al.<sup>28</sup> informed that the presence of amino groups in protein and hydroxyl groups  
238 in amylose and amylopectin fractions in wheat flour as raw material for making dough determines the  
239 moisture content, swelling index and cooking loss of wet noodles. The contribution of glutenin and  
240 gliadin proteins in wheat flour to form gluten networks determines the capability of noodles to swell  
241 and retain water in the system. Gliadin acts as an adhesive that causes dough to be elastic, while  
242 glutenin makes the dough to be firm and able to withstand CO<sub>2</sub> gas thus the dough can expand and  
243 form pores. Fadzil et al.<sup>29</sup> found that thermal treatment during the boiling process results in the  
244 denaturation of gluten and caused a monomer of proteins to determine other reactions at the disulfide  
245 or sulfhydryl chain. The existence of phenolic compounds from pluchea extract also increased the

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246 capacity of noodles to absorb water and determined water mobility. Widyawati et al.<sup>41</sup> also confirmed  
247 that hydrophilic compounds of proteins, carbohydrates, and polyphenolic components determine  
248 water mobility due to their ability to bind with water molecules through hydrogen bonding. Tuhumury  
249 et al.<sup>47</sup> informed that gluten formation can inhibit water absorption by starch granules so that can  
250 prevent gelatinization. Therefore, the addition of phenolic compounds from the hot extract of pluchea  
251 leaf powder can inhibit the formation of gluten so that it stimulates gelatinization of starch granules.

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252 As a result, the impact of increased the moisture content during boiling had an effect on the  
253 value of the swelling index and cooking loss of the wet noodles. Widyawati et al.<sup>41</sup> said that the swelling  
254 index is the capability to trap water which is dependent on the chemical composition, particle size, and  
255 water content. Gull et al.<sup>48</sup> also confirmed that the swelling index is an indicator to determine water  
256 absorption by starch and protein to make gelatinization and hydration. Setiyoko et al.<sup>28</sup> explained that  
257 cooking loss is the mass of noodle solids that come out of the noodle strands for boiling. Gull et al.<sup>48</sup>  
258 added that soluble starch and other soluble components leach out into the water during the cooking  
259 process, making the cooking water turned thicker. The moisture content results (64-67% wb) showed  
260 that the produced wet noodles exceeded the moisture content limit of wet noodles after cooking,  
261 which is between 54-58%<sup>44</sup>, while the cooking loss value of wet noodles should not be more than  
262 10%<sup>28</sup>. In this study, the cooking loss value was 3-4.2%. The cooking loss of samples during boiling  
263 noodles were caused the breaking of the bonding network that the polysaccharides are released and  
264 the gluten network breaks because of the addition of pluchea leaf extract. Widyawati et al.<sup>41</sup> supported  
265 that polyphenol can be bound with protein and starch with many non-covalent interactions, such as  
266 hydrogen bonding, electrostatic interaction, hydrophobic interaction, Van der Waals interaction, and

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267  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch to undergo  
268 gelatinization and gliadin and glutelin from the protein of wheat flour to form gluten.

269 The swelling index value obtained from this research was around 56-68 %. Based on the  
270 previous research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.)  
271 fruit was around 51%<sup>49</sup>. This means that the addition of pluchea leaf extract in wet noodles also affects  
272 the ability of noodles to absorb water. Widyawati et al.<sup>41</sup> and Suriyaphan<sup>6</sup> informed that bioactive  
273 compounds in hot water extract of pluchea leaf tea include 3-*O*-caffeoylquinic acid, 4-*O*-caffeoylquinic  
274 acid, 5-*O*-caffeoylquinic acid, 3,4-*O*-dicaffeoylquinic acid, 3,5-*O*-dicaffeoylquinic acid, 4,5-*O*-  
275 dicaffeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total  
276 anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was higher  
277 than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from extract in  
278 absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch granules to  
279 absorb water so that the swelling index and cooking loss increased. Suriyaphan<sup>6</sup> informed that hot  
280 extract of pluchea leaf tea contains 1.79 g/100 g protein, 8.65 g/100 g carbohydrate, and fiber (0.45  
281 g/100 g soluble and 0.89 g/100 g insoluble), these compounds can involve in increasing the swelling  
282 index from pluchea wet noodles.

283 Color is one of the physical characteristics possessed by wet noodles that becomes a benchmark  
284 for consumer acceptance. This research found that the color of wet noodles was influenced by the  
285 addition of pluchea extract. The addition of pluchea leaf extract no significant affected the redness  
286 ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it influenced the yellowness ( $b^*$ ) and lightness  
287 ( $L^*$ ) values. Using of pluchea leaf powder brewing decreased the brightness of wet noodles

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significantly, as the concentration of the extract increased. This is related to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to experience color changes. According to Widyawati et al.<sup>8</sup> tannins are water-soluble compounds that can give a brown color. Suriyaphan<sup>6</sup> and Widyawati et al.<sup>41</sup> also stated that Khlu tea from pluchea leaves contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and  $6.39$  mg/100 g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow color. Gull et al.<sup>48</sup> stated that this pigment was easily changed in the paste sample due to the swelling and discoloration of the pigment during cooking.

Thus, the addition of hot water extract of pluchea leaf powder significantly reduced the brightness of wet noodles, because brown-colored noodles were produced as the concentrations of added pluchea leaf extract increased. However, increasing the concentration of this extract had no influenced on the redness, hue, and chroma values in ANOVA at  $p \leq 5\%$ . The results showed that the redness value of wet noodles revolved from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet noodles ranged from  $82.1 \pm 3.1$  to  $86.5 \pm 1.0$ . Based on this value, the color of wet noodles is in the yellow to the red color range<sup>50</sup>, thus the visible color of the wet noodle product was yellow to brown (Figure 1). Yellowness increased significantly with the addition of pluchea leaf extract and the value ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the availability of tannins and chlorophyll compounds from pluchea leaf extract. The chroma value of wet noodles was obtained within the range of  $15.6 \pm 1.5$  to  $19.8 \pm 3.4$ . This means that the brewing of pluchea leaf powder did not change the intensity of the brown color in the resulting wet noodles.

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308 Texture analysis of pluchea wet noodles added with various concentrations of hot water extract  
309 from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness,  
310 elongation, and elasticity. Hardness is the maximum force given to a product until deformation<sup>51,52</sup>.  
311 From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher  
312 peak of graph shows the harder product<sup>30</sup>. Adhesiveness is force or tackiness that is required to pull  
313 the product from its surface, its value is obtained from the area between the first and second  
314 compressions<sup>53,54</sup>. Adhesiveness values show negative value; the bigger negative value means the  
315 product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and  
316 second compressions<sup>52,54</sup>. This is an indication of the internal forces that make up the product<sup>55</sup>.  
317 Elongation is the change in length of noodles when being exposed to a tensile force until the noodles  
318 break<sup>56</sup>. Elasticity is the time required for the product to withstand the load until it breaks. The more  
319 elastic a product, the longer the holding time. The data showed that the higher concentration of  
320 pluchea leaf powder within the hot water extract caused a significant increase in the hardness,  
321 stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati et al.<sup>41</sup>  
322 informed that the polyphenols contained in pluchea leaf extract can weakly interact either covalently  
323 or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch  
324 and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups  
325 that are polar. Amoako and Akiwa<sup>57</sup> and Zhu et al.<sup>58</sup> have also proven that polyphenolic compounds  
326 can interact with carbohydrates through the interaction of two hydrophobic and hydrophilic functional  
327 groups with amylose. Diez-Sánchez et al.<sup>59</sup> stated that polyphenolic compounds can interact with  
328 amylose and protein helical structures and largely determined by molecular weight, conformational

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mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and amylopectin can affect the gelatinization process in the amylose helical structure and interfere with the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss (> 98%) and swelling index (56.2 to 67.7%) data, it can be concluded that the interaction that occurs between the phenol group in pluchea leaf extract with amylose and protein was weak. The bioactive components of pluchea leaf extract are thought to affect the formation of disulfide cross-links (S-S) and turn into to form sulfhydryl groups (-SH) under the influence of heat. Ananingsih and Zhou<sup>60</sup> said that antioxidant compounds are a reducing agent that can have an impact on reducing S-S bonds and increasing the number of SH groups in the dough to produce a harder texture. According to Rahardjo et al.<sup>53</sup> phenolic compounds are hydroxyl compounds that influence the strength of the dough, where the higher the component of phenol compounds will weaken the gluten matrix and the dough thus becoming unstable. The instability of the dough can cause the texture to become hard.

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Many researchers also find that tannins and phenols influence the networking S-S bond in the dough of wet noodles. Wang et al. (2015) showed that tannins increase the relative amount of large, medium polymers in the gluten protein network so as to improve the dough quality. Zhang et al.<sup>61</sup> said that these polymer compounds are the results of interactions or combinations of protein-tannin compounds that form bonds with the type of covalent bonds, hydrogen bonds, or ionic bonds. Rauf and Andini<sup>62</sup> also added that phenol compounds can reduce S-S bonds to SH bonds. SH is a type of thiol

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350 compound group, where the thiol group can influence the stickiness, viscosity, cohesiveness,  
351 elongation, and extensibility of the dough. Wang et al.<sup>63</sup> found the effect of phenolic compounds from  
352 green tea extract to increase the stickiness of wheat bread. The cohesiveness of the dough is formed  
353 due to a large number of thiol bonds formed, thus increasing the viscosity of the dough. The increased  
354 viscosity of the dough is thought to be due to the formation of polyphenolic compounds with thiol  
355 groups, as in the research of Ananingsih and Zhou<sup>60</sup> that the formation of catechin-thiol can increase  
356 the viscosity of the dough and increase the stability of the dough. Zhu et al.<sup>64</sup> declared that the addition  
357 of phenolic compounds from green tea was able to increase the PV (peak viscosity) of wheat flour.  
358 Wang et al.<sup>65</sup> also found that the cohesiveness of the dough is influenced by tannins, where tannins  
359 can produce micro-glutens so as to produce a compact dough and increase the gluten network. The  
360 addition of pluchea leaf extract in making wet noodles could influence the elongation of wet noodles  
361 due to the components of polyphenol compounds such as tannins that can reduce the number of free  
362 amino groups. This is supported by Zhang et al.<sup>30</sup> and Wang et al.<sup>65</sup> that support the formation of other  
363 types of covalent bonds, such as bonds between amino groups and hydroxyl groups, by forming  
364 hydrogen bonds between phenolic compounds and protein gluten so as to improve the quality of  
365 dough strength and dough extensibility.

#### 366 Bioactive Compounds and Antioxidant Activity

367 Wet noodles added with pluchea leaf powder were analyzed based on its bioactive compounds  
368 and antioxidant activities. The analysis was conducted to determine the functional properties of wet  
369 noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles are  
370 presented in Table 5. The measured bioactive compounds (BC) included total phenolic content (TPC)

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and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical scavenging activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed that there was a positive and strong correlation between TPC and DPPH ( $r=0.990$ ), TPC and FRAP ( $r=0.986$ ), TFC and DPPH ( $r=0.974$ ), and TFC and FRAP ( $r=0.991$ ). This means that the antioxidant activity of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah et al.<sup>66</sup> informed that the PC ( $r$ ) > 0.699 indicates the strength and linear correlation between antioxidant activity (AA) and TPC, and also shows a strong positive relationship but PC ( $r$ ) < 0.699 obtains a moderately positive relationship. If the  $r$  value of TFC and AA is lower than TPC and AA, it indicates that the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship which is expected because both classes all contributed to AA plants. Aryal et al.<sup>67</sup> and Muflihah et al.<sup>66</sup> informed that phenolic compounds are soluble natural antioxidants and potential donating electrons depend on their number and position of hydroxyl groups contributed to antioxidant action. Consequently, these groups are responsible to scavenge the free radicals that TPC of pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the stable purple-colored to the yellow-colored solution. Based on FRAP analysis, it was showed that the bioactive compounds contained in pluchea wet noodles are a potential source of antioxidants because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive compounds contained in pluchea wet noodles can function as

primary and secondary antioxidants. Research data showed that the cooking quality of wet noodles tends to increase along with the increase in the value of TPC, TFC, DPPH, and FRAP.

#### Sensory Evaluation

Sensory pluchea wet noodles, namely color, aroma, taste, texture, and overall acceptance, were carried out using a hedonic test to determine the level of consumer preference for the product. This test was conducted to determine the quality differences between the products and to provide an assessment on certain properties<sup>42</sup>. The hedonic test itself is the most widely used test to determine the level of preference for production<sup>68</sup>. The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm 1.26$  (neutral-like). The statistical analysis showed that the higher concentration of hot water extract addition decreased lower color preference of wet noodles. The higher concentration of pluchea extract could reduce the level of preference for color because the color of the wet noodles was darker than control and turned to dark brown. This color change was due to the pluchea extract containing several components, including chlorophyll and tannins, which can alter the of wet noodles' color to be browner along with the increase in the concentration of pluchea extract. This result was in accordance to the effect of color analysis performed using color reader where the pluchea wet noodles' brightness declined, yellowness increased, and the color intensity increased with an increased concentration of pluchea extract. The occurrence of this process is related to the effect of light and heat on pluchea leaf powder which causes the degradation of chlorophyll into brown pheophytin due to drying, where the nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals<sup>69,70</sup>.

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413 Aroma is one of the parameters in sensory evaluation using the sense of smell and is an  
414 indicator of the assessment of a product<sup>71</sup>. The results of the preference value for aroma were ranged  
415 from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet  
416 noodles reduced the preference score for aroma due to distinct dry leaves (green) aroma. Lee et al.<sup>72</sup>  
417 informed that the unpleasant aroma on leaves comes from a group of aliphatic aldehyde compounds.  
418 The appearance of a distinctive leaf aroma in noodles is due to aromatic compounds. According to  
419 Martiyanti and Vita<sup>73</sup> aromatic compounds are chemical compounds that have an aroma or odor when  
420 the conditions are met, which is volatile, while Widyawati et al.<sup>74</sup> informed that pluchea leaves were  
421 detected to have 66 volatile compounds. The appearance of the aroma is due to the volatile  
422 compounds in the raw material reacting with water vapor when boiling the noodles. In addition, there  
423 is also an oxidation process of polyphenolic compounds such as catechins or tannins that can produce  
424 an aroma in pluchea wet noodles.

425 According to Martiyanti and Vita<sup>3</sup> taste attribute is one important sensory aspect in food  
426 products and has a great impact on the food selection by consumers. Tongue is able to detect basic  
427 tastes, namely sweet, salty, sour, and bitter, at different points. Lamusu<sup>71</sup> declared that taste is a  
428 component of flavor and an important criterion in assessing a product that is accepted by the tongue.  
429 The preference test of the taste of pluchea wet noodles resulted in values ranging from  $4.15 \pm 1.40$  to  
430  $5.50 \pm 1.28$  (neutral-slightly like). The increase in concentrations of pluchea extract was negatively  
431 correlated to the preference level of the taste of pluchea wet noodles assessed by the panelists. The  
432 statistical analysis results showed that the difference in the concentration of the extract significant  
433 influenced on the preference score for the taste of pluchea wet noodles. The increased concentration

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434 of pluchea extract produced a distinctive taste on wet noodles, such as a bitter and astringent tastes,  
435 due to the presence of compounds such as tannins and alkaloids from the pluchea leaves. Susetyarini<sup>75</sup>  
436 said that pluchea leaves contain tannins (2.351%), and alkaloids (0.316%). According to Pertiwi<sup>76</sup>,  
437 tannin compounds dominate the bitter and astringent taste, while alkaloid compounds cause a bitter  
438 taste. The high level of taste preference for wet noodles was found in noodles with lower content of  
439 pluchea extract.

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440 Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and  
441 swallowed) or touched with fingers<sup>77</sup>. Texture testing performed by the panelist is called mouthfeel  
442 testing. According to Martiyanti and Vita<sup>73</sup>, mouthfeel is the kinesthetic effect of chewing food in the  
443 mouth. In this study, the preference test results on the texture of pluchea wet noodles revolved from  
444  $5.5 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy  
445 and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet  
446 noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that  
447 can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and  
448 draining noodles. Subjective testing results based on sensory evaluation were in line with the objective  
449 testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to  
450 break, and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea  
451 wet noodles was influenced by the fiber and protein components. According to Shabrina<sup>78</sup>, the  
452 components of fiber, protein, and starch complete to bind water. Texture changes are also influenced  
453 by the polyphenol compositions in the pluchea extract which is able to reduce S-S bonds to SH bonds,  
454 where the increase in SH (thiol) groups can give a hard, sticky, and compact texture<sup>62,63,65</sup>. Besides, a

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455 high concentration of tannins capable of binding to proteins to form complex compounds into tannins-  
456 proteins are also able to build noodles' texture.

457 The interaction between color, aroma, taste, and texture created an overall taste of the food  
458 product and was assessed as the overall preference. The highest value on the overall preference was  
459 derived from control wet noodles, i.e., 6.63 (slightly like it), while the wet noodles added with 20%  
460 (w/v) concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The  
461 addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to  
462 10% (w/v) concentration with scores of 6.63 and 6.53, respectively. The area of the spider web chart  
463 for each treatment with the various concentrations of pluchea extract was seen in Figure 2. The best  
464 treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37  
465 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the  
466 scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like),  
467 respectively.

468 The use of pluchea leaf extract in the making of wet noodles was able to increase the functional  
469 value of wet noodles, based on the levels of bioactive compounds and antioxidant activity without  
470 changing the quality of cooking, which includes water content, swelling index and cooking loss. Besides  
471 that, the use of pluchea leaf extract did not significantly change the color and color intensity of the  
472 resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet  
473 noodles produced were still acceptable to the panelists, the addition of pluchea leaf extract as much  
474 as 10% (w/v) was the best treatment with an assessment that was almost close to the control wet  
475 noodles (without treatment).

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476 **Conclusion**

477 Addition of hot water extract of pluchea leaf powder influenced physical, chemical and sensory  
478 properties of wet noodles. Lightness, texture, bioactive compound content, antioxidant activity, and  
479 sensory properties of samples underwent significant difference. The higher concentration of pluchea  
480 extract caused the bigger these parameters of pluchea wet noodles. Using 10% (w/v) of hot water  
481 extract from pluchea leaf powder was the best treatment with color, aroma, taste, and texture scores  
482 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. Utilization of  
483 hot water extract of pluchea leaf powder at 10% (w/v) resulted wet noodle functional with TPC, TFC,  
484 DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg dried samples, 62.44  
485 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples and 51.33 mg GAE/kg dried samples,  
486 respectively.

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487 **Notes on Appendices**  
488

TPC	Total phenolic content
TFC	Total flavonoid content
DPPH	2,2-Diphenyl-1-picrylhydrazyl free radical
FRAP	Ferric reducing antioxidant power
AA	Antioxidant activity
PC	Person Correlation
LDL	Low Density Lipoprotein
w/v	Weight per volume

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CRD	Completely randomized design
CE	Catechin equivalent
GAE	Gallic acid equivalent
BC	Bioactive compounds
ANOVA	Analysis of variance
UV-Vis	Ultra violet-visible

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729 thesis]. Bandung: Indonesia University of Pasundan.2017. <http://repository.unpas.ac.id/28532/>  
730



731 Table 1. **Information of hot water extract of pluchea tea**

Materials	Concentration of hot water extract of pluchea leaf tea (% w/v)						
	0	5	10	15	20	25	30
Pluchea leaf tea (g)	0	10	20	30	40	50	60
Hot water (mL)	200	200	200	200	200	200	200

732

733

734 **Table 2. Ingredients** of pluchea wet noodles

Materials	Unit	Quantity
Wheat flour	g	200
Egg	g	40
Salt	g	4
Baking powder	g	2
Hot water extract	mL	70
Tapioca flour	g	10
TOTAL	g	326

735

**Table 3.** Color, moisture content, swelling index, and cooking loss of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Color					Moisture content (% wb)	Swelling index (%)	Cooking loss (%)
	L*	a*	b*	C	h			
0	67.1 ± 1.8 <sup>a</sup>	0.97±0.30	16.18±0.62 <sup>ab</sup>	16.2 ± 0.6	86.5 ± 1.0	63.90±1.51	56.2±17.4	3.40±1.31
5	59.5 ± 2.7 <sup>b</sup>	2.18±0.93	15.47±1.46 <sup>a</sup>	15.6 ± 1.5	82.1 ± 3.1	65.08±4.33	62.4±4.7	3.33±1.26
10	59.0 ± 1.8 <sup>b</sup>	1.95±1.66	16.76±2.33 <sup>abc</sup>	17.1 ± 2.2	83.3 ± 5.4	64.97±3.89	61.5±7.5	3.00±1.16
15	58.4 ± 2.2 <sup>b</sup>	1.69±1.48	19.72±3.50 <sup>c</sup>	19.8 ± 3.4	84.7 ± 4.6	65.56±2.18	63.1±6.3	3.31±0.92
20	56.5 ± 2.4 <sup>b</sup>	1.97±1.24	19.09±2.97 <sup>bc</sup>	19.2 ± 2.9	83.6 ± 4.3	66.81±1.81	67.7±5.9	4.06±0.51
25	59.1 ± 2.5 <sup>b</sup>	1.95±1.44	19.55±2.97 <sup>c</sup>	19.6 ± 2.9	83.8 ± 4.0	66.04±0.85	64.5±10.3	3.93±1.37
30	57.1 ± 2.1 <sup>b</sup>	2.09±1.51	18.08±4.94 <sup>abc</sup>	18.3 ± 4.8	82.5 ± 5.2	66.65±2.16	64.0±5.3	4.23±1.34

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$

**Table 4.** Texture of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Texture				
	Hardness (N)	Adhesiveness (g sec)	Cohesiveness	Elongation (%)	Elasticity (Pa)
0	135.8±5.9 <sup>a</sup>	-2.7 ±2.3 <sup>d</sup>	0.75±0.01 <sup>a</sup>	86.9±0.9 <sup>a</sup>	25336.7±104.2 <sup>a</sup>
5	120.1±2.1 <sup>a</sup>	-3.4±0.6 <sup>cd</sup>	0.68±0.00 <sup>b</sup>	97.3±1.6 <sup>b</sup>	25898.3±760.9 <sup>b</sup>
10	134.9±1.8 <sup>a</sup>	-3.9±0.7 <sup>bc</sup>	0.74±0.00 <sup>c</sup>	162.1±1.5 <sup>c</sup>	25807.7±761.9 <sup>b</sup>
15	180.5±5.1 <sup>b</sup>	-4.9±0.5 <sup>b</sup>	0.74±0.01 <sup>c</sup>	164.7±0.6 <sup>c</sup>	26971.6±516.7 <sup>b</sup>
20	195.1±14.1 <sup>b</sup>	-5.0±1.3 <sup>ab</sup>	0.75±0.01 <sup>cd</sup>	221.6±1.6 <sup>d</sup>	27474.4±453.8 <sup>b</sup>
25	244.6±8.8 <sup>c</sup>	-6.0±0.3 <sup>a</sup>	0.75±0.00 <sup>cd</sup>	230.7±0.7 <sup>e</sup>	27367.1±287.5 <sup>b</sup>
30	282.8±28.3 <sup>d</sup>	-6.1±0.2 <sup>a</sup>	0.79±0.01 <sup>d</sup>	255.4±0.4 <sup>f</sup>	26687.5±449.2 <sup>b</sup>

Note: the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$



**Table 5.** Total phenol content, total flavonoid content, the DPPH free radical scavenging activity, and iron ion reducing power of the pluchea wet noodles.

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	TPC (mg GAE/kg Dried Noodles)	TFC (mg CE/kg Dried Noodles)	DPPH (mg GAE/kg Dried Noodles)	FRAP (mg GAE/kg Dried noodles)
0	39.26±0.66 <sup>a</sup>	32.36±1.47 <sup>a</sup>	96.75±4.26 <sup>a</sup>	25.96±0.25 <sup>a</sup>
5	61.09±3.80 <sup>b</sup>	46.31±2.15 <sup>b</sup>	121.36±3.58 <sup>b</sup>	34.50±1.71 <sup>b</sup>
10	82.84±3.11 <sup>c</sup>	62.44±0.55 <sup>c</sup>	130.68±4.82 <sup>c</sup>	51.33±2.19 <sup>c</sup>
15	101.48±2.16 <sup>d</sup>	84.67±1.22 <sup>d</sup>	142.48±2.14 <sup>d</sup>	58.69±2.14 <sup>d</sup>
20	114.94±4.20 <sup>e</sup>	100.14±1.50 <sup>e</sup>	148.84±3.20 <sup>e</sup>	67.26±0.06 <sup>e</sup>
25	128.06±1.38 <sup>f</sup>	107.93±0.89 <sup>f</sup>	157.51±7.69 <sup>f</sup>	69.53±1.06 <sup>f</sup>
30	136.35±1.16 <sup>g</sup>	131.69±1.56 <sup>g</sup>	166.97±1.53 <sup>g</sup>	84.98±0.11 <sup>g</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

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**Table 6.** Effect of hot water extract from pluchea leaf powder to preferences for color, aroma, taste, texture, and overall acceptance of wet noodles at various concentrations

Concentration of Hot		Hedonic Score			
Extract from Pluchea					
Leaf Powder (% w/v)	Color	Aroma	Taste	Texture	Overall acceptance
0	6.19±1.25 <sup>d</sup>	5.52±1.08	5.50±1.18 <sup>c</sup>	6.20±1.13 <sup>b</sup>	6.63±1.49 <sup>c</sup>
5	5.62±1.28 <sup>c</sup>	5.52±0.83	5.51±1.29 <sup>c</sup>	6.37±1.14 <sup>bc</sup>	6.40±1.52 <sup>c</sup>
10	5.62±1.21 <sup>c</sup>	5.45±0.85	5.46±1.12 <sup>c</sup>	6.53±1.14 <sup>c</sup>	6.53±1.64 <sup>c</sup>
15	5.14±1.25 <sup>b</sup>	4.81±1.04	4.61±1.11 <sup>b</sup>	6.13±1.09 <sup>b</sup>	5.78±1.67 <sup>b</sup>
20	4.91±1.32 <sup>b</sup>	4.54±1.18	4.47±1.15 <sup>ab</sup>	5.80±1.06 <sup>a</sup>	5.17±1.70 <sup>a</sup>
25	4.54±1.40 <sup>a</sup>	4.26±1.23	4.20±1.24 <sup>a</sup>	5.50±1.04 <sup>a</sup>	5.23±1.75 <sup>a</sup>
30	4.47±1.33 <sup>a</sup>	4.05±1.34	4.15±1.40 <sup>a</sup>	5.59±1.05 <sup>a</sup>	5.37±1.91 <sup>a</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

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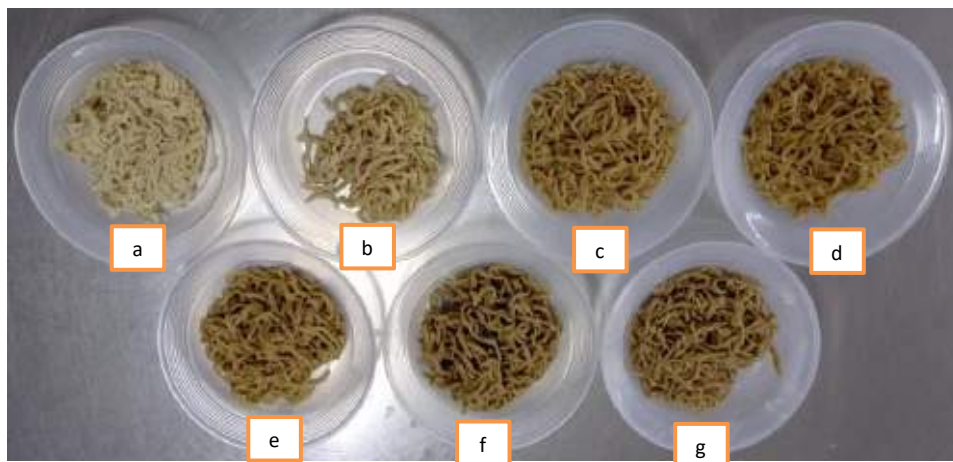


Figure 1. Wet noodles with hot water extract of pluchea leaf powder at concentrations

a. 0%; b. 5%; c. 10%; d. 15%; e. 20%; f. 25%; and g. 30% w/v

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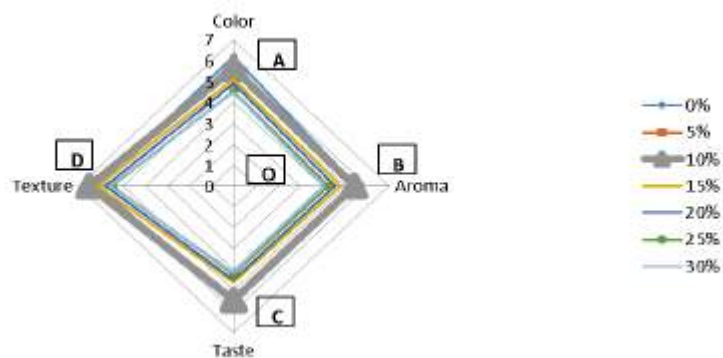


Figure 2. Spider web graph of sensory evaluation on wet noodles at various concentrations of hot water extract from pluchea leaf powder



4. Third revision: Re-evaluation Document (20-3-2023)

-Correspondence

-Re-evaluation Comments

-Re-evaluation Reviewer

-Revision Document

-Author Response to Reviewer's Comments

-



Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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## Request for Review - 3638

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**Managing Editor** <info@foodandnutritionjournal.org>

Mon, Mar 20, 2023 at 12:55 PM

To: Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

Dear Dr Paini Sri Widyawati,

Hope this email finds you well.

We would like to inform you that kindly send us the highlighted revised manuscript along with the revised author response form individually as mentioned in the re-evaluation comment.

We highly appreciate it if you could send us the desired documents for further processing at your earliest convenience.

Looking forward to hearing from you soon.

Best Regards

Yanha Ahmed

Editorial Assistant

[Current Research in Nutrition and Food Science](#)

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### 3 attachments

**Re-evaluation comments r2.docx**

58K

**Re-evaluation reviewer edited manuscript r2.docx**

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**Re-evaluation comments r1.docx**

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But for chemical properties, GC-MS, FTIR analysis are important to know the functional groups, antioxidant compounds.



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2. The authors need to check the text highlighted in **Blue**. Something is wrong.
3. The section on References needs corrections. Doi should be added.

## The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

### Abstract

Powdered *Pluchea indica* Less leaves have been utilized as herbal tea, brewing of pluchea tea in hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional value and influence physic, chemical, and sensory characteristics of food. The study was done to assess the effect of various concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with pluchea tea at concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v). Physical properties analyzed included water content, swelling index, cooking loss, color and texture. Chemical properties measured were bioactive contents of total phenolic content, total flavonoid content, and antioxidant ability to scavenge DPPH free radicals and to reduce iron ions. Sensory properties determined were taste, texture, color, aroma and overall acceptance. The addition of various concentrations of extract gave significantly effects on parameters of physical, chemical and sensory properties of noodles, except color (redness, chroma and hue), cooking loss, water content, swelling index and aroma. Using of 10% (w/v) of pluchea tea resulted in the best sensory properties such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. Generally, the study concluded that wet noodles can be made by adding pluchea tea at 10% (w/v). Dried samples TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg, 62.44 mg CE/kg, 130.68 mg GAE/kg and 51.33 mg GAE/kg, respectively.

### Key-words

Chemical, *Pluchea indica* Less, physical, sensory, wet noodles

### Introduction

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food<sup>1,2</sup>. The potency of pluchea leaves is related to phytochemical compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone, alkaloid, lignans and saponins<sup>2,3,4,5</sup>. Chan et al.<sup>1</sup> also reported that caffeoylquinic acids, phenolic acids, flavonoids and thiophenes in pluchea leaves are compounds with antioxidant activities. Furthermore,

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37 pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100 g, fat 0.49 g/100 g, insoluble dietary  
38 fiber 0.89 g/100 g, soluble dietary fiber 0.45 g/100 g, carbohydrate 8.65 g/100 g, calcium 251 mg/100  
39 g,  $\beta$ -carotene 1.225  $\mu$ g/100 g<sup>6</sup>.

40 **Pluchea tea brewed from pluchea leaves** has been proven to exhibit antioxidant activity<sup>6,7,8</sup>,  
41 anti-diabetic activity<sup>9</sup>, anti-inflammatory activity<sup>7</sup>, **anti-human** LDL oxidation activity<sup>10</sup>. Previous  
42 research uses pluchea leaf powder to make several food products to increase functional values, i.e.,  
43 jelly drink<sup>11</sup>, soy milk<sup>12</sup> and steamed bun<sup>13</sup>. Using 1% (w/v) pluchea leaf powder can improve the  
44 physicochemical properties of jelly drink and increase panelists' acceptance of the product<sup>11</sup>. Soy milk  
45 with the addition of pluchea leaves increases the viscosity and total dissolved solids and decreases the  
46 panelist acceptance rate<sup>12</sup>. The addition of 6% (w/v) brewing from pluchea leaf powder on steamed  
47 bun is the best treatment with the lowest level of hardness<sup>13</sup>. All previous research has proven that the  
48 addition of pluchea leaves can increase the bioactive compound contents based on total phenol and  
49 total flavonoids, as well as increase **the** antioxidant activity based on ferric reducing power and ability  
50 to scavenge DPPH free **radicals**.

51 To the best of our knowledge, the study of the addition of **of pluchea** tea in making wet noodles  
52 from wheat flour has not been conducted, as well as its impact on physicochemical and organoleptic  
53 characteristics of the noodles. Noodles are a popular food product that is widely consumed in the  
54 world. Indonesia is one of the countries with the largest noodle consumption after China<sup>14</sup>. Wet  
55 noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet noodles as an  
56 alternative to wet noodles, which contain higher protein, and the second popular food in ASEAN  
57 regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia<sup>16</sup>. The

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58 addition of other ingredients has been endeavored to enhance wet noodles' specific properties. Many  
59 researchers incorporated plant extracts or natural products to increase functional properties of wet  
60 noodles, such as red spinach<sup>17</sup>, green tea<sup>18,19</sup>, purple sweet potato leaves<sup>20</sup>, moringa leaves<sup>21</sup>, sea  
61 weed<sup>22</sup>, ash of rice straw, turmeric extract<sup>23</sup>, and betel leaf extract<sup>24</sup> that influenced the physical,  
62 chemical, and organoleptic properties of the wet noodles. The anthocyanin of red spinach ethanolic  
63 extract increased the hedonic score of wet noodles' flavor<sup>17</sup>. The addition of green tea improves the  
64 stability, elastic modulus and viscosity, retrogradation and cooking loss with , no significant effect on  
65 mouth-feel and overall acceptance from panelist on the produced wet noodles<sup>18</sup>. Moreover, the  
66 addition of sweet potatoes leaf extract on wet noodles increases moisture content, protein value and  
67 ash concentration, and improves hedonic score of texture<sup>20</sup>. Moringa extract influences protein  
68 content and decrease panelist acceptance of color, aroma and taste of wet noodles<sup>21</sup>. The use of  
69 seaweed to produce wet noodles influences moisture content, swelling index, absorption ability,  
70 elongation value and color<sup>22</sup>. The addition of ash from rice straw and turmeric extract influence the  
71 elasticity and sensory characteristics (color, taste, aroma and texture) of wet noodles<sup>23</sup>. Betel leaf  
72 extract used to make Hokkien (with dark soya source) noodles improves texture and acceptance score  
73 of all sensory attributes<sup>24</sup>.

74 Bioactive compounds and nutritive value of pluchea leaf can be an alternative ingredient to  
75 improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea  
76 leaves can serve as an antioxidant source in wet noodles and increase the functional value. This study  
77 was undertaken to assess the effect of various concentration of pluchea tea on the physical, chemical  
78 and sensory properties of wet noodles.

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## Materials and Methods

### Preparation of Hot Water Extract from Pluchea Leaf Powder

Young pluchea leaves (1-6) were picked from the shoots, sorted and washed. The selected leaves were dried at ambient temperature for 7 days to yield moisture content of  $10.00 \pm 0.04\%$  dry base<sup>25</sup>. Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at 120°C for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag for about 2 g/tea bag. Pluchea leaf powder in tea bags was extracted using hot water (95°C) for 5 min to get extract concentrations of 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

### Wet Noodles Processing

About 70 mL of hot extract from pluchea leaf powder with concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v) (Table 1) was manually mixed with egg, baking powder, salt and wheat flour for 5 min (Table 2). The mixture was kneaded to form a solid and homogenized dough using a mixer (Oxone Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to form noodle strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled water about 3 min in 300 mL water and coated with oil to prevent the noodles from sticking to each other. Wet noodles made without any addition of hot water of pluchea leaf extract were prepared as control. Wet noodles used in bioactive compounds and antioxidant activity assay were not added with oil to prevent the noodles from sticking to one another. The final characteristics of wet noodles have width and thickness of 0.45 cm and 0.30 cm, respectively.

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101 **Pluchea Wet Noodles Extraction**

102 About 100 g of wet noodles were dried using a freeze-dryer at a pressure of 0.1 bar and  
103 temperature -60°C for 28 hours to obtain dried noodles. Each dried of pluchea leaves were powdered  
104 using a chopper machine at the speed of 35 seconds. 20 g of powdered pluchea leaves were mixed by  
105 50 mL absolute methanol in a shaking water bath at 35°C, 70 rpm for 1 hour<sup>26</sup>. The filtration was done  
106 to separate filtrate using Whatman filter paper grade 40 and the residue extraction was done again  
107 with the same procedure. The collection of filtrates was done, then evaporation by rotary evaporator  
108 was done to get 3 mL of extract (Buchi Rotary Evaporator; Buchi Shanghai Ltd, China) at 200 bars, 50°C  
109 for 60 min. The obtained extract was kept at 0°C before further analysis.

110 **Moisture Content Assay**

111 Moisture content or water content of wet noodles was determined by thermos-gravimetric  
112 method<sup>27</sup>. The moisture content of wet noodles was determined by heating the samples in a drying  
113 oven (Binder, Merck KGaA, Darmstadt, Germany) and weighing the evaporated water content in the  
114 material.

115 **Measurement of Swelling Index**

116 The purpose of swelling index testing was to determine the capability of the noodles to swell  
117 during the boiling process<sup>16</sup>. The assay was done to determine the ability of wet noodles to absorb  
118 water per unit of time or the time needed to fully cook wet noodles. The amount of water absorbed  
119 by wet noodles was measured from the weight before and after boiling.

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before extraction

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122 **Determination of Cooking Loss**

123 Cooking loss is one of the necessary quality parameters to establish the quality of wet noodles  
124 after boiling<sup>28</sup>. The cooking loss assay was done by measuring the quantity of solids that leached out  
125 of the noodles during the boiling process, e.g., starch. A large cooking loss value affects the texture of  
126 wet noodles, which is easy to break and less slippery.

127 **Determination of Texture**

128 The texture of wet noodles with pluchea extract added was measured based on hardness,  
129 adhesiveness, cohesiveness, elongation and elasticity. The texture was analyzed by TA-XT2 texture  
130 analyzer (Stable Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the  
131 Texture Exponent 32 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were  
132 analyzed with a compression assay using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle strands  
133 with the length of 4 cm for each strand were laid side by side, touching each other, perpendicular to  
134 the 35 mm compression cylinder probe on a flat aluminum base. The cylinder probe was arranged to  
135 be at 15 mm distance from the lower plate at the start of the compression test, and was forced down  
136 through the noodle strips at the speed of 2 mm s<sup>-1</sup> until it touched the flat base to compress 75% of  
137 the noodle thickness, and was drawn back to at the end of the test. The profile curve was determined  
138 using a texture analyzer software<sup>24,29</sup>. The hardness was determined as the maximum force per gram.  
139 The adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area  
140 was obtained from the compression test under the curve. Cohesiveness was analyzed based on the  
141 ratio between the area under the second peak and the first peak<sup>24,29,30</sup>. The elongation and elasticity  
142 of the noodles were individually tested by putting one end into the lower roller arm slot and

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sufficiently winding the loosened arm to fasten the noodle end. Elongation was the maximum force to change of noodle form and break by extension that was analyzed by a test speed of  $3.0 \text{ mm s}^{-1}$  between two rollers with a 100 mm distance. The elongation at breaking was calculated per gram. Elasticity was determined by formula (1)<sup>31,32</sup>:

$$\text{Elasticity} = \frac{Fx lo}{Ax to} \frac{1}{v} \quad (1)$$

where F is the tensile strength, lo is the original length of the noodles between the limit arms (mm), A is the original cross-sectional area of the noodle ( $\text{mm}^2$ ), v is the rate of movement of the upper arm (mm/s), and t is break up time of the noodles (s). The measurement of texture was detected by the software and expressed as a graph.

#### Color Measurement

The color of the noodle sheets was determined by a colorimeter (Minolta CR 10, Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab  $L^*$ ,  $a^*$  and  $b^*$  values were analyzed based on the method by Fadzil et al.<sup>29</sup> The  $L^*$  value measured the position on the white/black axis, the  $a^*$  value as the position on the red/green axis, and the  $b^*$  value as the position on the yellow/blue axis.

#### Analysis of Total Phenolic Content

The total phenolic content analysis was analyzed based on the reaction between phenolic compounds and Folin Ciocalteu (FC) reagent or phosphomolybdic acid and phosphotungstic acid. The FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups to become a blue molybdenum-tungsten complex solution<sup>33</sup>. The intensity of the blue color was detected by a UV-Vis spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  760 nm. In the analysis,

163 7.5% Na<sub>2</sub>CO<sub>3</sub> solution was added to reach pH 10 that caused an electron transfer reaction (redox). The  
164 obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

#### 165 **Analysis of Total Flavonoid Content**

166 The flavonoid content assay was done using the spectrophotometric method based on the  
167 reaction between flavonoids and AlCl<sub>3</sub> to form a yellow complex solution. In the presence of NaOH  
168 solution, a pink color is formed which can be detected by spectrophotometer (Spectrophotometer UV-  
169 Vis 1800, Shimadzu, Japan) at λ 510 nm<sup>33,34,35</sup>. The obtained data were expressed in mg of catechin  
170 equivalent (CE)/L sample.

#### 171 **Analysis of DPPH Free Radical Scavenging Activity**

172 The ability of antioxidant compounds to scavenge DPPH (2,2-diphenyl-1-picrylhydrazyl) free  
173 radicals can be used to evaluate antioxidant activity. The principle of the DPPH method is to measure  
174 the absorbance of compounds that can react with DPPH radicals<sup>36</sup>. Antioxidant compounds can donate  
175 hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced to yellow<sup>37</sup>. The color  
176 change was measured as an absorbance at λ 517 nm by spectrophotometer (Spectrophotometer UV  
177 Vis 1800, Shimadzu, Japan)<sup>38</sup>. The data were expressed in mg gallic acid equivalent (GAE)/L dried  
178 noodles sample.

#### 179 **Analysis of Iron Ion Reduction Power**

180 This method identifies the capacity of antioxidant components using potassium ferricyanide,  
181 trichloroacetic acid and ferric chloride to produce color complexes that can be measured  
182 spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at λ 700 nm<sup>39</sup>. The  
183 principle of this testing is the ability antioxidants to reduce iron ions from K<sub>3</sub>Fe(CN)<sub>6</sub> (Fe<sup>3+</sup>) to K<sub>4</sub>Fe(CN)<sub>6</sub>

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184 (Fe<sup>2+</sup>). Then, potassium ferrocyanide reacts with FeCl<sub>3</sub> to form a Fe<sub>4</sub>[Fe(CN)<sub>6</sub>]<sub>3</sub> complex. The color  
185 change is from yellow to green<sup>40</sup>. The final data were expressed in mg gallic acid equivalent (GAE)/L  
186 dried noodles.

### 187 Sensory Evaluation

188 The hedonic test of all samples of wet noodles involved 100 untrained panelists with an age  
189 range of 17 to 25 years. A hedonic test used in this research was the hedonic scoring method, where  
190 the panelists gave a preference score value of all samples<sup>41</sup>. The hedonic scores were transformed to  
191 numeric scale and analyzed using statistical analysis<sup>42</sup>. The numeric scale in the sensory analysis used  
192 a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The panelists were  
193 asked to score according to their level of preference for texture, taste, color, flavor and overall  
194 acceptability. All the samples were blind coded with 3 digits which differed from each other<sup>43</sup>.

### 195 Statistical Analysis

196 The research design used in the physicochemical assay was a randomized block design (RBD)  
197 with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that  
198 consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25 and 30% (w/v). Each treatment was repeated four  
199 times that obtained 28 experiment units. A completely randomized design (CRD) was used to evaluate  
200 sensory assay with 100 untrained panelists with an aged 17 to 25 years.

201 The normal distribution and homogeneity data were stated as the mean ± SD of the triplicate  
202 determinations and were determined using ANOVA at p ≤ 5% using SPSS 17.0 software (SPSS Inc.,  
203 Chicago, IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan

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Multiple Range Test) at  $p \leq 5\%$  to determine treatment level that gave significant different results. The best treatment of pluchea extract addition on wet noodles was analyzed by a spider web graph.

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## Results and Discussion

Wet noodles added with hot extract of pluchea leaf powder were produced to increase the functional value of wet noodles. This is supported by previous studies related to the potential value of water extract of pluchea leaf that exhibits biological activities<sup>6,7,41</sup>. In this research, the cooking quality was observed after cooking wet noodles in 300 mL water/100 g samples for 3 min in boiling water.

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## Cooking Quality

Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at 0, 5, 10, 15, 20, 25 and 30% (w/v) was shown in Figure 1, Table 3 and Table 4. The addition of pluchea extract no significantly influenced the water content, cooking loss, swelling index, chroma, and hue of the produced wet noodles using statistical analysis by ANOVA at  $p \leq 5\%$ . Water content is one of the chemical properties of a food product determined shelf life of food products, because the water content measures the free and weakly bound water in foodstuffs<sup>44,45</sup>. This study identified that the moisture content of the cooked wet noodles ranged between 64-67% wb. Previous study showed that the water content of the cooked egg wet noodles was around 54-58% wb<sup>45</sup> and maximum of 65%<sup>20</sup>. Chairuni et al.<sup>44</sup> stated that the boiling process could cause a change in moisture content from around 35% to around 52%. The Indonesian National Standard<sup>46</sup> stipulates that the moisture content of cooked wet noodles is a maximum of 65%. This means that only control noodles (without treatment) exhibited a moisture content similar to the previous information. The obtained data showed a trend that an extract addition caused an increase in the water content of wet noodles, but statistical analysis at  $p \leq$

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225 5% showed no significant difference. This phenomenon was in accordance with the experimental  
226 results of Juliana et al.<sup>45</sup> that the using of spenochlea leaf extract to making wet noodles, as well as  
227 Hasmawati et al.<sup>20</sup> that the sweet potato leaf extract increased the moisture of fresh noodles. The  
228 water content of pluchea wet noodles was expected by reaction between many components in the  
229 dough that impacted to the swelling index and cooking loss. Mualim et al.<sup>14</sup>, Bilina et al.<sup>22</sup> and Setiyoko  
230 et al.<sup>28</sup> reported that the presence of amino groups in protein and hydroxyl groups in amylose and  
231 amylopectin fractions in wheat flour as raw material for making dough determines the moisture  
232 content, swelling index and cooking loss of wet noodles. The contribution of glutelin and gliadin  
233 proteins in wheat flour to form gluten networks determines the capability of noodles to swell and  
234 retain water in the system. Gliadin acts as an adhesive that causes dough to be elastic, while glutenin  
235 makes the dough to be firm and able to withstand CO<sub>2</sub> gas thus the dough can expand and form pores.  
236 Fadzil et al.<sup>29</sup> found that thermal treatment during the boiling process results in the denaturation of  
237 gluten and caused a monomer of proteins to determine other reactions at the disulfide or sulfhydryl  
238 chain. The existence of phenolic compounds from pluchea extract also increased the capacity of  
239 noodles to absorb water and determined water mobility. Widyawati et al.<sup>41</sup> also confirmed that  
240 hydrophilic compounds of proteins, carbohydrates, and polyphenolic components determine water  
241 mobility due to their ability to bind with water molecules through hydrogen bonding. Tuhumury et al.<sup>47</sup>  
242 informed that gluten formation can inhibit water absorption by starch granules so that can prevent  
243 gelatinization. Therefore, the addition of phenolic compounds from the hot extract of pluchea leaf  
244 powder can inhibit the formation of gluten so that it stimulates gelatinization of starch granules.

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246 As a result, the impact of increased the moisture content during boiling had an effect on the  
247 value of the swelling index and cooking loss of the wet noodles. Widyawati et al.<sup>41</sup> said that the swelling  
248 index is the capability to trap water which is dependent on the chemical composition, particle size, and  
249 water content. Gull et al.<sup>48</sup> also confirmed that the swelling index is an indicator to determine water  
250 absorption by starch and protein to make gelatinization and hydration. Setiyoko et al.<sup>28</sup> explained that  
251 cooking loss is the mass of noodle solids that come out of the noodle strands for boiling. Gull et al.<sup>48</sup>  
252 added that soluble starch and other soluble components leach out into the water during the cooking  
253 process, making the cooking water turned thicker. The moisture content results (64-67% wb) showed  
254 that the produced wet noodles exceeded the moisture content limit of wet noodles after cooking,  
255 which is between 54-58%<sup>44</sup>, while the cooking loss value of wet noodles should not be more than  
256 10%<sup>28</sup>. In this study, the cooking loss value was 3-4.2%. The cooking loss of samples during boiling  
257 noodles were caused the breaking of the bonding network that the polysaccharides are released and  
258 the gluten network breaks because of the addition of pluchea leaf extract. Widyawati et al.<sup>41</sup> supported  
259 that polyphenol can be bound with protein and starch with many non-covalent interactions, such as  
260 hydrogen bonding, electrostatic interaction, hydrophobic interaction, Van der Waal's interaction, and  
261  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch to undergo  
262 gelatinization and gliadin and glutelin from the protein of wheat flour to form gluten.

263 The swelling index value obtained from this research was around 56-68 %. Based on the  
264 previous research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.)  
265 fruit was around 51%<sup>49</sup>. This means that the addition of pluchea leaf extract in wet noodles also affects  
266 the ability of noodles to absorb water. Widyawati et al.<sup>41</sup> and Suriyaphan<sup>6</sup> noted that bioactive

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compounds in hot water extract of pluchea leaf tea include 3-*O*-caffeoylquinic acid, 4-*O*-caffeoylquinic acid, 5-*O*-caffeoylquinic acid, 3,4-*O*-dicaffeoylquinic acid, 3,5-*O*-dicaffeoylquinic acid, 4,5-*O*-dicaffeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was higher than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from extract in absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch granules to absorb water so that the swelling index and cooking loss increased. Suriyaphan<sup>6</sup> informed that hot extract of pluchea leaf tea contains 1.79 g/100 g protein, 8.65 g/100 g carbohydrate, and fiber (0.45 g/100 g soluble and 0.89 g/100 g insoluble), these compounds can involve in increasing the swelling index from pluchea wet noodles.

Color is one of the physical characteristics possessed by wet noodles that becomes a benchmark for consumer acceptance. This research found that the color of wet noodles was influenced by the addition of pluchea extract. The addition of pluchea leaf extract no significant affected the redness ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it influenced the yellowness ( $b^*$ ) and lightness ( $L^*$ ) values. Using of pluchea leaf powder brewing decreased the brightness of wet noodles significantly, as the concentration of the extract increased. This is related to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to experience color changes. According to Widyawati et al.<sup>8</sup> tannins are water-soluble compounds that can give a brown color. Suriyaphan<sup>6</sup> and Widyawati et al.<sup>41</sup> also stated that Khlu tea from pluchea leaves contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and 6.39 mg/100 g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow color.

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288 Gull et al.<sup>48</sup> stated that this pigment was easily changed in the paste sample due to the swelling and  
289 discoloration of the pigment during cooking.

290 Thus, the addition of hot water extract of pluchea leaf powder significantly reduced the  
291 brightness of wet noodles, because brown-colored noodles were produced as the concentrations of  
292 added pluchea leaf extract increased. However, increasing the concentration of this extract had no  
293 influenced on the redness, hue, and chroma values in ANOVA at  $p \leq 5\%$ . The results showed that the  
294 redness value of wet noodles revolved from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet  
295 noodles ranged from  $82.1 \pm 3.1$  to  $86.5 \pm 1.0$ . Based on this value, the color of wet noodles is in the  
296 yellow to the red color range<sup>50</sup>, thus the visible color of the wet noodle product was yellow to brown  
297 (Figure 1). Yellowness increased significantly with the addition of pluchea leaf extract and the value  
298 ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the availability of tannins and chlorophyll  
299 compounds from pluchea leaf extract. The chroma value of wet noodles was obtained within the range  
300 of  $15.6 \pm 1.5$  to  $19.8 \pm 3.4$ . This means that the brewing of pluchea leaf powder did not change the  
301 intensity of the brown color in the resulting wet noodles.

302 Texture analysis of pluchea wet noodles added with various concentrations of hot water extract  
303 from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness,  
304 elongation, and elasticity. Hardness is the maximum force given to a product until deformation<sup>51,52</sup>.  
305 From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher  
306 peak of graph shows the harder product<sup>30</sup>. Adhesiveness is force or tackiness that is required to pull  
307 the product from its surface, its value is obtained from the area between the first and second  
308 compressions<sup>53,54</sup>. Adhesiveness values show negative value; the bigger negative value means the

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product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and second compressions<sup>52,54</sup>. This is an indication of the internal forces that make up the product<sup>55</sup>. Elongation is the change in length of noodles when being exposed to a tensile force until the noodles break<sup>56</sup>. Elasticity is the time required for the product to withstand the load until it breaks. The more elastic a product, the longer the holding time. The data showed that the higher concentration of pluchea leaf powder within the hot water extract caused a significant increase in the hardness, stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati et al.<sup>41</sup> informed that the polyphenols contained in pluchea leaf extract can weakly interact either covalently or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups that are polar. Amoako and Akiwa<sup>57</sup> and Zhu et al.<sup>58</sup> have also proven that polyphenolic compounds can interact with carbohydrates through the interaction of two hydrophobic and hydrophilic functional groups with amylose. Diez-Sánchez et al.<sup>59</sup> stated that polyphenolic compounds can interact with amylose and protein helical structures and largely determined by molecular weight, conformational mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and amylopectin can affect the gelatinization process in the amylose helical structure and interfere with the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss (> 98%) and swelling index (56.2 to 67.7%) data, it can be concluded that the

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330 interaction that occurs between the phenol group in pluchea leaf extract with amylose and protein was  
331 weak. The bioactive components of pluchea leaf extract are thought to affect the formation of disulfide  
332 cross-links (S-S) and turn into to form sulfhydryl groups (-SH) under the influence of heat. Ananingsih  
333 and Zhou<sup>60</sup> said that antioxidant compounds are a reducing agent that can have an impact on reducing  
334 S-S bonds and increasing the number of SH groups in the dough to produce a harder texture. According  
335 to Rahardjo et al.<sup>53</sup> phenolic compounds are hydroxyl compounds that influence the strength of the  
336 dough, where the higher the component of phenol compounds will weaken the gluten matrix and the  
337 dough thus becoming unstable. The instability of the dough can cause the texture to become hard.

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338 Many researchers also find that tannins and phenols influence the networking S-S bond in the  
339 dough of wet noodles. Wang et al. (2015) showed that tannins increase the relative amount of large,  
340 medium polymers in the gluten protein network so as to improve the dough quality. Zhang et al.<sup>61</sup> said  
341 that these polymer compounds are the results of interactions or combinations of protein-tannin  
342 compounds that form bonds with the type of covalent bonds, hydrogen bonds, or ionic bonds. Rauf  
343 and Andini<sup>62</sup> also added that phenol compounds can reduce S-S bonds to SH bonds. SH is a type of thiol  
344 compound group, where the thiol group can influence the stickiness, viscosity, cohesiveness,  
345 elongation, and extensibility of the dough. Wang et al.<sup>63</sup> found the effect of phenolic compounds from  
346 green tea extract to increase the stickiness of wheat bread. The cohesiveness of the dough is formed  
347 due to a large number of thiol bonds formed, thus increasing the viscosity of the dough. The increased  
348 viscosity of the dough is thought to be due to the formation of polyphenolic compounds with thiol  
349 groups, as in the research of Ananingsih and Zhou<sup>60</sup> that the formation of catechin-thiol can increase  
350 the viscosity of the dough and increase the stability of the dough. Zhu et al.<sup>64</sup> mentioned that the

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addition of phenolic compounds from green tea was able to increase the PV (peak viscosity) of wheat flour. Wang et al.<sup>65</sup> also found that the cohesiveness of the dough is influenced by tannins, where tannins can produce micro-glutens so as to produce a compact dough and increase the gluten network. The addition of pluchea leaf extract in making wet noodles could influence the elongation of wet noodles due to the components of polyphenol compounds such as tannins that can reduce the number of free amino groups. This is supported by Zhang et al.<sup>30</sup> and Wang et al.<sup>65</sup> support the formation of other types of covalent bonds, such as bonds between amino groups and hydroxyl groups, by forming hydrogen bonds between phenolic compounds and protein gluten so as to improve the quality of dough strength and dough extensibility.

#### Bioactive Compounds and Antioxidant Activity

Wet noodles added with pluchea leaf powder were analyzed based on its bioactive compounds and antioxidant activities. The analysis was conducted to determine the functional properties of wet noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles are presented in Table 5. The measured bioactive compounds (BC) included total phenolic content (TPC) and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical scavenging activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed that there was a positive and strong correlation between TPC and DPPH ( $r = 0.990$ ), TPC and FRAP ( $r = 0.986$ ), TFC and DPPH ( $r = 0.974$ ), and TFC and FRAP ( $r = 0.991$ ). This means that the antioxidant activity

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of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah et al.<sup>66</sup> informed that the PC (r) > 0.699 indicates the strength and linear correlation between antioxidant activity (AA) and TPC, and also shows a strong positive relationship but PC (r) < 0.699 obtains a moderately positive relationship. If the r value of TFC and AA is lower than TPC and AA, it indicates that the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship which is expected because both classes all contributed to AA plants. Aryal et al.<sup>67</sup> and Muflihah et al.<sup>66</sup> informed that phenolic compounds are soluble natural antioxidants and potential donating electrons depend on their number and position of hydroxyl groups contributed to antioxidant action. Consequently, these groups are responsible to scavenge the free radicals that TPC of pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the stable purple-colored to the yellow-colored solution. Based on FRAP analysis, it was showed that the bioactive compounds contained in pluchea wet noodles are a potential source of antioxidants because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive compounds contained in pluchea wet noodles can function as primary and secondary antioxidants. Research data showed that the cooking quality of wet noodles tends to increase along with the increase in the value of TPC, TFC, DPPH and FRAP.

#### **Sensory Evaluation**

Sensory pluchea wet noodles, namely color, aroma, taste, texture, and overall acceptance, were carried out using a hedonic test to determine the level of consumer preference for the product. This test was conducted to determine the quality differences between the products and to provide an assessment on certain properties<sup>42</sup>. The hedonic test itself is the most widely used test to determine

the level of preference for production<sup>68</sup>. The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm 1.26$  (neutral-like). The statistical analysis showed that the higher concentration of hot water extract addition decreased lower color preference of wet noodles. The higher concentration of pluchea extract could reduce the level of preference for color because the color of the wet noodles was darker than control and turned to dark brown. This color change was due to the pluchea extract containing several components, including chlorophyll and tannins, which can alter the of wet noodles' color to be browner along with the increase in the concentration of pluchea extract. This result was in accordance to the effect of color analysis performed using color reader where the pluchea wet noodles' brightness declined, yellowness increased, and the color intensity increased with an increased concentration of pluchea extract. The occurrence of this process is related to the effect of light and heat on pluchea leaf powder which causes the degradation of chlorophyll into brown pheophytin due to drying, where the nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals<sup>69,70</sup>.

Aroma is one of the parameters in sensory evaluation using the sense of smell and is an indicator of the assessment of a product<sup>71</sup>. The results of the preference value for aroma were ranged from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet noodles reduced the preference score for aroma due to distinct dry leaves (green) aroma. According to Lee et al.<sup>72</sup> the unpleasant aroma on leaves comes from a group of aliphatic aldehyde compounds. The appearance of a distinctive leaf aroma in noodles is due to aromatic compounds. According to Martiyanti and Vita<sup>73</sup> aromatic compounds are chemical compounds that have an aroma or odor when

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the conditions are met, which is volatile, while Widyawati et al.<sup>74</sup> informed that pluchea leaves were detected to have 66 volatile compounds. The appearance of the aroma is due to the volatile compounds in the raw material reacting with water vapor when boiling the noodles. In addition, there is also an oxidation process of polyphenolic compounds such as catechins or tannins that can produce an aroma in pluchea wet noodles.

According to Martiyanti and Vita<sup>3</sup> taste attribute is one important sensory aspect in food products and has a great impact on the food selection by consumers. Tongue is able to detect basic tastes, namely sweet, salty, sour, and bitter, at different points. Lamusu<sup>71</sup> declared that taste is a component of flavor and an important criterion in assessing a product that is accepted by the tongue. The preference test of the taste of pluchea wet noodles resulted in values ranging from  $4.15 \pm 1.40$  to  $5.50 \pm 1.28$  (neutral-slightly like). The increase in concentrations of pluchea extract was negatively correlated to the preference level of the taste of pluchea wet noodles assessed by the panelists. The statistical analysis results showed that the difference in the concentration of the extract significantly influenced the preference score for the taste of pluchea wet noodles. The increased concentration of pluchea extract produced a distinctive taste on wet noodles, such as a bitter and astringent tastes, due to the presence of compounds such as tannins and alkaloids from the pluchea leaves. Susetyarini<sup>75</sup> said that pluchea leaves contain tannins (2.35%), and alkaloids (0.32%). According to Pertiwi<sup>76</sup>, tannin compounds dominate the bitter and astringent taste, while alkaloid compounds cause a bitter taste. The high level of taste preference for wet noodles was found in noodles with lower content of pluchea extract.

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Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and swallowed) or touched with fingers<sup>77</sup>. Texture testing performed by the panelist is called mouthfeel testing. According to Martiyanti and Vita<sup>73</sup>, mouthfeel is the kinesthetic effect of chewing food in the mouth. In this study, the preference test results on the texture of pluchea wet noodles revolved from  $5.5 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and draining noodles. Subjective testing results based on sensory evaluation were in line with the objective testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to break, and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea wet noodles was influenced by the fiber and protein components. According to Shabrina<sup>78</sup>, the components of fiber, protein, and starch complete to bind water. Texture changes are also influenced by the polyphenol compositions in the pluchea extract which is able to reduce S-S bonds to SH bonds, where the increase in SH (thiol) groups can give a hard, sticky, and compact texture<sup>62,63,65</sup>. Besides, a high concentration of tannins capable of binding to proteins to form complex compounds into tannins-proteins are also able to build noodles' texture.

The interaction between color, aroma, taste, and texture created an overall taste of the food product and was assessed as the overall preference. The highest value on the overall preference was derived from control wet noodles, i.e., 6.63 (slightly like it), while the wet noodles added with 20% (w/v) concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The

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addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to 10% (w/v) concentration with scores of 6.63 and 6.53, respectively. The area of the spider web chart for each treatment with the various concentrations of pluchea extract was seen in Figure 2. The best treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively.

The use of pluchea leaf extract in the making of wet noodles was able to increase the functional value of wet noodles, based on the levels of bioactive compounds and antioxidant activity without changing the quality of cooking, which includes water content, swelling index and cooking loss. Besides that, the use of pluchea leaf extract did not significantly change the color and color intensity of the resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet noodles produced were still acceptable to the panelists, the addition of pluchea leaf extract as much as 10% (w/v) was the best treatment with an assessment that was almost close to the control wet noodles (without treatment).

## Conclusion

Addition of hot water extract of pluchea leaf powder influenced physical, chemical and sensory properties of wet noodles. Lightness, texture, bioactive compound content, antioxidant activity, and sensory properties of samples underwent significant difference. The higher concentration of pluchea extract caused the bigger these parameters of pluchea wet noodles. Using 10% (w/v) of hot water extract from pluchea leaf powder was the best treatment with color, aroma, taste, and texture scores

476 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. Utilization of  
477 hot water extract of pluchea leaf powder at 10% (w/v) resulted wet noodle functional with TPC, TFC,  
478 DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg dried samples, 62.44  
479 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples and 51.33 mg GAE/kg dried samples,  
480 respectively.

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481  
482 **Notes on Appendices**

TPC	Total phenolic content
TFC	Total flavonoid content
DPPH	2,2-Diphenyl-1-picrylhydrazyl free radical
FRAP	Ferric reducing antioxidant power
AA	Antioxidant activity
PC	Pearson Correlation
LDL	Low Density Lipoprotein
w/v	Weight per volume
CRD	Completely randomized design
CE	Catechin equivalent
GAE	Gallic acid equivalent
BC	Bioactive compounds
ANOVA	Analysis of variance
UV-Vis	Ultra violet-visible

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694 thesis]. Bandung: Indonesia University of Pasundan.2017.  
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696 Table 1. **Information of hot water extract of pluchea tea**

Materials	Concentration of hot water extract of pluchea leaf tea (% w/v)						
	0	5	10	15	20	25	30
Pluchea leaf tea (g)	0	10	20	30	40	50	60
Hot water (mL)	200	200	200	200	200	200	200

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699 **Table 2. Ingredients** of pluchea wet noodles

Materials	Unit	Quantity
Wheat flour	g	200
Egg	g	40
Salt	g	4
Baking powder	g	2
Hot water extract	mL	70
Tapioca flour	g	10
TOTAL	g	326

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**Table 3.** Color, moisture content, swelling index, and cooking loss of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Color					Moisture content (% wb)	Swelling index (%)	Cooking loss (%)
	L*	a*	b*	C	h			
0	67.1 ± 1.8 <sup>a</sup>	0.97±0.30	16.18±0.62 <sup>ab</sup>	16.2 ± 0.6	86.5 ± 1.0	63.90±1.51	56.2±17.4	3.40±1.31
5	59.5 ± 2.7 <sup>b</sup>	2.18±0.93	15.47±1.46 <sup>a</sup>	15.6 ± 1.5	82.1 ± 3.1	65.08±4.33	62.4±4.7	3.33±1.26
10	59.0 ± 1.8 <sup>b</sup>	1.95±1.66	16.76±2.33 <sup>abc</sup>	17.1 ± 2.2	83.3 ± 5.4	64.97±3.89	61.5±7.5	3.00±1.16
15	58.4 ± 2.2 <sup>b</sup>	1.69±1.48	19.72±3.50 <sup>c</sup>	19.8 ± 3.4	84.7 ± 4.6	65.56±2.18	63.1±6.3	3.31±0.92
20	56.5 ± 2.4 <sup>b</sup>	1.97±1.24	19.09±2.97 <sup>bc</sup>	19.2 ± 2.9	83.6 ± 4.3	66.81±1.81	67.7±5.9	4.06±0.51
25	59.1 ± 2.5 <sup>b</sup>	1.95±1.44	19.55±2.97 <sup>c</sup>	19.6 ± 2.9	83.8 ± 4.0	66.04±0.85	64.5±10.3	3.93±1.37
30	57.1 ± 2.1 <sup>b</sup>	2.09±1.51	18.08±4.94 <sup>abc</sup>	18.3 ± 4.8	82.5 ± 5.2	66.65±2.16	64.0±5.3	4.23±1.34

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$

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**Table 4.** Texture of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Texture of pluchea wet noodle				
	Hardness (N)	Adhesiveness (g sec)	Cohesiveness	Elongation (%)	Elasticity (Pa)
0	135.8±5.9 <sup>a</sup>	-2.7 ±2.3 <sup>d</sup>	0.75±0.01 <sup>a</sup>	86.9±0.9 <sup>a</sup>	25336.7±104.2 <sup>a</sup>
5	120.1±2.1 <sup>a</sup>	-3.4±0.6 <sup>cd</sup>	0.68±0.00 <sup>b</sup>	97.3±1.6 <sup>b</sup>	25898.3±760.9 <sup>b</sup>
10	134.9±1.8 <sup>a</sup>	-3.9±0.7 <sup>bc</sup>	0.74±0.00 <sup>c</sup>	162.1±1.5 <sup>c</sup>	25807.7±761.9 <sup>b</sup>
15	180.5±5.1 <sup>b</sup>	-4.9±0.5 <sup>b</sup>	0.74±0.01 <sup>c</sup>	164.7±0.6 <sup>c</sup>	26971.6±516.7 <sup>b</sup>
20	195.1±14.1 <sup>b</sup>	-5.0±1.3 <sup>ab</sup>	0.75±0.01 <sup>cd</sup>	221.6±1.6 <sup>d</sup>	27474.4±453.8 <sup>b</sup>
25	244.6±8.8 <sup>c</sup>	-6.0±0.3 <sup>a</sup>	0.75±0.00 <sup>cd</sup>	230.7±0.7 <sup>e</sup>	27367.1±287.5 <sup>b</sup>
30	282.8±28.3 <sup>d</sup>	-6.1±0.2 <sup>a</sup>	0.79±0.01 <sup>d</sup>	255.4±0.4 <sup>f</sup>	26687.5±449.2 <sup>b</sup>

Note: the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$

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**Table 5.** Total phenol content, total flavonoid content, the DPPH free radical scavenging activity, and iron ion reducing power of the pluchea wet noodles.

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	TPC (mg GAE/kg Dried Noodles)	TFC (mg CE/kg Dried Noodles)	DPPH (mg GAE/kg Dried Noodles)	FRAP (mg GAE/kg Dried noodles)
0	39.26±0.66 <sup>a</sup>	32.36±1.47 <sup>a</sup>	96.75±4.26 <sup>a</sup>	25.96±0.25 <sup>a</sup>
5	61.09±3.80 <sup>b</sup>	46.31±2.15 <sup>b</sup>	121.36±3.58 <sup>b</sup>	34.50±1.71 <sup>b</sup>
10	82.84±3.11 <sup>c</sup>	62.44±0.55 <sup>c</sup>	130.68±4.82 <sup>c</sup>	51.33±2.19 <sup>c</sup>
15	101.48±2.16 <sup>d</sup>	84.67±1.22 <sup>d</sup>	142.48±2.14 <sup>d</sup>	58.69±2.14 <sup>d</sup>
20	114.94±4.20 <sup>e</sup>	100.14±1.50 <sup>e</sup>	148.84±3.20 <sup>e</sup>	67.26±0.06 <sup>e</sup>
25	128.06±1.38 <sup>f</sup>	107.93±0.89 <sup>f</sup>	157.51±7.69 <sup>f</sup>	69.53±1.06 <sup>f</sup>
30	136.35±1.16 <sup>g</sup>	131.69±1.56 <sup>g</sup>	166.97±1.53 <sup>g</sup>	84.98±0.11 <sup>g</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

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**Table 6.** Effect of hot water extract from pluchea leaf powder to preferences for color, aroma, taste, texture, and overall acceptance of wet noodles at various concentrations

Concentration of Hot		Hedonic Score			
Extract from Pluchea					
Leaf Powder (% w/v)	Color	Aroma	Taste	Texture	Overall acceptance
0	6.19±1.25 <sup>d</sup>	5.52±1.08	5.50±1.18 <sup>c</sup>	6.20±1.13 <sup>b</sup>	6.63±1.49 <sup>c</sup>
5	5.62±1.28 <sup>c</sup>	5.52±0.83	5.51±1.29 <sup>c</sup>	6.37±1.14 <sup>bc</sup>	6.40±1.52 <sup>c</sup>
10	5.62±1.21 <sup>c</sup>	5.45±0.85	5.46±1.12 <sup>c</sup>	6.53±1.14 <sup>c</sup>	6.53±1.64 <sup>c</sup>
15	5.14±1.25 <sup>b</sup>	4.81±1.04	4.61±1.11 <sup>b</sup>	6.13±1.09 <sup>b</sup>	5.78±1.67 <sup>b</sup>
20	4.91±1.32 <sup>b</sup>	4.54±1.18	4.47±1.15 <sup>ab</sup>	5.80±1.06 <sup>a</sup>	5.17±1.70 <sup>a</sup>
25	4.54±1.40 <sup>a</sup>	4.26±1.23	4.20±1.24 <sup>a</sup>	5.50±1.04 <sup>a</sup>	5.23±1.75 <sup>a</sup>
30	4.47±1.33 <sup>a</sup>	4.05±1.34	4.15±1.40 <sup>a</sup>	5.59±1.05 <sup>a</sup>	5.37±1.91 <sup>a</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means

with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

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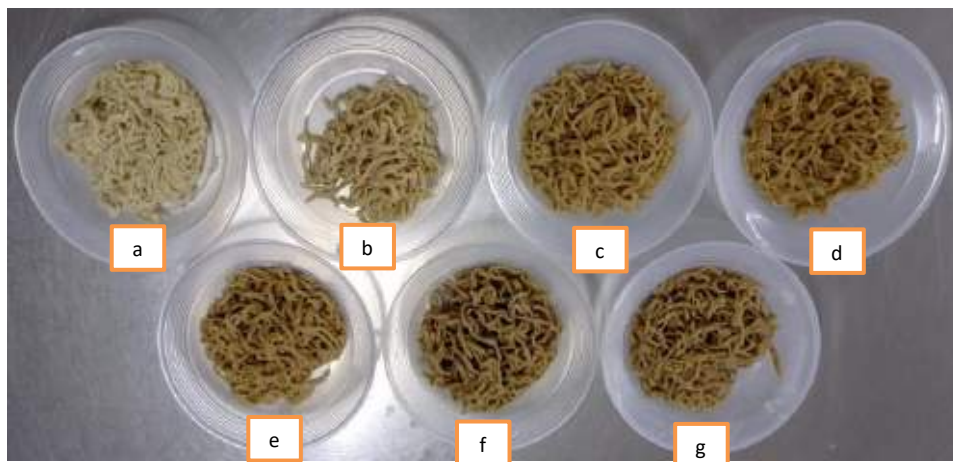


Figure 1. Wet noodles with hot water extract of pluchea leaf powder added at concentrations

a. 0%; b. 5%; c. 10%; d. 15%; e. 20%; f. 25%; and g. 30% w/v

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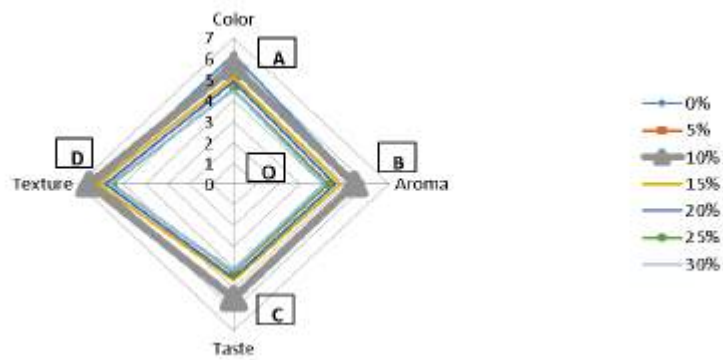


Figure 2. Spider web graph of sensory evaluation on wet noodles at various concentrations of hot water extract from pluchea leaf powder



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**Request for Review - 3638**

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**Paini Sri Widyawati** <paini@ukwms.ac.id>

Wed, Mar 22, 2023 at 11:48 PM

To: Managing Editor &lt;info@foodandnutritionjournal.org&gt;

Dear Ms Yanha Ahmed

I have revised my manuscript and sent it again. Related to a request from the reviewer about GC-MS and FTIR data, I can't fulfill it because I don't do it .

I apologize.

Thanks for attention

Regards

Paini Sri Widyawati

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## The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

### Abstract

Powdered *Pluchea indica* Less leaves have been utilized as herbal tea, brewing of pluchea tea in hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional value and influence physic, chemical, and sensory characteristics of food. The study was done to assess the effect of various concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with pluchea tea at concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v). Physical properties analyzed included water content, swelling index, cooking loss, color and texture. Chemical properties measured were bioactive contents of total phenolic content, total flavonoid content, and antioxidant ability to scavenge DPPH free radicals and to reduce iron ions. Sensory properties determined were taste, texture, color, aroma and overall acceptance. The addition of various concentrations of extract gave significantly effects on parameters of physical, chemical and sensory properties of noodles, except color (redness, chroma and hue), cooking loss, water content, swelling index and aroma. Using of 10% (w/v) of pluchea tea resulted in the best sensory properties such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. Generally, the study concluded that wet noodles can be made by adding pluchea tea at 10% (w/v). Dried samples TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg, 62.44 mg CE/kg, 130.68 mg GAE/kg and 51.33 mg GAE/kg, respectively.

### Key-words

Chemical, *Pluchea indica* Less, physical, sensory, wet noodles

### Introduction

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food<sup>1,2</sup>. The potency of pluchea leaves is related to phytochemical compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone, alkaloid, lignans and saponins<sup>2,3,4,5</sup>. Chan et al.<sup>1</sup> also reported that caffeoylquinic acids, phenolic acids, flavonoids and thiophenes in pluchea leaves are compounds with antioxidant activities. Furthermore,

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37 pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100 g, fat 0.49 g/100 g, insoluble dietary  
38 fiber 0.89 g/100 g, soluble dietary fiber 0.45 g/100 g, carbohydrate 8.65 g/100 g, calcium 251 mg/100  
39 g,  $\beta$ -carotene 1.225  $\mu$ g/100 g<sup>6</sup>.

40 **Pluchea tea brewed from pluchea leaves** has been proven to exhibit antioxidant activity<sup>6,7,8</sup>,  
41 anti-diabetic activity<sup>9</sup>, anti-inflammatory activity<sup>7</sup>, **anti-human** LDL oxidation activity<sup>10</sup>. Previous  
42 research uses pluchea leaf powder to make several food products to increase functional values, i.e.,  
43 jelly drink<sup>11</sup>, soy milk<sup>12</sup> and steamed bun<sup>13</sup>. Using 1% (w/v) pluchea leaf powder can improve the  
44 physicochemical properties of jelly drink and increase panelists' acceptance of the product<sup>11</sup>. Soy milk  
45 with the addition of pluchea leaves increases the viscosity and total dissolved solids and decreases the  
46 panelist acceptance rate<sup>12</sup>. The addition of 6% (w/v) brewing from pluchea leaf powder on steamed  
47 bun is the best treatment with the lowest level of hardness<sup>13</sup>. All previous research has proven that the  
48 addition of pluchea leaves can increase the bioactive compound contents based on total phenol and  
49 total flavonoids, as well as increase **the** antioxidant activity based on ferric reducing power and ability  
50 to scavenge DPPH free **radicals**.

51 To the best of our knowledge, the study of the addition of **of pluchea** tea in making wet noodles  
52 from wheat flour has not been conducted, as well as its impact on physicochemical and organoleptic  
53 characteristics of the noodles. Noodles are a popular food product that is widely consumed in the  
54 world. Indonesia is one of the countries with the largest noodle consumption after China<sup>14</sup>. Wet  
55 noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet noodles as an  
56 alternative to wet noodles, which contain higher protein, and the second popular food in ASEAN  
57 regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia<sup>16</sup>. The

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58 addition of other ingredients has been endeavored to enhance wet noodles' specific properties. Many  
59 researchers incorporated plant extracts or natural products to increase functional properties of wet  
60 noodles, such as red spinach<sup>17</sup>, green tea<sup>18,19</sup>, purple sweet potato leaves<sup>20</sup>, moringa leaves<sup>21</sup>, sea  
61 weed<sup>22</sup>, ash of rice straw, turmeric extract<sup>23</sup>, and betel leaf extract<sup>24</sup> that influenced the physical,  
62 chemical, and organoleptic properties of the wet noodles. The anthocyanin of red spinach ethanolic  
63 extract increased the hedonic score of wet noodles' flavor<sup>17</sup>. The addition of green tea improves the  
64 stability, elastic modulus and viscosity, retrogradation and cooking loss with, no significant effect on  
65 mouth-feel and overall acceptance from panelist on the produced wet noodles<sup>18</sup>. Moreover, the  
66 addition of sweet potatoes leaf extract on wet noodles increases moisture content, protein value and  
67 ash concentration, and improves hedonic score of texture<sup>20</sup>. Moringa extract influences protein  
68 content and decrease panelist acceptance of color, aroma and taste of wet noodles<sup>21</sup>. The use of  
69 seaweed to produce wet noodles influences moisture content, swelling index, absorption ability,  
70 elongation value and color<sup>22</sup>. The addition of ash from rice straw and turmeric extract influence the  
71 elasticity and sensory characteristics (color, taste, aroma and texture) of wet noodles<sup>23</sup>. Betel leaf  
72 extract used to make Hokkien (with dark soya source) noodles improves texture and acceptance score  
73 of all sensory attributes<sup>24</sup>.

74 Bioactive compounds and nutritive value of pluchea leaf can be an alternative ingredient to  
75 improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea  
76 leaves can serve as an antioxidant source in wet noodles and increase the functional value. This study  
77 was undertaken to assess the effect of various concentration of pluchea tea on the physical, chemical  
78 and sensory properties of wet noodles.

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## Materials and Methods

### Preparation of Hot Water Extract from Pluchea Leaf Powder

Young pluchea leaves (1-6) were picked from the shoots, sorted and washed. The selected leaves were dried at ambient temperature for 7 days to yield moisture content of  $10.00 \pm 0.04\%$  dry base<sup>25</sup>. Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at 120°C for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag for about 2 g/tea bag. Pluchea leaf powder in tea bags was extracted using hot water (95°C) for 5 min to get extract concentrations of 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

### Wet Noodles Processing

About 70 mL of hot extract from pluchea leaf powder with concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v) (Table 1) was manually mixed with egg, baking powder, salt and wheat flour for 5 min (Table 2). The mixture was kneaded to form a solid and homogenized dough using a mixer (Oxone Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to form noodle strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled water about 3 min in 300 mL water and coated with oil to prevent the noodles from sticking to each other. Wet noodles made without any addition of hot water of pluchea leaf extract were prepared as control. Wet noodles used in bioactive compounds and antioxidant activity assay were not added with oil to prevent the noodles from sticking to one another. The final characteristics of wet noodles have width and thickness of 0.45 cm and 0.30 cm, respectively.

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101 **Pluchea Wet Noodles Extraction**

102 About 100 g of wet noodles were dried using a freeze-dryer at a pressure of 0.1 bar and  
103 temperature -60°C for 28 hours. Dried noodles were powdered using a chopper machine for 35  
104 seconds. And then, 20 g of samples were mixed by 50 mL absolute methanol by a shaking water-bath  
105 at 35°C, 70 rpm for 1 hour<sup>26</sup>. Filtrate was separated using Whatman filter paper grade 40 and residue  
106 was extracted again with the same procedure. The filtrate was collected and evaporated by rotary  
107 evaporator until getting 3 mL of extract (Buchi Rotary Evaporator; Buchi Shanghai Ltd, China) at 200  
108 bars, 50°C for 60 min. The extract was kept at 0°C before further analysis.

109 **Moisture Content Assay**

110 Moisture content or water content of wet noodles was determined by thermos-gravimetric  
111 method<sup>27</sup>. The moisture content of wet noodles was determined by heating the samples in a drying  
112 oven (Binder, Merck KGaA, Darmstadt, Germany) and weighing the evaporated water content in the  
113 material.

114 **Measurement of Swelling Index**

115 The purpose of swelling index testing was to determine the capability of the noodles to swell  
116 during the boiling process<sup>16</sup>. The assay was done to determine the ability of wet noodles to absorb  
117 water per unit of time or the time needed to fully cook wet noodles. The amount of water absorbed  
118 by wet noodles was measured from the weight before and after boiling.

119 **Determination of Cooking Loss**

120 Cooking loss is one of the necessary quality parameters to establish the quality of wet noodles  
121 after boiling<sup>28</sup>. The cooking loss assay was done by measuring the quantity of solids that leached out

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before extraction

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of the noodles during the boiling process, e.g., starch. A large cooking loss value affects the texture of wet noodles, which is easy to break and less slippery.

#### Determination of Texture

The texture of wet noodles with pluchea extract added was measured based on hardness, adhesiveness, cohesiveness, elongation and elasticity. The texture was analyzed by TA-XT2 texture analyzer (Stable Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the Texture Exponent 32 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were analyzed with a compression assay using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle strands with the length of 4 cm for each strand were laid side by side, touching each other, perpendicular to the 35 mm compression cylinder probe on a flat aluminum base. The cylinder probe was arranged to be at 15 mm distance from the lower plate at the start of the compression test, and was forced down through the noodle strips at the speed of 2 mm s<sup>-1</sup> until it touched the flat base to compress 75% of the noodle thickness, and was drawn back to at the end of the test. The profile curve was determined using a texture analyzer software<sup>24,29</sup>. The hardness was determined as the maximum force per gram. The adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area was obtained from the compression test under the curve. Cohesiveness was analyzed based on the ratio between the area under the second peak and the first peak<sup>24,29,30</sup>. The elongation and elasticity of the noodles were individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. Elongation was the maximum force to change of noodle form and break by extension that was analyzed by a test speed of 3.0 mm s<sup>-1</sup>

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142 between two rollers with a 100 mm distance. The elongation at breaking was calculated per gram.

143 Elasticity was determined by formula (1)<sup>31,32</sup>:

$$144 \quad \text{Elasticity} = \frac{Fx lo}{Ax to} \frac{1}{v} \quad (1)$$

145 where F is the tensile strength, lo is the original length of the noodles between the limit arms (mm), A  
146 is the original cross-sectional area of the noodle (mm<sup>2</sup>), v is the rate of movement of the upper arm  
147 (mm/s), and t is break up time of the noodles (s). The measurement of texture was detected by the  
148 software and expressed as a graph.

#### 149 **Color Measurement**

150 The color of the noodle sheets was determined by a colorimeter (Minolta CR 10, Minolta Co.  
151 Ltd., Osaka, Japan), and the CIE-Lab L\*, a\* and b\* values were analyzed based on the method by Fadzil  
152 et al.<sup>29</sup> The L\* value measured the position on the white/black axis, the a\* value as the position on the  
153 red/green axis, and the b\* value as the position on the yellow/blue axis.

#### 154 **Analysis of Total Phenolic Content**

155 The total phenolic content analysis was analyzed based on the reaction between phenolic  
156 compounds and Folin Ciocalteu (FC) reagent or phosphomolybdic acid and phosphotungstic acid. The  
157 FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups to become a blue molybdenum-  
158 tungsten complex solution<sup>33</sup>. The intensity of the blue color was detected by a UV-Vis  
159 spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 760 nm. In the analysis,  
160 7.5% Na<sub>2</sub>CO<sub>3</sub> solution was added to reach pH 10 that caused an electron transfer reaction (redox). The  
161 obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

162

### 163 **Analysis of Total Flavonoid Content**

164 The flavonoid content assay was done using the spectrophotometric method based on the  
165 reaction between flavonoids and  $\text{AlCl}_3$  to form a yellow complex solution. In the presence of NaOH  
166 solution, a pink color is formed which can be detected by spectrophotometer (Spectrophotometer UV-  
167 Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm<sup>33,34,35</sup>. The obtained data were expressed in mg of catechin  
168 equivalent (CE)/L sample.

### 169 **Analysis of DPPH Free Radical Scavenging Activity**

170 The ability of antioxidant compounds to scavenge DPPH (2,2-diphenyl-1-picrylhydrazyl) free  
171 radicals can be used to evaluate antioxidant activity. The principle of the DPPH method is to measure  
172 the absorbance of compounds that can react with DPPH radicals<sup>36</sup>. Antioxidant compounds can donate  
173 hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced to yellow<sup>37</sup>. The color  
174 change was measured as an absorbance at  $\lambda$  517 nm by spectrophotometer (Spectrophotometer UV  
175 Vis 1800, Shimadzu, Japan)<sup>38</sup>. The data were expressed in mg gallic acid equivalent (GAE)/L dried  
176 noodles sample.

### 177 **Analysis of Iron Ion Reduction Power**

178 This method identifies the capacity of antioxidant components using potassium ferricyanide,  
179 trichloroacetic acid and ferric chloride to produce color complexes that can be measured  
180 spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm<sup>39</sup>. The  
181 principle of this testing is the ability antioxidants to reduce iron ions from  $\text{K}_3\text{Fe}(\text{CN})_6$  ( $\text{Fe}^{3+}$ ) to  $\text{K}_4\text{Fe}(\text{CN})_6$   
182 ( $\text{Fe}^{2+}$ ). Then, potassium ferrocyanide reacts with  $\text{FeCl}_3$  to form a  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$  complex. The color

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change is from yellow to green<sup>40</sup>. The final data were expressed in mg gallic acid equivalent (GAE)/L dried noodles.

### Sensory Evaluation

The hedonic test of all samples of wet noodles involved 100 untrained panelists with an age range of 17 to 25 years. A hedonic test used in this research was the hedonic scoring method, where the panelists gave a preference score value of all samples<sup>41</sup>. The hedonic scores were transformed to numeric scale and analyzed using statistical analysis<sup>42</sup>. The numeric scale in the sensory analysis used a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The panelists were asked to score according to their level of preference for texture, taste, color, flavor and overall acceptability. All the samples were blind coded with 3 digits which differed from each other<sup>43</sup>.

### Statistical Analysis

The research design used in the physicochemical assay was a randomized block design (RBD) with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25 and 30% (w/v). Each treatment was repeated four times that obtained 28 experiment units. A completely randomized design (CRD) was used to evaluate sensory assay with 100 untrained panelists with an aged 17 to 25 years.

The normal distribution and homogeneity data were stated as the mean  $\pm$  SD of the triplicate determinations and were determined using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan Multiple Range Test) at  $p \leq 5\%$  to determine treatment level that gave significant different results. The best treatment of pluchea extract addition on wet noodles was analyzed by a spider web graph.

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## 204 Results and Discussion

205 Wet noodles added with hot extract of pluchea leaf powder were produced to increase the  
206 functional value of wet noodles. This is supported by previous studies related to the potential value of  
207 water extract of pluchea leaf that exhibits biological activities<sup>6,7,41</sup>. In this research, the cooking quality  
208 was observed after cooking wet noodles in 300 mL water/100 g samples for 3 min in boiling water.

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## 209 Cooking Quality

210 Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at 0, 5,  
211 10, 15, 20, 25 and 30% (w/v) was shown in Figure 1, Table 3 and Table 4. The addition of pluchea  
212 extract no significantly influenced the water content, cooking loss, swelling index, chroma, and hue of  
213 the produced wet noodles using statistical analysis by ANOVA at  $p \leq 5\%$ . Water content is one of the  
214 chemical properties of a food product determined shelf life of food products, because the water  
215 content measures the free and weakly bound water in foodstuffs<sup>44,45</sup>. This study identified that the  
216 moisture content of the cooked wet noodles ranged between 64-67% wb. Previous study showed that  
217 the water content of the cooked egg wet noodles was around 54-58% wb<sup>45</sup> and maximum of 65%<sup>20</sup>.  
218 Chairuni et al.<sup>44</sup> stated that the boiling process could cause a change in moisture content from around  
219 35% to around 52%. The Indonesian National Standard<sup>46</sup> stipulates that the moisture content of cooked  
220 wet noodles is a maximum of 65%. This means that only control noodles (without treatment) exhibited  
221 a moisture content similar to the previous information. The obtained data showed a trend that an  
222 extract addition caused an increase in the water content of wet noodles, but statistical analysis at  $p \leq$   
223 5% showed no significant difference. This phenomenon was in accordance with the experimental  
224 results of Juliana et al.<sup>47</sup> that the using of spenochlea leaf extract to making wet noodles, as well as

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225 Hasmawati et al.<sup>20</sup> that the sweet potato leaf extract increased the moisture of fresh noodles. The  
226 water content of pluchea wet noodles was expected by reaction between many components in the  
227 dough that impacted to the swelling index and cooking loss. Mualim et al.<sup>14</sup>, Bilina et al.<sup>22</sup> and Setiyoko  
228 et al.<sup>28</sup> reported that the presence of amino groups in protein and hydroxyl groups in amylose and  
229 amylopectin fractions in wheat flour as raw material for making dough determines the moisture  
230 content, swelling index and cooking loss of wet noodles. The contribution of glutenin and gliadin  
231 proteins in wheat flour to form gluten networks determines the capability of noodles to swell and  
232 retain water in the system. Gliadin acts as an adhesive that causes dough to be elastic, while glutenin  
233 makes the dough to be firm and able to withstand CO<sub>2</sub> gas thus the dough can expand and form pores.  
234 Fadzil et al.<sup>29</sup> found that thermal treatment during the boiling process results in the denaturation of  
235 gluten and caused a monomer of proteins to determine other reactions at the disulfide or sulfhydryl  
236 chain. The existence of phenolic compounds from pluchea extract also increased the capacity of  
237 noodles to absorb water and determined water mobility. Widyawati et al.<sup>41</sup> also confirmed that  
238 hydrophilic compounds of proteins, carbohydrates, and polyphenolic components determine water  
239 mobility due to their ability to bind with water molecules through hydrogen bonding. Tuhumury et al.<sup>48</sup>  
240 informed that gluten formation can inhibit water absorption by starch granules so that can prevent  
241 gelatinization. Therefore, the addition of phenolic compounds from the hot extract of pluchea leaf  
242 powder can inhibit the formation of gluten so that it stimulates gelatinization of starch granules.

243 As a result, the impact of increased the moisture content during boiling had an effect on the  
244 value of the swelling index and cooking loss of the wet noodles. Widyawati et al.<sup>41</sup> said that the swelling  
245 index is the capability to trap water which is dependent on the chemical composition, particle size, and

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246 water content. Gull et al.<sup>49</sup> also confirmed that the swelling index is an indicator to determine water  
247 absorption by starch and protein to make gelatinization and hydration. Setiyoko et al.<sup>28</sup> explained that  
248 cooking loss is the mass of noodle solids that come out of the noodle strands for boiling. Gull et al.<sup>49</sup>  
249 added that soluble starch and other soluble components leach out into the water during the cooking  
250 process, making the cooking water turned thicker. The moisture content results (64-67% wb) showed  
251 that the produced wet noodles exceeded the moisture content limit of wet noodles after cooking,  
252 which is between 54-58%<sup>44</sup>, while the cooking loss value of wet noodles should not be more than  
253 10%<sup>28</sup>. In this study, the cooking loss value was 3-4.2%. The cooking loss of samples during boiling  
254 noodles were caused the breaking of the bonding network that the polysaccharides are released and  
255 the gluten network breaks because of the addition of pluchea leaf extract. Widyawati et al.<sup>41</sup> supported  
256 that polyphenol can be bound with protein and starch with many non-covalent interactions, such as  
257 hydrogen bonding, electrostatic interaction, hydrophobic interaction, Van der Waal's interaction, and  
258  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch to undergo  
259 gelatinization and gliadin and glutelin from the protein of wheat flour to form gluten.

260 The swelling index value obtained from this research was around 56-68 %. Based on the  
261 previous research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.)  
262 fruit was around 51%<sup>50</sup>. This means that the addition of pluchea leaf extract in wet noodles also affects  
263 the ability of noodles to absorb water. Widyawati et al.<sup>41</sup> and Suriyaphan<sup>6</sup> noted that bioactive  
264 compounds in hot water extract of pluchea leaf tea include 3-*O*-caffeoylquinic acid, 4-*O*-caffeoylquinic  
265 acid, 5-*O*-caffeoylquinic acid, 3,4-*O*-dicaffeoylquinic acid, 3,5-*O*-dicaffeoylquinic acid, 4,5-*O*-  
266 dicaffeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total

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anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was higher than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from extract in absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch granules to absorb water so that the swelling index and cooking loss increased. Suriyaphan<sup>6</sup> informed that hot extract of pluchea leaf tea contains 1.79 g/100 g protein, 8.65 g/100 g carbohydrate, and fiber (0.45 g/100 g soluble and 0.89 g/100 g insoluble), these compounds can involve in increasing the swelling index from pluchea wet noodles.

Color is one of the physical characteristics possessed by wet noodles that becomes a benchmark for consumer acceptance. This research found that the color of wet noodles was influenced by the addition of pluchea extract. The addition of pluchea leaf extract no significant affected the redness ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it influenced the yellowness ( $b^*$ ) and lightness ( $L^*$ ) values. Using of pluchea leaf powder brewing decreased the brightness of wet noodles significantly, as the concentration of the extract increased. This is related to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to experience color changes. According to Widyawati et al.<sup>8</sup> tannins are water-soluble compounds that can give a brown color. Suriyaphan<sup>6</sup> and Widyawati et al.<sup>41</sup> also stated that Khlu tea from pluchea leaves contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and 6.39 mg/100 g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow color. Gull et al.<sup>49</sup> stated that this pigment was easily changed in the paste sample due to the swelling and discoloration of the pigment during cooking.

Thus, the addition of hot water extract of pluchea leaf powder significantly reduced the

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288 brightness of wet noodles, because brown-colored noodles were produced as the concentrations of  
289 added pluchea leaf extract increased. However, increasing the concentration of this extract had no  
290 influenced on the redness, hue, and chroma values in ANOVA at  $p \leq 5\%$ . The results showed that the  
291 redness value of wet noodles revolved from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet  
292 noodles ranged from  $82.1 \pm 3.1$  to  $86.5 \pm 1.0$ . Based on this value, the color of wet noodles is in the  
293 yellow to the red color range<sup>51</sup>, thus the visible color of the wet noodle product was yellow to brown  
294 (Figure 1). Yellowness increased significantly with the addition of pluchea leaf extract and the value  
295 ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the availability of tannins and chlorophyll  
296 compounds from pluchea leaf extract. The chroma value of wet noodles was obtained within the range  
297 of  $15.6 \pm 1.5$  to  $19.8 \pm 3.4$ . This means that the brewing of pluchea leaf powder did not change the  
298 intensity of the brown color in the resulting wet noodles.

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299 Texture analysis of pluchea wet noodles added with various concentrations of hot water extract  
300 from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness,  
301 elongation, and elasticity. Hardness is the maximum force given to a product until deformation<sup>52,53</sup>.  
302 From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher  
303 peak of graph shows the harder product<sup>30</sup>. Adhesiveness is force or tackiness that is required to pull  
304 the product from its surface, its value is obtained from the area between the first and second  
305 compressions<sup>54,55</sup>. Adhesiveness values show negative value; the bigger negative value means the  
306 product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and  
307 second compressions<sup>53,55</sup>. This is an indication of the internal forces that make up the product<sup>56</sup>.  
308 Elongation is the change in length of noodles when being exposed to a tensile force until the noodles

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break<sup>57</sup>. Elasticity is the time required for the product to withstand the load until it breaks. The more elastic a product, the longer the holding time. The data showed that the higher concentration of pluchea leaf powder within the hot water extract caused a significant increase in the hardness, stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati et al.<sup>41</sup> informed that the polyphenols contained in pluchea leaf extract can weakly interact either covalently or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups that are polar. Amoako and Akiwa<sup>58</sup> and Zhu et al.<sup>59</sup> have also proven that polyphenolic compounds can interact with carbohydrates through the interaction of two hydrophobic and hydrophilic functional groups with amylose. Diez-Sánchez et al.<sup>60</sup> stated that polyphenolic compounds can interact with amylose and protein helical structures and largely determined by molecular weight, conformational mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and amylopectin can affect the gelatinization process in the amylose helical structure and interfere with the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss (> 98%) and swelling index (56.2 to 67.7%) data, it can be concluded that the interaction that occurs between the phenol group in pluchea leaf extract with amylose and protein was weak. The bioactive components of pluchea leaf extract are thought to affect the formation of disulfide cross-links (S-S) and turn into to form sulfhydryl groups (-SH) under the influence of heat. Ananingsih

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330 and Zhou<sup>61</sup> said that antioxidant compounds are a reducing agent that can have an impact on reducing  
331 S-S bonds and increasing the number of SH groups in the dough to produce a harder texture. According  
332 to Rahardjo [et al.](#)<sup>54</sup> phenolic compounds are hydroxyl compounds that influence the strength of the  
333 dough, where the higher the component of phenol compounds will weaken the gluten matrix and the  
334 dough thus becoming unstable. The instability of the dough can cause the texture to become hard.

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335 Many researchers also find that tannins and phenols influence the networking S-S bond in the  
336 dough of wet noodles. Wang [et al.](#)<sup>62</sup> showed that tannins increase the relative amount of large, medium  
337 polymers in the gluten protein network so as to improve the dough quality. Zhang [et al.](#)<sup>63</sup> said that  
338 these polymer compounds are the results of interactions or combinations of protein-tannin

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339 compounds that form bonds with the type of covalent bonds, hydrogen bonds, or ionic bonds. Rauf  
340 and Andini<sup>64</sup> also added that phenol compounds can **reduce** S-S bonds to SH bonds. SH is a type of thiol

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341 compound group, where the thiol group can influence the stickiness, viscosity, cohesiveness,  
342 elongation, and extensibility of the dough. Wang [et al.](#)<sup>65</sup> found the effect of phenolic compounds from

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343 green tea extract to increase the stickiness of wheat bread. The cohesiveness of the dough is formed  
344 due to a large number of thiol bonds formed, thus increasing the viscosity of the dough. The increased  
345 viscosity of the dough is thought to be due to the formation of polyphenolic compounds with thiol

346 groups, as in the research of Ananingsih and Zhou<sup>61</sup> that the formation of catechin-thiol can increase  
347 the viscosity of the dough and increase the stability of the dough. Zhu [et al.](#)<sup>66</sup> **mentioned** that the

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348 addition of phenolic compounds from green tea was able to increase the PV (peak viscosity) of wheat  
349 flour. Wang [et al.](#)<sup>62</sup> also found that the cohesiveness of the dough is influenced by tannins, where

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350 tannins can produce micro-glutens so as to produce a compact dough and increase the gluten network.

351 The addition of pluchea leaf extract in making wet noodles could influence the elongation of wet  
352 noodles due to the components of polyphenol compounds such as tannins that can reduce the number  
353 of free amino groups. This is supported by Zhang et al.<sup>30</sup> and Wang et al.<sup>62</sup> support the formation of  
354 other types of covalent bonds, such as bonds between amino groups and hydroxyl groups, by forming  
355 hydrogen bonds between phenolic compounds and protein gluten so as to improve the quality of  
356 dough strength and dough extensibility.

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#### 357 Bioactive Compounds and Antioxidant Activity

358 Wet noodles added with pluchea leaf powder were analyzed based on its bioactive compounds  
359 and antioxidant activities. The analysis was conducted to determine the functional properties of wet  
360 noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles are  
361 presented in Table 5. The measured bioactive compounds (BC) included total phenolic content (TPC)  
362 and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical scavenging  
363 activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea  
364 leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed  
365 that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a  
366 tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed  
367 that there was a positive and strong correlation between TPC and DPPH ( $r = 0.990$ ), TPC and FRAP ( $r =$   
368  $0.986$ ), TFC and DPPH ( $r = 0.974$ ), and TFC and FRAP ( $r = 0.991$ ). This means that the antioxidant activity  
369 of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah et al.<sup>67</sup> informed that the PC  
370 ( $r > 0.699$ ) indicates the strength and linear correlation between antioxidant activity (AA) and TPC, and  
371 also shows a strong positive relationship but PC ( $r < 0.699$ ) obtains a moderately positive relationship.

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If the r value of TFC and AA is lower than TPC and AA, it indicates that the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship which is expected because both classes all contributed to AA plants. Aryal et al.<sup>68</sup> and Muflihah et al.<sup>67</sup> informed that phenolic compounds are soluble natural antioxidants and potential donating electrons depend on their number and position of hydroxyl groups contributed to antioxidant action. Consequently, these groups are responsible to scavenge the free radicals that TPC of pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the stable purple-colored to the yellow-colored solution. Based on FRAP analysis, it was showed that the bioactive compounds contained in pluchea wet noodles are a potential source of antioxidants because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive compounds contained in pluchea wet noodles can function as primary and secondary antioxidants. Research data showed that the cooking quality of wet noodles tends to increase along with the increase in the value of TPC, TFC, DPPH and FRAP.

### Sensory Evaluation

Sensory pluchea wet noodles, namely color, aroma, taste, texture, and overall acceptance, were carried out using a hedonic test to determine the level of consumer preference for the product. This test was conducted to determine the quality differences between the products and to provide an assessment on certain properties<sup>42</sup>. The hedonic test itself is the most widely used test to determine the level of preference for production<sup>69</sup>. The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

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392 The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm$   
 393  $1.26$  (neutral-like). The statistical analysis showed that the higher concentration of hot water extract  
 394 addition decreased lower color preference of wet noodles. The higher concentration of pluchea extract  
 395 could reduce the level of preference for color because the color of the wet noodles was darker than  
 396 control and turned to dark brown. This color change was due to the pluchea extract containing several  
 397 components, including chlorophyll and tannins, which can alter the of wet noodles' color to be  
 398 browner along with the increase in the concentration of pluchea extract. This result was in accordance  
 399 to the effect of color analysis performed using color reader where the pluchea wet noodles' brightness  
 400 declined, yellowness increased, and the color intensity increased with an increased concentration of  
 401 pluchea extract. The occurrence of this process is related to the effect of light and heat on pluchea leaf  
 402 powder which causes the degradation of chlorophyll into brown pheophytin due to drying, where the  
 403 nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals<sup>70,71</sup>.

404 Aroma is one of the parameters in sensory evaluation using the sense of smell and is an  
 405 indicator of the assessment of a product<sup>72</sup>. The results of the preference value for aroma were ranged  
 406 from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet  
 407 noodles reduced the preference score for aroma due to distinct dry leaves (green) aroma. According  
 408 to Lee et al.<sup>73</sup> the unpleasant aroma on leaves comes from a group of aliphatic aldehyde compounds.  
 409 The appearance of a distinctive leaf aroma in noodles is due to aromatic compounds. According to  
 410 Martiyanti and Vita<sup>74</sup> aromatic compounds are chemical compounds that have an aroma or odor when  
 411 the conditions are met, which is volatile, while Widyawati et al.<sup>75</sup> informed that pluchea leaves were  
 412 detected to have 66 volatile compounds. The appearance of the aroma is due to the volatile

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413 compounds in the raw material reacting with water vapor when boiling the noodles. In addition, there  
414 is also an oxidation process of polyphenolic compounds such as catechins or tannins that can produce  
415 an aroma in pluchea wet noodles.

416 According to Martiyanti and Vita<sup>3</sup> taste attribute is one important sensory aspect in food  
417 products and has a great impact on the food selection by consumers. Tongue **is** able to detect basic  
418 tastes, namely sweet, salty, sour, and bitter, at different points. Lamusu<sup>71</sup> declared that taste is a  
419 component of flavor and an important criterion in assessing a product that is accepted by the tongue.  
420 The preference test of the taste of pluchea wet noodles resulted in values ranging from **4.15 ± 1.40 to**  
421 **5.50 ± 1.28** (neutral-slightly like). The increase in concentrations of pluchea extract was negatively  
422 correlated to the preference level of **the taste of** pluchea wet **noodles** assessed by the panelists. The  
423 statistical analysis results showed that the difference in the concentration of the extract significant  
424 influenced on the preference score for the taste of pluchea wet noodles. The increased concentration  
425 of pluchea extract produced a distinctive taste on wet noodles, such as a bitter **and** astringent tastes,  
426 due to the presence of compounds such as tannins and alkaloids from the pluchea leaves. Susetyarin<sup>76</sup>  
427 said that pluchea leaves contain tannins (**2.35%**), and alkaloids (**0.32%**). According to Pertiwi<sup>77</sup>, tannin  
428 compounds dominate the bitter and astringent taste, while alkaloid compounds cause a bitter taste.  
429 The high level of taste preference for wet noodles was found in noodles with lower content of pluchea  
430 extract.

431 Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and  
432 swallowed) or touched with **fingers**<sup>78</sup>. Texture testing performed by the panelist is called mouthfeel  
433 testing. According to Martiyanti and Vita<sup>74</sup>, mouthfeel is the kinesthetic effect of chewing food in the

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434 mouth. In this study, the preference test results on the texture of pluchea wet noodles revolved from  
435  $5.5 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy  
436 and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet  
437 noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that  
438 can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and  
439 draining noodles. Subjective testing results based on sensory evaluation were in line with the objective  
440 testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to  
441 break, and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea  
442 wet noodles was influenced by the fiber and protein components. According to Shabrina<sup>79</sup>, the  
443 components of fiber, protein, and starch **complete** to bind water. Texture changes are also influenced  
444 by the polyphenol compositions in the pluchea extract which is able to reduce S-S bonds to SH bonds,  
445 where the increase in SH (thiol) groups can give a hard, sticky, and compact **texture**<sup>62,64,65</sup>. Besides, a  
446 high concentration of tannins capable of binding to proteins to form complex compounds into tannins-  
447 proteins are also able to build noodles' texture.

448 The interaction between color, aroma, taste, and texture created an overall taste of the food  
449 product and was assessed as the overall preference. The highest value on the overall preference was  
450 derived from control wet noodles, i.e., 6.63 (slightly like it), while the wet noodles added with 20%  
451 (w/v) concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The  
452 addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to  
453 10% (w/v) concentration with scores of 6.63 and 6.53, respectively. The area of the spider web chart  
454 for each treatment with the various concentrations of pluchea extract was seen in Figure 2. The best

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455 treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37  
456 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the  
457 scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like),  
458 respectively.

459 The use of pluchea leaf extract in the making of wet noodles was able to increase the functional  
460 value of wet noodles, based on the levels of bioactive compounds and antioxidant activity without  
461 changing the quality of cooking, which includes water content, swelling index and cooking loss. Besides  
462 that, the use of pluchea leaf extract did not significantly change the color and color intensity of the  
463 resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet  
464 noodles produced were still acceptable to the panelists, the addition of pluchea leaf extract as much  
465 as 10% (w/v) was the best treatment with an assessment that was almost close to the control wet  
466 noodles (without treatment).

#### 467 Conclusion

468 Addition of hot water extract of pluchea leaf powder influenced physical, chemical and sensory  
469 properties of wet noodles. Lightness, texture, bioactive compound content, antioxidant activity, and  
470 sensory properties of samples underwent significant difference. The higher concentration of pluchea  
471 extract caused the bigger these parameters of pluchea wet noodles. Using 10% (w/v) of hot water  
472 extract from pluchea leaf powder was the best treatment with color, aroma, taste, and texture scores  
473 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. Utilization of  
474 hot water extract of pluchea leaf powder at 10% (w/v) resulted wet noodle functional with TPC, TFC,  
475 DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg dried samples, 62.44



476 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples and 51.33 mg GAE/kg dried samples,  
477 respectively.

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479 **Notes on Appendices**

TPC	Total phenolic content
TFC	Total flavonoid content
DPPH	2,2-Diphenyl-1-picrylhydrazyl free radical
FRAP	Ferric reducing antioxidant power
AA	Antioxidant activity
PC	Pearson Correlation
LDL	Low Density Lipoprotein
w/v	Weight per volume
CRD	Completely randomized design
CE	Catechin equivalent
GAE	Gallic acid equivalent
BC	Bioactive compounds
ANOVA	Analysis of variance
UV-Vis	Ultra violet-visible

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714

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715 Table 1. **Information of hot water extract of pluchea tea**

Materials	Concentration of hot water extract of pluchea leaf tea (% w/v)						
	0	5	10	15	20	25	30
Pluchea leaf tea (g)	0	10	20	30	40	50	60
Hot water (mL)	200	200	200	200	200	200	200

716

717



718 **Table 2. Ingredients** of pluchea wet noodles

Materials	Unit	Quantity
Wheat flour	g	200
Egg	g	40
Salt	g	4
Baking powder	g	2
Hot water extract	mL	70
Tapioca flour	g	10
TOTAL	g	326

719

**Table 3.** Color, moisture content, swelling index, and cooking loss of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Color					Moisture content (% wb)	Swelling index (%)	Cooking loss (%)
	L*	a*	b*	C	h			
0	67.1 ± 1.8 <sup>a</sup>	0.97±0.30	16.18±0.62 <sup>ab</sup>	16.2 ± 0.6	86.5 ± 1.0	63.90±1.51	56.2±17.4	3.40±1.31
5	59.5 ± 2.7 <sup>b</sup>	2.18±0.93	15.47±1.46 <sup>a</sup>	15.6 ± 1.5	82.1 ± 3.1	65.08±4.33	62.4±4.7	3.33±1.26
10	59.0 ± 1.8 <sup>b</sup>	1.95±1.66	16.76±2.33 <sup>abc</sup>	17.1 ± 2.2	83.3 ± 5.4	64.97±3.89	61.5±7.5	3.00±1.16
15	58.4 ± 2.2 <sup>b</sup>	1.69±1.48	19.72±3.50 <sup>c</sup>	19.8 ± 3.4	84.7 ± 4.6	65.56±2.18	63.1±6.3	3.31±0.92
20	56.5 ± 2.4 <sup>b</sup>	1.97±1.24	19.09±2.97 <sup>bc</sup>	19.2 ± 2.9	83.6 ± 4.3	66.81±1.81	67.7±5.9	4.06±0.51
25	59.1 ± 2.5 <sup>b</sup>	1.95±1.44	19.55±2.97 <sup>c</sup>	19.6 ± 2.9	83.8 ± 4.0	66.04±0.85	64.5±10.3	3.93±1.37
30	57.1 ± 2.1 <sup>b</sup>	2.09±1.51	18.08±4.94 <sup>abc</sup>	18.3 ± 4.8	82.5 ± 5.2	66.65±2.16	64.0±5.3	4.23±1.34

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$

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**Table 4.** Texture of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Texture of pluchea wet noodle				
	Hardness (N)	Adhesiveness (g sec)	Cohesiveness	Elongation (%)	Elasticity (Pa)
0	135.8±5.9 <sup>a</sup>	-2.7 ±2.3 <sup>d</sup>	0.75±0.01 <sup>a</sup>	86.9±0.9 <sup>a</sup>	25336.7±104.2 <sup>a</sup>
5	120.1±2.1 <sup>a</sup>	-3.4±0.6 <sup>cd</sup>	0.68±0.00 <sup>b</sup>	97.3±1.6 <sup>b</sup>	25898.3±760.9 <sup>b</sup>
10	134.9±1.8 <sup>a</sup>	-3.9±0.7 <sup>bc</sup>	0.74±0.00 <sup>c</sup>	162.1±1.5 <sup>c</sup>	25807.7±761.9 <sup>b</sup>
15	180.5±5.1 <sup>b</sup>	-4.9±0.5 <sup>b</sup>	0.74±0.01 <sup>c</sup>	164.7±0.6 <sup>c</sup>	26971.6±516.7 <sup>b</sup>
20	195.1±14.1 <sup>b</sup>	-5.0±1.3 <sup>ab</sup>	0.75±0.01 <sup>cd</sup>	221.6±1.6 <sup>d</sup>	27474.4±453.8 <sup>b</sup>
25	244.6±8.8 <sup>c</sup>	-6.0±0.3 <sup>a</sup>	0.75±0.00 <sup>cd</sup>	230.7±0.7 <sup>e</sup>	27367.1±287.5 <sup>b</sup>
30	282.8±28.3 <sup>d</sup>	-6.1±0.2 <sup>a</sup>	0.79±0.01 <sup>d</sup>	255.4±0.4 <sup>f</sup>	26687.5±449.2 <sup>b</sup>

Note: the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$

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**Table 5.** Total phenol content, total flavonoid content, the DPPH free radical scavenging activity, and iron ion reducing power of the pluchea wet noodles.

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	TPC (mg GAE/kg Dried Noodles)	TFC (mg CE/kg Dried Noodles)	DPPH (mg GAE/kg Dried Noodles)	FRAP (mg GAE/kg Dried noodles)
0	39.26±0.66 <sup>a</sup>	32.36±1.47 <sup>a</sup>	96.75±4.26 <sup>a</sup>	25.96±0.25 <sup>a</sup>
5	61.09±3.80 <sup>b</sup>	46.31±2.15 <sup>b</sup>	121.36±3.58 <sup>b</sup>	34.50±1.71 <sup>b</sup>
10	82.84±3.11 <sup>c</sup>	62.44±0.55 <sup>c</sup>	130.68±4.82 <sup>c</sup>	51.33±2.19 <sup>c</sup>
15	101.48±2.16 <sup>d</sup>	84.67±1.22 <sup>d</sup>	142.48±2.14 <sup>d</sup>	58.69±2.14 <sup>d</sup>
20	114.94±4.20 <sup>e</sup>	100.14±1.50 <sup>e</sup>	148.84±3.20 <sup>e</sup>	67.26±0.06 <sup>e</sup>
25	128.06±1.38 <sup>f</sup>	107.93±0.89 <sup>f</sup>	157.51±7.69 <sup>f</sup>	69.53±1.06 <sup>f</sup>
30	136.35±1.16 <sup>g</sup>	131.69±1.56 <sup>g</sup>	166.97±1.53 <sup>g</sup>	84.98±0.11 <sup>g</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

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**Table 6.** Effect of hot water extract from pluchea leaf powder to preferences for color, aroma, taste, texture, and overall acceptance of wet noodles at various concentrations

Concentration of Hot		Hedonic Score			
Extract from Pluchea					
Leaf Powder (% w/v)	Color	Aroma	Taste	Texture	Overall acceptance
0	6.19±1.25 <sup>d</sup>	5.52±1.08	5.50±1.18 <sup>c</sup>	6.20±1.13 <sup>b</sup>	6.63±1.49 <sup>c</sup>
5	5.62±1.28 <sup>c</sup>	5.52±0.83	5.51±1.29 <sup>c</sup>	6.37±1.14 <sup>bc</sup>	6.40±1.52 <sup>c</sup>
10	5.62±1.21 <sup>c</sup>	5.45±0.85	5.46±1.12 <sup>c</sup>	6.53±1.14 <sup>c</sup>	6.53±1.64 <sup>c</sup>
15	5.14±1.25 <sup>b</sup>	4.81±1.04	4.61±1.11 <sup>b</sup>	6.13±1.09 <sup>b</sup>	5.78±1.67 <sup>b</sup>
20	4.91±1.32 <sup>b</sup>	4.54±1.18	4.47±1.15 <sup>ab</sup>	5.80±1.06 <sup>a</sup>	5.17±1.70 <sup>a</sup>
25	4.54±1.40 <sup>a</sup>	4.26±1.23	4.20±1.24 <sup>a</sup>	5.50±1.04 <sup>a</sup>	5.23±1.75 <sup>a</sup>
30	4.47±1.33 <sup>a</sup>	4.05±1.34	4.15±1.40 <sup>a</sup>	5.59±1.05 <sup>a</sup>	5.37±1.91 <sup>a</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means

with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

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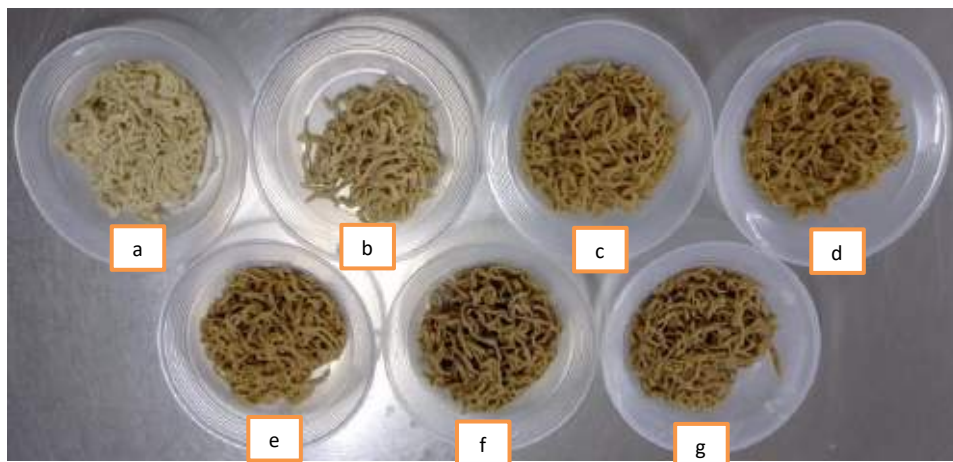


Figure 1. Wet noodles with hot water extract of pluchea leaf powder added at concentrations

a. 0%; b. 5%; c. 10%; d. 15%; e. 20%; f. 25%; and g. 30% w/v

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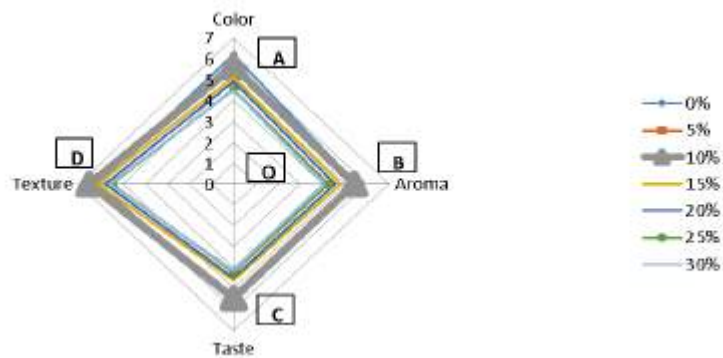


Figure 2. Spider web graph of sensory evaluation on wet noodles at various concentrations of hot water extract from pluchea leaf powder



Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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## Request for Review - 3638

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**Managing Editor** <info@foodandnutritionjournal.org>

Thu, Mar 23, 2023 at 3:25 PM

To: Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

Dear Dr Paini,

Thank you for your email. We understand your concern.

Kindly send us both of the re-evaluation response forms with the mentioned explanation addressing the reviewer's comments and your response. also, regarding the **"GC-MS and FTIR data"**.

Let us know if you need any further assistance.

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Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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## Request for Review - 3638

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**Paini Sri Widyawati** <paini@ukwms.ac.id>

Thu, Mar 23, 2023 at 9:24 PM

To: Managing Editor &lt;info@foodandnutritionjournal.org&gt;

Dear Ms Yanha Ahmed

I have completed and sent both of the re-evaluation forms.  
Thanks for attentions

Regards

Paini Sw

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### 2 attachments

**Response Form 1 (2).docx**

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**Response Form 2 (2).docx**

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## Author's Response to Reviewer's Comments

Reviewer number 1

Paper title: The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

Title	Reviewer's Comments	Author's Response
Abstract Should be more scientifically written, English has to be improved throughout the manuscript. References must be uniform.		Author receives reviewer suggestion
Keywords		Author receives reviewer suggestion
Introduction		Author receives reviewer suggestion
Methodology		Author receives reviewer suggestion and revises blue words
Results		Author receives reviewer suggestion and revises blue words
Discussion		Author receives reviewer suggestion and revises blue words
Conclusion		Author receives reviewer suggestion
References (Appropriateness)		Author receives reviewer suggestion and revises blue words

## Author's Response to Reviewer's Comments

Reviewer number 2

Paper title: The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

Title	Reviewer's Comments	Author's Response
Abstract		Author receives reviewer suggestion
Keywords		Author receives reviewer suggestion
Introduction		Author receives reviewer suggestion
Methodology		Author doesn't fulfill reviewer suggestion to add GC-MS and FTIR data because author doesn't do these analysis
Results		Author receives reviewer suggestion
Discussion		Author receives reviewer suggestion
Conclusion		Author receives reviewer suggestion
References (Appropriateness)		Author receives reviewer suggestion



Paini Sri Widyawati <paini@ukwms.ac.id>

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## Request for Review - 3638

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**Managing Editor** <info@foodandnutritionjournal.org>

Fri, Mar 24, 2023 at 12:35 PM

To: Paini Sri Widyawati <paini@ukwms.ac.id>

Dear Dr Paini,

We would like to inform you that kindly mention the improvements done by the author in response to the reviewer's comments.

Kindly do the needful and update you soon accordingly.

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Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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## Request for Review - 3638

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**Paini Sri Widyawati** <paini@ukwms.ac.id>

Fri, Mar 24, 2023 at 6:37 PM

To: Managing Editor &lt;info@foodandnutritionjournal.org&gt;

Dear Ms Yanha Ahmed

I send my manuscript revise and re-evaluation forms

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### 3 attachments

**Response Form 1 (2).docx**  
49K**Response Form 2 (2).docx**  
48K**The Effect of Hot Water Extract of Pluchea indica Leaf Powder on the Physical-Revision.docx**  
754K

## Author's Response to Reviewer's Comments

Reviewer number 1

Paper title: The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

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Abstract Should be more scientifically written, English has to be improved throughout the manuscript. References must be uniform.		Author receives reviewer suggestion
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Conclusion		Author receives reviewer suggestion
References (Appropriateness)		Author receives reviewer suggestion and revises blue words

## Author's Response to Reviewer's Comments

Reviewer number 2

Paper title: The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

Title	Reviewer's Comments	Author's Response
Abstract		Author receives reviewer suggestion
Keywords		Author receives reviewer suggestion
Introduction		Author receives reviewer suggestion
Methodology		Author doesn't fulfill reviewer suggestion to add GC-MS and FTIR data because author doesn't do these analysis
Results		Author receives reviewer suggestion
Discussion		Author receives reviewer suggestion
Conclusion		Author receives reviewer suggestion
References (Appropriateness)		Author receives reviewer suggestion

## The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

### Abstract

Powdered *Pluchea indica* Less leaves have been utilized as herbal tea, brewing of pluchea tea in hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional value and influence physic, chemical, and sensory characteristics of food. The study was done to assess the effect of various concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with pluchea tea at concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v). Physical properties analyzed included water content, swelling index, cooking loss, color and texture. Chemical properties measured were bioactive contents of total phenolic content, total flavonoid content, and antioxidant ability to scavenge DPPH free radicals and to reduce iron ions. Sensory properties determined were taste, texture, color, aroma and overall acceptance. The addition of various concentrations of extract gave significantly effects on parameters of physical, chemical and sensory properties of noodles, except color (redness, chroma and hue), cooking loss, water content, swelling index and aroma. Using of 10% (w/v) of pluchea tea resulted in the best sensory properties such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. Generally, the study concluded that wet noodles can be made by adding pluchea tea at 10% (w/v). Dried samples TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg, 62.44 mg CE/kg, 130.68 mg GAE/kg and 51.33 mg GAE/kg, respectively.

### Key-words

Chemical, *Pluchea indica* Less, physical, sensory, wet noodles

### Introduction

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food<sup>1,2</sup>. The potency of pluchea leaves is related to phytochemical compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone, alkaloid, lignans and saponins<sup>2,3,4,5</sup>. Chan et al.<sup>1</sup> also reported that caffeoylquinic acids, phenolic acids, flavonoids and thiophenes in pluchea leaves are compounds with antioxidant activities. Furthermore,

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37 pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100 g, fat 0.49 g/100 g, insoluble dietary  
38 fiber 0.89 g/100 g, soluble dietary fiber 0.45 g/100 g, carbohydrate 8.65 g/100 g, calcium 251 mg/100  
39 g,  $\beta$ -carotene 1.225  $\mu$ g/100 g<sup>6</sup>.

40 **Pluchea tea brewed from pluchea leaves** has been proven to exhibit antioxidant activity<sup>6,7,8</sup>,  
41 anti-diabetic activity<sup>9</sup>, anti-inflammatory activity<sup>7</sup>, **anti-human** LDL oxidation activity<sup>10</sup>. Previous  
42 research uses pluchea leaf powder to make several food products to increase functional values, i.e.,  
43 jelly drink<sup>11</sup>, soy milk<sup>12</sup> and steamed bun<sup>13</sup>. Using 1% (w/v) pluchea leaf powder can improve the  
44 physicochemical properties of jelly drink and increase panelists' acceptance of the product<sup>11</sup>. Soy milk  
45 with the addition of pluchea leaves increases the viscosity and total dissolved solids and decreases the  
46 panelist acceptance rate<sup>12</sup>. The addition of 6% (w/v) brewing from pluchea leaf powder on steamed  
47 bun is the best treatment with the lowest level of hardness<sup>13</sup>. All previous research has proven that the  
48 addition of pluchea leaves can increase the bioactive compound contents based on total phenol and  
49 total flavonoids, as well as increase **the** antioxidant activity based on ferric reducing power and ability  
50 to scavenge DPPH free **radicals**.

51 To the best of our knowledge, the study of the addition of **of pluchea** tea in making wet noodles  
52 from wheat flour has not been conducted, as well as its impact on physicochemical and organoleptic  
53 characteristics of the noodles. Noodles are a popular food product that is widely consumed in the  
54 world. Indonesia is one of the countries with the largest noodle consumption after China<sup>14</sup>. Wet  
55 noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet noodles as an  
56 alternative to wet noodles, which contain higher protein, and the second popular food in ASEAN  
57 regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia<sup>16</sup>. The

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58 addition of other ingredients has been endeavored to enhance wet noodles' specific properties. Many  
59 researchers incorporated plant extracts or natural products to increase functional properties of wet  
60 noodles, such as red spinach<sup>17</sup>, green tea<sup>18,19</sup>, purple sweet potato leaves<sup>20</sup>, moringa leaves<sup>21</sup>, sea  
61 weed<sup>22</sup>, ash of rice straw, turmeric extract<sup>23</sup>, and betel leaf extract<sup>24</sup> that influenced the physical,  
62 chemical, and organoleptic properties of the wet noodles. The anthocyanin of red spinach ethanolic  
63 extract increased the hedonic score of wet noodles' flavor<sup>17</sup>. The addition of green tea improves the  
64 stability, elastic modulus and viscosity, retrogradation and cooking loss with, no significant effect on  
65 mouth-feel and overall acceptance from panelist on the produced wet noodles<sup>18</sup>. Moreover, the  
66 addition of sweet potatoes leaf extract on wet noodles increases moisture content, protein value and  
67 ash concentration, and improves hedonic score of texture<sup>20</sup>. Moringa extract influences protein  
68 content and decrease panelist acceptance of color, aroma and taste of wet noodles<sup>21</sup>. The use of  
69 seaweed to produce wet noodles influences moisture content, swelling index, absorption ability,  
70 elongation value and color<sup>22</sup>. The addition of ash from rice straw and turmeric extract influence the  
71 elasticity and sensory characteristics (color, taste, aroma and texture) of wet noodles<sup>23</sup>. Betel leaf  
72 extract used to make Hokkien (with dark soya source) noodles improves texture and acceptance score  
73 of all sensory attributes<sup>24</sup>.

74 Bioactive compounds and nutritive value of pluchea leaf can be an alternative ingredient to  
75 improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea  
76 leaves can serve as an antioxidant source in wet noodles and increase the functional value. This study  
77 was undertaken to assess the effect of various concentration of pluchea tea on the physical, chemical  
78 and sensory properties of wet noodles.

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## Materials and Methods

### Preparation of Hot Water Extract from Pluchea Leaf Powder

Young pluchea leaves (1-6) were picked from the shoots, sorted and washed. The selected leaves were dried at ambient temperature for 7 days to yield moisture content of  $10.00 \pm 0.04\%$  dry base<sup>25</sup>. Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at 120°C for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag for about 2 g/tea bag. Pluchea leaf powder in tea bags was extracted using hot water (95°C) for 5 min to get extract concentrations of 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

### Wet Noodles Processing

About 70 mL of hot extract from pluchea leaf powder with concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v) (Table 1) was manually mixed with egg, baking powder, salt and wheat flour for 5 min (Table 2). The mixture was kneaded to form a solid and homogenized dough using a mixer (Oxone Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to form noodle strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled water about 3 min in 300 mL water and coated with oil to prevent the noodles from sticking to each other. Wet noodles made without any addition of hot water of pluchea leaf extract were prepared as control. Wet noodles used in bioactive compounds and antioxidant activity assay were not added with oil to prevent the noodles from sticking to one another. The final characteristics of wet noodles have width and thickness of 0.45 cm and 0.30 cm, respectively.

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101 **Pluchea Wet Noodles Extraction**

102 About 100 g of wet noodles were dried using a freeze-dryer at a pressure of 0.1 bar and  
103 temperature -60°C for 28 hours. Dried noodles were powdered using a chopper machine for 35  
104 seconds. And then, 20 g of samples were mixed by 50 mL absolute methanol by a shaking water-bath  
105 at 35°C, 70 rpm for 1 hour<sup>26</sup>. Filtrate was separated using Whatman filter paper grade 40 and residue  
106 was extracted again with the same procedure. The filtrate was collected and evaporated by rotary  
107 evaporator until getting 3 mL of extract (Buchi Rotary Evaporator; Buchi Shanghai Ltd, China) at 200  
108 bars, 50°C for 60 min. The extract was kept at 0°C before further analysis.

109 **Moisture Content Assay**

110 Moisture content or water content of wet noodles was determined by thermos-gravimetric  
111 method<sup>27</sup>. The moisture content of wet noodles was determined by heating the samples in a drying  
112 oven (Binder, Merck KGaA, Darmstadt, Germany) and weighing the evaporated water content in the  
113 material.

114 **Measurement of Swelling Index**

115 The purpose of swelling index testing was to determine the capability of the noodles to swell  
116 during the boiling process<sup>16</sup>. The assay was done to determine the ability of wet noodles to absorb  
117 water per unit of time or the time needed to fully cook wet noodles. The amount of water absorbed  
118 by wet noodles was measured from the weight before and after boiling.

119 **Determination of Cooking Loss**

120 Cooking loss is one of the necessary quality parameters to establish the quality of wet noodles  
121 after boiling<sup>28</sup>. The cooking loss assay was done by measuring the quantity of solids that leached out

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before extraction

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of the noodles during the boiling process, e.g., starch. A large cooking loss value affects the texture of wet noodles, which is easy to break and less slippery.

#### Determination of Texture

The texture of wet noodles with pluchea extract added was measured based on hardness, adhesiveness, cohesiveness, elongation and elasticity. The texture was analyzed by TA-XT2 texture analyzer (Stable Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the Texture Exponent 32 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were analyzed with a compression assay using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle strands with the length of 4 cm for each strand were laid side by side, touching each other, perpendicular to the 35 mm compression cylinder probe on a flat aluminum base. The cylinder probe was arranged to be at 15 mm distance from the lower plate at the start of the compression test, and was forced down through the noodle strips at the speed of 2 mm s<sup>-1</sup> until it touched the flat base to compress 75% of the noodle thickness, and was drawn back to at the end of the test. The profile curve was determined using a texture analyzer software<sup>24,29</sup>. The hardness was determined as the maximum force per gram. The adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area was obtained from the compression test under the curve. Cohesiveness was analyzed based on the ratio between the area under the second peak and the first peak<sup>24,29,30</sup>. The elongation and elasticity of the noodles were individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. Elongation was the maximum force to change of noodle form and break by extension that was analyzed by a test speed of 3.0 mm s<sup>-1</sup>

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142 between two rollers with a 100 mm distance. The elongation at breaking was calculated per gram.

143 Elasticity was determined by formula (1)<sup>31,32</sup>:

$$144 \quad \text{Elasticity} = \frac{Fx lo}{Ax to} \frac{1}{v} \quad (1)$$

145 where F is the tensile strength, lo is the original length of the noodles between the limit arms (mm), A  
146 is the original cross-sectional area of the noodle (mm<sup>2</sup>), v is the rate of movement of the upper arm  
147 (mm/s), and t is break up time of the noodles (s). The measurement of texture was detected by the  
148 software and expressed as a graph.

#### 149 **Color Measurement**

150 The color of the noodle sheets was determined by a colorimeter (Minolta CR 10, Minolta Co.  
151 Ltd., Osaka, Japan), and the CIE-Lab L\*, a\* and b\* values were analyzed based on the method by Fadzil  
152 et al.<sup>29</sup> The L\* value measured the position on the white/black axis, the a\* value as the position on the  
153 red/green axis, and the b\* value as the position on the yellow/blue axis.

#### 154 **Analysis of Total Phenolic Content**

155 The total phenolic content analysis was analyzed based on the reaction between phenolic  
156 compounds and Folin Ciocalteu (FC) reagent or phosphomolybdic acid and phosphotungstic acid. The  
157 FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups to become a blue molybdenum-  
158 tungsten complex solution<sup>33</sup>. The intensity of the blue color was detected by a UV-Vis  
159 spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 760 nm. In the analysis,  
160 7.5% Na<sub>2</sub>CO<sub>3</sub> solution was added to reach pH 10 that caused an electron transfer reaction (redox). The  
161 obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

162

### 163 **Analysis of Total Flavonoid Content**

164 The flavonoid content assay was done using the spectrophotometric method based on the  
165 reaction between flavonoids and  $\text{AlCl}_3$  to form a yellow complex solution. In the presence of NaOH  
166 solution, a pink color is formed which can be detected by spectrophotometer (Spectrophotometer UV-  
167 Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm<sup>33,34,35</sup>. The obtained data were expressed in mg of catechin  
168 equivalent (CE)/L sample.

### 169 **Analysis of DPPH Free Radical Scavenging Activity**

170 The ability of antioxidant compounds to scavenge DPPH (2,2-diphenyl-1-picrylhydrazyl) free  
171 radicals can be used to evaluate antioxidant activity. The principle of the DPPH method is to measure  
172 the absorbance of compounds that can react with DPPH radicals<sup>36</sup>. Antioxidant compounds can donate  
173 hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced to yellow<sup>37</sup>. The color  
174 change was measured as an absorbance at  $\lambda$  517 nm by spectrophotometer (Spectrophotometer UV  
175 Vis 1800, Shimadzu, Japan)<sup>38</sup>. The data were expressed in mg gallic acid equivalent (GAE)/L dried  
176 noodles sample.

### 177 **Analysis of Iron Ion Reduction Power**

178 This method identifies the capacity of antioxidant components using potassium ferricyanide,  
179 trichloroacetic acid and ferric chloride to produce color complexes that can be measured  
180 spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm<sup>39</sup>. The  
181 principle of this testing is the ability antioxidants to reduce iron ions from  $\text{K}_3\text{Fe}(\text{CN})_6$  ( $\text{Fe}^{3+}$ ) to  $\text{K}_4\text{Fe}(\text{CN})_6$   
182 ( $\text{Fe}^{2+}$ ). Then, potassium ferrocyanide reacts with  $\text{FeCl}_3$  to form a  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$  complex. The color

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change is from yellow to green<sup>40</sup>. The final data were expressed in mg gallic acid equivalent (GAE)/L dried noodles.

### Sensory Evaluation

The hedonic test of all samples of wet noodles involved 100 untrained panelists with an age range of 17 to 25 years. A hedonic test used in this research was the hedonic scoring method, where the panelists gave a preference score value of all samples<sup>41</sup>. The hedonic scores were transformed to numeric scale and analyzed using statistical analysis<sup>42</sup>. The numeric scale in the sensory analysis used a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The panelists were asked to score according to their level of preference for texture, taste, color, flavor and overall acceptability. All the samples were blind coded with 3 digits which differed from each other<sup>43</sup>.

### Statistical Analysis

The research design used in the physicochemical assay was a randomized block design (RBD) with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25 and 30% (w/v). Each treatment was repeated four times that obtained 28 experiment units. A completely randomized design (CRD) was used to evaluate sensory assay with 100 untrained panelists with an aged 17 to 25 years.

The normal distribution and homogeneity data were stated as the mean  $\pm$  SD of the triplicate determinations and were determined using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan Multiple Range Test) at  $p \leq 5\%$  to determine treatment level that gave significant different results. The best treatment of pluchea extract addition on wet noodles was analyzed by a spider web graph.

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## 204 Results and Discussion

205 Wet noodles added with hot extract of pluchea leaf powder were produced to increase the  
206 functional value of wet noodles. This is supported by previous studies related to the potential value of  
207 water extract of pluchea leaf that exhibits biological activities<sup>6,7,41</sup>. In this research, the cooking quality  
208 was observed after cooking wet noodles in 300 mL water/100 g samples for 3 min in boiling water.

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## 209 Cooking Quality

210 Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at 0, 5,  
211 10, 15, 20, 25 and 30% (w/v) was shown in Figure 1, Table 3 and Table 4. The addition of pluchea  
212 extract no significantly influenced the water content, cooking loss, swelling index, chroma, and hue of  
213 the produced wet noodles using statistical analysis by ANOVA at  $p \leq 5\%$ . Water content is one of the  
214 chemical properties of a food product determined shelf life of food products, because the water  
215 content measures the free and weakly bound water in foodstuffs<sup>44,45</sup>. This study identified that the  
216 moisture content of the cooked wet noodles ranged between 64-67% wb. Previous study showed that  
217 the water content of the cooked egg wet noodles was around 54-58% wb<sup>45</sup> and maximum of 65%<sup>20</sup>.  
218 Chairuni et al.<sup>44</sup> stated that the boiling process could cause a change in moisture content from around  
219 35% to around 52%. The Indonesian National Standard<sup>46</sup> stipulates that the moisture content of cooked  
220 wet noodles is a maximum of 65%. This means that only control noodles (without treatment) exhibited  
221 a moisture content similar to the previous information. The obtained data showed a trend that an  
222 extract addition caused an increase in the water content of wet noodles, but statistical analysis at  $p \leq$   
223 5% showed no significant difference. This phenomenon was in accordance with the experimental  
224 results of Juliana et al.<sup>47</sup> that the using of spenochlea leaf extract to making wet noodles, as well as

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225 Hasmawati et al.<sup>20</sup> that the sweet potato leaf extract increased the moisture of fresh noodles. The  
226 water content of pluchea wet noodles was expected by reaction between many components in the  
227 dough that impacted to the swelling index and cooking loss. Mualim et al.<sup>14</sup>, Bilina et al.<sup>22</sup> and Setiyoko  
228 et al.<sup>28</sup> reported that the presence of amino groups in protein and hydroxyl groups in amylose and  
229 amylopectin fractions in wheat flour as raw material for making dough determines the moisture  
230 content, swelling index and cooking loss of wet noodles. The contribution of glutenin and gliadin  
231 proteins in wheat flour to form gluten networks determines the capability of noodles to swell and  
232 retain water in the system. Gliadin acts as an adhesive that causes dough to be elastic, while glutenin  
233 makes the dough to be firm and able to withstand CO<sub>2</sub> gas thus the dough can expand and form pores.  
234 Fadzil et al.<sup>29</sup> found that thermal treatment during the boiling process results in the denaturation of  
235 gluten and caused a monomer of proteins to determine other reactions at the disulfide or sulfhydryl  
236 chain. The existence of phenolic compounds from pluchea extract also increased the capacity of  
237 noodles to absorb water and determined water mobility. Widyawati et al.<sup>41</sup> also confirmed that  
238 hydrophilic compounds of proteins, carbohydrates, and polyphenolic components determine water  
239 mobility due to their ability to bind with water molecules through hydrogen bonding. Tuhumury et al.<sup>48</sup>  
240 informed that gluten formation can inhibit water absorption by starch granules so that can prevent  
241 gelatinization. Therefore, the addition of phenolic compounds from the hot extract of pluchea leaf  
242 powder can inhibit the formation of gluten so that it stimulates gelatinization of starch granules.

243 As a result, the impact of increased the moisture content during boiling had an effect on the  
244 value of the swelling index and cooking loss of the wet noodles. Widyawati et al.<sup>41</sup> said that the swelling  
245 index is the capability to trap water which is dependent on the chemical composition, particle size, and

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246 water content. Gull et al.<sup>49</sup> also confirmed that the swelling index is an indicator to determine water  
247 absorption by starch and protein to make gelatinization and hydration. Setiyoko et al.<sup>28</sup> explained that  
248 cooking loss is the mass of noodle solids that come out of the noodle strands for boiling. Gull et al.<sup>49</sup>  
249 added that soluble starch and other soluble components leach out into the water during the cooking  
250 process, making the cooking water turned thicker. The moisture content results (64-67% wb) showed  
251 that the produced wet noodles exceeded the moisture content limit of wet noodles after cooking,  
252 which is between 54-58%<sup>44</sup>, while the cooking loss value of wet noodles should not be more than  
253 10%<sup>28</sup>. In this study, the cooking loss value was 3-4.2%. The cooking loss of samples during boiling  
254 noodles were caused the breaking of the bonding network that the polysaccharides are released and  
255 the gluten network breaks because of the addition of pluchea leaf extract. Widyawati et al.<sup>41</sup> supported  
256 that polyphenol can be bound with protein and starch with many non-covalent interactions, such as  
257 hydrogen bonding, electrostatic interaction, hydrophobic interaction, Van der Waal's interaction, and  
258  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch to undergo  
259 gelatinization and gliadin and glutelin from the protein of wheat flour to form gluten.

260 The swelling index value obtained from this research was around 56-68 %. Based on the  
261 previous research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.)  
262 fruit was around 51%<sup>50</sup>. This means that the addition of pluchea leaf extract in wet noodles also affects  
263 the ability of noodles to absorb water. Widyawati et al.<sup>41</sup> and Suriyaphan<sup>6</sup> noted that bioactive  
264 compounds in hot water extract of pluchea leaf tea include 3-*O*-caffeoylquinic acid, 4-*O*-caffeoylquinic  
265 acid, 5-*O*-caffeoylquinic acid, 3,4-*O*-dicaffeoylquinic acid, 3,5-*O*-dicaffeoylquinic acid, 4,5-*O*-  
266 dicaffeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total

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anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was higher than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from extract in absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch granules to absorb water so that the swelling index and cooking loss increased. Suriyaphan<sup>6</sup> informed that hot extract of pluchea leaf tea contains 1.79 g/100 g protein, 8.65 g/100 g carbohydrate, and fiber (0.45 g/100 g soluble and 0.89 g/100 g insoluble), these compounds can involve in increasing the swelling index from pluchea wet noodles.

Color is one of the physical characteristics possessed by wet noodles that becomes a benchmark for consumer acceptance. This research found that the color of wet noodles was influenced by the addition of pluchea extract. The addition of pluchea leaf extract no significant affected the redness ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it influenced the yellowness ( $b^*$ ) and lightness ( $L^*$ ) values. Using of pluchea leaf powder brewing decreased the brightness of wet noodles significantly, as the concentration of the extract increased. This is related to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to experience color changes. According to Widyawati et al.<sup>8</sup> tannins are water-soluble compounds that can give a brown color. Suriyaphan<sup>6</sup> and Widyawati et al.<sup>41</sup> also stated that Khlu tea from pluchea leaves contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and 6.39 mg/100 g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow color. Gull et al.<sup>49</sup> stated that this pigment was easily changed in the paste sample due to the swelling and discoloration of the pigment during cooking.

Thus, the addition of hot water extract of pluchea leaf powder significantly reduced the

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brightness of wet noodles, because brown-colored noodles were produced as the concentrations of added pluchea leaf extract increased. However, increasing the concentration of this extract had no influenced on the redness, hue, and chroma values in ANOVA at  $p \leq 5\%$ . The results showed that the redness value of wet noodles revolved from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet noodles ranged from  $82.1 \pm 3.1$  to  $86.5 \pm 1.0$ . Based on this value, the color of wet noodles is in the yellow to the red color range<sup>51</sup>, thus the visible color of the wet noodle product was yellow to brown (Figure 1). Yellowness increased significantly with the addition of pluchea leaf extract and the value ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the availability of tannins and chlorophyll compounds from pluchea leaf extract. The chroma value of wet noodles was obtained within the range of  $15.6 \pm 1.5$  to  $19.8 \pm 3.4$ . This means that the brewing of pluchea leaf powder did not change the intensity of the brown color in the resulting wet noodles.

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Texture analysis of pluchea wet noodles added with various concentrations of hot water extract from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness, elongation, and elasticity. Hardness is the maximum force given to a product until deformation<sup>52,53</sup>. From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher peak of graph shows the harder product<sup>30</sup>. Adhesiveness is force or tackiness that is required to pull the product from its surface, its value is obtained from the area between the first and second compressions<sup>54,55</sup>. Adhesiveness values show negative value; the bigger negative value means the product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and second compressions<sup>53,55</sup>. This is an indication of the internal forces that make up the product<sup>56</sup>. Elongation is the change in length of noodles when being exposed to a tensile force until the noodles

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309 break<sup>57</sup>. Elasticity is the time required for the product to withstand the load until it breaks. The more  
310 elastic a product, the longer the holding time. The data showed that the higher concentration of  
311 pluchea leaf powder within the hot water extract caused a significant increase in the hardness,  
312 stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati et al.<sup>41</sup>  
313 informed that the polyphenols contained in pluchea leaf extract can weakly interact either covalently  
314 or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch  
315 and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups  
316 that are polar. Amoako and Akiwa<sup>58</sup> and Zhu et al.<sup>59</sup> have also proven that polyphenolic compounds  
317 can interact with carbohydrates through the interaction of two hydrophobic and hydrophilic functional  
318 groups with amylose. Diez-Sánchez et al.<sup>60</sup> stated that polyphenolic compounds can interact with  
319 amylose and protein helical structures and largely determined by molecular weight, conformational  
320 mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in  
321 protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and  
322 amylopectin can affect the gelatinization process in the amylose helical structure and interfere with  
323 the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network  
324 that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture  
325 content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on  
326 the high cooking loss (> 98%) and swelling index (56.2 to 67.7%) data, it can be concluded that the  
327 interaction that occurs between the phenol group in pluchea leaf extract with amylose and protein was  
328 weak. The bioactive components of pluchea leaf extract are thought to affect the formation of disulfide  
329 cross-links (S-S) and turn into to form sulfhydryl groups (-SH) under the influence of heat. Ananingsih

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330 and Zhou<sup>61</sup> said that antioxidant compounds are a reducing agent that can have an impact on reducing  
331 S-S bonds and increasing the number of SH groups in the dough to produce a harder texture. According  
332 to Rahardjo <sup>et al.</sup><sup>54</sup> phenolic compounds are hydroxyl compounds that influence the strength of the  
333 dough, where the higher the component of phenol compounds will weaken the gluten matrix and the  
334 dough thus becoming unstable. The instability of the dough can cause the texture to become hard.

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335 Many researchers also find that tannins and phenols influence the networking S-S bond in the  
336 dough of wet noodles. Wang <sup>et al.</sup><sup>62</sup> showed that tannins increase the relative amount of large, medium  
337 polymers in the gluten protein network so as to improve the dough quality. Zhang et al.<sup>63</sup> said that  
338 these polymer compounds are the results of interactions or combinations of protein-tannin

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339 compounds that form bonds with the type of covalent bonds, hydrogen bonds, or ionic bonds. Rauf  
340 and Andini<sup>64</sup> also added that phenol compounds can reduce S-S bonds to SH bonds. SH is a type of thiol

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341 compound group, where the thiol group can influence the stickiness, viscosity, cohesiveness,  
342 elongation, and extensibility of the dough. Wang et al.<sup>65</sup> found the effect of phenolic compounds from

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343 green tea extract to increase the stickiness of wheat bread. The cohesiveness of the dough is formed  
344 due to a large number of thiol bonds formed, thus increasing the viscosity of the dough. The increased  
345 viscosity of the dough is thought to be due to the formation of polyphenolic compounds with thiol

346 groups, as in the research of Ananingsih and Zhou<sup>61</sup> that the formation of catechin-thiol can increase  
347 the viscosity of the dough and increase the stability of the dough. Zhu et al.<sup>66</sup> mentioned that the

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348 addition of phenolic compounds from green tea was able to increase the PV (peak viscosity) of wheat  
349 flour. Wang <sup>et al.</sup><sup>62</sup> also found that the cohesiveness of the dough is influenced by tannins, where

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350 tannins can produce micro-glutens so as to produce a compact dough and increase the gluten network.

351 The addition of pluchea leaf extract in making wet noodles could influence the elongation of wet  
352 noodles due to the components of polyphenol compounds such as tannins that can reduce the number  
353 of free amino groups. This is supported by Zhang *et al.*<sup>30</sup> and Wang *et al.*<sup>62</sup> support the formation of  
354 other types of covalent bonds, such as bonds between amino groups and hydroxyl groups, by forming  
355 hydrogen bonds between phenolic compounds and protein gluten so as to improve the quality of  
356 dough strength and dough extensibility.

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#### 357 Bioactive Compounds and Antioxidant Activity

358 Wet noodles added with pluchea leaf powder were analyzed based on its bioactive compounds  
359 and antioxidant activities. The analysis was conducted to determine the functional properties of wet  
360 noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles are  
361 presented in Table 5. The measured bioactive compounds (BC) included total phenolic content (TPC)  
362 and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical scavenging  
363 activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea  
364 leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed  
365 that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a  
366 tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed  
367 that there was a positive and strong correlation between TPC and DPPH ( $r = 0.990$ ), TPC and FRAP ( $r =$   
368  $0.986$ ), TFC and DPPH ( $r = 0.974$ ), and TFC and FRAP ( $r = 0.991$ ). This means that the antioxidant activity  
369 of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah *et al.*<sup>67</sup> informed that the PC  
370 ( $r > 0.699$ ) indicates the strength and linear correlation between antioxidant activity (AA) and TPC, and  
371 also shows a strong positive relationship but PC ( $r < 0.699$ ) obtains a moderately positive relationship.

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If the r value of TFC and AA is lower than TPC and AA, it indicates that the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship which is expected because both classes all contributed to AA plants. Aryal et al.<sup>68</sup> and Muflihah et al.<sup>67</sup> informed that phenolic compounds are soluble natural antioxidants and potential donating electrons depend on their number and position of hydroxyl groups contributed to antioxidant action. Consequently, these groups are responsible to scavenge the free radicals that TPC of pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the stable purple-colored to the yellow-colored solution. Based on FRAP analysis, it was showed that the bioactive compounds contained in pluchea wet noodles are a potential source of antioxidants because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive compounds contained in pluchea wet noodles can function as primary and secondary antioxidants. Research data showed that the cooking quality of wet noodles tends to increase along with the increase in the value of TPC, TFC, DPPH and FRAP.

### Sensory Evaluation

Sensory pluchea wet noodles, namely color, aroma, taste, texture, and overall acceptance, were carried out using a hedonic test to determine the level of consumer preference for the product. This test was conducted to determine the quality differences between the products and to provide an assessment on certain properties<sup>42</sup>. The hedonic test itself is the most widely used test to determine the level of preference for production<sup>69</sup>. The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

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392 The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm$   
393  $1.26$  (neutral-like). The statistical analysis showed that the higher concentration of hot water extract  
394 addition decreased lower color preference of wet noodles. The higher concentration of pluchea extract  
395 could reduce the level of preference for color because the color of the wet noodles was darker than  
396 control and turned to dark brown. This color change was due to the pluchea extract containing several  
397 components, including chlorophyll and tannins, which can alter the of wet noodles' color to be  
398 browner along with the increase in the concentration of pluchea extract. This result was in accordance  
399 to the effect of color analysis performed using color reader where the pluchea wet noodles' brightness  
400 declined, yellowness increased, and the color intensity increased with an increased concentration of  
401 pluchea extract. The occurrence of this process is related to the effect of light and heat on pluchea leaf  
402 powder which causes the degradation of chlorophyll into brown pheophytin due to drying, where the  
403 nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals<sup>70,71</sup>.

404 Aroma is one of the parameters in sensory evaluation using the sense of smell and is an  
405 indicator of the assessment of a product<sup>72</sup>. The results of the preference value for aroma were ranged  
406 from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet  
407 noodles reduced the preference score for aroma due to distinct dry leaves (green) aroma. According  
408 to Lee et al.<sup>73</sup> the unpleasant aroma on leaves comes from a group of aliphatic aldehyde compounds.  
409 The appearance of a distinctive leaf aroma in noodles is due to aromatic compounds. According to  
410 Martiyanti and Vita<sup>74</sup> aromatic compounds are chemical compounds that have an aroma or odor when  
411 the conditions are met, which is volatile, while Widyawati et al.<sup>75</sup> informed that pluchea leaves were  
412 detected to have 66 volatile compounds. The appearance of the aroma is due to the volatile

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413 compounds in the raw material reacting with water vapor when boiling the noodles. In addition, there  
414 is also an oxidation process of polyphenolic compounds such as catechins or tannins that can produce  
415 an aroma in pluchea wet noodles.

416 According to Martiyanti and Vita<sup>3</sup> taste attribute is one important sensory aspect in food  
417 products and has a great impact on the food selection by consumers. Tongue **is** able to detect basic  
418 tastes, namely sweet, salty, sour, and bitter, at different points. Lamusu<sup>71</sup> declared that taste is a  
419 component of flavor and an important criterion in assessing a product that is accepted by the tongue.  
420 The preference test of the taste of pluchea wet noodles resulted in values ranging from **4.15 ± 1.40 to**  
421 **5.50 ± 1.28** (neutral-slightly like). The increase in concentrations of pluchea extract was negatively  
422 correlated to the preference level of **the taste of** pluchea wet **noodles** assessed by the panelists. The  
423 statistical analysis results showed that the difference in the concentration of the extract significant  
424 influenced on the preference score for the taste of pluchea wet noodles. The increased concentration  
425 of pluchea extract produced a distinctive taste on wet noodles, such as a bitter **and** astringent tastes,  
426 due to the presence of compounds such as tannins and alkaloids from the pluchea leaves. Susetyarin<sup>76</sup>  
427 said that pluchea leaves contain tannins (**2.35%**), and alkaloids (**0.32%**). According to Pertiwi<sup>77</sup>, tannin  
428 compounds dominate the bitter and astringent taste, while alkaloid compounds cause a bitter taste.  
429 The high level of taste preference for wet noodles was found in noodles with lower content of pluchea  
430 extract.

431 Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and  
432 swallowed) or touched with **fingers**<sup>78</sup>. Texture testing performed by the panelist is called mouthfeel  
433 testing. According to Martiyanti and Vita<sup>74</sup>, mouthfeel is the kinesthetic effect of chewing food in the

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434 mouth. In this study, the preference test results on the texture of pluchea wet noodles revolved from  
435  $5.5 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy  
436 and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet  
437 noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that  
438 can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and  
439 draining noodles. Subjective testing results based on sensory evaluation were in line with the objective  
440 testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to  
441 break, and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea  
442 wet noodles was influenced by the fiber and protein components. According to Shabrina<sup>79</sup>, the  
443 components of fiber, protein, and starch **complete** to bind water. Texture changes are also influenced  
444 by the polyphenol compositions in the pluchea extract which is able to reduce S-S bonds to SH bonds,  
445 where the increase in SH (thiol) groups can give a hard, sticky, and compact **texture**<sup>62,64,65</sup>. Besides, a  
446 high concentration of tannins capable of binding to proteins to form complex compounds into tannins-  
447 proteins are also able to build noodles' texture.

448 The interaction between color, aroma, taste, and texture created an overall taste of the food  
449 product and was assessed as the overall preference. The highest value on the overall preference was  
450 derived from control wet noodles, i.e., 6.63 (slightly like it), while the wet noodles added with 20%  
451 (w/v) concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The  
452 addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to  
453 10% (w/v) concentration with scores of 6.63 and 6.53, respectively. The area of the spider web chart  
454 for each treatment with the various concentrations of pluchea extract was seen in Figure 2. The best

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455 treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37  
456 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the  
457 scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like),  
458 respectively.

459 The use of pluchea leaf extract in the making of wet noodles was able to increase the functional  
460 value of wet noodles, based on the levels of bioactive compounds and antioxidant activity without  
461 changing the quality of cooking, which includes water content, swelling index and cooking loss. Besides  
462 that, the use of pluchea leaf extract did not significantly change the color and color intensity of the  
463 resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet  
464 noodles produced were still acceptable to the panelists, the addition of pluchea leaf extract as much  
465 as 10% (w/v) was the best treatment with an assessment that was almost close to the control wet  
466 noodles (without treatment).

#### 467 Conclusion

468 Addition of hot water extract of pluchea leaf powder influenced physical, chemical and sensory  
469 properties of wet noodles. Lightness, texture, bioactive compound content, antioxidant activity, and  
470 sensory properties of samples underwent significant difference. The higher concentration of pluchea  
471 extract caused the bigger these parameters of pluchea wet noodles. Using 10% (w/v) of hot water  
472 extract from pluchea leaf powder was the best treatment with color, aroma, taste, and texture scores  
473 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. Utilization of  
474 hot water extract of pluchea leaf powder at 10% (w/v) resulted wet noodle functional with TPC, TFC,  
475 DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg dried samples, 62.44

476 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples and 51.33 mg GAE/kg dried samples,  
477 respectively.

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479 **Notes on Appendices**

TPC	Total phenolic content
TFC	Total flavonoid content
DPPH	2,2-Diphenyl-1-picrylhydrazyl free radical
FRAP	Ferric reducing antioxidant power
AA	Antioxidant activity
PC	Pearson Correlation
LDL	Low Density Lipoprotein
w/v	Weight per volume
CRD	Completely randomized design
CE	Catechin equivalent
GAE	Gallic acid equivalent
BC	Bioactive compounds
ANOVA	Analysis of variance
UV-Vis	Ultra violet-visible

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712 *Ensiformis* L) and Fermentation Time on The Characteristics of White Bread. [Undergraduate  
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714

Commented [A150]: Added website

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715 Table 1. **Information of hot water extract of pluchea tea**

Materials	Concentration of hot water extract of pluchea leaf tea (% w/v)						
	0	5	10	15	20	25	30
Pluchea leaf tea (g)	0	10	20	30	40	50	60
Hot water (mL)	200	200	200	200	200	200	200

716

717

718 **Table 2. Ingredients** of pluchea wet noodles

Materials	Unit	Quantity
Wheat flour	g	200
Egg	g	40
Salt	g	4
Baking powder	g	2
Hot water extract	mL	70
Tapioca flour	g	10
TOTAL	g	326

719

**Table 3.** Color, moisture content, swelling index, and cooking loss of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Color					Moisture content (% wb)	Swelling index (%)	Cooking loss (%)
	L*	a*	b*	C	h			
0	67.1 ± 1.8 <sup>a</sup>	0.97±0.30	16.18±0.62 <sup>ab</sup>	16.2 ± 0.6	86.5 ± 1.0	63.90±1.51	56.2±17.4	3.40±1.31
5	59.5 ± 2.7 <sup>b</sup>	2.18±0.93	15.47±1.46 <sup>a</sup>	15.6 ± 1.5	82.1 ± 3.1	65.08±4.33	62.4±4.7	3.33±1.26
10	59.0 ± 1.8 <sup>b</sup>	1.95±1.66	16.76±2.33 <sup>abc</sup>	17.1 ± 2.2	83.3 ± 5.4	64.97±3.89	61.5±7.5	3.00±1.16
15	58.4 ± 2.2 <sup>b</sup>	1.69±1.48	19.72±3.50 <sup>c</sup>	19.8 ± 3.4	84.7 ± 4.6	65.56±2.18	63.1±6.3	3.31±0.92
20	56.5 ± 2.4 <sup>b</sup>	1.97±1.24	19.09±2.97 <sup>bc</sup>	19.2 ± 2.9	83.6 ± 4.3	66.81±1.81	67.7±5.9	4.06±0.51
25	59.1 ± 2.5 <sup>b</sup>	1.95±1.44	19.55±2.97 <sup>c</sup>	19.6 ± 2.9	83.8 ± 4.0	66.04±0.85	64.5±10.3	3.93±1.37
30	57.1 ± 2.1 <sup>b</sup>	2.09±1.51	18.08±4.94 <sup>abc</sup>	18.3 ± 4.8	82.5 ± 5.2	66.65±2.16	64.0±5.3	4.23±1.34

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$

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**Table 4.** Texture of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Texture of pluchea wet noodle				
	Hardness (N)	Adhesiveness (g sec)	Cohesiveness	Elongation (%)	Elasticity (Pa)
0	135.8±5.9 <sup>a</sup>	-2.7 ±2.3 <sup>d</sup>	0.75±0.01 <sup>a</sup>	86.9±0.9 <sup>a</sup>	25336.7±104.2 <sup>a</sup>
5	120.1±2.1 <sup>a</sup>	-3.4±0.6 <sup>cd</sup>	0.68±0.00 <sup>b</sup>	97.3±1.6 <sup>b</sup>	25898.3±760.9 <sup>b</sup>
10	134.9±1.8 <sup>a</sup>	-3.9±0.7 <sup>bc</sup>	0.74±0.00 <sup>c</sup>	162.1±1.5 <sup>c</sup>	25807.7±761.9 <sup>b</sup>
15	180.5±5.1 <sup>b</sup>	-4.9±0.5 <sup>b</sup>	0.74±0.01 <sup>c</sup>	164.7±0.6 <sup>c</sup>	26971.6±516.7 <sup>b</sup>
20	195.1±14.1 <sup>b</sup>	-5.0±1.3 <sup>ab</sup>	0.75±0.01 <sup>cd</sup>	221.6±1.6 <sup>d</sup>	27474.4±453.8 <sup>b</sup>
25	244.6±8.8 <sup>c</sup>	-6.0±0.3 <sup>a</sup>	0.75±0.00 <sup>cd</sup>	230.7±0.7 <sup>e</sup>	27367.1±287.5 <sup>b</sup>
30	282.8±28.3 <sup>d</sup>	-6.1±0.2 <sup>a</sup>	0.79±0.01 <sup>d</sup>	255.4±0.4 <sup>f</sup>	26687.5±449.2 <sup>b</sup>

Note: the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$

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**Table 5.** Total phenol content, total flavonoid content, the DPPH free radical scavenging activity, and iron ion reducing power of the pluchea wet noodles.

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	TPC (mg GAE/kg Dried Noodles)	TFC (mg CE/kg Dried Noodles)	DPPH (mg GAE/kg Dried Noodles)	FRAP (mg GAE/kg Dried noodles)
0	39.26±0.66 <sup>a</sup>	32.36±1.47 <sup>a</sup>	96.75±4.26 <sup>a</sup>	25.96±0.25 <sup>a</sup>
5	61.09±3.80 <sup>b</sup>	46.31±2.15 <sup>b</sup>	121.36±3.58 <sup>b</sup>	34.50±1.71 <sup>b</sup>
10	82.84±3.11 <sup>c</sup>	62.44±0.55 <sup>c</sup>	130.68±4.82 <sup>c</sup>	51.33±2.19 <sup>c</sup>
15	101.48±2.16 <sup>d</sup>	84.67±1.22 <sup>d</sup>	142.48±2.14 <sup>d</sup>	58.69±2.14 <sup>d</sup>
20	114.94±4.20 <sup>e</sup>	100.14±1.50 <sup>e</sup>	148.84±3.20 <sup>e</sup>	67.26±0.06 <sup>e</sup>
25	128.06±1.38 <sup>f</sup>	107.93±0.89 <sup>f</sup>	157.51±7.69 <sup>f</sup>	69.53±1.06 <sup>f</sup>
30	136.35±1.16 <sup>g</sup>	131.69±1.56 <sup>g</sup>	166.97±1.53 <sup>g</sup>	84.98±0.11 <sup>g</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

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**Table 6.** Effect of hot water extract from pluchea leaf powder to preferences for color, aroma, taste, texture, and overall acceptance of wet noodles at various concentrations

Concentration of Hot		Hedonic Score			
Extract from Pluchea					
Leaf Powder (% w/v)	Color	Aroma	Taste	Texture	Overall acceptance
0	6.19±1.25 <sup>d</sup>	5.52±1.08	5.50±1.18 <sup>c</sup>	6.20±1.13 <sup>b</sup>	6.63±1.49 <sup>c</sup>
5	5.62±1.28 <sup>c</sup>	5.52±0.83	5.51±1.29 <sup>c</sup>	6.37±1.14 <sup>bc</sup>	6.40±1.52 <sup>c</sup>
10	5.62±1.21 <sup>c</sup>	5.45±0.85	5.46±1.12 <sup>c</sup>	6.53±1.14 <sup>c</sup>	6.53±1.64 <sup>c</sup>
15	5.14±1.25 <sup>b</sup>	4.81±1.04	4.61±1.11 <sup>b</sup>	6.13±1.09 <sup>b</sup>	5.78±1.67 <sup>b</sup>
20	4.91±1.32 <sup>b</sup>	4.54±1.18	4.47±1.15 <sup>ab</sup>	5.80±1.06 <sup>a</sup>	5.17±1.70 <sup>a</sup>
25	4.54±1.40 <sup>a</sup>	4.26±1.23	4.20±1.24 <sup>a</sup>	5.50±1.04 <sup>a</sup>	5.23±1.75 <sup>a</sup>
30	4.47±1.33 <sup>a</sup>	4.05±1.34	4.15±1.40 <sup>a</sup>	5.59±1.05 <sup>a</sup>	5.37±1.91 <sup>a</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means

with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

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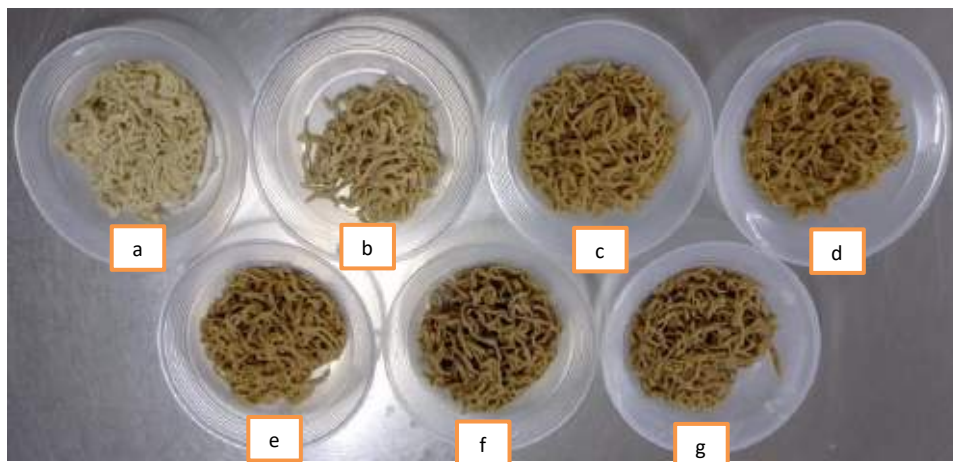


Figure 1. Wet noodles with hot water extract of pluchea leaf powder added at concentrations

a. 0%; b. 5%; c. 10%; d. 15%; e. 20%; f. 25%; and g. 30% w/v

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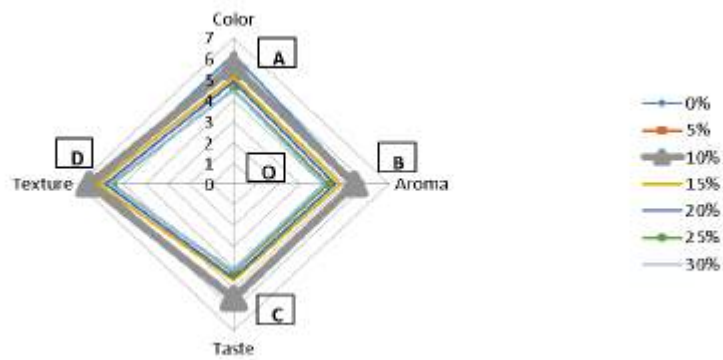


Figure 2. Spider web graph of sensory evaluation on wet noodles at various concentrations of hot water extract from pluchea leaf powder



Paini Sri Widyawati <paini@ukwms.ac.id>

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## Request for Review - 3638

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**Managing Editor** <info@foodandnutritionjournal.org>

Mon, Mar 27, 2023 at 2:26 PM

To: Paini Sri Widyawati <paini@ukwms.ac.id>

Dear Dr Paini,

Thank you for your response.

We are forwarding your article for further process, we will update you soon accordingly.

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5. Fourth revision: Final Comment (3 -4-2023)

- Correspondence
- Re-evaluation Comments
- Re-evaluation Reviewer
- Revision Document
- Author Response to Reviewer's Comments
- Certificate Proofreading



Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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## Request for revision as per editorial comments - 3638

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**Managing Editor** <info@foodandnutritionjournal.org>

Mon, Apr 3, 2023 at 1:47 PM

To: Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

Dear Dr Paini Sri Widyawati,

We have received the final comments on your manuscript from our editorial board member.

Attached are their suggestions for your reference.

**"1. The author has accepted reviewer suggestions and made modifications to the manuscript.****2. Keyword: please write alphabetically.****3. Lines 52-53: please change the word 'organolectic characteristics to sensory properties.****4. Line 82: please add the photo of Plucea indicia leaves to make it clear.****5. Please add a reference to the noodle processing method that use in this study.****6. Concerning sensory evaluation, whether the author has made concerns form before the examination? If yes, please add the sentence regarding 'all panellists supplied informed consent before the examination'. Line 187, please make an explanation why the author uses panellists 17 to 25 years old. Please add the word 'old' after 17 and 25 years.****7. Tables 3 & 4, please be consistent to write one or two valuers after commas. Suggestion, please write two values after the comma, for example, please change  $59.5 \pm 2.7$  to  $59.50 \pm 2.70$ . Please check and change all the manuscripts.****8. Strong suggestion to the author, please proofread the manuscript with the English editor before resubmission. Please add the certificate of proofreading together with the resubmission."**

We kindly request you revise the file as per their comments and resend us along with the response form at your earliest convenience as the deadline for closing the issue is in the first week of April.

Kindly do the needful so that we will move forward with the publication process in a timely manner.

Best Regards

Yanha Ahmed

Editorial Assistant

Current Research in Nutrition and Food Science

**Response Form\_Final Comments.docx**

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Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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**Request for revision as per editorial comments - 3638**

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**Paini Sri Widyawati** <paini@ukwms.ac.id>

Tue, Apr 4, 2023 at 11:33 AM

To: Managing Editor &lt;info@foodandnutritionjournal.org&gt;

Dear Ms Yanha Ahmed

Regarding the editor's request that my manuscript be proofread before I send it to your journal, is there no proofreading from the journal, so I will pay the total fee, because I'm worried if I ask for proofreading from outsiders it won't be safe.

Please inform me

Regards

Paini Sri Widyawati

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Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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**Request for revision as per editorial comments - 3638**

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**Managing Editor** <info@foodandnutritionjournal.org>

Tue, Apr 4, 2023 at 12:39 PM

To: Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

Dear Dr Paini,

Thank you for your email.

We would like to inform you that our journal does not provide an English proofreading certificate as requested by our Editorial Board Member, You are requested to proofread the language of your manuscript with the help of a reputed agency.

Let us know if you need any further assistance in this regard.

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Paini Sri Widyawati <paini@ukwms.ac.id>

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## Request for revision as per editorial comments - 3638

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**Paini Sri Widyawati** <paini@ukwms.ac.id>

Wed, Apr 5, 2023 at 2:40 PM

To: Managing Editor <info@foodandnutritionjournal.org>

Dear Ms Yanha Ahmed

Related to Easter holidays at our institution, I need extended time to send back my proofreading publication until the second week of April.

Thank you for attention

Regards

Paini Sri Widyawati

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Paini Sri Widyawati <paini@ukwms.ac.id>

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## Request for revision as per editorial comments - 3638

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**Paini Sri Widyawati** <paini@ukwms.ac.id>

Wed, Apr 5, 2023 at 5:05 PM

To: Managing Editor <info@foodandnutritionjournal.org>

Dear Ms. Yanha Ahmed

I can try to get a proofreading certificate as soon as possible and I will inform you soon.  
Thanks for attention

Regards

Paini Sri Widyawati

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Paini Sri Widyawati <paini@ukwms.ac.id>

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## Request for revision as per editorial comments - 3638

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**Managing Editor** <info@foodandnutritionjournal.org>

Thu, Apr 6, 2023 at 12:17 PM

To: Paini Sri Widyawati <paini@ukwms.ac.id>

Dear Dr Paini,

Thank you for updating us.

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Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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**Request for revision as per editorial comments - 3638**

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**Paini Sri Widyawati** <paini@ukwms.ac.id>

Fri, Apr 7, 2023 at 12:46 AM

To: Managing Editor &lt;info@foodandnutritionjournal.org&gt;

Dear Ms Yanha Ahmed

Sorry to bother you. I have received a statement letter from the language institute in our city and they have corrected the manuscript of my publication and sent back the revised and corrected manuscript to you along with a response in the form of final comments. Thank you for your patience and kindness in all of this.

Regards

Paini Sri Widyawati

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**3 attachments****Proofreading certificate.jpg**  
1528K**Response Form\_Final Comments.docx**  
48K**The Effect of Hot Water Extract of Pluchea indica Leaf Powder on the Physical-Revision (1).docx**  
995K

## To Whom It May Concern

The undersigned, hereby certify that the manuscript under the title "The effect of hot water extract of *Pluchea indica* leaf powder on the physical, chemical and sensory properties of wet noodles" has been proofreading and revised dated 06<sup>th</sup> April 2023

Yours Sincerely,



Surjati Suroso

### Author's Response to Editor's Comments

Paper title: **The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles**

Title	Editor's Comments	Author's Response
Abstract		
Keywords		
Introduction		
Methodology		I have added reference And reason using of panelist with 17–25yearold
Results		List of reference number has been revised
Discussion		
Conclusion		
References (Appropriateness)		List of reference number has been revised

## The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

### Abstract

Powdered *Pluchea indica* Less leaves have been utilized as herbal tea, brewing of pluchea tea in hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional values and influence physic, chemical, and sensory characteristics of food. The study was carried out to assess the effect of various concentration of *pluchea* tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with pluchea tea at concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v). Physical properties analyzed included water content, swelling index, cooking loss, color and texture. Chemical properties measured were bioactive contents of total phenolic content, total flavonoid content, and antioxidant ability to scavenge DPPH free radicals and to reduce iron ions. Sensory properties determined were taste, texture, color, aroma and overall acceptance. The addition of various concentrations of extract offers significantly effects on parameters of physical, chemical and sensory properties of noodles, except color (redness, chroma and hue), cooking loss, water content, swelling index and aroma. Using of 10% (w/v) of pluchea tea resulted in the best sensory properties such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. Generally, the study concluded that wet noodles can be made by adding pluchea tea at 10% (w/v). Dried samples TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg, 62.44 mg CE/kg, 130.68 mg GAE/kg and 51.33 mg GAE/kg, respectively.

### Key-words

Chemical, physical, *Pluchea indica* Less, sensory, wet noodles

### Introduction

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food<sup>1,2</sup>. The potency of pluchea leaves is related to phytochemical compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone, alkaloid, lignans and saponins<sup>2,3,4,5</sup>. Chan et al.<sup>1</sup> also reported that caffeoylquinic acids, phenolic acids, flavonoids and thiophenes in pluchea leaves are compounds with antioxidant activities. Furthermore,

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37 pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100 g, fat 0.49 g/100 g, insoluble dietary  
38 fiber 0.89 g/100 g, soluble dietary fiber 0.45 g/100 g, carbohydrate 8.65 g/100 g, calcium 251 mg/100  
39 g,  $\beta$ -carotene 1.225  $\mu$ g/100 g<sup>6</sup>.

40 **Pluchea tea brewed from pluchea leaves** has been proven to exhibit antioxidant activity<sup>6,7,8</sup>,  
41 anti-diabetic activity<sup>9</sup>, anti-inflammatory activity<sup>7</sup>, **anti-human** LDL oxidation activity<sup>10</sup>. Previous  
42 research uses pluchea leaf powder to make several food products to increase functional values, i.e.,  
43 jelly drink<sup>11</sup>, soy milk<sup>12</sup> and steamed bun<sup>13</sup>. Using 1% (w/v) pluchea leaf powder can improve the  
44 physicochemical properties of jelly drink and increase panelists' acceptance of the product<sup>11</sup>. Soy milk  
45 with the addition of pluchea leaves increases the viscosity and total dissolved solids and decreases the  
46 panelist acceptance rate<sup>12</sup>. The addition of 6% (w/v) brewing from pluchea leaf powder on steamed  
47 bun is the best treatment with the lowest level of hardness<sup>13</sup>. **Previous** research has proven that the  
48 addition of pluchea leaves can increase the bioactive compound contents based on total phenol and  
49 total flavonoids, as well as increase **the** antioxidant activity based on ferric reducing power and ability  
50 to scavenge DPPH free **radicals**.

51 To the best of our knowledge, the study of the addition of **of pluchea** tea in making wet noodles  
52 from wheat flour has not been conducted, as well as its impact on physicochemical and **sensory**  
53 characteristics of the noodles. Noodles are a popular food product that is widely consumed in the  
54 world. Indonesia is one of the countries with the largest noodle consumption after China<sup>14</sup>. Wet  
55 noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet noodles as an  
56 alternative to wet noodles, which contain higher protein, and the second popular food in ASEAN  
57 regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia<sup>16</sup>. The

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58 addition of other ingredients has been endeavored to enhance wet noodles' specific properties. Many  
59 researchers incorporated plant extracts or natural products to increase functional properties of wet  
60 noodles, such as red spinach<sup>17</sup>, green tea<sup>18,19</sup>, purple sweet potato leaves<sup>20</sup>, moringa leaves<sup>21</sup>, sea  
61 weed<sup>22</sup>, ash of rice straw, turmeric extract<sup>23</sup>, and betel leaf extract<sup>24</sup> that influenced the physical,  
62 chemical, and organoleptic properties of the wet noodles. The anthocyanin of red spinach ethanolic  
63 extract increases the hedonic score of wet noodles' flavor<sup>17</sup>. The addition of green tea improves the  
64 stability, elastic modulus and viscosity, retrogradation and cooking loss with, no significant effect on  
65 mouth-feel and overall acceptance from panelist on the produced wet noodles<sup>18</sup>. Moreover, the  
66 addition of sweet potatoes leaf extract on wet noodles increases moisture content, protein value and  
67 ash concentration, and improves hedonic score of texture<sup>20</sup>. Moringa extract influences protein  
68 content and decreases panelist acceptance of color, aroma and taste of wet noodles<sup>21</sup>. The use of  
69 seaweed to produce wet noodles influences moisture content, swelling index, absorption ability,  
70 elongation value and color<sup>22</sup>. The addition of ash from rice straw and turmeric extract influences the  
71 elasticity and sensory characteristics (color, taste, aroma and texture) of wet noodles<sup>23</sup>. Betel leaf  
72 extract used to make Hokkien (with dark soya source) noodles improves texture and acceptance score  
73 of all sensory attributes<sup>24</sup>.

74 Bioactive compounds and nutritive values of pluchea leaf can be an alternative ingredient to  
75 improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea  
76 leaves can serve as an antioxidant source in wet noodles and increase the functional value. This study  
77 was undertaken to assess the effect of various concentration of pluchea tea on the physical, chemical  
78 and sensory properties of wet noodles.

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79 **Materials and Methods**80  
81 **Preparation of Hot Water Extract from Pluchea Leaf Powder**

82 Young pluchea leaves (1-6) (Figure 1) were picked from the shoots, sorted and washed. The  
83 selected leaves were dried at ambient temperature for 7 days to yield moisture content of 10.00 ±  
84 0.04% dry base<sup>25</sup>. Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at 120°C  
85 for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag for  
86 about 2 g/tea bag. Pluchea leaf powder in tea bags was extracted using hot water (95°C) for 5 min to  
87 get extract concentrations of 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

88 **Wet Noodles Processing**

89 About 70 mL of hot extract from pluchea leaf powder with concentrations of 0, 5, 10, 15, 20, 25  
90 and 30% (w/v) (Table 1) was manually mixed with egg, baking powder, salt and wheat flour for 5 min  
91 (Table 2). The mixture was kneaded to form a solid and homogenized dough using a mixer (Oxone  
92 Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to form noodle  
93 strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled water about  
94 3 min in 300 mL water and coated with oil to prevent the noodles from sticking to each other<sup>26, 27, 28</sup>.  
95 Wet noodles made without any addition of hot water of pluchea leaf extract were prepared as control.  
96 Wet noodles used in bioactive compounds and antioxidant activity assay were not added with oil to  
97 prevent the noodles from sticking to one another. The final characteristics of wet noodles have width  
98 and thickness of 0.45 cm and 0.30 cm, respectively.

99

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list

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## 101 Pluchea Wet Noodles Extraction

102 About 100 g of wet noodles were dried using a freeze-dryer at a pressure of 0.1 bar and  
103 temperature -60°C for 28 hours. Dried noodles were powdered using a chopper machine for 35  
104 seconds. And then, 20 g of samples were mixed by 50 mL absolute methanol by a shaking water-bath  
105 at 35°C, 70 rpm for 1 hour<sup>29</sup>. Filtrate was separated using Whatman filter paper grade 40 and residue  
106 was extracted again with the same procedure. The filtrate was collected and evaporated by rotary  
107 evaporator until getting 3 mL of extract (Buchi Rotary Evaporator; Buchi Shanghai Ltd, China) at 200  
108 bars, 50°C for 60 min. The extract was kept at 0°C before further analysis.

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## 109 Moisture Content Assay

110 Moisture or water content of wet noodles was determined by thermos-gravimetric method<sup>30</sup>.  
111 The moisture content of wet noodles was determined by heating the samples in a drying oven (Binder,  
112 Merck KGaA, Darmstadt, Germany) and weighing the evaporated water content in the material.

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## 113 Measurement of Swelling Index

114 The purpose of swelling index testing was to determine the capability of the noodles to swell  
115 during the boiling process<sup>16</sup>. The assay was done to determine the ability of wet noodles to absorb  
116 water per unit of time or the time needed to fully cooked wet noodles. The amount of water absorbed  
117 by wet noodles was measured from the weight before and after boiling.

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## 118 Determination of Cooking Loss

119 Cooking loss is one of the necessary quality parameters to establish the quality of wet noodles  
120 after boiling<sup>31</sup>. The cooking loss assay was done by measuring the quantity of solids that leached out

121 of the noodles during the boiling process, e.g., starch. A large cooking loss value affects the texture of  
122 wet noodles, which is easy to break and less slippery.

### 123 Determination of Texture

124 The texture of pluchea wet noodles was measured based on hardness, adhesiveness,  
125 cohesiveness, elongation and elasticity. The texture was analyzed by TA-XT2 texture analyzer (Stable  
126 Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the Texture Exponent 32  
127 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were analyzed with a  
128 compression assay using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle strands with the length  
129 of 4 cm for each strand were laid side by side, touching each other, perpendicular to the 35 mm  
130 compression cylinder probe on a flat aluminum base. The cylinder probe was arranged to be at 15 mm  
131 distance from the lower plate at the start of the compression test, and was pressed down through the  
132 noodle strips at the speed of 2 mm s<sup>-1</sup> until it touched the flat base to compress 75% of the noodle  
133 thickness, and was drawn back to at the end of the test. The profile curve was determined using a  
134 texture analyzer software.<sup>24,32</sup> The hardness was determined as the maximum force per gram. The  
135 adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area was  
136 obtained from the compression test under the curve. Cohesiveness was analyzed based on the ratio  
137 between the area under the first and the second peaks<sup>24,32,33</sup> The elongation and elasticity of the  
138 noodles were individually tested by putting one end into the lower roller arm slot and sufficiently  
139 winding the loosened arm to fasten the noodle end. Elongation was the maximum force to change of  
140 noodle form and break by extension that was analyzed by a test speed of 3.0 mm s<sup>-1</sup> between two

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rollers with a 100 mm distance. The elongation at breaking was calculated per gram. Elasticity was determined by formula (1)<sup>34,35</sup>:

$$\text{Elasticity} = \frac{Fx lo}{Ax to} \frac{1}{v} \quad (1)$$

where F is the tensile strength, lo is the original length of the noodles between the limit arms (mm), A is the original cross-sectional area of the noodle (mm<sup>2</sup>), v is the rate of movement of the upper arm (mm/s), and t is break up time of the noodles (s). The measurement of texture was detected by the software and expressed as a graph.

#### Color Measurement

The color of the noodle sheets was determined by a colorimeter (Minolta CR 10, Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab L\*, a\* and b\* values were analyzed based on the method by Fadzil et al.<sup>36</sup> The L\* value measured the position on the white/black axis, the a\* value as the position on the red/green axis, and the b\* value as the position on the yellow/blue axis.

#### Analysis of Total Phenolic Content

The total phenolic content analysis was analyzed based on the reaction between phenolic compounds and Folin Ciocalteu (FC) reagent or phosphomolybdic acid and phosphotungstic acid. The FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups to become a blue molybdenum-tungsten complex solution<sup>36</sup>. The intensity of the blue color was detected by a UV-Vis spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 760 nm. In the analysis, 7.5% Na<sub>2</sub>CO<sub>3</sub> solution was added to reach pH 10 that caused an electron transfer reaction (redox). The obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

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## 162 Analysis of Total Flavonoid Content

163 The flavonoid content assay was done using the spectrophotometric method based on the  
164 reaction between flavonoids and  $\text{AlCl}_3$  to form a yellow complex solution. In the presence of NaOH  
165 solution, a pink color is formed which can be detected by spectrophotometer (Spectrophotometer UV-  
166 Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm<sup>36,37,38</sup>. The obtained data were expressed in mg of catechin  
167 equivalent (CE)/L sample.

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## 168 Analysis of DPPH Free Radical Scavenging Activity

169 The ability of antioxidant compounds to scavenge DPPH (2,2-diphenyl-1-picrylhydrazyl) free  
170 radicals can be used to evaluate antioxidant activity. The principle of the DPPH method is to measure  
171 the absorbance of compounds that can react with DPPH radicals<sup>39</sup>. Antioxidant compounds can donate  
172 hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced to yellow<sup>40</sup>. The color  
173 change was measured as an absorbance at  $\lambda$  517 nm by spectrophotometer (Spectrophotometer UV  
174 Vis 1800, Shimadzu, Japan)<sup>41</sup>. The data were expressed in mg gallic acid equivalent (GAE)/L dried  
175 noodles sample.

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## 176 Analysis of Iron Ion Reduction Power

177 This method identifies the capacity of antioxidant components using potassium ferricyanide,  
178 trichloroacetic acid and ferric chloride to produce color complexes that can be measured  
179 spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm<sup>42</sup>. The  
180 principle of this testing is the ability antioxidants to reduce iron ions from  $\text{K}_3\text{Fe}(\text{CN})_6$  ( $\text{Fe}^{3+}$ ) to  $\text{K}_4\text{Fe}(\text{CN})_6$   
181 ( $\text{Fe}^{2+}$ ). Then, potassium ferrocyanide reacts with  $\text{FeCl}_3$  to form a  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$  complex. The color

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182 change is from yellow to green<sup>43</sup> The final data were expressed in mg gallic acid equivalent (GAE)/L  
183 dried noodles.

#### 184 Sensory Evaluation

185 The hedonic test of all samples of wet noodles involved 100 untrained panelists with an age  
186 range of 17 to 25 years old, because they are students in food technology department that who have  
187 received provision about hedonic food preference test. All panelist supplied informed consent before  
188 the examination. A hedonic test used in this research was the hedonic scoring method, where the  
189 panelists gave a preference score value of all samples<sup>26</sup>. The hedonic scores were transformed to  
190 numeric scale and analyzed using statistical analysis<sup>44</sup>. The numeric scale in the sensory analysis used  
191 a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The panelists were  
192 asked to score according to their level of preference for texture, taste, color, flavor and overall  
193 acceptability. All the samples were blind coded with 3 digits which differed from each other<sup>45</sup>

#### 194 Statistical Analysis

195 The research design used in the physicochemical assay was a randomized block design (RBD)  
196 with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that  
197 consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25 and 30% (w/v). Each treatment was repeated four  
198 times that obtained 28 experiment units. A completely randomized design (CRD) was used to evaluate  
199 sensory assay with 100 untrained panelists with an aged 17 to 25 years old.

200 The normal distribution and homogeneity data were stated as the mean  $\pm$  SD of the triplicate  
201 determinations and determined using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc., Chicago,  
202 IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan Multiple

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203 Range Test) at  $p \leq 5\%$  to determine treatment level that gave significant different results. The best  
204 treatment of pluchea extract addition on wet noodles was analyzed by a spider web graph.

## 205 Results and Discussion

206 Wet noodles added with hot extract of pluchea leaf powder were produced to increase the  
207 functional values of wet noodles. This is supported by previous studies related to the potential values  
208 of water extract of pluchea leaf that exhibits biological activities<sup>6,7,26</sup>. In this research, the cooking  
209 quality was observed after cooking wet noodles in 300 mL water/100 g samples for 3 min in boiling  
210 water.

## 211 Cooking Quality

212 Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at 0, 5,  
213 10, 15, 20, 25 and 30% (w/v) was shown in Figure 2, Table 3 and Table 4. The addition of pluchea  
214 extract no significantly influenced the water content, cooking loss, swelling index, chroma, and hue of  
215 the produced wet noodles using statistical analysis by ANOVA at  $p \leq 5\%$ . Water content is one of the  
216 chemical properties of a food product determined shelf life of food products, because the water  
217 content measures the free and weakly bound water in foodstuffs<sup>46,47</sup>. This study identified that the  
218 moisture content of the cooked wet noodles ranged between 64-67% wb. Previous study showed that  
219 the water content of the cooked egg wet noodles was around 54-58% wb<sup>47</sup> and maximum of 65%<sup>20</sup>.  
220 Chairuni et al.<sup>46</sup> stated that the boiling process could cause a change in moisture content from about  
221 35% to about 52%. The Indonesian National Standard<sup>48</sup> stipulates that the moisture content of cooked  
222 wet noodles is a maximum of 65%. This means that only control noodles (without treatment) exhibited  
223 a moisture content similar to the previous information. The obtained data showed a trend that an

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224 extract addition caused an increase in the water content of wet noodles, but statistical analysis at  $p \leq$   
 225 5% showed no significant difference. This phenomenon was in accordance with the experimental  
 226 results of Juliana et al.<sup>49</sup> that the using of spenochlea leaf extract for making wet noodles, as well as  
 227 Hasmawati et al.<sup>20</sup> that the sweet potato leaf extract increased the moisture of fresh noodles. The  
 228 water content of pluchea wet noodles was expected by reaction between many components in the  
 229 dough that impacted to the swelling index and cooking loss. Mualim et al.<sup>14</sup>, Bilina et al.<sup>22</sup> and Setiyoko  
 230 et al.<sup>31</sup> reported that the presence of amino in protein and hydroxyl groups in amylose and amylopectin  
 231 fractions in wheat flour as raw material for making dough determines the moisture content, swelling  
 232 index and cooking loss of wet noodles. The contribution of glutenin and gliadin proteins in wheat flour  
 233 to form gluten networks determines the capability of noodles to swell and retain water in the system.  
 234 Gliadin acts as an adhesive that causes dough to be elastic, while glutenin makes the dough to be firm  
 235 and able to withstand CO<sub>2</sub> gas thus, the dough can expand and form pores. Fadzil et al.<sup>32</sup> found that  
 236 thermal treatment during the boiling process results in the denaturation of gluten and causes a  
 237 monomer of proteins to determine other reactions at the disulfide or sulfhydryl chain. The existence  
 238 of phenolic compounds from pluchea extract also increased the capacity of noodles to absorb water  
 239 and determined water mobility. Widyawati et al.<sup>26</sup> confirmed that hydrophilic compounds of proteins,  
 240 carbohydrates, and polyphenolic components determine water mobility due to their ability to bind  
 241 with water molecules through hydrogen bonding. Tuhumury et al.<sup>50</sup> informed that gluten formation  
 242 can inhibit water absorption by starch granules so that can prevent gelatinization. Therefore, the  
 243 addition of phenolic compounds from the hot extract of pluchea leaf powder can inhibit the formation  
 244 of gluten so that stimulates gelatinization of starch granules.

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245 As a result, the impact of increased the moisture content during boiling had an effect on the  
246 value of the swelling index and cooking loss of the wet noodles. Widyawati et al.<sup>26</sup> claimed that the  
247 swelling index is the capability to trap water which is dependent on the chemical composition, particle  
248 size, and water content. Gull et al.<sup>51</sup> further confirmed that the swelling index is an indicator to  
249 determine water absorption by starch and protein to make gelatinization and hydration. Setiyoko et  
250 al.<sup>3</sup> explained that cooking loss is the mass of noodle solids that come out of the noodle strands for  
251 boiling. Gull et al.<sup>51</sup> added that soluble starch and other soluble components leach out into the water  
252 during the cooking process, making the cooking water turned thicker. The moisture content results  
253 (64-67% wb) showed that the produced wet noodles exceeded the moisture content limit of wet  
254 noodles after cooking, which is between 54-58%<sup>46</sup>, while the cooking loss value of wet noodles should  
255 not be more than 10%<sup>51</sup>. In this study, the cooking loss value was 3-4.2%. The cooking loss of samples  
256 during boiling noodles were caused the breaking of the bonding network that the polysaccharides are  
257 released and the gluten network breaks because of the addition of pluchea leaf extract. Widyawati et  
258 al.<sup>26</sup> supported that polyphenol can be bound with protein and starch with many non-covalent  
259 interactions, such as hydrogen bonding, electrostatic interaction, hydrophobic interaction, Van der  
260 Waal's interaction, and  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch  
261 to undergo gelatinization and gliadin and glutelin from the protein of wheat flour to form gluten.

262 The swelling index value derived from this research was about 56-68 %. Based on the previous  
263 research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.) fruit was  
264 around 51%<sup>51</sup>. This means that the addition of pluchea leaf extract in wet noodles also affects the  
265 ability of noodles to absorb water. Widyawati et al.<sup>26</sup> and Suriyaphan<sup>6</sup> noted that bioactive compounds

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in hot water extract of pluchea leaf tea include 3-*O*-caffeoylquinic acid, 4-*O*-caffeoylquinic acid, 5-*O*-caffeoylquinic acid, 3,4-*O*-dicaffeoylquinic acid, 3,5-*O*-dicaffeoylquinic acid, 4,5-*O*-dicaffeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was higher than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from extract in absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch granules to absorb water so that the swelling index and cooking loss increased. Suriyaphan<sup>6</sup> informed that hot extract of pluchea leaf tea contains 1.79 g/100 g protein, 8.65 g/100 g carbohydrate, and fiber (0.45 g/100 g soluble and 0.89 g/100 g insoluble), these compounds can involve in increasing the swelling index from pluchea wet noodles.

Color is one of the physical characteristics possessed by wet noodles that becomes a benchmark for consumer acceptance. This research found that the color of wet noodles was influenced by the addition of pluchea extract. The addition of pluchea leaf extract no significant affected the redness ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it influenced the yellowness ( $b^*$ ) and lightness ( $L^*$ ) values. Using of pluchea leaf powder brewing decreased the brightness of wet noodles significantly, as the concentration of the extract increased. This is related to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to experience color changes. According to Widyawati et al.<sup>8</sup> tannins are water-soluble compounds that can give a brown color. Suriyaphan<sup>6</sup> and Widyawati et al.<sup>26</sup> also stated that Khlu tea from pluchea leaves contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and 6.39 mg/100 g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow color.

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287 Gull et al.<sup>51</sup> stated that this pigment was easily changed in the paste sample due to the swelling and  
288 discoloration of the pigment during cooking.

289 Thus, the addition of hot water extract of pluchea leaf powder significantly reduced the  
290 brightness of wet noodles, because brown-colored noodles were produced as the concentrations of  
291 added pluchea leaf extract increased. However, increasing the concentration of this extract had no  
292 influenced on the redness, hue, and chroma values in ANOVA at  $p \leq 5\%$ . The results showed that the  
293 redness value of wet noodles revolved from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet  
294 noodles ranged from  $82.12 \pm 3.05$  to  $86.47 \pm 1.04$ . Based on this value, the color of wet noodles is in  
295 the yellow to the red color range<sup>52</sup>, thus the visible color of the wet noodle product was yellow to  
296 brown (Figure 2). Yellowness increased significantly with the addition of pluchea leaf extract and the  
297 value ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the availability of tannins and  
298 chlorophyll compounds from pluchea leaf extract. The chroma value of wet noodles was obtained  
299 within the range of  $15.6 \pm 1.5$  to  $19.8 \pm 3.4$ . This means that the brewing of pluchea leaf powder did  
300 not change the intensity of the brown color in the resulting wet noodles.

301 Texture analysis of pluchea wet noodles added with various concentrations of hot water extract  
302 from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness,  
303 elongation, and elasticity. Hardness is the maximum force given to a product until deformation<sup>54,55</sup>.  
304 From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher  
305 peak of graph shows the harder product<sup>53</sup>. Adhesiveness is force or tackiness that is required to pull  
306 the product from its surface, its value is obtained from the area between the first and second  
307 compressions<sup>56,57</sup>. Adhesiveness values show negative value; the bigger negative value means the

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product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and second compressions<sup>55,57</sup>. This is an indication of the internal forces that make up the product<sup>58</sup>. Elongation is the change in length of noodles when being exposed to a tensile force until the noodles break<sup>59</sup>. Elasticity is the time required for the product to withstand the load until it breaks. The more elastic a product, the longer the holding time. The data showed that the higher concentration of pluchea leaf powder within the hot water extract caused a significant increase in the hardness, stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati et al.<sup>26</sup> informed that the polyphenols contained in pluchea leaf extract can be weakly interacted either covalently or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups that are polar. Amoako and Akiwa<sup>60</sup> and Zhu et al.<sup>61</sup> have also proven that polyphenolic compounds can be interacted with carbohydrates through the interaction of two hydrophobic and hydrophilic functional groups with amylose. Diez-Sánchez et al.<sup>62</sup> stated that polyphenolic compounds can be reacted with amylose and protein helical structures and largely determined by molecular weight, conformational mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and amylopectin can affect the gelatinization process in the amylose helical structure and interfere with the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss (> 98%) and swelling index (56.2 to 67.7%)

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329 data, it can be concluded that the interaction that occurs between the phenol group in pluchea leaf  
330 extract with amylose and protein was weak. The bioactive components of pluchea leaf extract are  
331 thought to affect the formation of disulfide cross-links (S-S) and turn into to form sulfhydryl groups (-  
332 SH) under the influence of heat. Ananingsih and Zhou<sup>63</sup> said that antioxidant compounds are a reducing  
333 agent that can have an impact on reducing S-S bonds and increasing the number of SH groups in the  
334 dough to produce a harder texture. According to Rahardjo et al.<sup>54</sup> phenolic compounds are hydroxyl  
335 compounds that influence the strength of the dough, where the higher the component of phenol  
336 compounds will weaken the gluten matrix and the dough thus becoming unstable. The instability of  
337 the dough can cause the texture to become hard.

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338 Many researchers also find that tannins and phenols influence the networking S-S bond in the  
339 dough of wet noodles. Wang et al.<sup>64</sup> showed that tannins increase the relative amount of large, medium  
340 polymers in the gluten protein network so as to improve the dough quality. Zhang et al.<sup>65</sup> claimed that  
341 these polymer compounds are the results of interactions or combinations of protein-tannin  
342 compounds that form bonds with the type of covalent, hydrogen, or ionic bonds. Rauf and Andini<sup>66</sup>  
343 also added that phenol compounds can reduce S-S bonds to SH bonds. SH is a type of thiol compound  
344 group, where the thiol group can influence the stickiness, viscosity, cohesiveness, elongation, and  
345 extensibility of the dough. Wang et al.<sup>67</sup> discovered the effect of phenolic compounds from green tea  
346 extract to increase the stickiness of wheat bread. The cohesiveness of the dough is formed due to a  
347 large number of thiol bonds formed, thus increasing the viscosity of the dough. The increased viscosity  
348 of the dough is thought to be due to the formation of polyphenolic compounds with thiol groups, as in  
349 the research of Ananingsih and Zhou<sup>63</sup> that the formation of catechin-thiol can increase the viscosity of

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the dough and the stability of the dough. Zhu et al.<sup>63</sup> mentioned that the addition of phenolic compounds from green tea was able to increase the PV (peak viscosity) of wheat flour. Wang et al.<sup>64</sup> also found that the cohesiveness of the dough is influenced by tannins, where tannins can produce micro-glutens so as to produce a compact dough and increase the gluten network. The addition of pluchea leaf extract in making wet noodles could influence the elongation of wet noodles due to the components of polyphenol compounds such as tannins that can reduce the number of free amino groups. This is supported by Zhang et al.<sup>65</sup> and Wang et al.<sup>66</sup> that the formation of other types of covalent bonds, such as bonds between amino and hydroxyl groups, by forming hydrogen bonds between phenolic compounds and protein gluten so as to improve the quality of dough strength and dough extensibility.

### Bioactive Compounds and Antioxidant Activity

Wet noodles added with pluchea leaf powder were analyzed based on its bioactive compounds and antioxidant activities. The analysis was conducted to determine the functional properties of wet noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles were presented in Table 5. The measured bioactive compounds (BC) involved total phenolic content (TPC) and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical scavenging activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed that there was a positive and strong correlation between TPC and DPPH ( $r = 0.990$ ), TPC

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371 and FRAP ( $r = 0.986$ ), TFC and DPPH ( $r = 0.974$ ), and TFC and FRAP ( $r = 0.991$ ). This means that the  
372 antioxidant activity of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah et al.<sup>69</sup>  
373 informed that the PC ( $r$ ) > 0.699 indicates the strength and linear correlation between antioxidant  
374 activity (AA) and TPC, and also shows a strong positive relationship but PC ( $r$ ) < 0.699 obtains a  
375 moderately positive relationship. If the  $r$  value of TFC and AA is lower than TPC and AA, it indicates that  
376 the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other  
377 components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship  
378 which is expected because both classes contributed to AA plants. Aryal et al.<sup>70</sup> and Muflihah et al.<sup>69</sup>  
379 informed that phenolic compounds are soluble natural antioxidants and potential donating electrons  
380 depend on their number and position of hydroxyl groups contributed to antioxidant action.  
381 Consequently, these groups are responsible to scavenge the free radicals which is expressed as TPC of  
382 pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the  
383 stable purple-colored to the yellow-colored solution. Based on FRAP analysis, it was showed that the  
384 bioactive compounds contained in pluchea wet noodles were a potential source of antioxidants  
385 because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive  
386 compounds in pluchea wet noodles can function as primary and secondary antioxidants. Research data  
387 showed that the cooking quality of wet noodles tends to increase along with the increase in the values  
388 of TPC, TFC, DPPH and FRAP.

### 389 Sensory Evaluation

390 Sensory assay of pluchea wet noodles, namely color, aroma, taste, texture, and overall  
391 acceptance, was carried out using a hedonic test to determine the level of consumer preference for

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the product. This test was conducted to determine the quality differences between the products and to provide an assessment on certain properties<sup>72</sup>. The hedonic test is the most widely used assessment to determine the level of preference for product<sup>73</sup>. The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm 1.26$  (neutral-like). The statistical analysis showed that the higher concentration of hot water extract addition decreased lower color preference of wet noodles. The higher concentration of pluchea extract could reduce the level of color preference because the color of the wet noodles was darker than control and turned to dark brown. This color change was due to the pluchea extract containing several components, including chlorophyll and tannins, which can alter the of wet noodles' color to be browner along with the increase in the concentration of pluchea extract. This result was in accordance to the effect of color analysis performed using color reader where the pluchea wet noodles' brightness declined, yellowness increased, and the color intensity increased with an increased concentration of pluchea extract. The occurrence of this process is related to the effect of light and heat on pluchea leaf powder which causes the degradation of chlorophyll into brown pheophytin due to drying, where the nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals<sup>72,73</sup>.

Aroma is one of the parameters in sensory evaluation using the sense of smell and an indicator of the assessment of a product<sup>74</sup>. The results of the preference values for aroma were ranged from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet noodles reduced the preference score for aroma due to distinct dry leaves (green) aroma. According to Lee et al.<sup>75</sup> the unpleasant aroma on leaves comes from a group of aliphatic aldehyde compounds. The

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413 appearance of a distinctive leaf aroma in noodles is due to aromatic compounds. According to  
414 Martiyanti and Vita<sup>76</sup> aromatic compounds are chemical compounds that have an aroma or odor when  
415 the conditions are met, which is volatile, while Widyawati et al.<sup>77</sup> informed that pluchea leaves were  
416 detected to have 66 volatile compounds. The appearance of the aroma is due to the volatile  
417 compounds in the raw material reacting with water vapor when boiling the noodles. In addition, there  
418 is also an oxidation process of polyphenolic compounds such as catechins or tannins that can produce  
419 an aroma in pluchea wet noodles.

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420 According to Martiyanti and Vita<sup>3</sup> taste attribute is one important sensory aspect in food  
421 products and has a great impact on the food selection by consumers. Tongue is able to detect basic  
422 tastes, such as sweet, salty, sour, and bitter, at different points. Lamusu<sup>78</sup> declared that taste is a  
423 component of flavor and an important criterion in assessing a product that is accepted by the tongue.  
424 The preference test of the taste of pluchea wet noodles resulted in values ranging from  $4.15 \pm 1.40$  to  
425  $5.50 \pm 1.28$  (neutral-slightly like). The increase in concentrations of pluchea extract was negatively  
426 correlated to the preference level of the taste of pluchea wet noodles assessed by the panelists. The  
427 statistical analysis results showed that the difference in the concentration of the extract significant  
428 influenced on the preference score for the taste of pluchea wet noodles. The increased concentration  
429 of pluchea extract produced a distinctive taste on wet noodles, such as a bitter and astringent tastes,  
430 due to the presence of compounds such as tannins and alkaloids from the pluchea leaves.  
431 Susetyarin<sup>79</sup> said that pluchea leaves contain tannins (2.35%), and alkaloids (0.32%). According to  
432 Pertiwi<sup>79</sup> tannin compounds dominate the bitter and astringent taste, while alkaloid compounds cause

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433 a bitter taste. The high level of taste preference for wet noodles was found in noodles with lower  
434 content of pluchea extract.

435 Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and  
436 swallowed) or touched with fingers<sup>80</sup>. Texture testing performed by the panelist is called mouthfeel  
437 testing. According to Martiyanti and Vita<sup>76</sup>, mouthfeel is the kinesthetic effect of chewing food in the

438 mouth. In this study, the preference test results on the texture of pluchea wet noodles revolved from  
439  $5.50 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy

440 and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet  
441 noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that  
442 can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and  
443 draining noodles. Subjective testing results based on sensory evaluation were in line with the objective  
444 testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to  
445 break, and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea

446 wet noodles was influenced by the fiber and protein components. According to Shabrina<sup>81</sup>, the  
447 components of fiber, protein, and starch complete to bind water. Texture changes are also influenced  
448 by the polyphenol compositions in the pluchea extract which is able to reduce S-S bonds to SH bonds,

449 where the increase in SH (thiol) groups can cause a hard, sticky, and compact texture<sup>64,66,67</sup>. Besides, a  
450 high concentration of tannins capable of binding to proteins to form complex compounds into tannins-  
451 proteins are also able to build noodles' texture.

452 The interaction between color, aroma, taste, and texture created an overall taste of the food  
453 product and was assessed as the overall preference. The highest value on the overall preference was

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454 derived from control wet noodles, i.e., 6.63 (slightly like it), while the wet noodles added with 20%  
455 (w/v) concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The  
456 addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to  
457 10% (w/v) concentration with scores of 6.63 and 6.53, respectively. The area of the spider web chart  
458 for each treatment with the various concentrations of pluchea extract was seen in Figure 3. The best  
459 treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37  
460 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the  
461 scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like),  
462 respectively.

463 The use of pluchea leaf extract in the making of wet noodles was able to increase the functional  
464 values of wet noodles, based on the levels of bioactive compounds and antioxidant activity without  
465 changing the quality of cooking, which included water content, swelling index and cooking loss. Besides  
466 that, the use of pluchea leaf extract did not significantly change the color and color intensity of the  
467 resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet  
468 noodles produced were still acceptable to the panelists, the addition of pluchea leaf extract as much  
469 as 10% (w/v) was the best treatment with an assessment that was almost closed to the control wet  
470 noodles (without treatment).

#### 471 Conclusion

472 Addition of hot water extract of pluchea leaf powder influenced physical, chemical and sensory  
473 properties of wet noodles. Lightness, texture, bioactive compound content, antioxidant activity, and  
474 sensory properties of samples underwent significant difference. The higher concentration of pluchea

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475 extract caused the bigger these parameters of pluchea wet noodles. Using 10% (w/v) of hot water  
476 extract from pluchea leaf powder was the best treatment with color, aroma, taste, and texture scores  
477 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. Utilization of  
478 hot water extract of pluchea leaf powder at 10% (w/v) resulted functional wet noodles with TPC, TFC,  
479 DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg dried samples, 62.44  
480 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples and 51.33 mg GAE/kg dried samples,  
481 respectively.

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#### 482 483 Notes on Appendices

TPC	Total phenolic content
TFC	Total flavonoid content
DPPH	2,2-Diphenyl-1-picrylhydrazyl free radical
FRAP	Ferric reducing antioxidant power
AA	Antioxidant activity
PC	Pearson Correlation
LDL	Low Density Lipoprotein
w/v	Weight per volume
CRD	Completely randomized design
CE	Catechin equivalent
GAE	Gallic acid equivalent
BC	Bioactive compounds

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ANOVA Analysis of variance

UV-Vis Ultra violet-visible

Wb Wet base

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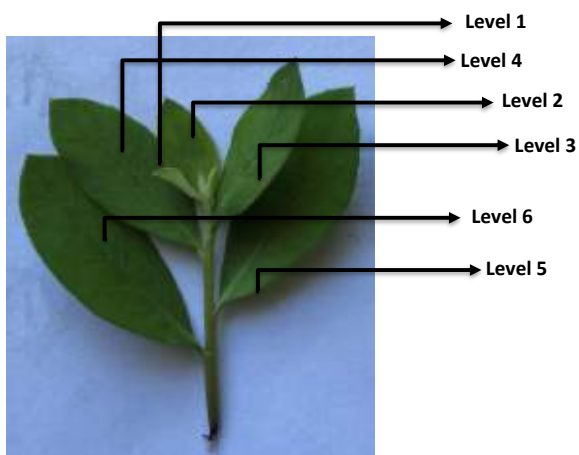


Figure 1. Young *Pluchea indica* Less leaves

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Table 1. Information of hot water extract of pluchea tea

Materials	Concentration of hot water extract of pluchea leaf tea (% w/v)						
	0	5	10	15	20	25	30
Pluchea leaf tea (g)	0	10	20	30	40	50	60
Hot water (mL)	200	200	200	200	200	200	200

743 **Table 2. Ingredients** of pluchea wet noodles

Materials	Unit	Quantity
Wheat flour	g	200
Egg	g	40
Salt	g	4
Baking powder	g	2
Hot water extract	mL	70
Tapioca flour	g	10
TOTAL	g	326

744

**Table 3.** Color, moisture content, swelling index, and cooking loss of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Color					Moisture content (% wb)	Swelling index (%)	Cooking loss (%)
	L*	a*	b*	C	h			
0	67.14 ± 1.77 <sup>a</sup>	0.97±0.30	16.18±0.62 <sup>ab</sup>	16.20 ± 0.63	86.47 ± 1.04	63.90±1.51	56.22±17.36	3.40±1.31
5	59.49 ± 2.67 <sup>b</sup>	2.18±0.93	15.47±1.46 <sup>a</sup>	15.62 ± 1.53	82.12 ± 3.05	65.08±4.33	62.40± 4.71	3.33±1.26
10	58.95 ± 1.80 <sup>b</sup>	1.95±1.66	16.76±2.33 <sup>abc</sup>	17.08 ± 2.16	83.29 ± 5.37	64.97±3.89	61.50± 7.51	3.00±1.16
15	58.35 ± 2.24 <sup>b</sup>	1.69±1.48	19.72±3.50 <sup>c</sup>	19.77 ± 3.38	84.67 ± 4.64	65.56±2.18	63.09± 6.31	3.31±0.92
20	56.48 ± 2.40 <sup>b</sup>	1.97±1.24	19.09±2.97 <sup>bc</sup>	19.18 ± 2.90	83.62 ± 4.33	66.81±1.81	67.74± 5.91	4.06±0.51
25	59.07 ± 2.49 <sup>b</sup>	1.95±1.44	19.55±2.97 <sup>c</sup>	19.58 ± 2.90	83.83 ± 4.41	66.04±0.85	64.46±10.32	3.93±1.37
30	57.10 ± 2.06 <sup>b</sup>	2.09±1.51	18.08±4.94 <sup>abc</sup>	18.28 ± 4.84	82.49 ± 5.22	66.65±2.16	63.96± 5.31	4.23±1.34

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$

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749 **Table 4.** Texture of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Texture of pluchea wet noodles				
	Hardness (N)	Adhesiveness (g sec)	Cohesiveness	Elongation (%)	Elasticity (Pa)
0	135.75±5.91 <sup>a</sup>	-2.67 ±0.30 <sup>d</sup>	0.65±0.01 <sup>a</sup>	86.89±0.90 <sup>a</sup>	25336.72±104.20 <sup>a</sup>
5	120.13±2.05 <sup>a</sup>	-3.36±0.60 <sup>cd</sup>	0.68±0.00 <sup>b</sup>	97.25±1.59 <sup>b</sup>	25898.27±760.94 <sup>b</sup>
10	134.85±1.77 <sup>a</sup>	-3.91±0.65 <sup>bc</sup>	0.74±0.00 <sup>c</sup>	162.10±1.49 <sup>c</sup>	25807.73±761.85 <sup>b</sup>
15	180.48±5.06 <sup>b</sup>	-4.91±0.47 <sup>b</sup>	0.74±0.01 <sup>c</sup>	164.74±0.60 <sup>c</sup>	26971.61±516.71 <sup>b</sup>
20	195.11±14.14 <sup>b</sup>	-4.95±1.26 <sup>ab</sup>	0.75±0.01 <sup>cd</sup>	221.60±1.55 <sup>d</sup>	27474.38±453.80 <sup>b</sup>
25	244.57±8.81 <sup>c</sup>	-6.03±0.29 <sup>a</sup>	0.75±0.00 <sup>cd</sup>	230.65±0.73 <sup>e</sup>	27367.05±287.48 <sup>b</sup>
30	282.79±28.31 <sup>d</sup>	-6.05±0.22 <sup>a</sup>	0.79±0.01 <sup>d</sup>	255.38±0.36 <sup>f</sup>	26687.52±449.19 <sup>b</sup>

750 Note: the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in  
751 the same column are significantly different,  $p \leq 5\%$

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**Table 5.** Total phenol content, total flavonoid content, the DPPH free radical scavenging activity, and iron ion reducing power of the pluchea wet noodles.

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	TPC (mg GAE/kg Dried Noodles)	TFC (mg CE/kg Dried Noodles)	DPPH (mg GAE/kg Dried Noodles)	FRAP (mg GAE/kg Dried noodles)
0	39.26±0.66 <sup>a</sup>	32.36±1.47 <sup>a</sup>	96.75±4.26 <sup>a</sup>	25.96±0.25 <sup>a</sup>
5	61.09±3.80 <sup>b</sup>	46.31±2.15 <sup>b</sup>	121.36±3.58 <sup>b</sup>	34.50±1.71 <sup>b</sup>
10	82.84±3.11 <sup>c</sup>	62.44±0.55 <sup>c</sup>	130.68±4.82 <sup>c</sup>	51.33±2.19 <sup>c</sup>
15	101.48±2.16 <sup>d</sup>	84.67±1.22 <sup>d</sup>	142.48±2.14 <sup>d</sup>	58.69±2.14 <sup>d</sup>
20	114.94±4.20 <sup>e</sup>	100.14±1.50 <sup>e</sup>	148.84±3.20 <sup>e</sup>	67.26±0.06 <sup>e</sup>
25	128.06±1.38 <sup>f</sup>	107.93±0.89 <sup>f</sup>	157.51±7.69 <sup>f</sup>	69.53±1.06 <sup>f</sup>
30	136.35±1.16 <sup>g</sup>	131.69±1.56 <sup>g</sup>	166.97±1.53 <sup>g</sup>	84.98±0.11 <sup>g</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

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**Table 6.** Effect of hot water extract from pluchea leaf powder to preferences for color, aroma, taste, texture, and overall acceptance of wet noodles at various concentrations

Concentration of Hot		Hedonic Score			
Extract from Pluchea					
Leaf Powder (% w/v)	Color	Aroma	Taste	Texture	Overall acceptance
0	6.19±1.25 <sup>d</sup>	5.52±1.08	5.50±1.18 <sup>c</sup>	6.20±1.13 <sup>b</sup>	6.63±1.49 <sup>c</sup>
5	5.62±1.28 <sup>c</sup>	5.52±0.83	5.51±1.29 <sup>c</sup>	6.37±1.14 <sup>bc</sup>	6.40±1.52 <sup>c</sup>
10	5.62±1.21 <sup>c</sup>	5.45±0.85	5.46±1.12 <sup>c</sup>	6.53±1.14 <sup>c</sup>	6.53±1.64 <sup>c</sup>
15	5.14±1.25 <sup>b</sup>	4.81±1.04	4.61±1.11 <sup>b</sup>	6.13±1.09 <sup>b</sup>	5.78±1.67 <sup>b</sup>
20	4.91±1.32 <sup>b</sup>	4.54±1.18	4.47±1.15 <sup>ab</sup>	5.80±1.06 <sup>a</sup>	5.17±1.70 <sup>a</sup>
25	4.54±1.40 <sup>a</sup>	4.26±1.23	4.20±1.24 <sup>a</sup>	5.50±1.04 <sup>a</sup>	5.23±1.75 <sup>a</sup>
30	4.47±1.33 <sup>a</sup>	4.05±1.34	4.15±1.40 <sup>a</sup>	5.59±1.05 <sup>a</sup>	5.37±1.91 <sup>a</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means

with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

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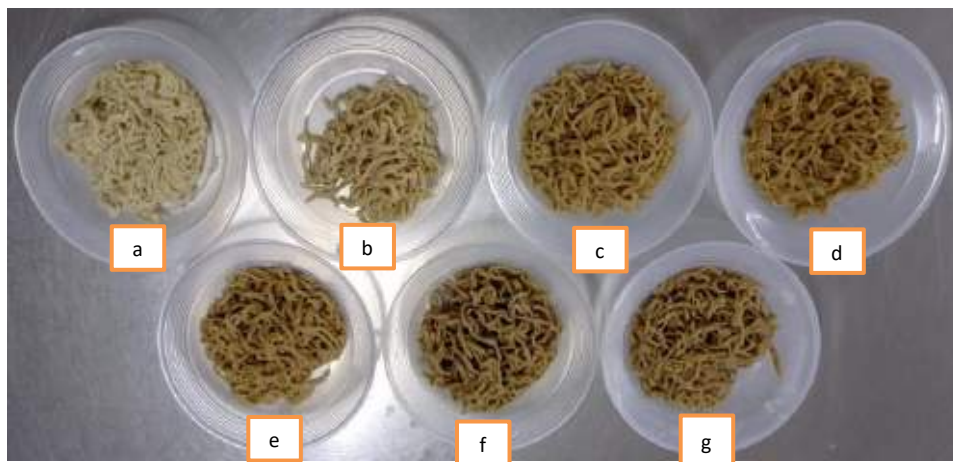
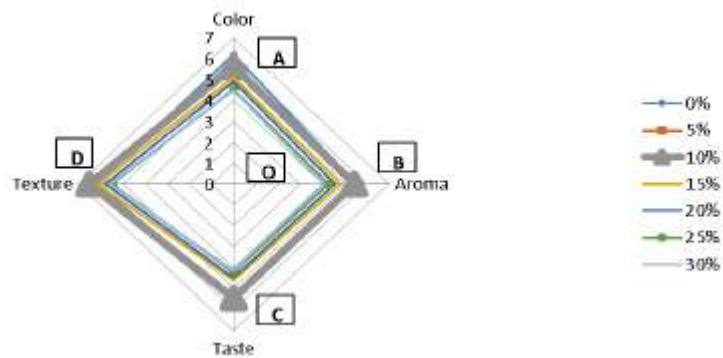


Figure 2. Wet noodles with hot water extract of pluchea leaf powder added at concentrations

a. 0%; b. 5%; c. 10%; d. 15%; e. 20%; f. 25%; and g. 30% w/v

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**Commented [D230]:** Changed Figure 2



**Figure 3.** Spider web graph of sensory evaluation on wet noodles at various concentrations of hot water extract from pluchea leaf powder

**Commented [D231]:** Changed Figure 3



Paini Sri Widyawati <paini@ukwms.ac.id>

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## Request for revision as per editorial comments - 3638

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**Managing Editor** <info@foodandnutritionjournal.org>

Fri, Apr 7, 2023 at 1:53 PM

To: Paini Sri Widyawati <paini@ukwms.ac.id>

Dear Dr Paini,

Thank you for submitting the revised manuscript.

We are forwarding your article to our editorial board member for the re-evaluation process, we will update you soon accordingly.

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Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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## Request for revision as per editorial comments - 3638

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**Managing Editor** <info@foodandnutritionjournal.org>

Wed, Apr 12, 2023 at 1:01 PM

To: Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

Dear Dr Paini Sri Widyawati,

We have received the final comments on your manuscript from our editorial board member.

Attached are their suggestions for your reference - **"Please re-read again what I said in my previous email:****5. Please add a reference to the noodle processing method that use in this study.****6. Concerning sensory evaluation, whether the author has made concerns form before the examination? If yes, please add the sentence regarding 'all panellists supplied informed consent before the examination'. Line 187, please make an explanation why the author uses panellists 17 to 25 years old? Please add the word 'old' after 17 and 25 years.****I state again:**

- 1. The author did not change to put a reference to noodle processing.**
- 2. The author did not explain why they use panellists 17 to 25 years old."**

We kindly request you revise the file as per their comments and resend us along with the response form at your earliest convenience

Kindly do the needful so that we will move forward with the publication process in a timely manner.

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**Response Form\_Final Comments.docx**

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Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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## Request for revision as per editorial comments - 3638

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**Paini Sri Widyawati** <paini@ukwms.ac.id>

Thu, Apr 13, 2023 at 8:00 AM

To: Managing Editor &lt;info@foodandnutritionjournal.org&gt;

Dear Ms Yanha Ahmed

I have sent my revised manuscript with adding :

1. The reason of choosing panelist and statement **"all panellists supplied informed consent before the examination"**
  2. Two references to making wet noodles (Risti et al., 2013 and Permatasari et al., 2009)
  3. Revision of list number of references
- All revisions have been given a green color sign.

Thanks for attention

Regards

Paini SW

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### 2 attachments

**Response Form\_Final Comments (3).docx**

48K

**The Effect of Hot Water Extract of Pluchea indica Leaf Powder on the Physical-Revision (1) (1).docx**

989K



### Author's Response to Editor's Comments

Paper title: The effect of hot water extract of *Pluchea indica* leaf powder on the sensory properties of wet noodles

Title	Editor's Comments	Author's Response
Abstract		Have been revised and corrected
Keywords		Have been revised and corrected
Introduction		Have been revised and corrected
Methodology		Have been revised and corrected
Results		Have been revised and corrected
Discussion		Have been revised and corrected
Conclusion		Have been revised and corrected
References (Appropriateness)		Have been revised and corrected
Data /Figure/Table		Have been revised and corrected

# The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

## Abstract

Powdered *Pluchea indica* Less leaves have been utilized as herbal tea, brewing of pluchea tea in hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional values and influence physic, chemical, and sensory characteristics of food. The study was carried out to assess the effect of various concentration of *pluchea* tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with pluchea tea at concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v). Physical properties analyzed included water content, swelling index, cooking loss, color and texture. Chemical properties measured were bioactive contents of total phenolic content, total flavonoid content, and antioxidant ability to scavenge DPPH free radicals and to reduce iron ions. Sensory properties determined were taste, texture, color, aroma and overall acceptance. The addition of various concentrations of extract offers significantly effects on parameters of physical, chemical and sensory properties of noodles, except color (redness, chroma and hue), cooking loss, water content, swelling index and aroma. Using of 10% (w/v) of pluchea tea resulted in the best sensory properties such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. Generally, the study concluded that wet noodles can be made by adding pluchea tea at 10% (w/v). Dried samples TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg, 62.44 mg CE/kg, 130.68 mg GAE/kg and 51.33 mg GAE/kg, respectively.

## Key-words

Chemical, physical, *Pluchea indica* Less, sensory, wet noodles

## Introduction

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food<sup>1,2</sup>. The potency of pluchea leaves is related to phytochemical compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone, alkaloid, lignans and saponins<sup>2,3,4,5</sup>. Chan et al.<sup>1</sup> also reported that caffeoylquinic acids, phenolic acids, flavonoids and thiophenes in pluchea leaves are compounds with antioxidant activities. Furthermore,

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37 pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100 g, fat 0.49 g/100 g, insoluble dietary  
38 fiber 0.89 g/100 g, soluble dietary fiber 0.45 g/100 g, carbohydrate 8.65 g/100 g, calcium 251 mg/100  
39 g,  $\beta$ -carotene 1.225  $\mu$ g/100 g<sup>6</sup>.

40 **Pluchea tea brewed from pluchea leaves** has been proven to exhibit antioxidant activity<sup>6,7,8</sup>,  
41 anti-diabetic activity<sup>9</sup>, anti-inflammatory activity<sup>7</sup>, **anti-human** LDL oxidation activity<sup>10</sup>. Previous  
42 research uses pluchea leaf powder to make several food products to increase functional values, i.e.,  
43 jelly drink<sup>11</sup>, soy milk<sup>12</sup> and steamed bun<sup>13</sup>. Using 1% (w/v) pluchea leaf powder can improve the  
44 physicochemical properties of jelly drink and increase panelists' acceptance of the product<sup>11</sup>. Soy milk  
45 with the addition of pluchea leaves increases the viscosity and total dissolved solids and decreases the  
46 panelist acceptance rate<sup>12</sup>. The addition of 6% (w/v) brewing from pluchea leaf powder on steamed  
47 bun is the best treatment with the lowest level of hardness<sup>13</sup>. **Previous** research has proven that the  
48 addition of pluchea leaves can increase the bioactive compound contents based on total phenol and  
49 total flavonoids, as well as increase **the** antioxidant activity based on ferric reducing power and ability  
50 to scavenge DPPH free **radicals**.

51 To the best of our knowledge, the study of the addition of **of pluchea** tea in making wet noodles  
52 from wheat flour has not been conducted, as well as its impact on physicochemical and **sensory**  
53 characteristics of the noodles. Noodles are a popular food product that is widely consumed in the  
54 world. Indonesia is one of the countries with the largest noodle consumption after China<sup>14</sup>. Wet  
55 noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet noodles as an  
56 alternative to wet noodles, which contain higher protein, and the second popular food in ASEAN  
57 regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia<sup>16</sup>. The

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58 addition of other ingredients has been endeavored to enhance wet noodles' specific properties. Many  
59 researchers incorporated plant extracts or natural products to increase functional properties of wet  
60 noodles, such as red spinach<sup>17</sup>, green tea<sup>18,19</sup>, purple sweet potato leaves<sup>20</sup>, moringa leaves<sup>21</sup>, sea  
61 weed<sup>22</sup>, ash of rice straw, turmeric extract<sup>23</sup>, and betel leaf extract<sup>24</sup> that influenced the physical,  
62 chemical, and organoleptic properties of the wet noodles. The anthocyanin of red spinach ethanolic  
63 extract increases the hedonic score of wet noodles' flavor<sup>17</sup>. The addition of green tea improves the  
64 stability, elastic modulus and viscosity, retrogradation and cooking loss with, no significant effect on  
65 mouth-feel and overall acceptance from panelist on the produced wet noodles<sup>18</sup>. Moreover, the  
66 addition of sweet potatoes leaf extract on wet noodles increases moisture content, protein value and  
67 ash concentration, and improves hedonic score of texture<sup>20</sup>. Moringa extract influences protein  
68 content and decreases panelist acceptance of color, aroma and taste of wet noodles<sup>21</sup>. The use of  
69 seaweed to produce wet noodles influences moisture content, swelling index, absorption ability,  
70 elongation value and color<sup>22</sup>. The addition of ash from rice straw and turmeric extract influences the  
71 elasticity and sensory characteristics (color, taste, aroma and texture) of wet noodles<sup>23</sup>. Betel leaf  
72 extract used to make Hokkien (with dark soya source) noodles improves texture and acceptance score  
73 of all sensory attributes<sup>24</sup>.

74 Bioactive compounds and nutritive values of pluchea leaf can be an alternative ingredient to  
75 improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea  
76 leaves can serve as an antioxidant source in wet noodles and increase the functional value. This study  
77 was undertaken to assess the effect of various concentration of pluchea tea on the physical, chemical  
78 and sensory properties of wet noodles.

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79 **Materials and Methods**80  
81 **Preparation of Hot Water Extract from Pluchea Leaf Powder**

82 Young pluchea leaves (1-6) (Figure 1) were picked from the shoots, sorted and washed. The  
83 selected leaves were dried at ambient temperature for 7 days to yield moisture content of 10.00 ±  
84 0.04% dry base<sup>25</sup>. Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at 120°C  
85 for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag for  
86 about 2 g/tea bag. Pluchea leaf powder in tea bags was extracted using hot water (95°C) for 5 min to  
87 get extract concentrations of 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

88 **Wet Noodles Processing**

89 About 70 mL of hot extract from pluchea leaf powder with concentrations of 0, 5, 10, 15, 20, 25  
90 and 30% (w/v) (Table 1) was manually mixed with egg, baking powder, salt and wheat flour for 5 min  
91 (Table 2). The mixture was kneaded to form a solid and homogenized dough using a mixer (Oxone  
92 Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to form noodle  
93 strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled water about  
94 3 min in 300 mL water and coated with oil to prevent the noodles from sticking to each other<sup>26</sup>. Wet  
95 noodles made without any addition of hot water of pluchea leaf extract were prepared as control. Wet  
96 noodles used in bioactive compounds and antioxidant activity assay were not added with oil to prevent  
97 the noodles from sticking to one another. The final characteristics of wet noodles have width and  
98 thickness of 0.45 cm and 0.30 cm, respectively.

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## 101 Pluchea Wet Noodles Extraction

102 About 100 g of wet noodles were dried using a freeze-dryer at a pressure of 0.1 bar and  
103 temperature -60°C for 28 hours. Dried noodles were powdered using a chopper machine for 35  
104 seconds. And then, 20 g of samples were mixed by 50 mL absolute methanol by a shaking water-bath  
105 at 35°C, 70 rpm for 1 hour<sup>27</sup>. Filtrate was separated using Whatman filter paper grade 40 and residue  
106 was extracted again with the same procedure. The filtrate was collected and evaporated by rotary  
107 evaporator until getting 3 mL of extract (Buchi Rotary Evaporator; Buchi Shanghai Ltd, China) at 200  
108 bars, 50°C for 60 min. The extract was kept at 0°C before further analysis.

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## 109 Moisture Content Assay

110 Moisture or water content of wet noodles was determined by thermos-gravimetric method<sup>28</sup>.  
111 The moisture content of wet noodles was determined by heating the samples in a drying oven (Binder,  
112 Merck KGaA, Darmstadt, Germany) and weighing the evaporated water content in the material.

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## 113 Measurement of Swelling Index

114 The purpose of swelling index testing was to determine the capability of the noodles to swell  
115 during the boiling process<sup>16</sup>. The assay was done to determine the ability of wet noodles to absorb  
116 water per unit of time or the time needed to fully cooked wet noodles. The amount of water absorbed  
117 by wet noodles was measured from the weight before and after boiling.

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## 118 Determination of Cooking Loss

119 Cooking loss is one of the necessary quality parameters to establish the quality of wet noodles  
120 after boiling<sup>29</sup>. The cooking loss assay was done by measuring the quantity of solids that leached out

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121 of the noodles during the boiling process, e.g., starch. A large cooking loss value affects the texture of  
122 wet noodles, which is easy to break and less slippery.

### 123 Determination of Texture

124 The texture of pluchea wet noodles was measured based on hardness, adhesiveness,  
125 cohesiveness, elongation and elasticity. The texture was analyzed by TA-XT2 texture analyzer (Stable  
126 Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the Texture Exponent 32  
127 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were analyzed with a  
128 compression assay using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle strands with the length  
129 of 4 cm for each strand were laid side by side, touching each other, perpendicular to the 35 mm  
130 compression cylinder probe on a flat aluminum base. The cylinder probe was arranged to be at 15 mm  
131 distance from the lower plate at the start of the compression test, and was pressed down through the  
132 noodle strips at the speed of 2 mm s<sup>-1</sup> until it touched the flat base to compress 75% of the noodle  
133 thickness, and was drawn back to at the end of the test. The profile curve was determined using a  
134 texture analyzer software<sup>24,30</sup>. The hardness was determined as the maximum force per gram. The  
135 adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area was  
136 obtained from the compression test under the curve. Cohesiveness was analyzed based on the ratio  
137 between the area under the first and the second peaks<sup>24,30,31</sup>. The elongation and elasticity of the  
138 noodles were individually tested by putting one end into the lower roller arm slot and sufficiently  
139 winding the loosened arm to fasten the noodle end. Elongation was the maximum force to change of  
140 noodle form and break by extension that was analyzed by a test speed of 3.0 mm s<sup>-1</sup> between two

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rollers with a 100 mm distance. The elongation at breaking was calculated per gram. Elasticity was determined by formula (1)<sup>32,33</sup>:

$$\text{Elasticity} = \frac{Fx}{Ax} \frac{lo}{to} \frac{1}{v} \quad (1)$$

where F is the tensile strength, lo is the original length of the noodles between the limit arms (mm), A is the original cross-sectional area of the noodle (mm<sup>2</sup>), v is the rate of movement of the upper arm (mm/s), and t is break up time of the noodles (s). The measurement of texture was detected by the software and expressed as a graph.

#### Color Measurement

The color of the noodle sheets was determined by a colorimeter (Minolta CR 10, Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab L\*, a\* and b\* values were analyzed based on the method by Fadzil et al.<sup>30</sup> The L\* value measured the position on the white/black axis, the a\* value as the position on the red/green axis, and the b\* value as the position on the yellow/blue axis.

#### Analysis of Total Phenolic Content

The total phenolic content analysis was analyzed based on the reaction between phenolic compounds and Folin Ciocalteu (FC) reagent or phosphomolybdic acid and phosphotungstic acid. The FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups to become a blue molybdenum-tungsten complex solution<sup>34</sup>. The intensity of the blue color was detected by a UV-Vis spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 760 nm. In the analysis, 7.5% Na<sub>2</sub>CO<sub>3</sub> solution was added to reach pH 10 that caused an electron transfer reaction (redox). The obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

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## 162 Analysis of Total Flavonoid Content

163 The flavonoid content assay was done using the spectrophotometric method based on the  
164 reaction between flavonoids and  $\text{AlCl}_3$  to form a yellow complex solution. In the presence of NaOH  
165 solution, a pink color is formed which can be detected by spectrophotometer (Spectrophotometer UV-  
166 Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm<sup>34,35,36</sup>. The obtained data were expressed in mg of catechin  
167 equivalent (CE)/L sample.

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## 168 Analysis of DPPH Free Radical Scavenging Activity

169 The ability of antioxidant compounds to scavenge DPPH (2,2-diphenyl-1-picrylhydrazyl) free  
170 radicals can be used to evaluate antioxidant activity. The principle of the DPPH method is to measure  
171 the absorbance of compounds that can react with DPPH radicals<sup>37</sup>. Antioxidant compounds can donate  
172 hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced to yellow<sup>38</sup>. The color  
173 change was measured as an absorbance at  $\lambda$  517 nm by spectrophotometer (Spectrophotometer UV  
174 Vis 1800, Shimadzu, Japan)<sup>39</sup>. The data were expressed in mg gallic acid equivalent (GAE)/L dried  
175 noodles sample.

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## 176 Analysis of Iron Ion Reduction Power

177 This method identifies the capacity of antioxidant components using potassium ferricyanide,  
178 trichloroacetic acid and ferric chloride to produce color complexes that can be measured  
179 spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm<sup>40</sup>. The  
180 principle of this testing is the ability antioxidants to reduce iron ions from  $\text{K}_3\text{Fe}(\text{CN})_6$  ( $\text{Fe}^{3+}$ ) to  $\text{K}_4\text{Fe}(\text{CN})_6$   
181 ( $\text{Fe}^{2+}$ ). Then, potassium ferrocyanide reacts with  $\text{FeCl}_3$  to form a  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$  complex. The color

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182 change is from yellow to green<sup>41</sup>. The final data were expressed in mg gallic acid equivalent (GAE)/L  
183 dried noodles.

#### 184 Sensory Evaluation

185 The hedonic test of all samples of wet noodles involved 100 untrained panelists with an age  
186 range of 17 to 25 years old. All panelist supplied informed consent before the examination. A hedonic  
187 test used in this research was the hedonic scoring method, where the panelists gave a preference score  
188 value of all samples<sup>26</sup>. The hedonic scores were transformed to numeric scale and analyzed using  
189 statistical analysis<sup>42</sup>. The numeric scale in the sensory analysis used a 9-point hedonic scale ranging  
190 from 1 (extremely disliked) to 9 (extremely liked). The panelists were asked to score according to their  
191 level of preference for texture, taste, color, flavor and overall acceptability. All the samples were blind  
192 coded with 3 digits which differed from each other<sup>43</sup>.

#### 193 Statistical Analysis

194 The research design used in the physicochemical assay was a randomized block design (RBD)  
195 with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that  
196 consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25 and 30% (w/v). Each treatment was repeated four  
197 times that obtained 28 experiment units. A completely randomized design (CRD) was used to evaluate  
198 sensory assay with 100 untrained panelists with an aged 17 to 25 years old.

199 The normal distribution and homogeneity data were stated as the mean  $\pm$  SD of the triplicate  
200 determinations and determined using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc., Chicago,  
201 IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan Multiple

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202 Range Test) at  $p \leq 5\%$  to determine treatment level that gave significant different results. The best  
203 treatment of pluchea extract addition on wet noodles was analyzed by a spider web graph.

## 204 Results and Discussion

205 Wet noodles added with hot extract of pluchea leaf powder were produced to increase the  
206 functional values of wet noodles. This is supported by previous studies related to the potential values  
207 of water extract of pluchea leaf that exhibits biological activities<sup>6,7,26</sup>. In this research, the cooking  
208 quality was observed after cooking wet noodles in 300 mL water/100 g samples for 3 min in boiling  
209 water.

## 210 Cooking Quality

211 Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at 0, 5,  
212 10, 15, 20, 25 and 30% (w/v) was shown in Figure 2, Table 3 and Table 4. The addition of pluchea  
213 extract no significantly influenced the water content, cooking loss, swelling index, chroma, and hue of  
214 the produced wet noodles using statistical analysis by ANOVA at  $p \leq 5\%$ . Water content is one of the  
215 chemical properties of a food product determined shelf life of food products, because the water  
216 content measures the free and weakly bound water in foodstuffs<sup>44,45</sup>. This study identified that the  
217 moisture content of the cooked wet noodles ranged between 64-67% wb. Previous study showed that  
218 the water content of the cooked egg wet noodles was around 54-58% wb<sup>45</sup> and maximum of 65%<sup>20</sup>.  
219 Chairuni et al.<sup>44</sup> stated that the boiling process could cause a change in moisture content from about  
220 35% to about 52%. The Indonesian National Standard<sup>46</sup> stipulates that the moisture content of cooked  
221 wet noodles is a maximum of 65%. This means that only control noodles (without treatment) exhibited  
222 a moisture content similar to the previous information. The obtained data showed a trend that an

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223 extract addition caused an increase in the water content of wet noodles, but statistical analysis at  $p \leq$   
 224 5% showed no significant difference. This phenomenon was in accordance with the experimental  
 225 results of Juliana et al.<sup>47</sup> that the using of spenochlea leaf extract for making wet noodles, as well as  
 226 Hasmawati et al.<sup>20</sup> that the sweet potato leaf extract increased the moisture of fresh noodles. The  
 227 water content of pluchea wet noodles was expected by reaction between many components in the  
 228 dough that impacted to the swelling index and cooking loss. Mualim et al.<sup>14</sup>, Bilina et al.<sup>22</sup> and Setiyoko  
 229 et al.<sup>29</sup> reported that the presence of amino in protein and hydroxyl groups in amylose and amylopectin  
 230 fractions in wheat flour as raw material for making dough determines the moisture content, swelling  
 231 index and cooking loss of wet noodles. The contribution of glutenin and gliadin proteins in wheat flour  
 232 to form gluten networks determines the capability of noodles to swell and retain water in the system.  
 233 Gliadin acts as an adhesive that causes dough to be elastic, while glutenin makes the dough to be firm  
 234 and able to withstand CO<sub>2</sub> gas thus, the dough can expand and form pores. Fadzil et al.<sup>30</sup> found that  
 235 thermal treatment during the boiling process results in the denaturation of gluten and causes a  
 236 monomer of proteins to determine other reactions at the disulfide or sulfhydryl chain. The existence  
 237 of phenolic compounds from pluchea extract also increased the capacity of noodles to absorb water  
 238 and determined water mobility. Widyawati et al.<sup>26</sup> confirmed that hydrophilic compounds of proteins,  
 239 carbohydrates, and polyphenolic components determine water mobility due to their ability to bind  
 240 with water molecules through hydrogen bonding. Tuhumury et al.<sup>48</sup> informed that gluten formation  
 241 can inhibit water absorption by starch granules so that can prevent gelatinization. Therefore, the  
 242 addition of phenolic compounds from the hot extract of pluchea leaf powder can inhibit the formation  
 243 of gluten so that stimulates gelatinization of starch granules.

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244 As a result, the impact of increased the moisture content during boiling had an effect on the  
245 value of the swelling index and cooking loss of the wet noodles. Widyawati et al.<sup>26</sup> claimed that the  
246 swelling index is the capability to trap water which is dependent on the chemical composition, particle  
247 size, and water content. Gull et al.<sup>49</sup> further confirmed that the swelling index is an indicator to  
248 determine water absorption by starch and protein to make gelatinization and hydration. Setiyoko et  
249 al.<sup>29</sup> explained that cooking loss is the mass of noodle solids that come out of the noodle strands for  
250 boiling. Gull et al.<sup>49</sup> added that soluble starch and other soluble components leach out into the water  
251 during the cooking process, making the cooking water turned thicker. The moisture content results  
252 (64-67% wb) showed that the produced wet noodles exceeded the moisture content limit of wet  
253 noodles after cooking, which is between 54-58%<sup>44</sup>, while the cooking loss value of wet noodles should  
254 not be more than 10%<sup>29</sup>. In this study, the cooking loss value was 3-4.2%. The cooking loss of samples  
255 during boiling noodles were caused the breaking of the bonding network that the polysaccharides are  
256 released and the gluten network breaks because of the addition of pluchea leaf extract. Widyawati et  
257 al.<sup>26</sup> supported that polyphenol can be bound with protein and starch with many non-covalent  
258 interactions, such as hydrogen bonding, electrostatic interaction, hydrophobic interaction, Van der  
259 Waal's interaction, and  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch  
260 to undergo gelatinization and gliadin and glutelin from the protein of wheat flour to form gluten.

261 The swelling index value derived from this research was about 56-68 %. Based on the previous  
262 research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.) fruit was  
263 around 51%<sup>50</sup>. This means that the addition of pluchea leaf extract in wet noodles also affects the  
264 ability of noodles to absorb water. Widyawati et al.<sup>26</sup> and Suriyaphan<sup>6</sup> noted that bioactive compounds

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in hot water extract of pluchea leaf tea include 3-*O*-caffeoylquinic acid, 4-*O*-caffeoylquinic acid, 5-*O*-caffeoylquinic acid, 3,4-*O*-dicaffeoylquinic acid, 3,5-*O*-dicaffeoylquinic acid, 4,5-*O*-dicaffeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was higher than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from extract in absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch granules to absorb water so that the swelling index and cooking loss increased. Suriyaphan<sup>6</sup> informed that hot extract of pluchea leaf tea contains 1.79 g/100 g protein, 8.65 g/100 g carbohydrate, and fiber (0.45 g/100 g soluble and 0.89 g/100 g insoluble), these compounds can involve in increasing the swelling index from pluchea wet noodles.

Color is one of the physical characteristics possessed by wet noodles that becomes a benchmark for consumer acceptance. This research found that the color of wet noodles was influenced by the addition of pluchea extract. The addition of pluchea leaf extract no significant affected the redness ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it influenced the yellowness ( $b^*$ ) and lightness ( $L^*$ ) values. Using of pluchea leaf powder brewing decreased the brightness of wet noodles significantly, as the concentration of the extract increased. This is related to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to experience color changes. According to Widyawati et al.<sup>8</sup> tannins are water-soluble compounds that can give a brown color. Suriyaphan<sup>6</sup> and Widyawati et al.<sup>26</sup> also stated that Khlu tea from pluchea leaves contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and 6.39 mg/100 g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow color.

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286 Gull et al.<sup>49</sup> stated that this pigment was easily changed in the paste sample due to the swelling and  
287 discoloration of the pigment during cooking.

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288 Thus, the addition of hot water extract of pluchea leaf powder significantly reduced the  
289 brightness of wet noodles, because brown-colored noodles were produced as the concentrations of  
290 added pluchea leaf extract increased. However, increasing the concentration of this extract had no  
291 influenced on the redness, hue, and chroma values in ANOVA at  $p \leq 5\%$ . The results showed that the  
292 redness value of wet noodles revolved from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet  
293 noodles ranged from  $82.12 \pm 3.05$  to  $86.47 \pm 1.04$ . Based on this value, the color of wet noodles is in  
294 the yellow to the red color range<sup>51</sup>, thus the visible color of the wet noodle product was yellow to  
295 brown (Figure 2). Yellowness increased significantly with the addition of pluchea leaf extract and the  
296 value ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the availability of tannins and  
297 chlorophyll compounds from pluchea leaf extract. The chroma value of wet noodles was obtained  
298 within the range of  $15.6 \pm 1.5$  to  $19.8 \pm 3.4$ . This means that the brewing of pluchea leaf powder did  
299 not change the intensity of the brown color in the resulting wet noodles.

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300 Texture analysis of pluchea wet noodles added with various concentrations of hot water extract  
301 from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness,  
302 elongation, and elasticity. Hardness is the maximum force given to a product until deformation<sup>52</sup><sup>53</sup>.  
303 From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher  
304 peak of graph shows the harder product<sup>30</sup>. Adhesiveness is force or tackiness that is required to pull  
305 the product from its surface, its value is obtained from the area between the first and second  
306 compressions<sup>54</sup><sup>55</sup>. Adhesiveness values show negative value; the bigger negative value means the

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product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and second compressions<sup>53,55</sup>. This is an indication of the internal forces that make up the product<sup>56</sup>. Elongation is the change in length of noodles when being exposed to a tensile force until the noodles break<sup>57</sup>. Elasticity is the time required for the product to withstand the load until it breaks. The more elastic a product, the longer the holding time. The data showed that the higher concentration of pluchea leaf powder within the hot water extract caused a significant increase in the hardness, stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati et al.<sup>26</sup> informed that the polyphenols contained in pluchea leaf extract can be weakly interacted either covalently or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups that are polar. Amoako and Akiwa<sup>58</sup> and Zhu et al.<sup>59</sup> have also proven that polyphenolic compounds can be interacted with carbohydrates through the interaction of two hydrophobic and hydrophilic functional groups with amylose. Diez-Sánchez et al.<sup>60</sup> stated that polyphenolic compounds can be reacted with amylose and protein helical structures and largely determined by molecular weight, conformational mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and amylopectin can affect the gelatinization process in the amylose helical structure and interfere with the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss (> 98%) and swelling index (56.2 to 67.7%)

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328 data, it can be concluded that the interaction that occurs between the phenol group in pluchea leaf  
329 extract with amylose and protein was weak. The bioactive components of pluchea leaf extract are  
330 thought to affect the formation of disulfide cross-links (S-S) and turn into to form sulfhydryl groups (-  
331 SH) under the influence of heat. Ananingsih and Zhou<sup>61</sup> said that antioxidant compounds are a reducing  
332 agent that can have an impact on reducing S-S bonds and increasing the number of SH groups in the  
333 dough to produce a harder texture. According to Rahardjo <sup>et al.</sup><sup>54</sup> phenolic compounds are hydroxyl  
334 compounds that influence the strength of the dough, where the higher the component of phenol  
335 compounds will weaken the gluten matrix and the dough thus becoming unstable. The instability of  
336 the dough can cause the texture to become hard.

337 Many researchers also find that tannins and phenols influence the networking S-S bond in the  
338 dough of wet noodles. Wang <sup>et al.</sup><sup>62</sup> showed that tannins increase the relative amount of large, medium  
339 polymers in the gluten protein network so as to improve the dough quality. Zhang <sup>et al.</sup><sup>63</sup> claimed that  
340 these polymer compounds are the results of interactions or combinations of protein-tannin  
341 compounds that form bonds with the type of covalent, hydrogen, or ionic bonds. Rauf and Andini<sup>64</sup>  
342 also added that phenol compounds can reduce S-S bonds to SH bonds. SH is a type of thiol compound  
343 group, where the thiol group can influence the stickiness, viscosity, cohesiveness, elongation, and  
344 extensibility of the dough. Wang <sup>et al.</sup><sup>65</sup> discovered the effect of phenolic compounds from green tea  
345 extract to increase the stickiness of wheat bread. The cohesiveness of the dough is formed due to a  
346 large number of thiol bonds formed, thus increasing the viscosity of the dough. The increased viscosity  
347 of the dough is thought to be due to the formation of polyphenolic compounds with thiol groups, as in  
348 the research of Ananingsih and Zhou<sup>61</sup> that the formation of catechin-thiol can increase the viscosity

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of the dough and the stability of the dough. Zhu et al.<sup>66</sup> mentioned that the addition of phenolic compounds from green tea was able to increase the PV (peak viscosity) of wheat flour. Wang et al.<sup>62</sup> also found that the cohesiveness of the dough is influenced by tannins, where tannins can produce micro-glutens so as to produce a compact dough and increase the gluten network. The addition of pluchea leaf extract in making wet noodles could influence the elongation of wet noodles due to the components of polyphenol compounds such as tannins that can reduce the number of free amino groups. This is supported by Zhang et al.<sup>30</sup> and Wang et al.<sup>62</sup> that the formation of other types of covalent bonds, such as bonds between amino and hydroxyl groups, by forming hydrogen bonds between phenolic compounds and protein gluten so as to improve the quality of dough strength and dough extensibility.

### Bioactive Compounds and Antioxidant Activity

Wet noodles added with pluchea leaf powder were analyzed based on its bioactive compounds and antioxidant activities. The analysis was conducted to determine the functional properties of wet noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles were presented in Table 5. The measured bioactive compounds (BC) involved total phenolic content (TPC) and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical scavenging activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed that there was a positive and strong correlation between TPC and DPPH ( $r = 0.990$ ), TPC

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370 and FRAP ( $r = 0.986$ ), TFC and DPPH ( $r = 0.974$ ), and TFC and FRAP ( $r = 0.991$ ). This means that the  
371 antioxidant activity of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah et al.<sup>67</sup>  
372 informed that the PC ( $r > 0.699$ ) indicates the strength and linear correlation between antioxidant  
373 activity (AA) and TPC, and also shows a strong positive relationship but PC ( $r < 0.699$ ) obtains a  
374 moderately positive relationship. If the r value of TFC and AA is lower than TPC and AA, it indicates that  
375 the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other  
376 components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship  
377 which is expected because both classes contributed to AA plants. Aryal et al.<sup>68</sup> and Muflihah et al.<sup>67</sup>  
378 informed that phenolic compounds are soluble natural antioxidants and potential donating electrons  
379 depend on their number and position of hydroxyl groups contributed to antioxidant action.  
380 Consequently, these groups are responsible to scavenge the free radicals which is expressed as TPC of  
381 pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the  
382 stable purple-colored to the yellow-colored solution. Based on FRAP analysis, it was showed that the  
383 bioactive compounds contained in pluchea wet noodles were a potential source of antioxidants  
384 because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive  
385 compounds in pluchea wet noodles can function as primary and secondary antioxidants. Research data  
386 showed that the cooking quality of wet noodles tends to increase along with the increase in the values  
387 of TPC, TFC, DPPH and FRAP.

### 388 Sensory Evaluation

389 Sensory assay of pluchea wet noodles, namely color, aroma, taste, texture, and overall  
390 acceptance, was carried out using a hedonic test to determine the level of consumer preference for

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the product. This test was conducted to determine the quality differences between the products and to provide an assessment on certain properties<sup>42</sup>. The hedonic test is the most widely used assessment to determine the level of preference for product<sup>69</sup>. The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm 1.26$  (neutral-like). The statistical analysis showed that the higher concentration of hot water extract addition decreased lower color preference of wet noodles. The higher concentration of pluchea extract could reduce the level of color preference because the color of the wet noodles was darker than control and turned to dark brown. This color change was due to the pluchea extract containing several components, including chlorophyll and tannins, which can alter the of wet noodles' color to be browner along with the increase in the concentration of pluchea extract. This result was in accordance to the effect of color analysis performed using color reader where the pluchea wet noodles' brightness declined, yellowness increased, and the color intensity increased with an increased concentration of pluchea extract. The occurrence of this process is related to the effect of light and heat on pluchea leaf powder which causes the degradation of chlorophyll into brown pheophytin due to drying, where the nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals<sup>70,71</sup>.

Aroma is one of the parameters in sensory evaluation using the sense of smell and an indicator of the assessment of a product<sup>72</sup>. The results of the preference values for aroma were ranged from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet noodles reduced the preference score for aroma due to distinct dry leaves (green) aroma. According to Lee et al.<sup>73</sup> the unpleasant aroma on leaves comes from a group of aliphatic aldehyde compounds. The

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412 appearance of a distinctive leaf aroma in noodles is due to aromatic compounds. According to  
413 Martiyanti and Vita<sup>74</sup> aromatic compounds are chemical compounds that have an aroma or odor when  
414 the conditions are met, which is volatile, while Widyawati et al<sup>75</sup> informed that pluchea leaves were  
415 detected to have 66 volatile compounds. The appearance of the aroma is due to the volatile  
416 compounds in the raw material reacting with water vapor when boiling the noodles. In addition, there  
417 is also an oxidation process of polyphenolic compounds such as catechins or tannins that can produce  
418 an aroma in pluchea wet noodles.

419 According to Martiyanti and Vita<sup>3</sup> taste attribute is one important sensory aspect in food  
420 products and has a great impact on the food selection by consumers. Tongue is able to detect basic  
421 tastes, such as sweet, salty, sour, and bitter, at different points. Lamusu<sup>71</sup> declared that taste is a  
422 component of flavor and an important criterion in assessing a product that is accepted by the tongue.  
423 The preference test of the taste of pluchea wet noodles resulted in values ranging from  $4.15 \pm 1.40$  to  
424  $5.50 \pm 1.28$  (neutral-slightly like). The increase in concentrations of pluchea extract was negatively  
425 correlated to the preference level of the taste of pluchea wet noodles assessed by the panelists. The  
426 statistical analysis results showed that the difference in the concentration of the extract significant  
427 influenced on the preference score for the taste of pluchea wet noodles. The increased concentration  
428 of pluchea extract produced a distinctive taste on wet noodles, such as a bitter and astringent tastes,  
429 due to the presence of compounds such as tannins and alkaloids from the pluchea leaves. Susetyarini<sup>76</sup>  
430 said that pluchea leaves contain tannins (2.35%), and alkaloids (0.32%). According to Pertiwi<sup>77</sup>, tannin  
431 compounds dominate the bitter and astringent taste, while alkaloid compounds cause a bitter taste.

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432 The high level of taste preference for wet noodles was found in noodles with lower content of pluchea  
433 extract.

434 Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and  
435 swallowed) or touched with fingers<sup>78</sup>. Texture testing performed by the panelist is called mouthfeel  
436 testing. According to Martiyanti and Vita<sup>74</sup>, mouthfeel is the kinesthetic effect of chewing food in the

437 mouth. In this study, the preference test results on the texture of pluchea wet noodles revolved from  
438  $5.50 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy

439 and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet  
440 noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that  
441 can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and  
442 draining noodles. Subjective testing results based on sensory evaluation were in line with the objective  
443 testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to  
444 break, and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea

445 wet noodles was influenced by the fiber and protein components. According to Shabrina<sup>79</sup>, the  
446 components of fiber, protein, and starch complete to bind water. Texture changes are also influenced  
447 by the polyphenol compositions in the pluchea extract which is able to reduce S-S bonds to SH bonds,  
448 where the increase in SH (thiol) groups can cause a hard, sticky, and compact texture<sup>62,64,65</sup>. Besides, a  
449 high concentration of tannins capable of binding to proteins to form complex compounds into tannins-  
450 proteins are also able to build noodles' texture.

451 The interaction between color, aroma, taste, and texture created an overall taste of the food  
452 product and was assessed as the overall preference. The highest value on the overall preference was

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453 derived from control wet noodles, i.e., 6.63 (slightly like it), while the wet noodles added with 20%  
454 (w/v) concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The  
455 addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to  
456 10% (w/v) concentration with scores of 6.63 and 6.53, respectively. The area of the spider web chart  
457 for each treatment with the various concentrations of pluchea extract was seen in Figure 3. The best  
458 treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37  
459 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the  
460 scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like),  
461 respectively.

462 The use of pluchea leaf extract in the making of wet noodles was able to increase the functional  
463 values of wet noodles, based on the levels of bioactive compounds and antioxidant activity without  
464 changing the quality of cooking, which included water content, swelling index and cooking loss. Besides  
465 that, the use of pluchea leaf extract did not significantly change the color and color intensity of the  
466 resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet  
467 noodles produced were still acceptable to the panelists, the addition of pluchea leaf extract as much  
468 as 10% (w/v) was the best treatment with an assessment that was almost closed to the control wet  
469 noodles (without treatment).

#### 470 Conclusion

471 Addition of hot water extract of pluchea leaf powder influenced physical, chemical and sensory  
472 properties of wet noodles. Lightness, texture, bioactive compound content, antioxidant activity, and  
473 sensory properties of samples underwent significant difference. The higher concentration of pluchea

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474 extract caused the bigger these parameters of pluchea wet noodles. Using 10% (w/v) of hot water  
475 extract from pluchea leaf powder was the best treatment with color, aroma, taste, and texture scores  
476 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. Utilization of  
477 hot water extract of pluchea leaf powder at 10% (w/v) resulted functional wet noodles with TPC, TFC,  
478 DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg dried samples, 62.44  
479 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples and 51.33 mg GAE/kg dried samples,  
480 respectively.

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481  
482 **Notes on Appendices**

TPC	Total phenolic content
TFC	Total flavonoid content
DPPH	2,2-Diphenyl-1-picrylhydrazyl free radical
FRAP	Ferric reducing antioxidant power
AA	Antioxidant activity
PC	Pearson Correlation
LDL	Low Density Lipoprotein
w/v	Weight per volume
CRD	Completely randomized design
CE	Catechin equivalent
GAE	Gallic acid equivalent
BC	Bioactive compounds

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ANOVA Analysis of variance

UV-Vis Ultra violet-visible

Wb Wet base

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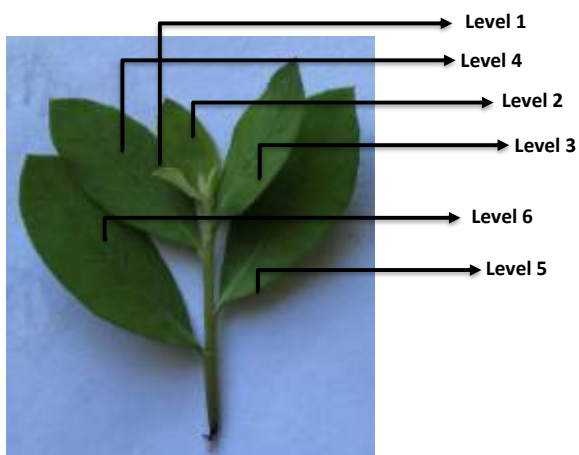


Figure 1. Young *Pluchea indica* Less leaves

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731 Table 1. **Information of hot water extract of pluchea tea**

Materials	Concentration of hot water extract of pluchea leaf tea (% w/v)						
	0	5	10	15	20	25	30
Pluchea leaf tea (g)	0	10	20	30	40	50	60
Hot water (mL)	200	200	200	200	200	200	200

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734 **Table 2. Ingredients** of pluchea wet noodles

Materials	Unit	Quantity
Wheat flour	g	200
Egg	g	40
Salt	g	4
Baking powder	g	2
Hot water extract	mL	70
Tapioca flour	g	10
TOTAL	g	326

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**Table 3.** Color, moisture content, swelling index, and cooking loss of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Color					Moisture content (% wb)	Swelling index (%)	Cooking loss (%)
	L*	a*	b*	C	h			
0	67.14 ± 1.77 <sup>a</sup>	0.97±0.30	16.18±0.62 <sup>ab</sup>	16.20 ± 0.63	86.47 ± 1.04	63.90±1.51	56.22±17.36	3.40±1.31
5	59.49 ± 2.67 <sup>b</sup>	2.18±0.93	15.47±1.46 <sup>a</sup>	15.62 ± 1.53	82.12 ± 3.05	65.08±4.33	62.40± 4.71	3.33±1.26
10	58.95 ± 1.80 <sup>b</sup>	1.95±1.66	16.76±2.33 <sup>abc</sup>	17.08 ± 2.16	83.29 ± 5.37	64.97±3.89	61.50± 7.51	3.00±1.16
15	58.35 ± 2.24 <sup>b</sup>	1.69±1.48	19.72±3.50 <sup>c</sup>	19.77 ± 3.38	84.67 ± 4.64	65.56±2.18	63.09± 6.31	3.31±0.92
20	56.48 ± 2.40 <sup>b</sup>	1.97±1.24	19.09±2.97 <sup>bc</sup>	19.18 ± 2.90	83.62 ± 4.33	66.81±1.81	67.74± 5.91	4.06±0.51
25	59.07 ± 2.49 <sup>b</sup>	1.95±1.44	19.55±2.97 <sup>c</sup>	19.58 ± 2.90	83.83 ± 4.41	66.04±0.85	64.46±10.32	3.93±1.37
30	57.10 ± 2.06 <sup>b</sup>	2.09±1.51	18.08±4.94 <sup>abc</sup>	18.28 ± 4.84	82.49 ± 5.22	66.65±2.16	63.96± 5.31	4.23±1.34

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$

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740 **Table 4.** Texture of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Texture of pluchea wet noodles				
	Hardness (N)	Adhesiveness (g sec)	Cohesiveness	Elongation (%)	Elasticity (Pa)
0	135.75±5.91 <sup>a</sup>	-2.67 ±0.30 <sup>d</sup>	0.65±0.01 <sup>a</sup>	86.89±0.90 <sup>a</sup>	25336.72±104.20 <sup>a</sup>
5	120.13±2.05 <sup>a</sup>	-3.36±0.60 <sup>cd</sup>	0.68±0.00 <sup>b</sup>	97.25±1.59 <sup>b</sup>	25898.27±760.94 <sup>b</sup>
10	134.85±1.77 <sup>a</sup>	-3.91±0.65 <sup>bc</sup>	0.74±0.00 <sup>c</sup>	162.10±1.49 <sup>c</sup>	25807.73±761.85 <sup>b</sup>
15	180.48±5.06 <sup>b</sup>	-4.91±0.47 <sup>b</sup>	0.74±0.01 <sup>c</sup>	164.74±0.60 <sup>c</sup>	26971.61±516.71 <sup>b</sup>
20	195.11±14.14 <sup>b</sup>	-4.95±1.26 <sup>ab</sup>	0.75±0.01 <sup>cd</sup>	221.60±1.55 <sup>d</sup>	27474.38±453.80 <sup>b</sup>
25	244.57±8.81 <sup>c</sup>	-6.03±0.29 <sup>a</sup>	0.75±0.00 <sup>cd</sup>	230.65±0.73 <sup>e</sup>	27367.05±287.48 <sup>b</sup>
30	282.79±28.31 <sup>d</sup>	-6.05±0.22 <sup>a</sup>	0.79±0.01 <sup>d</sup>	255.38±0.36 <sup>f</sup>	26687.52±449.19 <sup>b</sup>

741 Note: the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in  
742 the same column are significantly different,  $p \leq 5\%$

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**Table 5.** Total phenol content, total flavonoid content, the DPPH free radical scavenging activity, and iron ion reducing power of the pluchea wet noodles.

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	TPC (mg GAE/kg Dried Noodles)	TFC (mg CE/kg Dried Noodles)	DPPH (mg GAE/kg Dried Noodles)	FRAP (mg GAE/kg Dried noodles)
0	39.26±0.66 <sup>a</sup>	32.36±1.47 <sup>a</sup>	96.75±4.26 <sup>a</sup>	25.96±0.25 <sup>a</sup>
5	61.09±3.80 <sup>b</sup>	46.31±2.15 <sup>b</sup>	121.36±3.58 <sup>b</sup>	34.50±1.71 <sup>b</sup>
10	82.84±3.11 <sup>c</sup>	62.44±0.55 <sup>c</sup>	130.68±4.82 <sup>c</sup>	51.33±2.19 <sup>c</sup>
15	101.48±2.16 <sup>d</sup>	84.67±1.22 <sup>d</sup>	142.48±2.14 <sup>d</sup>	58.69±2.14 <sup>d</sup>
20	114.94±4.20 <sup>e</sup>	100.14±1.50 <sup>e</sup>	148.84±3.20 <sup>e</sup>	67.26±0.06 <sup>e</sup>
25	128.06±1.38 <sup>f</sup>	107.93±0.89 <sup>f</sup>	157.51±7.69 <sup>f</sup>	69.53±1.06 <sup>f</sup>
30	136.35±1.16 <sup>g</sup>	131.69±1.56 <sup>g</sup>	166.97±1.53 <sup>g</sup>	84.98±0.11 <sup>g</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

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**Table 6.** Effect of hot water extract from pluchea leaf powder to preferences for color, aroma, taste, texture, and overall acceptance of wet noodles at various concentrations

Concentration of Hot		Hedonic Score			
Extract from Pluchea Leaf Powder (% w/v)					Overall
	Color	Aroma	Taste	Texture	acceptance
0	6.19±1.25 <sup>d</sup>	5.52±1.08	5.50±1.18 <sup>c</sup>	6.20±1.13 <sup>b</sup>	6.63±1.49 <sup>c</sup>
5	5.62±1.28 <sup>c</sup>	5.52±0.83	5.51±1.29 <sup>c</sup>	6.37±1.14 <sup>bc</sup>	6.40±1.52 <sup>c</sup>
10	5.62±1.21 <sup>c</sup>	5.45±0.85	5.46±1.12 <sup>c</sup>	6.53±1.14 <sup>c</sup>	6.53±1.64 <sup>c</sup>
15	5.14±1.25 <sup>b</sup>	4.81±1.04	4.61±1.11 <sup>b</sup>	6.13±1.09 <sup>b</sup>	5.78±1.67 <sup>b</sup>
20	4.91±1.32 <sup>b</sup>	4.54±1.18	4.47±1.15 <sup>ab</sup>	5.80±1.06 <sup>a</sup>	5.17±1.70 <sup>a</sup>
25	4.54±1.40 <sup>a</sup>	4.26±1.23	4.20±1.24 <sup>a</sup>	5.50±1.04 <sup>a</sup>	5.23±1.75 <sup>a</sup>
30	4.47±1.33 <sup>a</sup>	4.05±1.34	4.15±1.40 <sup>a</sup>	5.59±1.05 <sup>a</sup>	5.37±1.91 <sup>a</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

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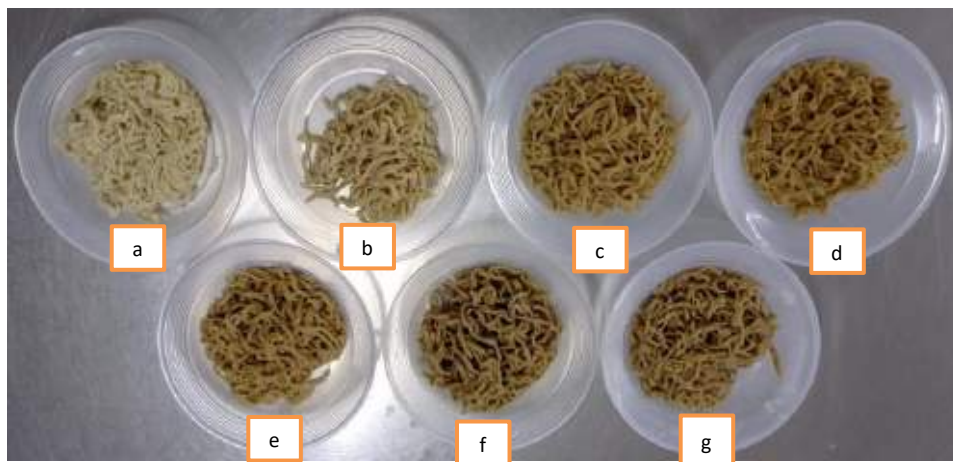
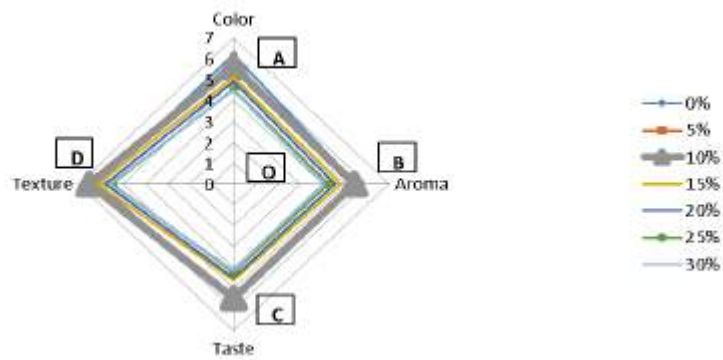


Figure 2. Wet noodles with hot water extract of pluchea leaf powder added at concentrations

a. 0%; b. 5%; c. 10%; d. 15%; e. 20%; f. 25%; and g. 30% w/v

**Commented [D267]:** I have changed the position of figure /clockwise from bottom right has been changed. I have added sample code

**Commented [D268]:** Changed Figure 2



**Figure 3.** Spider web graph of sensory evaluation on wet noodles at various concentrations of hot water extract from pluchea leaf powder

**Commented [D269]:** Changed Figure 3



Paini Sri Widyawati <paini@ukwms.ac.id>

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## Request for revision as per editorial comments - 3638

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Thu, Apr 13, 2023 at 5:08 PM

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We are forwarding your article to our assigned reviewers for the re-evaluation process, we will update you soon accordingly.

We will update you soon accordingly.

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Looking forward to hearing from you soon.

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**3 attachments**

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## The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

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### Abstract

Powdered *Pluchea indica* Less leaves have been utilized as herbal tea, brewing of pluchea tea in hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional values and influence physic, chemical, and sensory characteristics of food. The study was carried out to assess the effect of various concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with pluchea tea at concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v). Physical properties analyzed included water content, swelling index, cooking loss, color and texture. Chemical properties measured were bioactive contents of total phenolic content, total flavonoid content, and antioxidant ability to scavenge DPPH free radicals and to reduce iron ions. Sensory properties determined were taste, texture, color, aroma and overall acceptance. The addition of various concentrations of extract offers significantly effects on parameters of physical, chemical and sensory properties of noodles, except color (redness, chroma and hue), cooking loss, water content, swelling index and aroma. Using of 10% (w/v) of pluchea tea resulted in the best sensory properties such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. Generally, the study concluded that wet noodles can be made by adding pluchea tea at 10% (w/v). Dried samples TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg, 62.44 mg CE/kg, 130.68 mg GAE/kg and 51.33 mg GAE/kg, respectively.

### Key-words

Chemical, physical, *Pluchea indica* Less, sensory, wet noodles

### Introduction

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food<sup>1,2</sup>. The potency of pluchea leaves is related to phytochemical compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone,

alkaloid, lignans and saponins<sup>2,3,4,5</sup>. Chan et al.<sup>1</sup> also reported that caffeoylquinic acids, phenolic acids, flavonoids and thiophenes in pluchea leaves are compounds with antioxidant activities. Furthermore, pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100 g, fat 0.49 g/100 g, insoluble dietary fiber 0.89 g/100 g, soluble dietary fiber 0.45 g/100 g, carbohydrate 8.65 g/100 g, calcium 251 mg/100 g,  $\beta$ -carotene 1.225  $\mu$ g/100 g<sup>6</sup>.

Pluchea tea brewed from pluchea leaves has been proven to exhibit antioxidant activity<sup>6,7,8</sup>, anti-diabetic activity<sup>9</sup>, anti-inflammatory activity<sup>7</sup>, anti-human LDL oxidation activity<sup>10</sup>. Previous research uses pluchea leaf powder to make several food products to increase functional values, i.e., jelly drink<sup>11</sup>, soy milk<sup>12</sup> and steamed bun<sup>13</sup>. Using 1% (w/v) pluchea leaf powder can improve the physicochemical properties of jelly drink and increase panelists' acceptance of the product<sup>11</sup>. Soy milk with the addition of pluchea leaves increases the viscosity and total dissolved solids and decreases the panelist acceptance rate<sup>12</sup>. The addition of 6% (w/v) brewing from pluchea leaf powder on steamed bun is the best treatment with the lowest level of hardness<sup>13</sup>. Previous research has proven that the addition of pluchea leaves can increase the bioactive compound contents based on total phenol and total flavonoids, as well as increase the antioxidant activity based on ferric reducing power and ability to scavenge DPPH free radicals.

To the best of our knowledge, the study of the addition of pluchea tea in making wet noodles from wheat flour has not been conducted, as well as its impact on physicochemical and sensory characteristics of the noodles. Noodles are a popular food product that is widely consumed in the world. Indonesia is one of the countries with the largest noodle consumption after China<sup>14</sup>. Wet noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet noodles as an

61 alternative to wet noodles, which contain higher protein, and the second popular food in ASEAN  
62 regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia<sup>16</sup>. The  
63 addition of other ingredients has been endeavored to enhance wet noodles' specific properties. Many  
64 researchers incorporated plant extracts or natural products to increase functional properties of wet  
65 noodles, such as red spinach<sup>17</sup>, green tea<sup>18,19</sup>, purple sweet potato leaves<sup>20</sup>, moringa leaves<sup>21</sup>, sea  
66 weed<sup>22</sup>, ash of rice straw, turmeric extract<sup>23</sup>, and betel leaf extract<sup>24</sup> that influenced the physical,  
67 chemical, and organoleptic properties of the wet noodles. The anthocyanin of red spinach ethanolic  
68 extract increases the hedonic score of wet noodles' flavor<sup>17</sup>. The addition of green tea improves the  
69 stability, elastic modulus and viscosity, retrogradation and cooking loss with, no significant effect on  
70 mouth-feel and overall acceptance from panelist on the produced wet noodles<sup>18</sup>. Moreover, the  
71 addition of sweet potatoes leaf extract on wet noodles increases moisture content, protein value and  
72 ash concentration, and improves hedonic score of texture<sup>20</sup>. Moringa extract influences protein  
73 content and decreases panelist acceptance of color, aroma and taste of wet noodles<sup>21</sup>. The use of  
74 seaweed to produce wet noodles influences moisture content, swelling index, absorption ability,  
75 elongation value and color<sup>22</sup>. The addition of ash from rice straw and turmeric extract influences the  
76 elasticity and sensory characteristics (color, taste, aroma and texture) of wet noodles<sup>23</sup>. Betel leaf  
77 extract used to make Hokkien (with dark soya source) noodles improves texture and acceptance score  
78 of all sensory attributes<sup>24</sup>.

79 Bioactive compounds and nutritive values of pluchea leaf can be an alternative ingredient to  
80 improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea  
81 leaves can serve as an antioxidant source in wet noodles and increase the functional value. This study

82 was undertaken to assess the effect of various concentration of pluchea tea on the physical, chemical  
83 and sensory properties of wet noodles.

## 84 **Materials and Methods**

85

### 86 **Preparation of Hot Water Extract from Pluchea Leaf Powder**

87 Young pluchea leaves (1-6) (Figure 1) were picked from the shoots, sorted and washed. The  
88 selected leaves were dried at ambient temperature for 7 days to yield moisture content of  $10.00 \pm$   
89  $0.04\%$  dry base<sup>25</sup>. Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at  $120^{\circ}\text{C}$   
90 for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag for  
91 about 2 g/tea bag. Pluchea leaf powder in tea bags was extracted using hot water ( $95^{\circ}\text{C}$ ) for 5 min to  
92 get extract concentrations of 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

### 93 **Wet Noodles Processing**

94 About 70 mL of hot extract from pluchea leaf powder with concentrations of 0, 5, 10, 15, 20, 25  
95 and 30% (w/v) (Table 1) was manually mixed with egg, baking powder, salt and wheat flour for 5 min  
96 (Table 2). The mixture was kneaded to form a solid and homogenized dough using a mixer (Oxone  
97 Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to form noodle  
98 strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled water about  
99 3 min in 300 mL water and coated with oil to prevent the noodles from sticking to each other<sup>26, 27, 28</sup>.  
100 Wet noodles made without any addition of hot water of pluchea leaf extract were prepared as control.  
101 Wet noodles used in bioactive compounds and antioxidant activity assay were not added with oil to  
102 prevent the noodles from sticking to one another. The final characteristics of wet noodles have width  
103 and thickness of 0.45 cm and 0.30 cm, respectively.

104

105

106 **Pluchea Wet Noodles Extraction**

107 About 100 g of wet noodles were dried using a freeze-dryer at a pressure of 0.1 bar and  
108 temperature -60°C for 28 hours. Dried noodles were powdered using a chopper machine for 35  
109 seconds. And then, 20 g of samples were mixed by 50 mL absolute methanol by a shaking water-bath  
110 at 35°C, 70 rpm for 1 hour<sup>29</sup>. Filtrate was separated using Whatman filter paper grade 40 and residue  
111 was extracted again with the same procedure. The filtrate was collected and evaporated by rotary  
112 evaporator until getting 3 mL of extract (Buchi Rotary Evaporator; Buchi Shanghai Ltd, China) at 200  
113 bars, 50°C for 60 min. The extract was kept at 0°C before further analysis.

114 **Moisture Content Assay**

115 Moisture or water content of wet noodles was determined by thermos-gravimetric method<sup>30</sup>.  
116 The moisture content of wet noodles was determined by heating the samples in a drying oven (Binder,  
117 Merck KGaA, Darmstadt, Germany) and weighing the evaporated water content in the material.

118 **Measurement of Swelling Index**

119 The purpose of swelling index testing was to determine the capability of the noodles to swell  
120 during the boiling process<sup>16</sup>. The assay was done to determine the ability of wet noodles to absorb  
121 water per unit of time or the time needed to fully cooked wet noodles. The amount of water absorbed  
122 by wet noodles was measured from the weight before and after boiling.

123 **Determination of Cooking Loss**

124 Cooking loss is one of the necessary quality parameters to establish the quality of wet noodles  
125 after boiling<sup>31</sup>. The cooking loss assay was done by measuring the quantity of solids that leached out  
126 of the noodles during the boiling process, e.g., starch. A large cooking loss value affects the texture of  
127 wet noodles, which is easy to break and less slippery.

#### 128 **Determination of Texture**

129 The texture of pluchea wet noodles was measured based on hardness, adhesiveness,  
130 cohesiveness, elongation and elasticity. The texture was analyzed by TA-XT2 texture analyzer (Stable  
131 Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the Texture Exponent 32  
132 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were analyzed with a  
133 compression assay using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle strands with the length  
134 of 4 cm for each strand were laid side by side, touching each other, perpendicular to the 35 mm  
135 compression cylinder probe on a flat aluminum base. The cylinder probe was arranged to be at 15 mm  
136 distance from the lower plate at the start of the compression test, and was pressed down through the  
137 noodle strips at the speed of 2 mm s<sup>-1</sup> until it touched the flat base to compress 75% of the noodle  
138 thickness, and was drawn back to at the end of the test. The profile curve was determined using a  
139 texture analyzer software.<sup>24,32</sup> The hardness was determined as the maximum force per gram. The  
140 adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area was  
141 obtained from the compression test under the curve. Cohesiveness was analyzed based on the ratio  
142 between the area under the first and the second peaks<sup>24,32,33</sup> The elongation and elasticity of the  
143 noodles were individually tested by putting one end into the lower roller arm slot and sufficiently  
144 winding the loosened arm to fasten the noodle end. Elongation was the maximum force to change of

noodle form and break by extension that was analyzed by a test speed of  $3.0 \text{ mm s}^{-1}$  between two rollers with a 100 mm distance. The elongation at breaking was calculated per gram. Elasticity was determined by formula (1)<sup>34,35</sup>:

$$\text{Elasticity} = \frac{Fx lo}{Ax to} \frac{1}{v} \quad (1)$$

where F is the tensile strength, lo is the original length of the noodles between the limit arms (mm), A is the original cross-sectional area of the noodle ( $\text{mm}^2$ ), v is the rate of movement of the upper arm (mm/s), and t is break up time of the noodles (s). The measurement of texture was detected by the software and expressed as a graph.

### Color Measurement

The color of the noodle sheets was determined by a colorimeter (Minolta CR 10, Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab  $L^*$ ,  $a^*$  and  $b^*$  values were analyzed based on the method by Fadzil et al<sup>32</sup>. The  $L^*$  value measured the position on the white/black axis, the  $a^*$  value as the position on the red/green axis, and the  $b^*$  value as the position on the yellow/blue axis.

### Analysis of Total Phenolic Content

The total phenolic content analysis was analyzed based on the reaction between phenolic compounds and Folin Ciocalteu (FC) reagent or phosphomolybdic acid and phosphotungstic acid. The FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups to become a blue molybdenum-tungsten complex solution<sup>36</sup>. The intensity of the blue color was detected by a UV-Vis spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  760 nm. In the analysis, 7.5%  $\text{Na}_2\text{CO}_3$  solution was added to reach pH 10 that caused an electron transfer reaction (redox). The obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

166

167 **Analysis of Total Flavonoid Content**

168 The flavonoid content assay was done using the spectrophotometric method based on the  
169 reaction between flavonoids and  $\text{AlCl}_3$  to form a yellow complex solution. In the presence of NaOH  
170 solution, a pink color is formed which can be detected by spectrophotometer (Spectrophotometer UV-  
171 Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm<sup>36,37,38</sup>. The obtained data were expressed in mg of catechin  
172 equivalent (CE)/L sample.

173 **Analysis of DPPH Free Radical Scavenging Activity**

174 The ability of antioxidant compounds to scavenge DPPH (2,2-diphenyl-1-picrylhydrazyl) free  
175 radicals can be used to evaluate antioxidant activity. The principle of the DPPH method is to measure  
176 the absorbance of compounds that can react with DPPH radicals<sup>39</sup>. Antioxidant compounds can donate  
177 hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced to yellow<sup>40</sup>. The color  
178 change was measured as an absorbance at  $\lambda$  517 nm by spectrophotometer (Spectrophotometer UV  
179 Vis 1800, Shimadzu, Japan)<sup>41</sup>. The data were expressed in mg gallic acid equivalent (GAE)/L dried  
180 noodles sample.

181 **Analysis of Iron Ion Reduction Power**

182 This method identifies the capacity of antioxidant components using potassium ferricyanide,  
183 trichloroacetic acid and ferric chloride to produce color complexes that can be measured  
184 spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm<sup>42</sup>. The  
185 principle of this testing is the ability antioxidants to reduce iron ions from  $\text{K}_3\text{Fe}(\text{CN})_6$  ( $\text{Fe}^{3+}$ ) to  $\text{K}_4\text{Fe}(\text{CN})_6$   
186 ( $\text{Fe}^{2+}$ ). Then, potassium ferrocyanide reacts with  $\text{FeCl}_3$  to form a  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$  complex. The color



change is from yellow to green<sup>43</sup>. The final data were expressed in mg gallic acid equivalent (GAE)/L dried noodles.

### Sensory Evaluation

The hedonic test of all samples of wet noodles involved 100 untrained panelists with an age range of 17 to 25 years old, because they are students in food technology department that who have received provision about hedonic food preference test. All panelist supplied informed consent before the examination. A hedonic test used in this research was the hedonic scoring method, where the panelists gave a preference score value of all samples<sup>26</sup>. The hedonic scores were transformed to numeric scale and analyzed using statistical analysis<sup>44</sup>. The numeric scale in the sensory analysis used a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The panelists were asked to score according to their level of preference for texture, taste, color, flavor and overall acceptability. All the samples were blind coded with 3 digits which differed from each other<sup>45</sup>.

### Statistical Analysis

The research design used in the physicochemical assay was a randomized block design (RBD) with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25 and 30% (w/v). Each treatment was repeated four times that obtained 28 experiment units. A completely randomized design (CRD) was used to evaluate sensory assay with 100 untrained panelists with an aged 17 to 25 years old.

The normal distribution and homogeneity data were stated as the mean  $\pm$  SD of the triplicate determinations and determined using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan Multiple

Range Test) at  $p \leq 5\%$  to determine treatment level that gave significant different results. The best treatment of pluchea extract addition on wet noodles was analyzed by a spider web graph.

## Results and Discussion

Wet noodles added with hot extract of pluchea leaf powder were produced to increase the functional values of wet noodles. This is supported by previous studies related to the potential values of water extract of pluchea leaf that exhibits biological activities<sup>6,7,26</sup>. In this research, the cooking quality was observed after cooking wet noodles in 300 mL water/100 g samples for 3 min in boiling water.

## Cooking Quality

Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at 0, 5, 10, 15, 20, 25 and 30% (w/v) was shown in Figure 2, Table 3 and Table 4. The addition of pluchea extract no significantly influenced the water content, cooking loss, swelling index, chroma, and hue of the produced wet noodles using statistical analysis by ANOVA at  $p \leq 5\%$ . Water content is one of the chemical properties of a food product determined shelf life of food products, because the water content measures the free and weakly bound water in foodstuffs<sup>46,47</sup>. This study identified that the moisture content of the cooked wet noodles ranged between 64-67% wb. Previous study showed that the water content of the cooked egg wet noodles was around 54-58% wb<sup>47</sup> and maximum of 65%<sup>20</sup>. Chairuni et al.<sup>46</sup> stated that the boiling process could cause a change in moisture content from about 35% to about 52%. The Indonesian National Standard<sup>48</sup> stipulates that the moisture content of cooked wet noodles is a maximum of 65%. This means that only control noodles (without treatment) exhibited a moisture content similar to the previous information. The obtained data showed a trend that an

229 extract addition caused an increase in the water content of wet noodles, but statistical analysis at  $p \leq$   
 230 5% showed no significant difference. This phenomenon was in accordance with the experimental  
 231 results of Juliana et al.<sup>49</sup> that the using of spenochlea leaf extract for making wet noodles, as well as  
 232 Hasmawati et al.<sup>20</sup> that the sweet potato leaf extract increased the moisture of fresh noodles. The  
 233 water content of pluchea wet noodles was expected by reaction between many components in the  
 234 dough that impacted to the swelling index and cooking loss. Mualim et al.<sup>14</sup>, Bilina et al.<sup>22</sup> and Setiyoko  
 235 et al.<sup>31</sup> reported that the presence of amino groups in protein and hydroxyl groups in amylose and  
 236 amylopectin fractions in wheat flour as raw material for making dough determines the moisture  
 237 content, swelling index and cooking loss of wet noodles. The contribution of glutelin and gliadin  
 238 proteins in wheat flour to form gluten networks determines the capability of noodles to swell and  
 239 retain water in the system. Gliadin acts as an adhesive that causes dough to be elastic, while glutenin  
 240 makes the dough to be firm and able to withstand CO<sub>2</sub> gas thus, the dough can expand and form pores.  
 241 Fadzil et al.<sup>32</sup> found that thermal treatment during the boiling process results in the denaturation of  
 242 gluten and causes a monomer of proteins to determine other reactions at the disulfide or sulfhydryl  
 243 chain. The existence of phenolic compounds from pluchea extract also increased the capacity of  
 244 noodles to absorb water and determined water mobility. Widyawati et al.<sup>26</sup> confirmed that hydrophilic  
 245 compounds of proteins, carbohydrates, and polyphenolic components determine water mobility due  
 246 to their ability to bind with water molecules through hydrogen bonding. Tuhumury et al.<sup>50</sup> informed  
 247 that gluten formation can inhibit water absorption by starch granules so that can prevent  
 248 gelatinization. Therefore, the addition of phenolic compounds from the hot extract of pluchea leaf  
 249 powder can inhibit the formation of gluten so that stimulates gelatinization of starch granules.

250 As a result, the impact of increased the moisture content during boiling had an effect on the  
251 value of the swelling index and cooking loss of the wet noodles. Widyawati et al.<sup>26</sup> claimed that the  
252 swelling index is the capability to trap water which is dependent on the chemical composition, particle  
253 size, and water content. Gull et al.<sup>51</sup> further confirmed that the swelling index is an indicator to  
254 determine water absorption by starch and protein to make gelatinization and hydration. Setiyoko et  
255 al.<sup>31</sup> explained that cooking loss is the mass of noodle solids that come out of the noodle strands for  
256 boiling. Gull et al.<sup>51</sup> added that soluble starch and other soluble components leach out into the water  
257 during the cooking process, making the cooking water turned thicker. The moisture content results  
258 (64-67% wb) showed that the produced wet noodles exceeded the moisture content limit of wet  
259 noodles after cooking, which is between 54-58%<sup>46</sup>, while the cooking loss value of wet noodles should  
260 not be more than 10%<sup>31</sup>. In this study, the cooking loss value was 3-4.2%. The cooking loss of samples  
261 during boiling noodles were caused the breaking of the bonding network that the polysaccharides are  
262 released and the gluten network breaks because of the addition of pluchea leaf extract. Widyawati et  
263 al.<sup>26</sup> supported that polyphenol can be bound with protein and starch with many non-covalent  
264 interactions, such as hydrogen bonding, electrostatic interaction, hydrophobic interaction, Van der  
265 Waal's interaction, and  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch  
266 to undergo gelatinization and gliadin and glutelin from the protein of wheat flour to form gluten.

267 The swelling index value derived from this research was about 56-68 %. Based on the previous  
268 research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.) fruit was  
269 around 51%<sup>51</sup>. This means that the addition of pluchea leaf extract in wet noodles also affects the  
270 ability of noodles to absorb water. Widyawati et al.<sup>26</sup> and Suriyaphan<sup>6</sup> noted that bioactive compounds

271 in hot water extract of pluchea leaf tea include 3-*O*-caffeoylquinic acid, 4-*O*-caffeoylquinic acid, 5-*O*-  
272 caffeoylquinic acid, 3,4-*O*-dicafeoylquinic acid, 3,5-*O*-dicafeoylquinic acid, 4,5-*O*-dicafeoylquinic  
273 acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total anthocyanins,  $\beta$ -carotene,  
274 and total carotenoids. The swelling index of pluchea wet noodles was higher than the addition of  
275 angkung fruit extract, due to the involvement of hydroxyl groups from extract in absorbing water, in  
276 inhibiting the formation of gluten and in increasing the ability of starch granules to absorb water so  
277 that the swelling index and cooking loss increased. Suriyaphan<sup>6</sup> informed that hot extract of pluchea  
278 leaf tea contains 1.79 g/100 g protein, 8.65 g/100 g carbohydrate, and fiber (0.45 g/100 g soluble and  
279 0.89 g/100 g insoluble), these compounds can involve in increasing the swelling index from pluchea  
280 wet noodles.

281 Color is one of the physical characteristics possessed by wet noodles that becomes a benchmark  
282 for consumer acceptance. This research found that the color of wet noodles was influenced by the  
283 addition of pluchea extract. The addition of pluchea leaf extract no significant affected the redness  
284 ( $a^*$ ), chroma (C), and hue ( $^\circ h$ ) of the wet noodles, but it influenced the yellowness ( $b^*$ ) and lightness  
285 ( $L^*$ ) values. Using of pluchea leaf powder brewing decreased the brightness of wet noodles  
286 significantly, as the concentration of the extract increased. This is related to the bioactive compounds  
287 of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to  
288 experience color changes. According to Widyawati et al.<sup>8</sup> tannins are water-soluble compounds that  
289 can give a brown color. Suriyaphan<sup>6</sup> and Widyawati et al.<sup>26</sup> also stated that Khlu tea from pluchea leaves  
290 contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and  $6.39$   
291 mg/100 g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow color.

292 Gull et al.<sup>51</sup> stated that this pigment was easily changed in the paste sample due to the swelling and  
293 discoloration of the pigment during cooking.

294 Thus, the addition of hot water extract of pluchea leaf powder significantly reduced the  
295 brightness of wet noodles, because brown-colored noodles were produced as the concentrations of  
296 added pluchea leaf extract increased. However, increasing the concentration of this extract had no  
297 influenced on the redness, hue, and chroma values in ANOVA at  $p \leq 5\%$ . The results showed that the  
298 redness value of wet noodles revolved from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet  
299 noodles ranged from  $82.12 \pm 3.05$  to  $86.47 \pm 1.04$ . Based on this value, the color of wet noodles is in  
300 the yellow to the red color range<sup>53</sup>, thus the visible color of the wet noodle product was yellow to  
301 brown (Figure 2). Yellowness increased significantly with the addition of pluchea leaf extract and the  
302 value ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the availability of tannins and  
303 chlorophyll compounds from pluchea leaf extract. The chroma value of wet noodles was obtained  
304 within the range of  $15.6 \pm 1.5$  to  $19.8 \pm 3.4$ . This means that the brewing of pluchea leaf powder did  
305 not change the intensity of the brown color in the resulting wet noodles.

306 Texture analysis of pluchea wet noodles added with various concentrations of hot water extract  
307 from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness,  
308 elongation, and elasticity. Hardness is the maximum force given to a product until deformation<sup>54,55</sup>.  
309 From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher  
310 peak of graph shows the harder product<sup>32</sup>. Adhesiveness is force or tackiness that is required to pull  
311 the product from its surface, its value is obtained from the area between the first and second  
312 compressions<sup>56,57</sup>. Adhesiveness values show negative value; the bigger negative value means the

product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and second compressions<sup>55,57</sup>. This is an indication of the internal forces that make up the product<sup>58</sup>. Elongation is the change in length of noodles when being exposed to a tensile force until the noodles break<sup>59</sup>. Elasticity is the time required for the product to withstand the load until it breaks. The more elastic a product, the longer the holding time. The data showed that the higher concentration of pluchea leaf powder within the hot water extract caused a significant increase in the hardness, stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati et al.<sup>26</sup> informed that the polyphenols contained in pluchea leaf extract can be weakly interacted either covalently or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups that are polar. Amoako and Akiwa<sup>60</sup> and Zhu et al.<sup>61</sup> have also proven that polyphenolic compounds can be interacted with carbohydrates through the interaction of two hydrophobic and hydrophilic functional groups with amylose. Diez-Sánchez et al.<sup>62</sup> stated that polyphenolic compounds can be reacted with amylose and protein helical structures and largely determined by molecular weight, conformational mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and amylopectin can affect the gelatinization process in the amylose helical structure and interfere with the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss (> 98%) and swelling index (56.2 to 67.7%)

334 data, it can be concluded that the interaction that occurs between the phenol group in pluchea leaf  
335 extract with amylose and protein was weak. The bioactive components of pluchea leaf extract are  
336 thought to affect the formation of disulfide cross-links (S-S) and turn into to form sulfhydryl groups (-  
337 SH) under the influence of heat. Ananingsih and Zhou<sup>63</sup> said that antioxidant compounds are a reducing  
338 agent that can have an impact on reducing S-S bonds and increasing the number of SH groups in the  
339 dough to produce a harder texture. According to Rahardjo et al.<sup>56</sup> phenolic compounds are hydroxyl  
340 compounds that influence the strength of the dough, where the higher the component of phenol  
341 compounds will weaken the gluten matrix and the dough thus becoming unstable. The instability of  
342 the dough can cause the texture to become hard.

343 Many researchers also find that tannins and phenols influence the networking S-S bond in the  
344 dough of wet noodles. Wang et al.<sup>64</sup> showed that tannins increase the relative amount of large, medium  
345 polymers in the gluten protein network so as to improve the dough quality. Zhang et al.<sup>65</sup> claimed that  
346 these polymer compounds are the results of interactions or combinations of protein-tannin  
347 compounds that form bonds with the type of covalent, hydrogen, or ionic bonds. Rauf and Andini<sup>66</sup>  
348 also added that phenol compounds can reduce S-S bonds to SH bonds. SH is a type of thiol compound  
349 group, where the thiol group can influence the stickiness, viscosity, cohesiveness, elongation, and  
350 extensibility of the dough. Wang et al.<sup>67</sup> discovered the effect of phenolic compounds from green tea  
351 extract to increase the stickiness of wheat bread. The cohesiveness of the dough is formed due to a  
352 large number of thiol bonds formed, thus increasing the viscosity of the dough. The increased viscosity  
353 of the dough is thought to be due to the formation of polyphenolic compounds with thiol groups, as in  
354 the research of Ananingsih and Zhou<sup>63</sup> that the formation of catechin-thiol can increase the viscosity of



the dough and the stability of the dough. Zhu et al.<sup>68</sup> mentioned that the addition of phenolic compounds from green tea was able to increase the PV (peak viscosity) of wheat flour. Wang et al.<sup>64</sup> also found that the cohesiveness of the dough is influenced by tannins, where tannins can produce micro-glutens so as to produce a compact dough and increase the gluten network. The addition of pluchea leaf extract in making wet noodles could influence the elongation of wet noodles due to the components of polyphenol compounds such as tannins that can reduce the number of free amino groups. This is supported by Zhang et al.<sup>32</sup> and Wang et al.<sup>64</sup> that the formation of other types of covalent bonds, such as bonds between amino and hydroxyl groups, by forming hydrogen bonds between phenolic compounds and protein gluten so as to improve the quality of dough strength and dough extensibility.

#### **Bioactive Compounds and Antioxidant Activity**

Wet noodles added with pluchea leaf powder were analyzed based on its bioactive compounds and antioxidant activities. The analysis was conducted to determine the functional properties of wet noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles were presented in Table 5. The measured bioactive compounds (BC) involved total phenolic content (TPC) and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical scavenging activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed that there was a positive and strong correlation between TPC and DPPH ( $r = 0.990$ ), TPC

and FRAP ( $r = 0.986$ ), TFC and DPPH ( $r = 0.974$ ), and TFC and FRAP ( $r = 0.991$ ). This means that the antioxidant activity of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah et al.<sup>69</sup> informed that the PC ( $r$ )  $> 0.699$  indicates the strength and linear correlation between antioxidant activity (AA) and TPC, and also shows a strong positive relationship but PC ( $r$ )  $< 0.699$  obtains a moderately positive relationship. If the  $r$  value of TFC and AA is lower than TPC and AA, it indicates that the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship which is expected because both classes contributed to AA plants. Aryal et al.<sup>70</sup> and Muflihah et al.<sup>69</sup> informed that phenolic compounds are soluble natural antioxidants and potential donating electrons depend on their number and position of hydroxyl groups contributed to antioxidant action. Consequently, these groups are responsible to scavenge the free radicals which is expressed as TPC of pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the stable purple-colored to the yellow-colored solution. Based on FRAP analysis, it was showed that the bioactive compounds contained in pluchea wet noodles were a potential source of antioxidants because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive compounds in pluchea wet noodles can function as primary and secondary antioxidants. Research data showed that the cooking quality of wet noodles tends to increase along with the increase in the values of TPC, TFC, DPPH and FRAP.

### **Sensory Evaluation**

Sensory assay of pluchea wet noodles, namely color, aroma, taste, texture, and overall acceptance, was carried out using a hedonic test to determine the level of consumer preference for

the product. This test was conducted to determine the quality differences between the products and to provide an assessment on certain properties<sup>44</sup>. The hedonic test is the most widely used assessment to determine the level of preference for product<sup>71</sup>. The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm 1.26$  (neutral-like). The statistical analysis showed that the higher concentration of hot water extract addition decreased lower color preference of wet noodles. The higher concentration of pluchea extract could reduce the level of color preference because the color of the wet noodles was darker than control and turned to dark brown. This color change was due to the pluchea extract containing several components, including chlorophyll and tannins, which can alter the of wet noodles' color to be browner along with the increase in the concentration of pluchea extract. This result was in accordance to the effect of color analysis performed using color reader where the pluchea wet noodles' brightness declined, yellowness increased, and the color intensity increased with an increased concentration of pluchea extract. The occurrence of this process is related to the effect of light and heat on pluchea leaf powder which causes the degradation of chlorophyll into brown pheophytin due to drying, where the nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals<sup>72,73</sup>.

Aroma is one of the parameters in sensory evaluation using the sense of smell and an indicator of the assessment of a product<sup>74</sup>. The results of the preference values for aroma were ranged from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet noodles reduced the preference score for aroma due to distinct dry leaves (green) aroma. According to Lee et al.<sup>75</sup> the unpleasant aroma on leaves comes from a group of aliphatic aldehyde compounds. The

418 appearance of a distinctive leaf aroma in noodles is due to aromatic compounds. According to  
419 Martiyanti and Vita<sup>76</sup> aromatic compounds are chemical compounds that have an aroma or odor when  
420 the conditions are met, which is volatile, while Widyawati et al.<sup>77</sup> informed that pluchea leaves were  
421 detected to have 66 volatile compounds. The appearance of the aroma is due to the volatile  
422 compounds in the raw material reacting with water vapor when boiling the noodles. In addition, there  
423 is also an oxidation process of polyphenolic compounds such as catechins or tannins that can produce  
424 an aroma in pluchea wet noodles.

425 According to Martiyanti and Vita<sup>3</sup> taste attribute is one important sensory aspect in food  
426 products and has a great impact on the food selection by consumers. Tongue is able to detect basic  
427 tastes, such as sweet, salty, sour, and bitter, at different points. Lamusu<sup>73</sup> declared that taste is a  
428 component of flavor and an important criterion in assessing a product that is accepted by the tongue.  
429 The preference test of the taste of pluchea wet noodles resulted in values ranging from  $4.15 \pm 1.40$  to  
430  $5.50 \pm 1.28$  (neutral-slightly like). The increase in concentrations of pluchea extract was negatively  
431 correlated to the preference level of the taste of pluchea wet noodles assessed by the panelists. The  
432 statistical analysis results showed that the difference in the concentration of the extract significant  
433 influenced on the preference score for the taste of pluchea wet noodles. The increased concentration  
434 of pluchea extract produced a distinctive taste on wet noodles, such as a bitter and astringent tastes,  
435 due to the presence of compounds such as tannins and alkaloids from the pluchea leaves.  
436 Susetyarini<sup>78</sup> said that pluchea leaves contain tannins (2.35%), and alkaloids (0.32%). According to  
437 Pertiwi<sup>79</sup> tannin compounds dominate the bitter and astringent taste, while alkaloid compounds cause

438 a bitter taste. The high level of taste preference for wet noodles was found in noodles with lower  
439 content of pluchea extract.

440 Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and  
441 swallowed) or touched with fingers<sup>80</sup>. Texture testing performed by the panelist is called mouthfeel  
442 testing. According to Martiyanti and Vita<sup>76</sup>, mouthfeel is the kinesthetic effect of chewing food in the  
443 mouth. In this study, the preference test results on the texture of pluchea wet noodles revolved from  
444  $5.50 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy  
445 and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet  
446 noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that  
447 can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and  
448 draining noodles. Subjective testing results based on sensory evaluation were in line with the objective  
449 testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to  
450 break, and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea  
451 wet noodles was influenced by the fiber and protein components. According to Shabrina<sup>81</sup>, the  
452 components of fiber, protein, and starch complete to bind water. Texture changes are also influenced  
453 by the polyphenol compositions in the pluchea extract which is able to reduce S-S bonds to SH bonds,  
454 where the increase in SH (thiol) groups can cause a hard, sticky, and compact texture<sup>64,66,67</sup>. Besides, a  
455 high concentration of tannins capable of binding to proteins to form complex compounds into tannins-  
456 proteins are also able to build noodles' texture.

457 The interaction between color, aroma, taste, and texture created an overall taste of the food  
458 product and was assessed as the overall preference. The highest value on the overall preference was

459 derived from control wet noodles, i.e., 6.63 (slightly like it), while the wet noodles added with 20%  
460 (w/v) concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The  
461 addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to  
462 10% (w/v) concentration with scores of 6.63 and 6.53, respectively. The area of the spider web chart  
463 for each treatment with the various concentrations of pluchea extract was seen in Figure 3. The best  
464 treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37  
465 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the  
466 scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like),  
467 respectively.

468 The use of pluchea leaf extract in the making of wet noodles was able to increase the functional  
469 values of wet noodles, based on the levels of bioactive compounds and antioxidant activity without  
470 changing the quality of cooking, which included water content, swelling index and cooking loss. Besides  
471 that, the use of pluchea leaf extract did not significantly change the color and color intensity of the  
472 resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet  
473 noodles produced were still acceptable to the panelists, the addition of pluchea leaf extract as much  
474 as 10% (w/v) was the best treatment with an assessment that was almost closed to the control wet  
475 noodles (without treatment).

## 476 Conclusion

477 Addition of hot water extract of pluchea leaf powder influenced physical, chemical and sensory  
478 properties of wet noodles. Lightness, texture, bioactive compound content, antioxidant activity, and  
479 sensory properties of samples underwent significant difference. The higher concentration of pluchea

480 extract caused the bigger these parameters of pluchea wet noodles. Using 10% (w/v) of hot water  
481 extract from pluchea leaf powder was the best treatment with color, aroma, taste, and texture scores  
482 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. Utilization of  
483 hot water extract of pluchea leaf powder at 10% (w/v) resulted functional wet noodles with TPC, TFC,  
484 DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg dried samples, 62.44  
485 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples and 51.33 mg GAE/kg dried samples,  
486 respectively.

487

488 **Notes on Appendices**

TPC	Total phenolic content
TFC	Total flavonoid content
DPPH	2,2-Diphenyl-1-picrylhydrazyl free radical
FRAP	Ferric reducing antioxidant power
AA	Antioxidant activity
PC	Pearson Correlation
LDL	Low Density Lipoprotein
w/v	Weight per volume
CRD	Completely randomized design
CE	Catechin equivalent
GAE	Gallic acid equivalent
BC	Bioactive compounds

ANOVA

Analysis of variance

UV-Vis

Ultra violet-visible

Wb

Wet base

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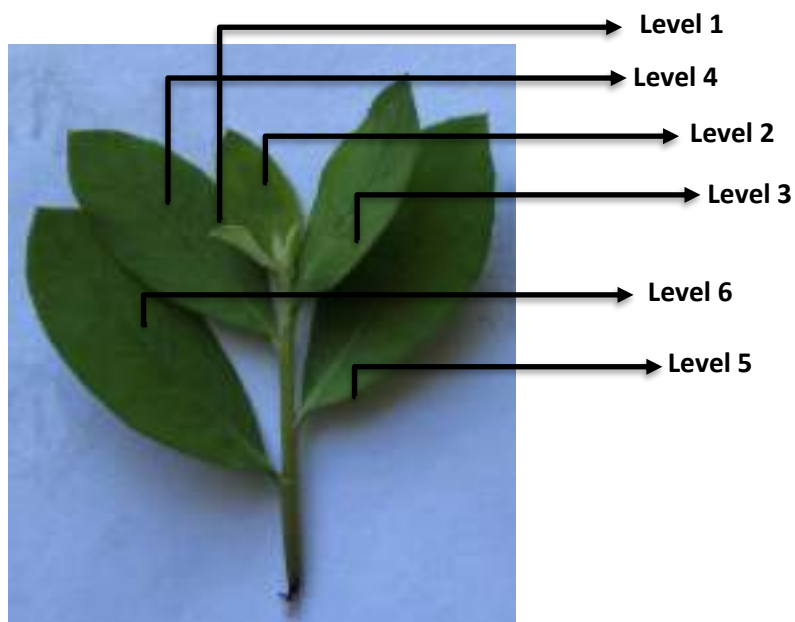


Figure 1. Young *Pluchea indica* Less leaves

745 Table 1. Information of hot water extract of pluchea tea

Materials	Concentration of hot water extract of pluchea leaf tea (% w/v)						
	0	5	10	15	20	25	30
Pluchea leaf tea (g)	0	10	20	30	40	50	60
Hot water (mL)	200	200	200	200	200	200	200

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747

748 **Table 2.** Ingredients of pluchea wet noodles

Materials	Unit	Quantity
Wheat flour	g	200
Egg	g	40
Salt	g	4
Baking powder	g	2
Hot water extract	mL	70
Tapioca flour	g	10
TOTAL	g	326

749



**Table 3.** Color, moisture content, swelling index, and cooking loss of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Color					Moisture content (% wb)	Swelling index (%)	Cooking loss (%)
	L*	a*	b*	C	h			
0	67.14 ± 1.77 <sup>a</sup>	0.97±0.30	16.18±0.62 <sup>ab</sup>	16.20 ± 0.63	86.47 ± 1.04	63.90±1.51	56.22±17.36	3.40±1.31
5	59.49 ± 2.67 <sup>b</sup>	2.18±0.93	15.47±1.46 <sup>a</sup>	15.62 ± 1.53	82.12 ± 3.05	65.08±4.33	62.40± 4.71	3.33±1.26
10	58.95 ± 1.80 <sup>b</sup>	1.95±1.66	16.76±2.33 <sup>abc</sup>	17.08 ± 2.16	83.29 ± 5.37	64.97±3.89	61.50± 7.51	3.00±1.16
15	58.35 ± 2.24 <sup>b</sup>	1.69±1.48	19.72±3.50 <sup>c</sup>	19.77 ± 3.38	84.67 ± 4.64	65.56±2.18	63.09± 6.31	3.31±0.92
20	56.48 ± 2.40 <sup>b</sup>	1.97±1.24	19.09±2.97 <sup>bc</sup>	19.18 ± 2.90	83.62 ± 4.33	66.81±1.81	67.74± 5.91	4.06±0.51
25	59.07 ± 2.49 <sup>b</sup>	1.95±1.44	19.55±2.97 <sup>c</sup>	19.58 ± 2.90	83.83 ± 4.41	66.04±0.85	64.46±10.32	3.93±1.37
30	57.10 ± 2.06 <sup>b</sup>	2.09±1.51	18.08±4.94 <sup>abc</sup>	18.28 ± 4.84	82.49 ± 5.22	66.65±2.16	63.96± 5.31	4.23±1.34

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$

754 **Table 4.** Texture of pluchea wet noodles.

Concentration of hot extract from pluchea leaf powder (% w/v)	Texture of pluchea wet noodles				
	Hardness (N)	Adhesiveness (g sec)	Cohesiveness	Elongation (%)	Elasticity (Pa)
0	135.75±5.91 <sup>a</sup>	-2.67 ±0.30 <sup>d</sup>	0.65±0.01 <sup>a</sup>	86.89±0.90 <sup>a</sup>	25336.72±104.20 <sup>a</sup>
5	120.13±2.05 <sup>a</sup>	-3.36±0.60 <sup>cd</sup>	0.68±0.00 <sup>b</sup>	97.25±1.59 <sup>b</sup>	25898.27±760.94 <sup>b</sup>
10	134.85±1.77 <sup>a</sup>	-3.91±0.65 <sup>bc</sup>	0.74±0.00 <sup>c</sup>	162.10±1.49 <sup>c</sup>	25807.73±761.85 <sup>b</sup>
15	180.48±5.06 <sup>b</sup>	-4.91±0.47 <sup>b</sup>	0.74±0.01 <sup>c</sup>	164.74±0.60 <sup>c</sup>	26971.61±516.71 <sup>b</sup>
20	195.11±14.14 <sup>b</sup>	-4.95±1.26 <sup>ab</sup>	0.75±0.01 <sup>cd</sup>	221.60±1.55 <sup>d</sup>	27474.38±453.80 <sup>b</sup>
25	244.57±8.81 <sup>c</sup>	-6.03±0.29 <sup>a</sup>	0.75±0.00 <sup>cd</sup>	230.65±0.73 <sup>e</sup>	27367.05±287.48 <sup>b</sup>
30	282.79±28.31 <sup>d</sup>	-6.05±0.22 <sup>a</sup>	0.79±0.01 <sup>d</sup>	255.38±0.36 <sup>f</sup>	26687.52±449.19 <sup>b</sup>

755 Note: the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in  
756 the same column are significantly different, p≤5%



**Table 5.** Total phenol content, total flavonoid content, the DPPH free radical scavenging activity, and iron ion reducing power of the pluchea wet noodles.

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	TPC (mg GAE/kg Dried Noodles)	TFC (mg CE/kg Dried Noodles)	DPPH (mg GAE/kg Dried Noodles)	FRAP (mg GAE/kg Dried noodles)
0	39.26±0.66 <sup>a</sup>	32.36±1.47 <sup>a</sup>	96.75±4.26 <sup>a</sup>	25.96±0.25 <sup>a</sup>
5	61.09±3.80 <sup>b</sup>	46.31±2.15 <sup>b</sup>	121.36±3.58 <sup>b</sup>	34.50±1.71 <sup>b</sup>
10	82.84±3.11 <sup>c</sup>	62.44±0.55 <sup>c</sup>	130.68±4.82 <sup>c</sup>	51.33±2.19 <sup>c</sup>
15	101.48±2.16 <sup>d</sup>	84.67±1.22 <sup>d</sup>	142.48±2.14 <sup>d</sup>	58.69±2.14 <sup>d</sup>
20	114.94±4.20 <sup>e</sup>	100.14±1.50 <sup>e</sup>	148.84±3.20 <sup>e</sup>	67.26±0.06 <sup>e</sup>
25	128.06±1.38 <sup>f</sup>	107.93±0.89 <sup>f</sup>	157.51±7.69 <sup>f</sup>	69.53±1.06 <sup>f</sup>
30	136.35±1.16 <sup>g</sup>	131.69±1.56 <sup>g</sup>	166.97±1.53 <sup>g</sup>	84.98±0.11 <sup>g</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .



**Table 6.** Effect of hot water extract from pluchea leaf powder to preferences for color, aroma, taste, texture, and overall acceptance of wet noodles at various concentrations

Concentration of Hot		Hedonic Score			
Extract from Pluchea					Overall
Leaf Powder (% w/v)	Color	Aroma	Taste	Texture	acceptance
0	6.19±1.25 <sup>d</sup>	5.52±1.08	5.50±1.18 <sup>c</sup>	6.20±1.13 <sup>b</sup>	6.63±1.49 <sup>c</sup>
5	5.62±1.28 <sup>c</sup>	5.52±0.83	5.51±1.29 <sup>c</sup>	6.37±1.14 <sup>bc</sup>	6.40±1.52 <sup>c</sup>
10	5.62±1.21 <sup>c</sup>	5.45±0.85	5.46±1.12 <sup>c</sup>	6.53±1.14 <sup>c</sup>	6.53±1.64 <sup>c</sup>
15	5.14±1.25 <sup>b</sup>	4.81±1.04	4.61±1.11 <sup>b</sup>	6.13±1.09 <sup>b</sup>	5.78±1.67 <sup>b</sup>
20	4.91±1.32 <sup>b</sup>	4.54±1.18	4.47±1.15 <sup>ab</sup>	5.80±1.06 <sup>a</sup>	5.17±1.70 <sup>a</sup>
25	4.54±1.40 <sup>a</sup>	4.26±1.23	4.20±1.24 <sup>a</sup>	5.50±1.04 <sup>a</sup>	5.23±1.75 <sup>a</sup>
30	4.47±1.33 <sup>a</sup>	4.05±1.34	4.15±1.40 <sup>a</sup>	5.59±1.05 <sup>a</sup>	5.37±1.91 <sup>a</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

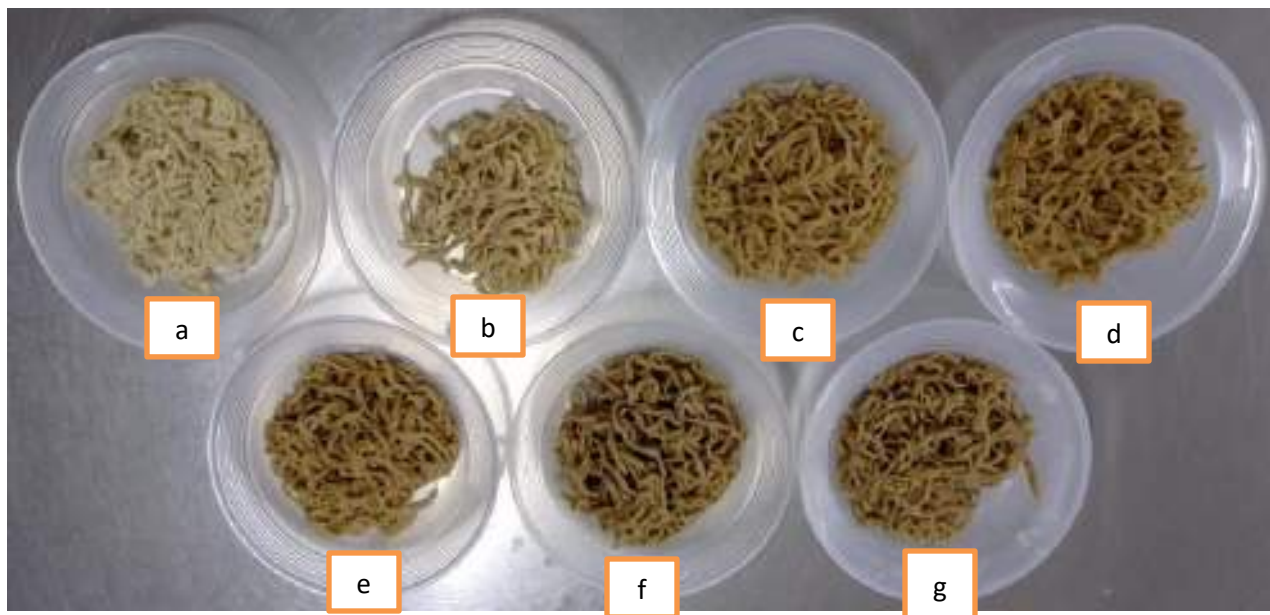


Figure 2. Wet noodles with hot water extract of pluchea leaf powder added at concentrations

a. 0%; b. 5%; c. 10%; d. 15%; e. 20%; f. 25%; and g. 30% w/v

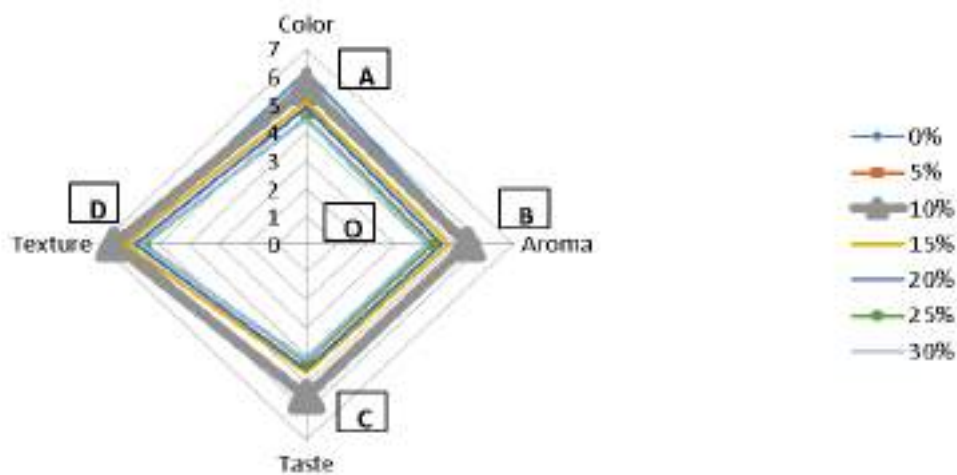


Figure 3. Spider web graph of sensory evaluation on wet noodles at various concentrations of hot water extract from pluchea leaf powder



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## **The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles**

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### **Abstract**

Powdered *Pluchea indica* Less leaves have been utilized as herbal tea, brewing of pluchea tea in hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional values and influence physic, chemical, and sensory characteristics of food. The study was carried out to assess the effect of various concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with pluchea tea at concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v). Physical properties analyzed included water content, swelling index, cooking loss, color and texture. Chemical properties measured were bioactive contents of total phenolic content, total flavonoid content, and antioxidant ability to scavenge DPPH free radicals and to reduce iron ions. Sensory properties determined were taste, texture, color, aroma and overall acceptance. The addition of various concentrations of extract offers significantly effects on parameters of physical, chemical and sensory properties of noodles, except color (redness, chroma and hue), cooking loss, water content, swelling index and aroma. Using of 10% (w/v) of pluchea tea resulted in the best sensory properties such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. Generally, the study concluded that wet noodles can be made by adding pluchea tea at 10% (w/v).



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Doi:

Dried samples TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg, 62.44 mg CE/kg, 130.68 mg GAE/kg and 51.33 mg GAE/kg, respectively.

## Introduction

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food.<sup>1,2</sup> The potency of pluchea leaves is related to phytochemical compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone, alkaloid, lignans and saponins.<sup>2,3,4,5</sup> Chan *et al.*<sup>1</sup> also reported that caffeoylquinic acids, phenolic acids, flavonoids and thiophenes in pluchea leaves are compounds with antioxidant activities. Furthermore, pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100 g, fat 0.49 g/100 g, insoluble dietary fiber 0.89 g/100 g, soluble dietary fiber 0.45 g/100 g, carbohydrate 8.65 g/100 g, calcium 251 mg/100 g,  $\beta$ -carotene 1.225  $\mu$ g/100 g.<sup>6</sup>

Pluchea tea brewed from pluchea leaves has been proven to exhibit antioxidant activity,<sup>6,7,8</sup> anti-diabetic activity,<sup>9</sup> anti-inflammatory activity,<sup>7</sup> anti-human LDL oxidation activity.<sup>10</sup> Previous research uses pluchea leaf powder to make several food products to increase functional values, i.e., jelly drink,<sup>11</sup> soy milk<sup>12</sup> and steamed bun<sup>13</sup> Using 1% (w/v) pluchea leaf powder can improve the physicochemical properties of jelly drink and increase panelists' acceptance of the product.<sup>11</sup> Soy milk with the addition of pluchea leaves increases the viscosity and total dissolved solids and decreases the panelist acceptance rate.<sup>12</sup> The addition of 6% (w/v) brewing from pluchea leaf powder on steamed bun is the best treatment with the lowest level of hardness.<sup>13</sup> Previous research has proven that the addition of pluchea leaves can increase the bioactive compound contents based on total phenol and total flavonoids, as well as increase the antioxidant activity based on ferric reducing power and ability to scavenge DPPH free radicals.

To the best of our knowledge, the study of the addition of pluchea tea in making wet noodles from wheat flour has not been conducted, as well as its impact on physicochemical and sensory characteristics of the noodles. Noodles are a popular food product that is widely consumed in the world. Indonesia is one of the countries with the largest noodle consumption

after China.<sup>14</sup> Wet noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet noodles as an alternative to wet noodles, which contain higher protein, and the second popular food in ASEAN regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia.<sup>16</sup> The addition of other ingredients has been endeavored to enhance wet noodles' specific properties. Many researchers incorporated plant extracts or natural products to increase functional properties of wet noodles, such as red spinach,<sup>17</sup> green tea,<sup>18,19</sup> purple sweet potato leaves,<sup>20</sup> moringa leaves,<sup>21</sup> sea weed,<sup>22</sup> ash of rice straw, turmeric extract,<sup>23</sup> and betel leaf extract<sup>24</sup> that influenced the physical, chemical, and organoleptic properties of the wet noodles. The anthocyanin of red spinach ethanolic extract increases the hedonic score of wet noodles' flavor.<sup>17</sup> The addition of green tea improves the stability, elastic modulus and viscosity, retrogradation and cooking loss with, no significant effect on mouth-feel and overall acceptance from panelist on the produced wet noodles.<sup>18</sup> Moreover, the addition of sweet potatoes leaf extract on wet noodles increases moisture content, protein value and ash concentration, and improves hedonic score of texture.<sup>20</sup> Moringa extract influences protein content and decreases panelist acceptance of color, aroma and taste of wet noodles.<sup>21</sup> The use of seaweed to produce wet noodles influences moisture content, swelling index, absorption ability, elongation value and color.<sup>22</sup> The addition of ash from rice straw and turmeric extract influences the elasticity and sensory characteristics (color, taste, aroma and texture) of wet noodles.<sup>23</sup> Betel leaf extract used to make Hokkien (with dark soya source) noodles improves texture and acceptance score of all sensory attributes.<sup>24</sup>

Bioactive compounds and nutritive values of pluchea leaf can be an alternative ingredient to improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea leaves can serve as an antioxidant source in wet noodles and increase the functional value. This study was undertaken to assess the effect of various

concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles.

### Materials and Methods

#### Preparation of Hot Water Extract from Pluchea Leaf Powder

Young pluchea leaves (1-6) (Figure 1) were picked from the shoots, sorted and washed. The selected leaves were dried at ambient temperature for 7

days to yield moisture content of  $10.00 \pm 0.04\%$  dry base.<sup>25</sup> Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at 120°C for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag for about 2 g/tea bag. Pluchea leaf powder in tea bags was extracted using hot water (95°C) for 5 min to get extract concentrations of 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

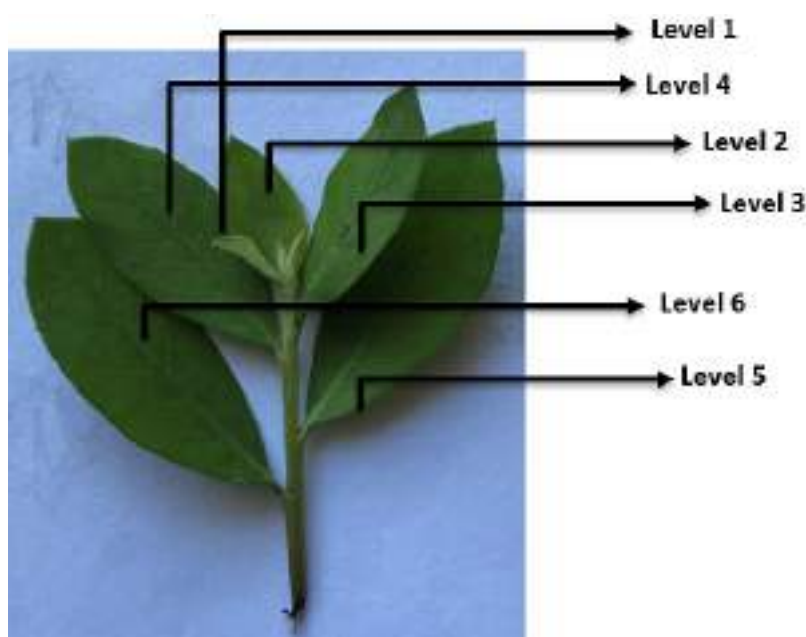


Fig. 1: Young *Pluchea indica* Less leaves

Table 1: Information of hot water extract of pluchea tea

Materials	Concentration of hot water extract of pluchea leaf tea (% w/v)						
	0	5	10	15	20	25	30
Pluchea leaf tea (g)	0	10	20	30	40	50	60
Hot water (mL)	200	200	200	200	200	200	200

#### Wet Noodles Processing

About 70 mL of hot extract from pluchea leaf powder with concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v) (Table 1) was manually mixed with egg, baking powder, salt and wheat flour for 5 min (Table 2). The mixture was kneaded to form a solid and homogenized dough using a mixer (Oxone Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to form noodle

strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled water about 3 min in 300 mL water and coated with oil to prevent the noodles from sticking to each other.<sup>26,27,28</sup> Wet noodles made without any addition of hot water of pluchea leaf extract were prepared as control. Wet noodles used in bioactive compounds and antioxidant activity assay were not added with oil to prevent the noodles from sticking to one another.

The final characteristics of wet noodles have width and thickness of 0.45 cm and 0.30 cm, respectively.

**Table 2: Ingredients of pluchea wet noodles**

Materials	Unit	Quantity
Wheat flour	g	200
Egg	g	40
Salt	g	4
Baking powder	g	2
Hot water extract	mL	70
Tapioca flour	g	10
TOTAL	g	326

#### Pluchea Wet Noodles Extraction

About 100 g of wet noodles were dried using a freeze-dryer at a pressure of 0.1 bar and temperature -60°C for 28 hours. Dried noodles were powdered using a chopper machine for 35 seconds. And then, 20 g of samples were mixed by 50 mL absolute methanol by a shaking water-bath at 35°C, 70 rpm for 1 hour.<sup>29</sup> Filtrate was separated using Whatman filter paper grade 40 and residue was extracted again with the same procedure. The filtrate was collected and evaporated by rotary evaporator until getting 3 mL of extract (Buchi Rotary Evaporator, Buchi Shanghai Ltd, China) at 200 bars, 50°C for 60 min. The extract was kept at 0°C before further analysis.

#### Moisture Content Assay

Moisture or water content of wet noodles was determined by thermos-gravimetric method.<sup>30</sup> The moisture content of wet noodles was determined by heating the samples in a drying oven (Binder, Merck KGaA, Darmstadt, Germany) and weighing the evaporated water content in the material.

#### Measurement of Swelling Index

The purpose of swelling index testing was to determine the capability of the noodles to swell during the boiling process.<sup>16</sup> The assay was done to determine the ability of wet noodles to absorb water per unit of time or the time needed to fully cooked wet noodles. The amount of water absorbed by wet noodles was measured from the weight before and after boiling.

#### Determination of Cooking Loss

Cooking loss is one of the necessary quality parameters to establish the quality of wet noodles after boiling.<sup>31</sup> The cooking loss assay was done by measuring the quantity of solids that leached out of the noodles during the boiling process, e.g., starch. A large cooking loss value affects the texture of wet noodles, which is easy to break and less slippery.

#### Determination of Texture

The texture of pluchea wet noodles was measured based on hardness, adhesiveness, cohesiveness, elongation and elasticity. The texture was analyzed by TA-XT2 texture analyzer (Stable Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the Texture Exponent 32 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were analyzed with a compression assay using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle strands with the length of 4 cm for each strand were laid side by side, touching each other, perpendicular to the 35 mm compression cylinder probe on a flat aluminum base. The cylinder probe was arranged to be at 15 mm distance from the lower plate at the start of the compression test, and was pressed down through the noodle strips at the speed of 2 mm s<sup>-1</sup> until it touched the flat base to compress 75% of the noodle thickness, and was drawn back to at the end of the test. The profile curve was determined using a texture analyzer software.<sup>24,32</sup> The hardness was determined as the maximum force per gram. The adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area was obtained from the compression test under the curve. Cohesiveness was analyzed based on the ratio between the area under the first and the second peaks<sup>24,32,33</sup> The elongation and elasticity of the noodles were individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. Elongation was the maximum force to change of noodle form and break by extension that was analyzed by a test speed of 3.0 mm s<sup>-1</sup> between two rollers with a 100 mm distance. The elongation at breaking was calculated per gram. Elasticity was determined by formula (1)<sup>34,35</sup>

$$\text{Elasticity} = (F_x l_0) / (A_x t_0) \quad 1/v \quad \dots(1)$$

where  $F$  is the tensile strength,  $l_0$  is the original length of the noodles between the limit arms (mm),  $A$  is the original cross-sectional area of the noodle ( $\text{mm}^2$ ),  $v$  is the rate of movement of the upper arm (mm/s), and  $t$  is break up time of the noodles (s). The measurement of texture was detected by the software and expressed as a graph.

#### Color Measurement

The color of the noodle sheets was determined by a colorimeter (Minolta CR 10, Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab  $L^*$ ,  $a^*$  and  $b^*$  values were analyzed based on the method by Fadzil *et al.*<sup>32</sup> The  $L^*$  value measured the position on the white/black axis, the  $a^*$  value as the position on the red/green axis, and the  $b^*$  value as the position on the yellow/blue axis.

#### Analysis of Total Phenolic Content

The total phenolic content analysis was analyzed based on the reaction between phenolic compounds and Folin Ciocalteu (FC) reagent or phosphomolybdic acid and phosphotungstic acid. The FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups to become a blue molybdenum-tungsten complex solution.<sup>36</sup> The intensity of the blue color was detected by a UV-Vis spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  760 nm. In the analysis, 7.5%  $\text{Na}_2\text{CO}_3$  solution was added to reach pH 10 that caused an electron transfer reaction (redox). The obtained data were expressed in mg of gallic acid equivalent (GAE)/L sample.

#### Analysis of Total Flavonoid Content

The flavonoid content assay was done using the spectrophotometric method based on the reaction between flavonoids and  $\text{AlCl}_3$  to form a yellow complex solution. In the presence of NaOH solution, a pink color is formed which can be detected by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm.<sup>36,37,38</sup> The obtained data were expressed in mg of catechin equivalent (CE)/L sample.

#### Analysis of DPPH Free Radical Scavenging Activity

The ability of antioxidant compounds to scavenge DPPH (2,2-diphenyl-1-picrylhydrazyl) free radicals can be used to evaluate antioxidant activity. The principle of the DPPH method is to measure

the absorbance of compounds that can react with DPPH radicals.<sup>39</sup> Antioxidant compounds can donate hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced to yellow.<sup>40</sup> The color change was measured as an absorbance at  $\lambda$  517 nm by spectrophotometer (Spectrophotometer UV Vis 1800, Shimadzu, Japan).<sup>41</sup> The data were expressed in mg gallic acid equivalent (GAE)/L dried noodles sample.

#### Analysis of Iron Ion Reduction Power

This method identifies the capacity of antioxidant components using potassium ferricyanide, trichloroacetic acid and ferric chloride to produce color complexes that can be measured spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm.<sup>42</sup> The principle of this testing is the ability antioxidants to reduce iron ions from  $\text{K}_3\text{Fe}(\text{CN})_6$  ( $\text{Fe}^{3+}$ ) to  $\text{K}_4\text{Fe}(\text{CN})_6$  ( $\text{Fe}^{2+}$ ). Then, potassium ferrocyanide reacts with  $\text{FeCl}_3$  to form a  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$  complex. The color change is from yellow to green.<sup>43</sup> The final data were expressed in mg gallic acid equivalent (GAE)/L dried noodles.

#### Sensory Evaluation

The hedonic test of all samples of wet noodles involved 100 untrained panelists with an age range of 17 to 25 years old, because they are students in food technology department that who have received provision about hedonic food preference test. All panelist supplied informed consent before the examination. A hedonic test used in this research was the hedonic scoring method, where the panelists gave a preference score value of all samples.<sup>26</sup> The hedonic scores were transformed to numeric scale and analyzed using statistical analysis.<sup>44</sup> The numeric scale in the sensory analysis used a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The panelists were asked to score according to their level of preference for texture, taste, color, flavor and overall acceptability. All the samples were blind coded with 3 digits which differed from each other.<sup>45</sup>

#### Statistical Analysis

The research design used in the physicochemical assay was a randomized block design (RBD) with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25 and 30% (w/v). Each treatment was repeated four times



that obtained 28 experiment units. A completely randomized design (CRD) was used to evaluate sensory assay with 100 untrained panelists with an aged 17 to 25 years old.

The normal distribution and homogeneity data were stated as the mean  $\pm$  SD of the triplicate determinations and determined using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan Multiple Range Test) at  $p \leq 5\%$  to determine treatment level that gave significant different results. The best

treatment of pluchea extract addition on wet noodles was analyzed by a spider web graph.

## Results and Discussion

Wet noodles added with hot extract of pluchea leaf powder were produced to increase the functional values of wet noodles. This is supported by previous studies related to the potential values of water extract of pluchea leaf that exhibits biological activities.<sup>6,7,26</sup> In this research, the cooking quality was observed after cooking wet noodles in 300 mL water/100 g samples for 3 min in boiling water.

**Table 3: Color, moisture content, swelling index, and cooking loss of pluchea wet noodles.**

Concentration of hot extract from pluchea leaf powder (% w/v)	Color					Moisture content (% wb)	Swelling index (%)	Cooking loss (%)
	L*	a*	b*	C	h			
0	67.14 $\pm$ 1.77 <sup>a</sup>	0.97 $\pm$ 0.30	16.18 $\pm$ 0.62 <sup>ab</sup>	16.20 $\pm$ 0.63	86.47 $\pm$ 1.04	63.90 $\pm$ 1.51	56.22 $\pm$ 17.36	3.40 $\pm$ 1.31
5	59.49 $\pm$ 2.67 <sup>b</sup>	2.18 $\pm$ 0.93	15.47 $\pm$ 1.46 <sup>a</sup>	15.62 $\pm$ 1.53	82.12 $\pm$ 3.05	65.08 $\pm$ 4.33	62.40 $\pm$ 4.71	3.33 $\pm$ 1.26
10	58.95 $\pm$ 1.80 <sup>b</sup>	1.95 $\pm$ 1.66	16.76 $\pm$ 2.33 <sup>abc</sup>	17.08 $\pm$ 2.16	83.29 $\pm$ 5.37	64.97 $\pm$ 3.89	61.50 $\pm$ 7.51	3.00 $\pm$ 1.16
15	58.35 $\pm$ 2.24 <sup>b</sup>	1.69 $\pm$ 1.48	19.72 $\pm$ 3.50 <sup>c</sup>	19.77 $\pm$ 3.38	84.67 $\pm$ 4.64	65.56 $\pm$ 2.18	63.09 $\pm$ 6.31	3.31 $\pm$ 0.92
20	56.48 $\pm$ 2.40 <sup>b</sup>	1.97 $\pm$ 1.24	19.09 $\pm$ 2.97 <sup>bc</sup>	19.18 $\pm$ 2.90	83.62 $\pm$ 4.33	66.81 $\pm$ 1.81	67.74 $\pm$ 5.91	4.06 $\pm$ 0.51
25	59.07 $\pm$ 2.49 <sup>b</sup>	1.95 $\pm$ 1.44	19.55 $\pm$ 2.97 <sup>c</sup>	19.58 $\pm$ 2.90	83.83 $\pm$ 4.41	66.04 $\pm$ 0.85	64.46 $\pm$ 10.32	3.93 $\pm$ 1.37
30	57.10 $\pm$ 2.06 <sup>b</sup>	2.09 $\pm$ 1.51	18.08 $\pm$ 4.94 <sup>abc</sup>	18.28 $\pm$ 4.84	82.49 $\pm$ 5.22	66.65 $\pm$ 2.16	63.96 $\pm$ 5.31	4.23 $\pm$ 1.34

Note the results were presented as SD of the means that were achieved by quadruplicate.

Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$

**Table 4: Texture of pluchea wet noodles.**

Concentration of hot extract from pluchea leaf powder (% w/v)	Texture of pluchea wet noodles				
	Hardness (N)	Adhesiveness (g sec)	Cohesiveness	Elongation (%)	Elasticity (Pa)
0	135.75 $\pm$ 5.91 <sup>a</sup>	-2.67 $\pm$ 0.30 <sup>d</sup>	0.65 $\pm$ 0.01 <sup>a</sup>	86.89 $\pm$ 0.90 <sup>a</sup>	25336.72 $\pm$ 104.20 <sup>a</sup>
5	120.13 $\pm$ 2.05 <sup>a</sup>	-3.36 $\pm$ 0.60 <sup>cd</sup>	0.68 $\pm$ 0.00 <sup>b</sup>	97.25 $\pm$ 1.59 <sup>b</sup>	25898.27 $\pm$ 760.94 <sup>b</sup>
10	134.85 $\pm$ 1.77 <sup>a</sup>	-3.91 $\pm$ 0.65 <sup>bc</sup>	0.74 $\pm$ 0.00 <sup>c</sup>	162.10 $\pm$ 1.49 <sup>c</sup>	25807.73 $\pm$ 761.85 <sup>b</sup>
15	180.48 $\pm$ 5.06 <sup>b</sup>	-4.91 $\pm$ 0.47 <sup>b</sup>	0.74 $\pm$ 0.01 <sup>c</sup>	164.74 $\pm$ 0.60 <sup>c</sup>	26971.61 $\pm$ 516.71 <sup>b</sup>
20	195.11 $\pm$ 14.14 <sup>b</sup>	-4.95 $\pm$ 1.26 <sup>ab</sup>	0.75 $\pm$ 0.01 <sup>cd</sup>	221.60 $\pm$ 1.55 <sup>d</sup>	2a7474.38 $\pm$ 453.80 <sup>b</sup>
25	244.57 $\pm$ 8.81 <sup>c</sup>	-6.03 $\pm$ 0.29 <sup>a</sup>	0.75 $\pm$ 0.00 <sup>cd</sup>	230.65 $\pm$ 0.73 <sup>e</sup>	27367.05 $\pm$ 287.48 <sup>b</sup>
30	282.79 $\pm$ 28.31 <sup>d</sup>	-6.05 $\pm$ 0.22 <sup>a</sup>	0.79 $\pm$ 0.01 <sup>d</sup>	255.38 $\pm$ 0.36 <sup>f</sup>	26687.52 $\pm$ 449.19 <sup>b</sup>

Note: the results were presented as SD of the means that were achieved by quadruplicate.

Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$





**Fig. 2: Wet noodles with hot water extract of pluchea leaf powder added at concentrations a. 0%; b. 5%; c. 10%; d. 15%; e. 20%; f. 25%; and g. 30% w/v**

### Cooking Quality

Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at 0, 5, 10, 15, 20, 25 and 30% (w/v) was shown in Figure 2, Table 3 and Table 4. The addition of pluchea extract no significantly influenced the water content, cooking loss, swelling index, chroma, and hue of the produced wet noodles using statistical analysis by ANOVA at  $p \leq 5\%$ . Water content is one of the chemical properties of a food product determined shelf life of food products, because the water content measures the free and weakly bound water in foodstuffs.<sup>46,47</sup> This study identified that the moisture content of the cooked wet noodles ranged between 64-67% wb. Previous study showed that the water content of the cooked egg wet noodles was around 54-58% wb<sup>47</sup> and maximum of 65%.<sup>20</sup> Chairuni *et al.*<sup>46</sup> stated that the boiling process could cause a change in moisture content from about 35% to about 52%. The Indonesian National Standard<sup>48</sup> stipulates that the moisture content of cooked wet noodles is a maximum of 65%. This means that only control noodles (without treatment) exhibited a moisture content similar to the previous information. The obtained data showed a trend that an extract addition caused an increase in the water content of wet noodles, but statistical analysis at  $p \leq 5\%$  showed no significant difference. This phenomenon was in accordance with the experimental results of Juliana *et al.*<sup>49</sup> that the using of spenochlea

leaf extract for making wet noodles, as well as Hasmawati *et al.*<sup>20</sup> that the sweet potato leaf extract increased the moisture of fresh noodles. The water content of pluchea wet noodles was expected by reaction between many components in the dough that impacted to the swelling index and cooking loss. Mualim *et al.*,<sup>14</sup> Bilina *et al.*<sup>22</sup> and Setiyoko *et al.*<sup>31</sup> reported that the presence of amino in protein and hydroxyl groups in amylose and amylopectin fractions in wheat flour as raw material for making dough determines the moisture content, swelling index and cooking loss of wet noodles. The contribution of glutenin and gliadin proteins in wheat flour to form gluten networks determines the capability of noodles to swell and retain water in the system. Gliadin acts as an adhesive that causes dough to be elastic, while glutenin makes the dough to be firm and able to withstand  $\text{CO}_2$  gas thus, the dough can expand and form pores. Fadzil *et al.*<sup>32</sup> found that thermal treatment during the boiling process results in the denaturation of gluten and causes a monomer of proteins to determine other reactions at the disulfide or sulfhydryl chain. The existence of phenolic compounds from pluchea extract also increased the capacity of noodles to absorb water and determined water mobility. Widyawati *et al.*<sup>26</sup> confirmed that hydrophilic compounds of proteins, carbohydrates, and polyphenolic components determine water mobility due to their ability to bind with water molecules through hydrogen bonding.

Tuhumury *et al.*<sup>50</sup> informed that gluten formation can inhibit water absorption by starch granules so that can prevent gelatinization. Therefore, the addition of phenolic compounds from the hot extract of pluchea leaf powder can inhibit the formation of gluten so that stimulates gelatinization of starch granules.

As a result, the impact of increased the moisture content during boiling had an effect on the value of the swelling index and cooking loss of the wet noodles. Widyawati *et al.*<sup>26</sup> claimed that the swelling index is the capability to trap water which is dependent on the chemical composition, particle size, and water content. Gull *et al.*<sup>51</sup> further confirmed that the swelling index is an indicator to determine water absorption by starch and protein to make gelatinization and hydration. Setiyoko *et al.*<sup>31</sup> explained that cooking loss is the mass of noodle solids that come out of the noodle strands for boiling. Gull *et al.*<sup>51</sup> added that soluble starch and other soluble components leach out into the water during the cooking process, making the cooking water turned thicker. The moisture content results (64-67% wb) showed that the produced wet noodles exceeded the moisture content limit of wet noodles after cooking, which is between 54-58%,<sup>46</sup> while the cooking loss value of wet noodles should not be more than 10%.<sup>31</sup> In this study, the cooking loss value was 3-4.2%. The cooking loss of samples during boiling noodles were caused the breaking of the bonding network that the polysaccharides are released and the gluten network breaks because of the addition of pluchea leaf extract. Widyawati *et al.*<sup>26</sup> supported that polyphenol can be bound with protein and starch with many non-covalent interactions, such as hydrogen bonding, electrostatic interaction, hydrophobic interaction, Van der Waal's interaction, and  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch to undergo gelatinization and gliadin and glutelin from the protein of wheat flour to form gluten.

The swelling index value derived from this research was about 56-68 %. Based on the previous research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.) fruit was around 51%.<sup>51</sup> This means that the addition of pluchea leaf extract in wet noodles also affects the ability of noodles to absorb water. Widyawati *et al.*<sup>26</sup> and Suriyaphan<sup>6</sup>

noted that bioactive compounds in hot water extract of pluchea leaf tea include 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, 4,5-O-dicaffeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was higher than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from extract in absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch granules to absorb water so that the swelling index and cooking loss increased. Suriyaphan<sup>6</sup> informed that hot extract of pluchea leaf tea contains 1.79 g/100 g protein, 8.65 g/100 g carbohydrate, and fiber (0.45 g/100 g soluble and 0.89 g/100 g insoluble), these compounds can involve in increasing the swelling index from pluchea wet noodles.

Color is one of the physical characteristics possessed by wet noodles that becomes a benchmark for consumer acceptance. This research found that the color of wet noodles was influenced by the addition of pluchea extract. The addition of pluchea leaf extract no significant affected the redness ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it influenced the yellowness ( $b^*$ ) and lightness ( $L^*$ ) values. Using of pluchea leaf powder brewing decreased the brightness of wet noodles significantly, as the concentration of the extract increased. This is related to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to experience color changes. According to Widyawati *et al.*<sup>8</sup> tannins are water-soluble compounds that can give a brown color. Suriyaphan<sup>6</sup> and Widyawati *et al.*<sup>26</sup> also stated that Khlu tea from pluchea leaves contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and  $6.39$  mg/100 g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow color. Gull *et al.*<sup>51</sup> stated that this pigment was easily changed in the paste sample due to the swelling and discoloration of the pigment during cooking.

Thus, the addition of hot water extract of pluchea leaf powder significantly reduced the brightness of wet noodles, because brown-colored noodles

were produced as the concentrations of added pluchea leaf extract increased. However, increasing the concentration of this extract had no influence on the redness, hue, and chroma values in ANOVA at  $p \leq 5\%$ . The results showed that the redness value of wet noodles revolved from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet noodles ranged from  $82.12 \pm 3.05$  to  $86.47 \pm 1.04$ . Based on this value, the color of wet noodles is in the yellow to the red color range,<sup>53</sup> thus the visible color of the wet noodle product was yellow to brown (Figure 2). Yellowness increased significantly with the addition of pluchea leaf extract and the value ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the availability of tannins and chlorophyll compounds from pluchea leaf extract. The chroma value of wet noodles was obtained within the range of  $15.6 \pm 1.5$  to  $19.8 \pm 3.4$ . This means that the brewing of pluchea leaf powder did not change the intensity of the brown color in the resulting wet noodles.

Texture analysis of pluchea wet noodles added with various concentrations of hot water extract from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness, elongation, and elasticity. Hardness is the maximum force given to a product until deformation.<sup>54,55</sup> From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher peak of graph shows the harder product.<sup>32</sup> Adhesiveness is force or tackiness that is required to pull the product from its surface, its value is obtained from the area between the first and second compressions.<sup>56,57</sup> Adhesiveness values show negative value, the bigger negative value means the product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and second compressions.<sup>55,57</sup> This is an indication of the internal forces that make up the product.<sup>58</sup> Elongation is the change in length of noodles when being exposed to a tensile force until the noodles break.<sup>59</sup> Elasticity is the time required for the product to withstand the load until it breaks. The more elastic a product, the longer the holding time. The data showed that the higher concentration of pluchea leaf powder within the hot water extract caused a significant increase in the hardness, stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati *et al.*<sup>26</sup> informed that the polyphenols contained in pluchea leaf extract can be weakly interacted either

covalently or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups that are polar. Amoako and Akiwa<sup>60</sup> and Zhu *et al.*<sup>61</sup> have also proven that polyphenolic compounds can be interacted with carbohydrates through the interaction of two hydrophobic and hydrophilic functional groups with amylose. Diez-Sánchez *et al.*<sup>62</sup> stated that polyphenolic compounds can be reacted with amylose and protein helical structures and largely determined by molecular weight, conformational mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and amylopectin can affect the gelatinization process in the amylose helical structure and interfere with the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss ( $> 98\%$ ) and swelling index (56.2 to 67.7%) data, it can be concluded that the interaction that occurs between the phenol group in pluchea leaf extract with amylose and protein was weak. The bioactive components of pluchea leaf extract are thought to affect the formation of disulfide cross-links (S-S) and turn into to form sulfhydryl groups (-SH) under the influence of heat. Ananingsih and Zhou<sup>63</sup> said that antioxidant compounds are a reducing agent that can have an impact on reducing S-S bonds and increasing the number of SH groups in the dough to produce a harder texture. According to Rahardjo *et al.*<sup>56</sup> phenolic compounds are hydroxyl compounds that influence the strength of the dough, where the higher the component of phenol compounds will weaken the gluten matrix and the dough thus becoming unstable. The instability of the dough can cause the texture to become hard.

Many researchers also find that tannins and phenols influence the networking S-S bond in the dough of wet noodles. Wang *et al.*<sup>64</sup> showed that tannins increase the relative amount of large, medium polymers in the gluten protein network so as to improve the dough quality. Zhang *et al.*<sup>65</sup> claimed that these polymer compounds are the

results of interactions or combinations of protein-tannin compounds that form bonds with the type of covalent, hydrogen, or ionic bonds. Rauf and Andini<sup>66</sup> also added that phenol compounds can reduce S-S bonds to SH bonds. SH is a type of thiol compound group, where the thiol group can influence the stickiness, viscosity, cohesiveness, elongation, and extensibility of the dough. Wang *et al.*<sup>67</sup> discovered the effect of phenolic compounds from green tea extract to increase the stickiness of wheat bread. The cohesiveness of the dough is formed due to a large number of thiol bonds formed, thus increasing the viscosity of the dough. The increased viscosity of the dough is thought to be due to the formation of polyphenolic compounds with thiol groups, as in the research of Ananingsih and Zhou<sup>63</sup> that the formation of catechin-thiol can increase the viscosity of the dough and the stability

of the dough. Zhu *et al.*<sup>68</sup> mentioned that the addition of phenolic compounds from green tea was able to increase the PV (peak viscosity) of wheat flour. Wang *et al.*<sup>64</sup> also found that the cohesiveness of the dough is influenced by tannins, where tannins can produce micro-glutens so as to produce a compact dough and increase the gluten network. The addition of pluchea leaf extract in making wet noodles could influence the elongation of wet noodles due to the components of polyphenol compounds such as tannins that can reduce the number of free amino groups. This is supported by Zhang *et al.*<sup>32</sup> and Wang *et al.*<sup>64</sup> that the formation of other types of covalent bonds, such as bonds between amino and hydroxyl groups, by forming hydrogen bonds between phenolic compounds and protein gluten so as to improve the quality of dough strength and dough extensibility.

**Table 5: Total phenol content, total flavonoid content, the DPPH free radical scavenging activity, and iron ion reducing power of the pluchea wet noodles.**

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	TPC (mg GAE/kg Dried Noodles)	TFC (mg CE/kg Dried Noodles)	DPPH (mg GAE/kg Dried Noodles)	FRAP (mg GAE/kg Dried noodles)
0	39.26±0.66 <sup>a</sup>	32.36±1.47 <sup>a</sup>	96.75±4.26 <sup>a</sup>	25.96±0.25 <sup>a</sup>
5	61.09±3.80 <sup>b</sup>	46.31±2.15 <sup>b</sup>	121.36±3.58 <sup>b</sup>	34.50±1.71 <sup>b</sup>
10	82.84±3.11 <sup>c</sup>	62.44±0.55 <sup>c</sup>	130.68±4.82 <sup>c</sup>	51.33±2.19 <sup>c</sup>
15	101.48±2.16 <sup>d</sup>	84.67±1.22 <sup>d</sup>	142.48±2.14 <sup>d</sup>	58.69±2.14 <sup>d</sup>
20	114.94±4.20 <sup>e</sup>	100.14±1.50 <sup>e</sup>	148.84±3.20 <sup>e</sup>	67.26±0.06 <sup>e</sup>
25	128.06±1.38 <sup>f</sup>	107.93±0.89 <sup>f</sup>	157.51±7.69 <sup>f</sup>	69.53±1.06 <sup>f</sup>
30	136.35±1.16 <sup>g</sup>	131.69±1.56 <sup>g</sup>	166.97±1.53 <sup>g</sup>	84.98±0.11 <sup>g</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate.

Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

#### Bioactive Compounds and Antioxidant Activity

Wet noodles added with pluchea leaf powder were analyzed based on its bioactive compounds and antioxidant activities. The analysis was conducted to determine the functional properties of wet noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles were presented in Table 5. The measured bioactive compounds (BC) involved total phenolic content (TPC) and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical

scavenging activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed that there was a positive and strong correlation between TPC and DPPH ( $r = 0.990$ ), TPC and FRAP ( $r = 0.986$ ), TFC and DPPH

( $r=0.974$ ), and TFC and FRAP ( $r=0.991$ ). This means that the antioxidant activity of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah *et al.*<sup>69</sup> informed that the PC ( $r$ ) > 0.699 indicates the strength and linear correlation between antioxidant activity (AA) and TPC, and also shows a strong positive relationship but PC ( $r$ ) < 0.699 obtains a moderately positive relationship. If the  $r$  value of TFC and AA is lower than TPC and AA, it indicates that the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship which is expected because both classes contributed to AA plants. Aryal *et al.*<sup>70</sup> and Muflihah *et al.*<sup>69</sup> informed that phenolic compounds are soluble natural antioxidants and potential donating electrons depend on their number and position of hydroxyl groups contributed to antioxidant action. Consequently, these groups are responsible to scavenge the free radicals which is expressed as TPC of pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the stable purple-colored to the yellow-

colored solution. Based on FRAP analysis, it was showed that the bioactive compounds contained in pluchea wet noodles were a potential source of antioxidants because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive compounds in pluchea wet noodles can function as primary and secondary antioxidants. Research data showed that the cooking quality of wet noodles tends to increase along with the increase in the values of TPC, TFC, DPPH and FRAP.

### Sensory Evaluation

Sensory assay of pluchea wet noodles, namely color, aroma, taste, texture, and overall acceptance, was carried out using a hedonic test to determine the level of consumer preference for the product. This test was conducted to determine the quality differences between the products and to provide an assessment on certain properties.<sup>44</sup> The hedonic test is the most widely used assessment to determine the level of preference for product.<sup>71</sup> The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

**Table 6: Effect of hot water extract from pluchea leaf powder to preferences for color, aroma, taste, texture, and overall acceptance of wet noodles at various concentrations**

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	Hedonic Score				
	Color	Aroma	Taste	Texture	Overall acceptance
0	6.19±1.25 <sup>d</sup>	5.52±1.08	5.50±1.18 <sup>c</sup>	6.20±1.13 <sup>b</sup>	6.63±1.49 <sup>c</sup>
5	5.62±1.28 <sup>c</sup>	5.52±0.83	5.51±1.29 <sup>c</sup>	6.37±1.14 <sup>bc</sup>	6.40±1.52 <sup>c</sup>
10	5.62±1.21 <sup>c</sup>	5.45±0.85	5.46±1.12 <sup>c</sup>	6.53±1.14 <sup>c</sup>	6.53±1.64 <sup>c</sup>
15	5.14±1.25 <sup>b</sup>	4.81±1.04	4.61±1.11 <sup>b</sup>	6.13±1.09 <sup>b</sup>	5.78±1.67 <sup>b</sup>
20	4.91±1.32 <sup>b</sup>	4.54±1.18	4.47±1.15 <sup>ab</sup>	5.80±1.06 <sup>a</sup>	5.17±1.70 <sup>a</sup>
25	4.54±1.40 <sup>a</sup>	4.26±1.23	4.20±1.24 <sup>a</sup>	5.50±1.04 <sup>a</sup>	5.23±1.75 <sup>a</sup>
30	4.47±1.33 <sup>a</sup>	4.05±1.34	4.15±1.40 <sup>a</sup>	5.59±1.05 <sup>a</sup>	5.37±1.91 <sup>a</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm 1.26$  (neutral-like). The statistical analysis showed that the higher concentration of hot water extract addition decreased lower color preference of wet noodles.

The higher concentration of pluchea extract could reduce the level of color preference because the color of the wet noodles was darker than control and turned to dark brown. This color change was due to the pluchea extract containing several components,



including chlorophyll and tannins, which can alter the of wet noodles' color to be browner along with the increase in the concentration of pluchea extract. This result was in accordance to the effect of color analysis performed using color reader where the pluchea wet noodles' brightness declined, yellowness increased, and the color intensity increased with an increased concentration of pluchea extract. The occurrence of this process is related to the effect of light and heat on pluchea leaf powder which causes the degradation of chlorophyll into brown pheophytin due to drying, where the nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals.<sup>72,73</sup>

Aroma is one of the parameters in sensory evaluation using the sense of smell and an indicator of the assessment of a product.<sup>74</sup> The results of the preference values for aroma were ranged from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet noodles reduced the preference score for aroma due to distinct dry leaves (green) aroma. According to Lee *et al.*<sup>75</sup> the unpleasant aroma on leaves comes from a group of aliphatic aldehyde compounds. The appearance of a distinctive leaf aroma in noodles is due to aromatic compounds. According to Martiyanti and Vita<sup>76</sup> aromatic compounds are chemical compounds that have an aroma or odor when the conditions are met, which is volatile, while Widyawati *et al.*<sup>77</sup> informed that pluchea leaves were detected to have 66 volatile compounds. The appearance of the aroma is due to the volatile compounds in the raw material reacting with water vapor when boiling the noodles. In addition, there is also an oxidation process of polyphenolic compounds such as catechins or tannins that can produce an aroma in pluchea wet noodles.

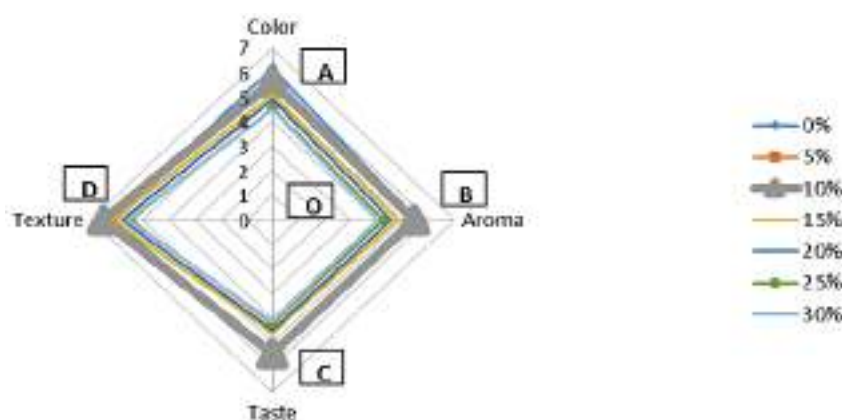
According to Martiyanti and Vita<sup>3</sup> taste attribute is one important sensory aspect in food products and has a great impact on the food selection by consumers. Tongue is able to detect basic tastes, such as sweet, salty, sour, and bitter, at different points. Lamusu<sup>73</sup> declared that taste is a component of flavor and an important criterion in assessing a product that is accepted by the tongue. The preference test of the taste of pluchea wet noodles resulted in values ranging from  $4.15 \pm 1.40$  to  $5.50 \pm 1.28$  (neutral-slightly like). The increase in concentrations of pluchea extract was negatively correlated to the preference level of the taste

of pluchea wet noodles assessed by the panelists. The statistical analysis results showed that the difference in the concentration of the extract significant influenced on the preference score for the taste of pluchea wet noodles. The increased concentration of pluchea extract produced a distinctive taste on wet noodles, such as a bitter and astringent tastes, due to the presence of compounds such as tannins and alkaloids from the pluchea leaves. Susetyarini<sup>78</sup> said that pluchea leaves contain tannins (2.35%), and alkaloids (0.32%). According to Pertiwi<sup>79</sup> tannin compounds dominate the bitter and astringent taste, while alkaloid compounds cause a bitter taste. The high level of taste preference for wet noodles was found in noodles with lower content of pluchea extract.

Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and swallowed) or touched with fingers.<sup>80</sup> Texture testing performed by the panelist is called mouthfeel testing. According to Martiyanti and Vita,<sup>76</sup> mouthfeel is the kinesthetic effect of chewing food in the mouth. In this study, the preference test results on the texture of pluchea wet noodles revolved from  $5.50 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and draining noodles. Subjective testing results based on sensory evaluation were in line with the objective testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to break, and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea wet noodles was influenced by the fiber and protein components. According to Shabrina,<sup>81</sup> the components of fiber, protein, and starch complete to bind water. Texture changes are also influenced by the polyphenol compositions in the pluchea extract which is able to reduce S-S bonds to SH bonds, where the increase in SH (thiol) groups can cause a hard, sticky, and compact texture.<sup>64,66,67</sup> Besides, a high concentration of tannins capable of binding to proteins to form complex compounds into tannins-proteins are also able to build noodles' texture.

The interaction between color, aroma, taste, and texture created an overall taste of the food product and was assessed as the overall preference. The highest value on the overall preference was derived from control wet noodles, i.e., 6.63 (slightly like it), while the wet noodles added with 20% (w/v) concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to 10% (w/v) concentration with scores

of 6.63 and 6.53, respectively. The area of the spider web chart for each treatment with the various concentrations of pluchea extract was seen in Figure 3. The best treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively.



**Fig. 3: Spider web graph of sensory evaluation on wet noodles at various concentrations of hot water extract from pluchea leaf powder**

The use of pluchea leaf extract in the making of wet noodles was able to increase the functional values of wet noodles, based on the levels of bioactive compounds and antioxidant activity without changing the quality of cooking, which included water content, swelling index and cooking loss. Besides that, the use of pluchea leaf extract did not significantly change the color and color intensity of the resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet noodles produced were still acceptable to the panelists, the addition of pluchea leaf extract as much as 10% (w/v) was the best treatment with an assessment that was almost closed to the control wet noodles (without treatment).

### Conclusion

Addition of hot water extract of pluchea leaf powder influenced physical, chemical and sensory properties of wet noodles. Lightness, texture, bioactive compound content, antioxidant

activity, and sensory properties of samples underwent significant difference. The higher concentration of pluchea extract caused the bigger these parameters of pluchea wet noodles. Using 10% (w/v) of hot water extract from pluchea leaf powder was the best treatment with color, aroma, taste, and texture scores 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. Utilization of hot water extract of pluchea leaf powder at 10% (w/v) resulted functional wet noodles with TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg dried samples, 62.44 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples and 51.33 mg GAE/kg dried samples, respectively.

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#### Conflict of Interest

The authors declare no conflict of interest.

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2. David Agus Wibisono is replaced to be David Agus Setiawan Wibisono

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## The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

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### Abstract

Powdered *Pluchea indica* Less leaves have been utilized as herbal tea, brewing of pluchea tea in hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional values and influence physic, chemical, and sensory characteristics of food. The study was carried out to assess the effect of various concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with pluchea tea at concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v). Physical properties analyzed included water content, swelling index, cooking loss, color and texture. Chemical properties measured were bioactive contents of total phenolic content, total flavonoid content, and antioxidant ability to scavenge DPPH free radicals and to reduce iron ions. Sensory properties determined were taste, texture, color, aroma and overall acceptance. The addition of various concentrations of extract offers significantly effects on parameters of physical, chemical and sensory properties of noodles, except color (redness, chroma and hue), cooking loss, water content, swelling index and aroma. Using of 10% (w/v) of pluchea tea resulted in the best sensory properties such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. Generally, the study concluded that wet noodles can be made by adding pluchea tea at 10% (w/v).



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Dried samples TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg, 62.44 mg CE/kg, 130.68 mg GAE/kg and 51.33 mg GAE/kg, respectively.

## Introduction

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food.<sup>1,2</sup> The potency of pluchea leaves is related to phytochemical compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone, alkaloid, lignans and saponins.<sup>2,3,4,5</sup> Chan *et al.*<sup>1</sup> also reported that caffeoylquinic acids, phenolic acids, flavonoids and thiophenes in pluchea leaves are compounds with antioxidant activities. Furthermore, pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100 g, fat 0.49 g/100 g, insoluble dietary fiber 0.89 g/100 g, soluble dietary fiber 0.45 g/100 g, carbohydrate 8.65 g/100 g, calcium 251 mg/100 g,  $\beta$ -carotene 1.225  $\mu$ g/100 g.<sup>6</sup>

Pluchea tea brewed from pluchea leaves has been proven to exhibit antioxidant activity,<sup>6,7,8</sup> anti-diabetic activity,<sup>9</sup> anti-inflammatory activity,<sup>7</sup> anti-human LDL oxidation activity.<sup>10</sup> Previous research uses pluchea leaf powder to make several food products to increase functional values, i.e., jelly drink,<sup>11</sup> soy milk<sup>12</sup> and steamed bun<sup>13</sup> Using 1% (w/v) pluchea leaf powder can improve the physicochemical properties of jelly drink and increase panelists' acceptance of the product.<sup>11</sup> Soy milk with the addition of pluchea leaves increases the viscosity and total dissolved solids and decreases the panelist acceptance rate.<sup>12</sup> The addition of 6% (w/v) brewing from pluchea leaf powder on steamed bun is the best treatment with the lowest level of hardness.<sup>13</sup> Previous research has proven that the addition of pluchea leaves can increase the bioactive compound contents based on total phenol and total flavonoids, as well as increase the antioxidant activity based on ferric reducing power and ability to scavenge DPPH free radicals.

To the best of our knowledge, the study of the addition of pluchea tea in making wet noodles from wheat flour has not been conducted, as well as its impact on physicochemical and sensory characteristics of the noodles. Noodles are a popular food product that is widely consumed in the world. Indonesia is one of the countries with the largest noodle consumption

after China.<sup>14</sup> Wet noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet noodles as an alternative to wet noodles, which contain higher protein, and the second popular food in ASEAN regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia.<sup>16</sup> The addition of other ingredients has been endeavored to enhance wet noodles' specific properties. Many researchers incorporated plant extracts or natural products to increase functional properties of wet noodles, such as red spinach,<sup>17</sup> green tea,<sup>18,19</sup> purple sweet potato leaves,<sup>20</sup> moringa leaves,<sup>21</sup> sea weed,<sup>22</sup> ash of rice straw, turmeric extract,<sup>23</sup> and betel leaf extract<sup>24</sup> that influenced the physical, chemical, and organoleptic properties of the wet noodles. The anthocyanin of red spinach ethanolic extract increases the hedonic score of wet noodles' flavor.<sup>17</sup> The addition of green tea improves the stability, elastic modulus and viscosity, retrogradation and cooking loss with, no significant effect on mouth-feel and overall acceptance from panelist on the produced wet noodles.<sup>18</sup> Moreover, the addition of sweet potatoes leaf extract on wet noodles increases moisture content, protein value and ash concentration, and improves hedonic score of texture.<sup>20</sup> Moringa extract influences protein content and decreases panelist acceptance of color, aroma and taste of wet noodles.<sup>21</sup> The use of seaweed to produce wet noodles influences moisture content, swelling index, absorption ability, elongation value and color.<sup>22</sup> The addition of ash from rice straw and turmeric extract influences the elasticity and sensory characteristics (color, taste, aroma and texture) of wet noodles.<sup>23</sup> Betel leaf extract used to make Hokkien (with dark soya source) noodles improves texture and acceptance score of all sensory attributes.<sup>24</sup>

Bioactive compounds and nutritive values of pluchea leaf can be an alternative ingredient to improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea leaves can serve as an antioxidant source in wet noodles and increase the functional value. This study was undertaken to assess the effect of various

concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles.

### Materials and Methods

#### Preparation of Hot Water Extract from Pluchea Leaf Powder

Young pluchea leaves (1-6) (Figure 1) were picked from the shoots, sorted and washed. The selected leaves were dried at ambient temperature for 7

days to yield moisture content of  $10.00 \pm 0.04\%$  dry base.<sup>25</sup> Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at 120°C for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag for about 2 g/tea bag. Pluchea leaf powder in tea bags was extracted using hot water (95°C) for 5 min to get extract concentrations of 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

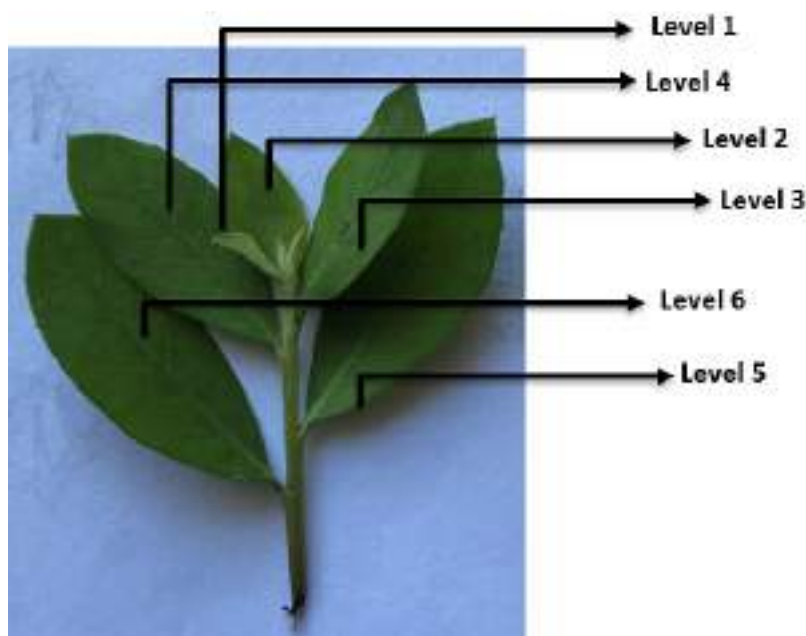


Fig. 1: Young *Pluchea indica* Less leaves

Table 1: Information of hot water extract of pluchea tea

Materials	Concentration of hot water extract of pluchea leaf tea (% w/v)						
	0	5	10	15	20	25	30
Pluchea leaf tea (g)	0	10	20	30	40	50	60
Hot water (mL)	200	200	200	200	200	200	200

#### Wet Noodles Processing

About 70 mL of hot extract from pluchea leaf powder with concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v) (Table 1) was manually mixed with egg, baking powder, salt and wheat flour for 5 min (Table 2). The mixture was kneaded to form a solid and homogenized dough using a mixer (Oxone Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to form noodle

strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled water about 3 min in 300 mL water and coated with oil to prevent the noodles from sticking to each other.<sup>26,27,28</sup> Wet noodles made without any addition of hot water of pluchea leaf extract were prepared as control. Wet noodles used in bioactive compounds and antioxidant activity assay were not added with oil to prevent the noodles from sticking to one another.

The final characteristics of wet noodles have width and thickness of 0.45 cm and 0.30 cm, respectively.

**Table 2: Ingredients of pluchea wet noodles**

Materials	Unit	Quantity
Wheat flour	g	200
Egg	g	40
Salt	g	4
Baking powder	g	2
Hot water extract	mL	70
Tapioca flour	g	10
TOTAL	g	326

#### Pluchea Wet Noodles Extraction

About 100 g of wet noodles were dried using a freeze-dryer at a pressure of 0.1 bar and temperature -60°C for 28 hours. Dried noodles were powdered using a chopper machine for 35 seconds. And then, 20 g of samples were mixed by 50 mL absolute methanol by a shaking water-bath at 35°C, 70 rpm for 1 hour.<sup>29</sup> Filtrate was separated using Whatman filter paper grade 40 and residue was extracted again with the same procedure. The filtrate was collected and evaporated by rotary evaporator until getting 3 mL of extract (Buchi Rotary Evaporator, Buchi Shanghai Ltd, China) at 200 bars, 50°C for 60 min. The extract was kept at 0°C before further analysis.

#### Moisture Content Assay

Moisture or water content of wet noodles was determined by thermos-gravimetric method.<sup>30</sup> The moisture content of wet noodles was determined by heating the samples in a drying oven (Binder, Merck KGaA, Darmstadt, Germany) and weighing the evaporated water content in the material.

#### Measurement of Swelling Index

The purpose of swelling index testing was to determine the capability of the noodles to swell during the boiling process.<sup>16</sup> The assay was done to determine the ability of wet noodles to absorb water per unit of time or the time needed to fully cooked wet noodles. The amount of water absorbed by wet noodles was measured from the weight before and after boiling.

#### Determination of Cooking Loss

Cooking loss is one of the necessary quality parameters to establish the quality of wet noodles after boiling.<sup>31</sup> The cooking loss assay was done by measuring the quantity of solids that leached out of the noodles during the boiling process, e.g., starch. A large cooking loss value affects the texture of wet noodles, which is easy to break and less slippery.

#### Determination of Texture

The texture of pluchea wet noodles was measured based on hardness, adhesiveness, cohesiveness, elongation and elasticity. The texture was analyzed by TA-XT2 texture analyzer (Stable Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the Texture Exponent 32 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were analyzed with a compression assay using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle strands with the length of 4 cm for each strand were laid side by side, touching each other, perpendicular to the 35 mm compression cylinder probe on a flat aluminum base. The cylinder probe was arranged to be at 15 mm distance from the lower plate at the start of the compression test, and was pressed down through the noodle strips at the speed of 2 mm s<sup>-1</sup> until it touched the flat base to compress 75% of the noodle thickness, and was drawn back to at the end of the test. The profile curve was determined using a texture analyzer software.<sup>24,32</sup> The hardness was determined as the maximum force per gram. The adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area was obtained from the compression test under the curve. Cohesiveness was analyzed based on the ratio between the area under the first and the second peaks.<sup>24,32,33</sup> The elongation and elasticity of the noodles were individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. Elongation was the maximum force to change of noodle form and break by extension that was analyzed by a test speed of 3.0 mm s<sup>-1</sup> between two rollers with a 100 mm distance. The elongation at breaking was calculated per gram. Elasticity was determined by formula (1)<sup>34,35</sup>

$$\text{Elasticity} = (F_x l_o) / (A_x t_o) \quad 1/v \quad \dots(1)$$

where  $F$  is the tensile strength,  $l_0$  is the original length of the noodles between the limit arms (mm),  $A$  is the original cross-sectional area of the noodle ( $\text{mm}^2$ ),  $v$  is the rate of movement of the upper arm (mm/s), and  $t$  is break up time of the noodles (s). The measurement of texture was detected by the software and expressed as a graph.

#### Color Measurement

The color of the noodle sheets was determined by a colorimeter (Minolta CR 10, Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab  $L^*$ ,  $a^*$  and  $b^*$  values were analyzed based on the method by Fadzil *et al.*<sup>32</sup> The  $L^*$  value measured the position on the white/black axis, the  $a^*$  value as the position on the red/green axis, and the  $b^*$  value as the position on the yellow/blue axis.

#### Analysis of Total Phenolic Content

The total phenolic content analysis was analyzed based on the reaction between phenolic compounds and Folin Ciocalteu (FC) reagent or phosphomolybdic acid and phosphotungstic acid. The FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups to become a blue molybdenum-tungsten complex solution.<sup>36</sup> The intensity of the blue color was detected by a UV-Vis spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  760 nm. In the analysis, 7.5%  $\text{Na}_2\text{CO}_3$  solution was added to reach pH 10 that caused an electron transfer reaction (redox). The obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

#### Analysis of Total Flavonoid Content

The flavonoid content assay was done using the spectrophotometric method based on the reaction between flavonoids and  $\text{AlCl}_3$  to form a yellow complex solution. In the presence of NaOH solution, a pink color is formed which can be detected by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm.<sup>36,37,38</sup> The obtained data were expressed in mg of catechin equivalent (CE)/L sample.

#### Analysis of DPPH Free Radical Scavenging Activity

The ability of antioxidant compounds to scavenge DPPH (2,2-diphenyl-1-picrylhydrazyl) free radicals can be used to evaluate antioxidant activity. The principle of the DPPH method is to measure

the absorbance of compounds that can react with DPPH radicals.<sup>39</sup> Antioxidant compounds can donate hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced to yellow.<sup>40</sup> The color change was measured as an absorbance at  $\lambda$  517 nm by spectrophotometer (Spectrophotometer UV Vis 1800, Shimadzu, Japan).<sup>41</sup> The data were expressed in mg gallic acid equivalent (GAE)/L dried noodles sample.

#### Analysis of Iron Ion Reduction Power

This method identifies the capacity of antioxidant components using potassium ferricyanide, trichloroacetic acid and ferric chloride to produce color complexes that can be measured spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm.<sup>42</sup> The principle of this testing is the ability antioxidants to reduce iron ions from  $\text{K}_3\text{Fe}(\text{CN})_6$  ( $\text{Fe}^{3+}$ ) to  $\text{K}_4\text{Fe}(\text{CN})_6$  ( $\text{Fe}^{2+}$ ). Then, potassium ferrocyanide reacts with  $\text{FeCl}_3$  to form a  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$  complex. The color change is from yellow to green.<sup>43</sup> The final data were expressed in mg gallic acid equivalent (GAE)/L dried noodles.

#### Sensory Evaluation

The hedonic test of all samples of wet noodles involved 100 untrained panelists with an age range of 17 to 25 years old, because they are students in food technology department that who have received provision about hedonic food preference test. All panelist supplied informed consent before the examination. A hedonic test used in this research was the hedonic scoring method, where the panelists gave a preference score value of all samples.<sup>26</sup> The hedonic scores were transformed to numeric scale and analyzed using statistical analysis.<sup>44</sup> The numeric scale in the sensory analysis used a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The panelists were asked to score according to their level of preference for texture, taste, color, flavor and overall acceptability. All the samples were blind coded with 3 digits which differed from each other.<sup>45</sup>

#### Statistical Analysis

The research design used in the physicochemical assay was a randomized block design (RBD) with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25 and 30% (w/v). Each treatment was repeated four times



that obtained 28 experiment units. A completely randomized design (CRD) was used to evaluate sensory assay with 100 untrained panelists with an aged 17 to 25 years old.

The normal distribution and homogeneity data were stated as the mean  $\pm$  SD of the triplicate determinations and determined using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan Multiple Range Test) at  $p \leq 5\%$  to determine treatment level that gave significant different results. The best

treatment of pluchea extract addition on wet noodles was analyzed by a spider web graph.

## Results and Discussion

Wet noodles added with hot extract of pluchea leaf powder were produced to increase the functional values of wet noodles. This is supported by previous studies related to the potential values of water extract of pluchea leaf that exhibits biological activities.<sup>6,7,26</sup> In this research, the cooking quality was observed after cooking wet noodles in 300 mL water/100 g samples for 3 min in boiling water.

**Table 3: Color, moisture content, swelling index, and cooking loss of pluchea wet noodles.**

Concentration of hot extract from pluchea leaf powder (% w/v)	Color					Moisture content (% wb)	Swelling index (%)	Cooking loss (%)
	L*	a*	b*	C	h			
0	67.14 $\pm$ 1.77 <sup>a</sup>	0.97 $\pm$ 0.30	16.18 $\pm$ 0.62 <sup>ab</sup>	16.20 $\pm$ 0.63	86.47 $\pm$ 1.04	63.90 $\pm$ 1.51	56.22 $\pm$ 17.36	3.40 $\pm$ 1.31
5	59.49 $\pm$ 2.67 <sup>b</sup>	2.18 $\pm$ 0.93	15.47 $\pm$ 1.46 <sup>a</sup>	15.62 $\pm$ 1.53	82.12 $\pm$ 3.05	65.08 $\pm$ 4.33	62.40 $\pm$ 4.71	3.33 $\pm$ 1.26
10	58.95 $\pm$ 1.80 <sup>b</sup>	1.95 $\pm$ 1.66	16.76 $\pm$ 2.33 <sup>abc</sup>	17.08 $\pm$ 2.16	83.29 $\pm$ 5.37	64.97 $\pm$ 3.89	61.50 $\pm$ 7.51	3.00 $\pm$ 1.16
15	58.35 $\pm$ 2.24 <sup>b</sup>	1.69 $\pm$ 1.48	19.72 $\pm$ 3.50 <sup>c</sup>	19.77 $\pm$ 3.38	84.67 $\pm$ 4.64	65.56 $\pm$ 2.18	63.09 $\pm$ 6.31	3.31 $\pm$ 0.92
20	56.48 $\pm$ 2.40 <sup>b</sup>	1.97 $\pm$ 1.24	19.09 $\pm$ 2.97 <sup>bc</sup>	19.18 $\pm$ 2.90	83.62 $\pm$ 4.33	66.81 $\pm$ 1.81	67.74 $\pm$ 5.91	4.06 $\pm$ 0.51
25	59.07 $\pm$ 2.49 <sup>b</sup>	1.95 $\pm$ 1.44	19.55 $\pm$ 2.97 <sup>c</sup>	19.58 $\pm$ 2.90	83.83 $\pm$ 4.41	66.04 $\pm$ 0.85	64.46 $\pm$ 10.32	3.93 $\pm$ 1.37
30	57.10 $\pm$ 2.06 <sup>b</sup>	2.09 $\pm$ 1.51	18.08 $\pm$ 4.94 <sup>abc</sup>	18.28 $\pm$ 4.84	82.49 $\pm$ 5.22	66.65 $\pm$ 2.16	63.96 $\pm$ 5.31	4.23 $\pm$ 1.34

Note the results were presented as SD of the means that were achieved by quadruplicate.

Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$

**Table 4: Texture of pluchea wet noodles.**

Concentration of hot extract from pluchea leaf powder (% w/v)	Texture of pluchea wet noodles				
	Hardness (N)	Adhesiveness (g sec)	Cohesiveness	Elongation (%)	Elasticity (Pa)
0	135.75 $\pm$ 5.91 <sup>a</sup>	-2.67 $\pm$ 0.30 <sup>d</sup>	0.65 $\pm$ 0.01 <sup>a</sup>	86.89 $\pm$ 0.90 <sup>a</sup>	25336.72 $\pm$ 104.20 <sup>a</sup>
5	120.13 $\pm$ 2.05 <sup>a</sup>	-3.36 $\pm$ 0.60 <sup>cd</sup>	0.68 $\pm$ 0.00 <sup>b</sup>	97.25 $\pm$ 1.59 <sup>b</sup>	25898.27 $\pm$ 760.94 <sup>b</sup>
10	134.85 $\pm$ 1.77 <sup>a</sup>	-3.91 $\pm$ 0.65 <sup>bc</sup>	0.74 $\pm$ 0.00 <sup>c</sup>	162.10 $\pm$ 1.49 <sup>c</sup>	25807.73 $\pm$ 761.85 <sup>b</sup>
15	180.48 $\pm$ 5.06 <sup>b</sup>	-4.91 $\pm$ 0.47 <sup>b</sup>	0.74 $\pm$ 0.01 <sup>c</sup>	164.74 $\pm$ 0.60 <sup>c</sup>	26971.61 $\pm$ 516.71 <sup>b</sup>
20	195.11 $\pm$ 14.14 <sup>b</sup>	-4.95 $\pm$ 1.26 <sup>ab</sup>	0.75 $\pm$ 0.01 <sup>cd</sup>	221.60 $\pm$ 1.55 <sup>d</sup>	2a7474.38 $\pm$ 453.80 <sup>b</sup>
25	244.57 $\pm$ 8.81 <sup>c</sup>	-6.03 $\pm$ 0.29 <sup>a</sup>	0.75 $\pm$ 0.00 <sup>cd</sup>	230.65 $\pm$ 0.73 <sup>e</sup>	27367.05 $\pm$ 287.48 <sup>b</sup>
30	282.79 $\pm$ 28.31 <sup>d</sup>	-6.05 $\pm$ 0.22 <sup>a</sup>	0.79 $\pm$ 0.01 <sup>d</sup>	255.38 $\pm$ 0.36 <sup>f</sup>	26687.52 $\pm$ 449.19 <sup>b</sup>

Note: the results were presented as SD of the means that were achieved by quadruplicate.

Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$



**Fig. 2: Wet noodles with hot water extract of pluchea leaf powder added at concentrations a. 0%; b. 5%; c. 10%; d. 15%; e. 20%; f. 25%; and g. 30% w/v**

### Cooking Quality

Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at 0, 5, 10, 15, 20, 25 and 30% (w/v) was shown in Figure 2, Table 3 and Table 4. The addition of pluchea extract no significantly influenced the water content, cooking loss, swelling index, chroma, and hue of the produced wet noodles using statistical analysis by ANOVA at  $p \leq 5\%$ . Water content is one of the chemical properties of a food product determined shelf life of food products, because the water content measures the free and weakly bound water in foodstuffs.<sup>46,47</sup> This study identified that the moisture content of the cooked wet noodles ranged between 64-67% wb. Previous study showed that the water content of the cooked egg wet noodles was around 54-58% wb<sup>47</sup> and maximum of 65%.<sup>20</sup> Chairuni *et al.*<sup>46</sup> stated that the boiling process could cause a change in moisture content from about 35% to about 52%. The Indonesian National Standard<sup>48</sup> stipulates that the moisture content of cooked wet noodles is a maximum of 65%. This means that only control noodles (without treatment) exhibited a moisture content similar to the previous information. The obtained data showed a trend that an extract addition caused an increase in the water content of wet noodles, but statistical analysis at  $p \leq 5\%$  showed no significant difference. This phenomenon was in accordance with the experimental results of Juliana *et al.*<sup>49</sup> that the using of spenochlea

leaf extract for making wet noodles, as well as Hasmawati *et al.*<sup>20</sup> that the sweet potato leaf extract increased the moisture of fresh noodles. The water content of pluchea wet noodles was expected by reaction between many components in the dough that impacted to the swelling index and cooking loss. Mualim *et al.*,<sup>14</sup> Bilina *et al.*<sup>22</sup> and Setiyoko *et al.*<sup>31</sup> reported that the presence of amino in protein and hydroxyl groups in amylose and amylopectin fractions in wheat flour as raw material for making dough determines the moisture content, swelling index and cooking loss of wet noodles. The contribution of glutenin and gliadin proteins in wheat flour to form gluten networks determines the capability of noodles to swell and retain water in the system. Gliadin acts as an adhesive that causes dough to be elastic, while glutenin makes the dough to be firm and able to withstand  $\text{CO}_2$  gas thus, the dough can expand and form pores. Fadzil *et al.*<sup>32</sup> found that thermal treatment during the boiling process results in the denaturation of gluten and causes a monomer of proteins to determine other reactions at the disulfide or sulfhydryl chain. The existence of phenolic compounds from pluchea extract also increased the capacity of noodles to absorb water and determined water mobility. Widyawati *et al.*<sup>26</sup> confirmed that hydrophilic compounds of proteins, carbohydrates, and polyphenolic components determine water mobility due to their ability to bind with water molecules through hydrogen bonding.



Tuhumury *et al.*<sup>50</sup> informed that gluten formation can inhibit water absorption by starch granules so that can prevent gelatinization. Therefore, the addition of phenolic compounds from the hot extract of pluchea leaf powder can inhibit the formation of gluten so that stimulates gelatinization of starch granules.

As a result, the impact of increased the moisture content during boiling had an effect on the value of the swelling index and cooking loss of the wet noodles. Widyawati *et al.*<sup>26</sup> claimed that the swelling index is the capability to trap water which is dependent on the chemical composition, particle size, and water content. Gull *et al.*<sup>51</sup> further confirmed that the swelling index is an indicator to determine water absorption by starch and protein to make gelatinization and hydration. Setiyoko *et al.*<sup>31</sup> explained that cooking loss is the mass of noodle solids that come out of the noodle strands for boiling. Gull *et al.*<sup>51</sup> added that soluble starch and other soluble components leach out into the water during the cooking process, making the cooking water turned thicker. The moisture content results (64-67% wb) showed that the produced wet noodles exceeded the moisture content limit of wet noodles after cooking, which is between 54-58%,<sup>46</sup> while the cooking loss value of wet noodles should not be more than 10%.<sup>31</sup> In this study, the cooking loss value was 3-4.2%. The cooking loss of samples during boiling noodles were caused the breaking of the bonding network that the polysaccharides are released and the gluten network breaks because of the addition of pluchea leaf extract. Widyawati *et al.*<sup>26</sup> supported that polyphenol can be bound with protein and starch with many non-covalent interactions, such as hydrogen bonding, electrostatic interaction, hydrophobic interaction, Van der Waal's interaction, and  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch to undergo gelatinization and gliadin and glutelin from the protein of wheat flour to form gluten.

The swelling index value derived from this research was about 56-68 %. Based on the previous research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.) fruit was around 51%.<sup>51</sup> This means that the addition of pluchea leaf extract in wet noodles also affects the ability of noodles to absorb water. Widyawati *et al.*<sup>26</sup> and Suriyaphan<sup>6</sup>

noted that bioactive compounds in hot water extract of pluchea leaf tea include 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, 4,5-O-dicaffeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was higher than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from extract in absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch granules to absorb water so that the swelling index and cooking loss increased. Suriyaphan<sup>6</sup> informed that hot extract of pluchea leaf tea contains 1.79 g/100 g protein, 8.65 g/100 g carbohydrate, and fiber (0.45 g/100 g soluble and 0.89 g/100 g insoluble), these compounds can involve in increasing the swelling index from pluchea wet noodles.

Color is one of the physical characteristics possessed by wet noodles that becomes a benchmark for consumer acceptance. This research found that the color of wet noodles was influenced by the addition of pluchea extract. The addition of pluchea leaf extract no significant affected the redness ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it influenced the yellowness ( $b^*$ ) and lightness ( $L^*$ ) values. Using of pluchea leaf powder brewing decreased the brightness of wet noodles significantly, as the concentration of the extract increased. This is related to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to experience color changes. According to Widyawati *et al.*<sup>8</sup> tannins are water-soluble compounds that can give a brown color. Suriyaphan<sup>6</sup> and Widyawati *et al.*<sup>26</sup> also stated that Khlu tea from pluchea leaves contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and  $6.39$  mg/100 g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow color. Gull *et al.*<sup>51</sup> stated that this pigment was easily changed in the paste sample due to the swelling and discoloration of the pigment during cooking.

Thus, the addition of hot water extract of pluchea leaf powder significantly reduced the brightness of wet noodles, because brown-colored noodles

were produced as the concentrations of added pluchea leaf extract increased. However, increasing the concentration of this extract had no influence on the redness, hue, and chroma values in ANOVA at  $p \leq 5\%$ . The results showed that the redness value of wet noodles revolved from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet noodles ranged from  $82.12 \pm 3.05$  to  $86.47 \pm 1.04$ . Based on this value, the color of wet noodles is in the yellow to the red color range,<sup>53</sup> thus the visible color of the wet noodle product was yellow to brown (Figure 2). Yellowness increased significantly with the addition of pluchea leaf extract and the value ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the availability of tannins and chlorophyll compounds from pluchea leaf extract. The chroma value of wet noodles was obtained within the range of  $15.6 \pm 1.5$  to  $19.8 \pm 3.4$ . This means that the brewing of pluchea leaf powder did not change the intensity of the brown color in the resulting wet noodles.

Texture analysis of pluchea wet noodles added with various concentrations of hot water extract from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness, elongation, and elasticity. Hardness is the maximum force given to a product until deformation.<sup>54,55</sup> From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher peak of graph shows the harder product.<sup>32</sup> Adhesiveness is force or tackiness that is required to pull the product from its surface, its value is obtained from the area between the first and second compressions.<sup>56,57</sup> Adhesiveness values show negative value, the bigger negative value means the product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and second compressions.<sup>55,57</sup> This is an indication of the internal forces that make up the product.<sup>58</sup> Elongation is the change in length of noodles when being exposed to a tensile force until the noodles break.<sup>59</sup> Elasticity is the time required for the product to withstand the load until it breaks. The more elastic a product, the longer the holding time. The data showed that the higher concentration of pluchea leaf powder within the hot water extract caused a significant increase in the hardness, stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati *et al.*<sup>26</sup> informed that the polyphenols contained in pluchea leaf extract can be weakly interacted either

covalently or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups that are polar. Amoako and Akiwa<sup>60</sup> and Zhu *et al.*<sup>61</sup> have also proven that polyphenolic compounds can be interacted with carbohydrates through the interaction of two hydrophobic and hydrophilic functional groups with amylose. Diez-Sánchez *et al.*<sup>62</sup> stated that polyphenolic compounds can be reacted with amylose and protein helical structures and largely determined by molecular weight, conformational mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and amylopectin can affect the gelatinization process in the amylose helical structure and interfere with the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss ( $> 98\%$ ) and swelling index (56.2 to 67.7%) data, it can be concluded that the interaction that occurs between the phenol group in pluchea leaf extract with amylose and protein was weak. The bioactive components of pluchea leaf extract are thought to affect the formation of disulfide cross-links (S-S) and turn into to form sulfhydryl groups (-SH) under the influence of heat. Ananingsih and Zhou<sup>63</sup> said that antioxidant compounds are a reducing agent that can have an impact on reducing S-S bonds and increasing the number of SH groups in the dough to produce a harder texture. According to Rahardjo *et al.*<sup>56</sup> phenolic compounds are hydroxyl compounds that influence the strength of the dough, where the higher the component of phenol compounds will weaken the gluten matrix and the dough thus becoming unstable. The instability of the dough can cause the texture to become hard.

Many researchers also find that tannins and phenols influence the networking S-S bond in the dough of wet noodles. Wang *et al.*<sup>64</sup> showed that tannins increase the relative amount of large, medium polymers in the gluten protein network so as to improve the dough quality. Zhang *et al.*<sup>65</sup> claimed that these polymer compounds are the

results of interactions or combinations of protein-tannin compounds that form bonds with the type of covalent, hydrogen, or ionic bonds. Rauf and Andini<sup>66</sup> also added that phenol compounds can reduce S-S bonds to SH bonds. SH is a type of thiol compound group, where the thiol group can influence the stickiness, viscosity, cohesiveness, elongation, and extensibility of the dough. Wang *et al.*<sup>67</sup> discovered the effect of phenolic compounds from green tea extract to increase the stickiness of wheat bread. The cohesiveness of the dough is formed due to a large number of thiol bonds formed, thus increasing the viscosity of the dough. The increased viscosity of the dough is thought to be due to the formation of polyphenolic compounds with thiol groups, as in the research of Ananingsih and Zhou<sup>63</sup> that the formation of catechin-thiol can increase the viscosity of the dough and the stability

of the dough. Zhu *et al.*<sup>68</sup> mentioned that the addition of phenolic compounds from green tea was able to increase the PV (peak viscosity) of wheat flour. Wang *et al.*<sup>64</sup> also found that the cohesiveness of the dough is influenced by tannins, where tannins can produce micro-glutens so as to produce a compact dough and increase the gluten network. The addition of pluchea leaf extract in making wet noodles could influence the elongation of wet noodles due to the components of polyphenol compounds such as tannins that can reduce the number of free amino groups. This is supported by Zhang *et al.*<sup>32</sup> and Wang *et al.*<sup>64</sup> that the formation of other types of covalent bonds, such as bonds between amino and hydroxyl groups, by forming hydrogen bonds between phenolic compounds and protein gluten so as to improve the quality of dough strength and dough extensibility.

**Table 5: Total phenol content, total flavonoid content, the DPPH free radical scavenging activity, and iron ion reducing power of the pluchea wet noodles.**

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	TPC (mg GAE/kg Dried Noodles)	TFC (mg CE/kg Dried Noodles)	DPPH (mg GAE/kg Dried Noodles)	FRAP (mg GAE/kg Dried noodles)
0	39.26±0.66 <sup>a</sup>	32.36±1.47 <sup>a</sup>	96.75±4.26 <sup>a</sup>	25.96±0.25 <sup>a</sup>
5	61.09±3.80 <sup>b</sup>	46.31±2.15 <sup>b</sup>	121.36±3.58 <sup>b</sup>	34.50±1.71 <sup>b</sup>
10	82.84±3.11 <sup>c</sup>	62.44±0.55 <sup>c</sup>	130.68±4.82 <sup>c</sup>	51.33±2.19 <sup>c</sup>
15	101.48±2.16 <sup>d</sup>	84.67±1.22 <sup>d</sup>	142.48±2.14 <sup>d</sup>	58.69±2.14 <sup>d</sup>
20	114.94±4.20 <sup>e</sup>	100.14±1.50 <sup>e</sup>	148.84±3.20 <sup>e</sup>	67.26±0.06 <sup>e</sup>
25	128.06±1.38 <sup>f</sup>	107.93±0.89 <sup>f</sup>	157.51±7.69 <sup>f</sup>	69.53±1.06 <sup>f</sup>
30	136.35±1.16 <sup>g</sup>	131.69±1.56 <sup>g</sup>	166.97±1.53 <sup>g</sup>	84.98±0.11 <sup>g</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate.

Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

#### Bioactive Compounds and Antioxidant Activity

Wet noodles added with pluchea leaf powder were analyzed based on its bioactive compounds and antioxidant activities. The analysis was conducted to determine the functional properties of wet noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles were presented in Table 5. The measured bioactive compounds (BC) involved total phenolic content (TPC) and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical

scavenging activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed that there was a positive and strong correlation between TPC and DPPH ( $r = 0.990$ ), TPC and FRAP ( $r = 0.986$ ), TFC and DPPH

( $r=0.974$ ), and TFC and FRAP ( $r=0.991$ ). This means that the antioxidant activity of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah *et al.*<sup>69</sup> informed that the PC ( $r$ ) > 0.699 indicates the strength and linear correlation between antioxidant activity (AA) and TPC, and also shows a strong positive relationship but PC ( $r$ ) < 0.699 obtains a moderately positive relationship. If the  $r$  value of TFC and AA is lower than TPC and AA, it indicates that the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship which is expected because both classes contributed to AA plants. Aryal *et al.*<sup>70</sup> and Muflihah *et al.*<sup>69</sup> informed that phenolic compounds are soluble natural antioxidants and potential donating electrons depend on their number and position of hydroxyl groups contributed to antioxidant action. Consequently, these groups are responsible to scavenge the free radicals which is expressed as TPC of pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the stable purple-colored to the yellow-

colored solution. Based on FRAP analysis, it was showed that the bioactive compounds contained in pluchea wet noodles were a potential source of antioxidants because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive compounds in pluchea wet noodles can function as primary and secondary antioxidants. Research data showed that the cooking quality of wet noodles tends to increase along with the increase in the values of TPC, TFC, DPPH and FRAP.

### Sensory Evaluation

Sensory assay of pluchea wet noodles, namely color, aroma, taste, texture, and overall acceptance, was carried out using a hedonic test to determine the level of consumer preference for the product. This test was conducted to determine the quality differences between the products and to provide an assessment on certain properties.<sup>44</sup> The hedonic test is the most widely used assessment to determine the level of preference for product.<sup>71</sup> The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

**Table 6: Effect of hot water extract from pluchea leaf powder to preferences for color, aroma, taste, texture, and overall acceptance of wet noodles at various concentrations**

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	Hedonic Score				
	Color	Aroma	Taste	Texture	Overall acceptance
0	6.19±1.25 <sup>d</sup>	5.52±1.08	5.50±1.18 <sup>c</sup>	6.20±1.13 <sup>b</sup>	6.63±1.49 <sup>c</sup>
5	5.62±1.28 <sup>c</sup>	5.52±0.83	5.51±1.29 <sup>c</sup>	6.37±1.14 <sup>bc</sup>	6.40±1.52 <sup>c</sup>
10	5.62±1.21 <sup>c</sup>	5.45±0.85	5.46±1.12 <sup>c</sup>	6.53±1.14 <sup>c</sup>	6.53±1.64 <sup>c</sup>
15	5.14±1.25 <sup>b</sup>	4.81±1.04	4.61±1.11 <sup>b</sup>	6.13±1.09 <sup>b</sup>	5.78±1.67 <sup>b</sup>
20	4.91±1.32 <sup>b</sup>	4.54±1.18	4.47±1.15 <sup>ab</sup>	5.80±1.06 <sup>a</sup>	5.17±1.70 <sup>a</sup>
25	4.54±1.40 <sup>a</sup>	4.26±1.23	4.20±1.24 <sup>a</sup>	5.50±1.04 <sup>a</sup>	5.23±1.75 <sup>a</sup>
30	4.47±1.33 <sup>a</sup>	4.05±1.34	4.15±1.40 <sup>a</sup>	5.59±1.05 <sup>a</sup>	5.37±1.91 <sup>a</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm 1.26$  (neutral-like). The statistical analysis showed that the higher concentration of hot water extract addition decreased lower color preference of wet noodles.

The higher concentration of pluchea extract could reduce the level of color preference because the color of the wet noodles was darker than control and turned to dark brown. This color change was due to the pluchea extract containing several components,

including chlorophyll and tannins, which can alter the of wet noodles' color to be browner along with the increase in the concentration of pluchea extract. This result was in accordance to the effect of color analysis performed using color reader where the pluchea wet noodles' brightness declined, yellowness increased, and the color intensity increased with an increased concentration of pluchea extract. The occurrence of this process is related to the effect of light and heat on pluchea leaf powder which causes the degradation of chlorophyll into brown pheophytin due to drying, where the nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals.<sup>72,73</sup>

Aroma is one of the parameters in sensory evaluation using the sense of smell and an indicator of the assessment of a product.<sup>74</sup> The results of the preference values for aroma were ranged from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet noodles reduced the preference score for aroma due to distinct dry leaves (green) aroma. According to Lee *et al.*<sup>75</sup> the unpleasant aroma on leaves comes from a group of aliphatic aldehyde compounds. The appearance of a distinctive leaf aroma in noodles is due to aromatic compounds. According to Martiyanti and Vita<sup>76</sup> aromatic compounds are chemical compounds that have an aroma or odor when the conditions are met, which is volatile, while Widyawati *et al.*<sup>77</sup> informed that pluchea leaves were detected to have 66 volatile compounds. The appearance of the aroma is due to the volatile compounds in the raw material reacting with water vapor when boiling the noodles. In addition, there is also an oxidation process of polyphenolic compounds such as catechins or tannins that can produce an aroma in pluchea wet noodles.

According to Martiyanti and Vita<sup>3</sup> taste attribute is one important sensory aspect in food products and has a great impact on the food selection by consumers. Tongue is able to detect basic tastes, such as sweet, salty, sour, and bitter, at different points. Lamusu<sup>73</sup> declared that taste is a component of flavor and an important criterion in assessing a product that is accepted by the tongue. The preference test of the taste of pluchea wet noodles resulted in values ranging from  $4.15 \pm 1.40$  to  $5.50 \pm 1.28$  (neutral-slightly like). The increase in concentrations of pluchea extract was negatively correlated to the preference level of the taste

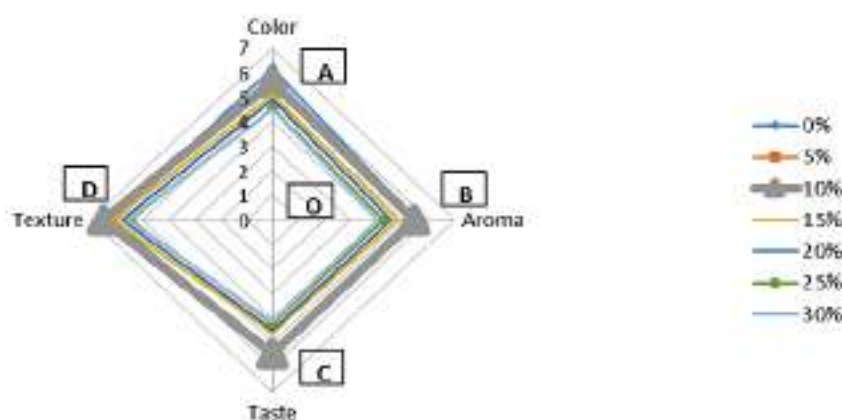
of pluchea wet noodles assessed by the panelists. The statistical analysis results showed that the difference in the concentration of the extract significant influenced on the preference score for the taste of pluchea wet noodles. The increased concentration of pluchea extract produced a distinctive taste on wet noodles, such as a bitter and astringent tastes, due to the presence of compounds such as tannins and alkaloids from the pluchea leaves. Susetyarini<sup>78</sup> said that pluchea leaves contain tannins (2.35%), and alkaloids (0.32%). According to Pertiwi<sup>79</sup> tannin compounds dominate the bitter and astringent taste, while alkaloid compounds cause a bitter taste. The high level of taste preference for wet noodles was found in noodles with lower content of pluchea extract.

Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and swallowed) or touched with fingers.<sup>80</sup> Texture testing performed by the panelist is called mouthfeel testing. According to Martiyanti and Vita,<sup>76</sup> mouthfeel is the kinesthetic effect of chewing food in the mouth. In this study, the preference test results on the texture of pluchea wet noodles revolved from  $5.50 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and draining noodles. Subjective testing results based on sensory evaluation were in line with the objective testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to break, and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea wet noodles was influenced by the fiber and protein components. According to Shabrina,<sup>81</sup> the components of fiber, protein, and starch complete to bind water. Texture changes are also influenced by the polyphenol compositions in the pluchea extract which is able to reduce S-S bonds to SH bonds, where the increase in SH (thiol) groups can cause a hard, sticky, and compact texture.<sup>64,66,67</sup> Besides, a high concentration of tannins capable of binding to proteins to form complex compounds into tannins-proteins are also able to build noodles' texture.



The interaction between color, aroma, taste, and texture created an overall taste of the food product and was assessed as the overall preference. The highest value on the overall preference was derived from control wet noodles, i.e., 6.63 (slightly like it), while the wet noodles added with 20% (w/v) concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to 10% (w/v) concentration with scores

of 6.63 and 6.53, respectively. The area of the spider web chart for each treatment with the various concentrations of pluchea extract was seen in Figure 3. The best treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively.



**Fig. 3: Spider web graph of sensory evaluation on wet noodles at various concentrations of hot water extract from pluchea leaf powder**

The use of pluchea leaf extract in the making of wet noodles was able to increase the functional values of wet noodles, based on the levels of bioactive compounds and antioxidant activity without changing the quality of cooking, which included water content, swelling index and cooking loss. Besides that, the use of pluchea leaf extract did not significantly change the color and color intensity of the resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet noodles produced were still acceptable to the panelists, the addition of pluchea leaf extract as much as 10% (w/v) was the best treatment with an assessment that was almost closed to the control wet noodles (without treatment).

### Conclusion

Addition of hot water extract of pluchea leaf powder influenced physical, chemical and sensory properties of wet noodles. Lightness, texture, bioactive compound content, antioxidant

activity, and sensory properties of samples underwent significant difference. The higher concentration of pluchea extract caused the bigger these parameters of pluchea wet noodles. Using 10% (w/v) of hot water extract from pluchea leaf powder was the best treatment with color, aroma, taste, and texture scores 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. Utilization of hot water extract of pluchea leaf powder at 10% (w/v) resulted functional wet noodles with TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg dried samples, 62.44 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples and 51.33 mg GAE/kg dried samples, respectively.

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### Conflict of Interest

The authors declare no conflict of interest.

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## The Effect of Hot Water Extract of *Pluchea indica* Leaf Powder on the Physical, Chemical and Sensory Properties of Wet Noodles

PAINI SRI WIDYAWATI, LAURENSIA MARIA YULIAN DD, ADRIANUS RULIANTO UTOMO, PAULINA EVELYN AMANUELA SALIM, DIYAN EKA MARTALIA, DAVID AGUS SETIAWAN WIBISONO\* and SYLLVIA SANTALOVA SANTOSO

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### Abstract

Powdered *Pluchea indica* Less leaves have been utilized as herbal tea, brewing of pluchea tea in hot water has antioxidant and antidiabetic activities, because of phytochemical compound content, namely tannins, alkaloids, phenol hydroquinone, phenolics, cardiac glycosides, flavonoids, and sterols. Using of this extract on food, such as jelly drinks, buns, and soymilk can increase functional values and influence physic, chemical, and sensory characteristics of food. The study was carried out to assess the effect of various concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles. A one-factor randomized design was applied with pluchea tea at concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v). Physical properties analyzed included water content, swelling index, cooking loss, color and texture. Chemical properties measured were bioactive contents of total phenolic content, total flavonoid content, and antioxidant ability to scavenge DPPH free radicals and to reduce iron ions. Sensory properties determined were taste, texture, color, aroma and overall acceptance. The addition of various concentrations of extract offers significantly effects on parameters of physical, chemical and sensory properties of noodles, except color (redness, chroma and hue), cooking loss, water content, swelling index and aroma. Using of 10% (w/v) of pluchea tea resulted in the best sensory properties such as color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively. Generally, the study concluded that wet noodles can be made by adding pluchea tea at 10% (w/v).



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Dried samples TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg, 62.44 mg CE/kg, 130.68 mg GAE/kg and 51.33 mg GAE/kg, respectively.

## Introduction

*Pluchea indica* Less is an herb plant including *Asteraceae* family usually used by people as traditional medicine and food.<sup>1,2</sup> The potency of pluchea leaves is related to phytochemical compounds, such as tannins, flavonoids, polyphenols, essential oils, sterols, phenol hydroquinone, alkaloid, lignans and saponins.<sup>2,3,4,5</sup> Chan *et al.*<sup>1</sup> also reported that caffeoylquinic acids, phenolic acids, flavonoids and thiophenes in pluchea leaves are compounds with antioxidant activities. Furthermore, pluchea leaves also contain nutritive value, i.e., protein 1.79 g/100 g, fat 0.49 g/100 g, insoluble dietary fiber 0.89 g/100 g, soluble dietary fiber 0.45 g/100 g, carbohydrate 8.65 g/100 g, calcium 251 mg/100 g,  $\beta$ -carotene 1.225  $\mu$ g/100 g.<sup>6</sup>

Pluchea tea brewed from pluchea leaves has been proven to exhibit antioxidant activity,<sup>6,7,8</sup> anti-diabetic activity,<sup>9</sup> anti-inflammatory activity,<sup>7</sup> anti-human LDL oxidation activity.<sup>10</sup> Previous research uses pluchea leaf powder to make several food products to increase functional values, i.e., jelly drink,<sup>11</sup> soy milk<sup>12</sup> and steamed bun<sup>13</sup> Using 1% (w/v) pluchea leaf powder can improve the physicochemical properties of jelly drink and increase panelists' acceptance of the product.<sup>11</sup> Soy milk with the addition of pluchea leaves increases the viscosity and total dissolved solids and decreases the panelist acceptance rate.<sup>12</sup> The addition of 6% (w/v) brewing from pluchea leaf powder on steamed bun is the best treatment with the lowest level of hardness.<sup>13</sup> Previous research has proven that the addition of pluchea leaves can increase the bioactive compound contents based on total phenol and total flavonoids, as well as increase the antioxidant activity based on ferric reducing power and ability to scavenge DPPH free radicals.

To the best of our knowledge, the study of the addition of pluchea tea in making wet noodles from wheat flour has not been conducted, as well as its impact on physicochemical and sensory characteristics of the noodles. Noodles are a popular food product that is widely consumed in the world. Indonesia is one of the countries with the largest noodle consumption

after China.<sup>14</sup> Wet noodles usually contain lower protein and higher carbohydrate<sup>15</sup> than that of egg wet noodles as an alternative to wet noodles, which contain higher protein, and the second popular food in ASEAN regions including Thailand, Vietnam, Laos, Myanmar, Malaysia, Singapore and Indonesia.<sup>16</sup> The addition of other ingredients has been endeavored to enhance wet noodles' specific properties. Many researchers incorporated plant extracts or natural products to increase functional properties of wet noodles, such as red spinach,<sup>17</sup> green tea,<sup>18,19</sup> purple sweet potato leaves,<sup>20</sup> moringa leaves,<sup>21</sup> sea weed,<sup>22</sup> ash of rice straw, turmeric extract,<sup>23</sup> and betel leaf extract<sup>24</sup> that influenced the physical, chemical, and organoleptic properties of the wet noodles. The anthocyanin of red spinach ethanolic extract increases the hedonic score of wet noodles' flavor.<sup>17</sup> The addition of green tea improves the stability, elastic modulus and viscosity, retrogradation and cooking loss with, no significant effect on mouth-feel and overall acceptance from panelist on the produced wet noodles.<sup>18</sup> Moreover, the addition of sweet potatoes leaf extract on wet noodles increases moisture content, protein value and ash concentration, and improves hedonic score of texture.<sup>20</sup> Moringa extract influences protein content and decreases panelist acceptance of color, aroma and taste of wet noodles.<sup>21</sup> The use of seaweed to produce wet noodles influences moisture content, swelling index, absorption ability, elongation value and color.<sup>22</sup> The addition of ash from rice straw and turmeric extract influences the elasticity and sensory characteristics (color, taste, aroma and texture) of wet noodles.<sup>23</sup> Betel leaf extract used to make Hokkien (with dark soya source) noodles improves texture and acceptance score of all sensory attributes.<sup>24</sup>

Bioactive compounds and nutritive values of pluchea leaf can be an alternative ingredient to improve quality and sensory from wet noodles. The use of hot water extract from powdered pluchea leaves can serve as an antioxidant source in wet noodles and increase the functional value. This study was undertaken to assess the effect of various



concentration of pluchea tea on the physical, chemical and sensory properties of wet noodles.

### Materials and Methods

#### Preparation of Hot Water Extract from Pluchea Leaf Powder

Young pluchea leaves (1-6) (Figure 1) were picked from the shoots, sorted and washed. The selected leaves were dried at ambient temperature for 7

days to yield moisture content of  $10.00 \pm 0.04\%$  dry base.<sup>25</sup> Dried pluchea leaves were powdered to the size of 45 mesh and sterilized at 120°C for 10 min by drying in oven (Binder, Merck KGaA, Darmstadt, Germany) and packed in tea bag for about 2 g/tea bag. Pluchea leaf powder in tea bags was extracted using hot water (95°C) for 5 min to get extract concentrations of 0, 5, 10, 15, 20, 25, and 30% (w/v), respectively (Table 1).

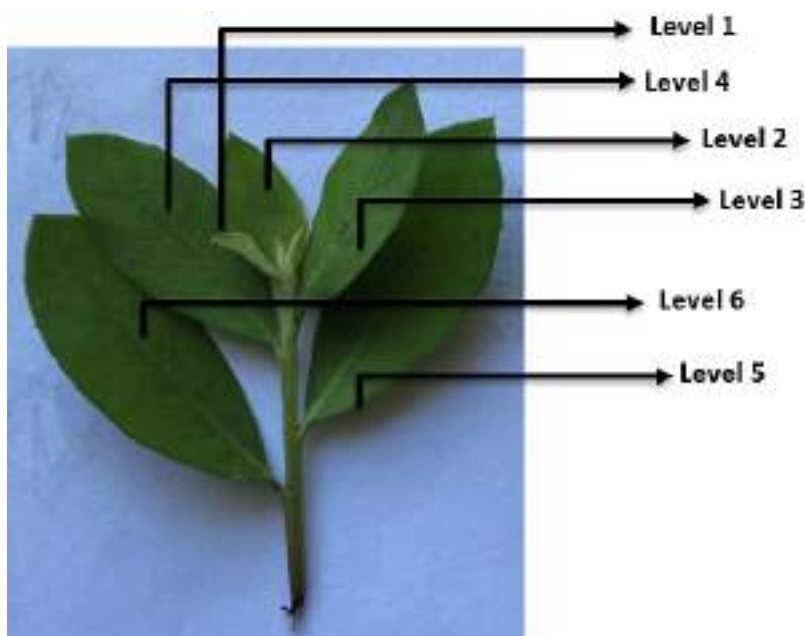


Fig. 1: Young *Pluchea indica* Less leaves

Table 1: Information of hot water extract of pluchea tea

Materials	Concentration of hot water extract of pluchea leaf tea (% w/v)						
	0	5	10	15	20	25	30
Pluchea leaf tea (g)	0	10	20	30	40	50	60
Hot water (mL)	200	200	200	200	200	200	200

#### Wet Noodles Processing

About 70 mL of hot extract from pluchea leaf powder with concentrations of 0, 5, 10, 15, 20, 25 and 30% (w/v) (Table 1) was manually mixed with egg, baking powder, salt and wheat flour for 5 min (Table 2). The mixture was kneaded to form a solid and homogenized dough using a mixer (Oxone Stand Mixer OX-855) for about 10-15 min. Furthermore, the dough was extruded to form noodle

strands (Oxone Noodle Machine OX 355). The wet noodle strands were parboiled in boiled water about 3 min in 300 mL water and coated with oil to prevent the noodles from sticking to each other.<sup>26,27,28</sup> Wet noodles made without any addition of hot water of pluchea leaf extract were prepared as control. Wet noodles used in bioactive compounds and antioxidant activity assay were not added with oil to prevent the noodles from sticking to one another.



The final characteristics of wet noodles have width and thickness of 0.45 cm and 0.30 cm, respectively.

**Table 2: Ingredients of pluchea wet noodles**

Materials	Unit	Quantity
Wheat flour	g	200
Egg	g	40
Salt	g	4
Baking powder	g	2
Hot water extract	mL	70
Tapioca flour	g	10
TOTAL	g	326

#### Pluchea Wet Noodles Extraction

About 100 g of wet noodles were dried using a freeze-dryer at a pressure of 0.1 bar and temperature -60°C for 28 hours. Dried noodles were powdered using a chopper machine for 35 seconds. And then, 20 g of samples were mixed by 50 mL absolute methanol by a shaking water-bath at 35°C, 70 rpm for 1 hour.<sup>29</sup> Filtrate was separated using Whatman filter paper grade 40 and residue was extracted again with the same procedure. The filtrate was collected and evaporated by rotary evaporator until getting 3 mL of extract (Buchi Rotary Evaporator, Buchi Shanghai Ltd, China) at 200 bars, 50°C for 60 min. The extract was kept at 0°C before further analysis.

#### Moisture Content Assay

Moisture or water content of wet noodles was determined by thermos-gravimetric method.<sup>30</sup> The moisture content of wet noodles was determined by heating the samples in a drying oven (Binder, Merck KGaA, Darmstadt, Germany) and weighing the evaporated water content in the material.

#### Measurement of Swelling Index

The purpose of swelling index testing was to determine the capability of the noodles to swell during the boiling process.<sup>16</sup> The assay was done to determine the ability of wet noodles to absorb water per unit of time or the time needed to fully cooked wet noodles. The amount of water absorbed by wet noodles was measured from the weight before and after boiling.

#### Determination of Cooking Loss

Cooking loss is one of the necessary quality parameters to establish the quality of wet noodles after boiling.<sup>31</sup> The cooking loss assay was done by measuring the quantity of solids that leached out of the noodles during the boiling process, e.g., starch. A large cooking loss value affects the texture of wet noodles, which is easy to break and less slippery.

#### Determination of Texture

The texture of pluchea wet noodles was measured based on hardness, adhesiveness, cohesiveness, elongation and elasticity. The texture was analyzed by TA-XT2 texture analyzer (Stable Micro System Co., Ltd., Surrey, UK) fitted with a 5 kg load cell equipped with the Texture Exponent 32 software V.4.0.5.0 (SMS). The hardness, adhesiveness and cohesiveness were analyzed with a compression assay using 2 mm s<sup>-1</sup> test speed and 75% strain. Five long noodle strands with the length of 4 cm for each strand were laid side by side, touching each other, perpendicular to the 35 mm compression cylinder probe on a flat aluminum base. The cylinder probe was arranged to be at 15 mm distance from the lower plate at the start of the compression test, and was pressed down through the noodle strips at the speed of 2 mm s<sup>-1</sup> until it touched the flat base to compress 75% of the noodle thickness, and was drawn back to at the end of the test. The profile curve was determined using a texture analyzer software.<sup>24,32</sup> The hardness was determined as the maximum force per gram. The adhesiveness was evaluated when the probe was drawn at the end of the test, a negative area was obtained from the compression test under the curve. Cohesiveness was analyzed based on the ratio between the area under the first and the second peaks.<sup>24,32,33</sup> The elongation and elasticity of the noodles were individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. Elongation was the maximum force to change of noodle form and break by extension that was analyzed by a test speed of 3.0 mm s<sup>-1</sup> between two rollers with a 100 mm distance. The elongation at breaking was calculated per gram. Elasticity was determined by formula (1)<sup>34,35</sup>

$$\text{Elasticity} = (F_x l_o) / (A_x t_o) \quad 1/v \quad \dots(1)$$

where  $F$  is the tensile strength,  $l_0$  is the original length of the noodles between the limit arms (mm),  $A$  is the original cross-sectional area of the noodle ( $\text{mm}^2$ ),  $v$  is the rate of movement of the upper arm (mm/s), and  $t$  is break up time of the noodles (s). The measurement of texture was detected by the software and expressed as a graph.

#### Color Measurement

The color of the noodle sheets was determined by a colorimeter (Minolta CR 10, Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab  $L^*$ ,  $a^*$  and  $b^*$  values were analyzed based on the method by Fadzil *et al.*<sup>32</sup> The  $L^*$  value measured the position on the white/black axis, the  $a^*$  value as the position on the red/green axis, and the  $b^*$  value as the position on the yellow/blue axis.

#### Analysis of Total Phenolic Content

The total phenolic content analysis was analyzed based on the reaction between phenolic compounds and Folin Ciocalteu (FC) reagent or phosphomolybdic acid and phosphotungstic acid. The FC reagent oxidizes phenolics (alkali salts) or phenolic-hydroxy groups to become a blue molybdenum-tungsten complex solution.<sup>36</sup> The intensity of the blue color was detected by a UV-Vis spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  760 nm. In the analysis, 7.5%  $\text{Na}_2\text{CO}_3$  solution was added to reach pH 10 that caused an electron transfer reaction (redox). The obtained data were expressed in mg of gallic acid equivalent (CE)/L sample.

#### Analysis of Total Flavonoid Content

The flavonoid content assay was done using the spectrophotometric method based on the reaction between flavonoids and  $\text{AlCl}_3$  to form a yellow complex solution. In the presence of NaOH solution, a pink color is formed which can be detected by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  510 nm.<sup>36,37,38</sup> The obtained data were expressed in mg of catechin equivalent (CE)/L sample.

#### Analysis of DPPH Free Radical Scavenging Activity

The ability of antioxidant compounds to scavenge DPPH (2,2-diphenyl-1-picrylhydrazyl) free radicals can be used to evaluate antioxidant activity. The principle of the DPPH method is to measure

the absorbance of compounds that can react with DPPH radicals.<sup>39</sup> Antioxidant compounds can donate hydrogen atoms to DPPH radicals that caused the purple DPPH to be reduced to yellow.<sup>40</sup> The color change was measured as an absorbance at  $\lambda$  517 nm by spectrophotometer (Spectrophotometer UV Vis 1800, Shimadzu, Japan).<sup>41</sup> The data were expressed in mg gallic acid equivalent (GAE)/L dried noodles sample.

#### Analysis of Iron Ion Reduction Power

This method identifies the capacity of antioxidant components using potassium ferricyanide, trichloroacetic acid and ferric chloride to produce color complexes that can be measured spectrophotometrically (Spectrophotometric UV-Vis 1800, Shimadzu, Japan) at  $\lambda$  700 nm.<sup>42</sup> The principle of this testing is the ability antioxidants to reduce iron ions from  $\text{K}_3\text{Fe}(\text{CN})_6$  ( $\text{Fe}^{3+}$ ) to  $\text{K}_4\text{Fe}(\text{CN})_6$  ( $\text{Fe}^{2+}$ ). Then, potassium ferrocyanide reacts with  $\text{FeCl}_3$  to form a  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$  complex. The color change is from yellow to green.<sup>43</sup> The final data were expressed in mg gallic acid equivalent (GAE)/L dried noodles.

#### Sensory Evaluation

The hedonic test of all samples of wet noodles involved 100 untrained panelists with an age range of 17 to 25 years old, because they are students in food technology department that who have received provision about hedonic food preference test. All panelist supplied informed consent before the examination. A hedonic test used in this research was the hedonic scoring method, where the panelists gave a preference score value of all samples.<sup>26</sup> The hedonic scores were transformed to numeric scale and analyzed using statistical analysis.<sup>44</sup> The numeric scale in the sensory analysis used a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). The panelists were asked to score according to their level of preference for texture, taste, color, flavor and overall acceptability. All the samples were blind coded with 3 digits which differed from each other.<sup>45</sup>

#### Statistical Analysis

The research design used in the physicochemical assay was a randomized block design (RBD) with a single factor, i.e., differences in the concentration of the hot extract of pluchea leaf tea that consisted of seven levels, i.e., 0, 5, 10, 15, 20, 25 and 30% (w/v). Each treatment was repeated four times

that obtained 28 experiment units. A completely randomized design (CRD) was used to evaluate sensory assay with 100 untrained panelists with an aged 17 to 25 years old.

The normal distribution and homogeneity data were stated as the mean  $\pm$  SD of the triplicate determinations and determined using ANOVA at  $p \leq 5\%$  using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). Any significant effect of factors by ANOVA test was followed with the DMRT (Duncan Multiple Range Test) at  $p \leq 5\%$  to determine treatment level that gave significant different results. The best

treatment of pluchea extract addition on wet noodles was analyzed by a spider web graph.

## Results and Discussion

Wet noodles added with hot extract of pluchea leaf powder were produced to increase the functional values of wet noodles. This is supported by previous studies related to the potential values of water extract of pluchea leaf that exhibits biological activities.<sup>6,7,26</sup> In this research, the cooking quality was observed after cooking wet noodles in 300 mL water/100 g samples for 3 min in boiling water.

**Table 3: Color, moisture content, swelling index, and cooking loss of pluchea wet noodles.**

Concentration of hot extract from pluchea leaf powder (% w/v)	Color					Moisture content (% wb)	Swelling index (%)	Cooking loss (%)
	L*	a*	b*	C	h			
0	67.14 $\pm$ 1.77 <sup>a</sup>	0.97 $\pm$ 0.30	16.18 $\pm$ 0.62 <sup>ab</sup>	16.20 $\pm$ 0.63	86.47 $\pm$ 1.04	63.90 $\pm$ 1.51	56.22 $\pm$ 17.36	3.40 $\pm$ 1.31
5	59.49 $\pm$ 2.67 <sup>b</sup>	2.18 $\pm$ 0.93	15.47 $\pm$ 1.46 <sup>a</sup>	15.62 $\pm$ 1.53	82.12 $\pm$ 3.05	65.08 $\pm$ 4.33	62.40 $\pm$ 4.71	3.33 $\pm$ 1.26
10	58.95 $\pm$ 1.80 <sup>b</sup>	1.95 $\pm$ 1.66	16.76 $\pm$ 2.33 <sup>abc</sup>	17.08 $\pm$ 2.16	83.29 $\pm$ 5.37	64.97 $\pm$ 3.89	61.50 $\pm$ 7.51	3.00 $\pm$ 1.16
15	58.35 $\pm$ 2.24 <sup>b</sup>	1.69 $\pm$ 1.48	19.72 $\pm$ 3.50 <sup>c</sup>	19.77 $\pm$ 3.38	84.67 $\pm$ 4.64	65.56 $\pm$ 2.18	63.09 $\pm$ 6.31	3.31 $\pm$ 0.92
20	56.48 $\pm$ 2.40 <sup>b</sup>	1.97 $\pm$ 1.24	19.09 $\pm$ 2.97 <sup>bc</sup>	19.18 $\pm$ 2.90	83.62 $\pm$ 4.33	66.81 $\pm$ 1.81	67.74 $\pm$ 5.91	4.06 $\pm$ 0.51
25	59.07 $\pm$ 2.49 <sup>b</sup>	1.95 $\pm$ 1.44	19.55 $\pm$ 2.97 <sup>c</sup>	19.58 $\pm$ 2.90	83.83 $\pm$ 4.41	66.04 $\pm$ 0.85	64.46 $\pm$ 10.32	3.93 $\pm$ 1.37
30	57.10 $\pm$ 2.06 <sup>b</sup>	2.09 $\pm$ 1.51	18.08 $\pm$ 4.94 <sup>abc</sup>	18.28 $\pm$ 4.84	82.49 $\pm$ 5.22	66.65 $\pm$ 2.16	63.96 $\pm$ 5.31	4.23 $\pm$ 1.34

Note the results were presented as SD of the means that were achieved by quadruplicate.

Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$

**Table 4: Texture of pluchea wet noodles.**

Concentration of hot extract from pluchea leaf powder (% w/v)	Texture of pluchea wet noodles				
	Hardness (N)	Adhesiveness (g sec)	Cohesiveness	Elongation (%)	Elasticity (Pa)
0	135.75 $\pm$ 5.91 <sup>a</sup>	-2.67 $\pm$ 0.30 <sup>d</sup>	0.65 $\pm$ 0.01 <sup>a</sup>	86.89 $\pm$ 0.90 <sup>a</sup>	25336.72 $\pm$ 104.20 <sup>a</sup>
5	120.13 $\pm$ 2.05 <sup>a</sup>	-3.36 $\pm$ 0.60 <sup>cd</sup>	0.68 $\pm$ 0.00 <sup>b</sup>	97.25 $\pm$ 1.59 <sup>b</sup>	25898.27 $\pm$ 760.94 <sup>b</sup>
10	134.85 $\pm$ 1.77 <sup>a</sup>	-3.91 $\pm$ 0.65 <sup>bc</sup>	0.74 $\pm$ 0.00 <sup>c</sup>	162.10 $\pm$ 1.49 <sup>c</sup>	25807.73 $\pm$ 761.85 <sup>b</sup>
15	180.48 $\pm$ 5.06 <sup>b</sup>	-4.91 $\pm$ 0.47 <sup>b</sup>	0.74 $\pm$ 0.01 <sup>c</sup>	164.74 $\pm$ 0.60 <sup>c</sup>	26971.61 $\pm$ 516.71 <sup>b</sup>
20	195.11 $\pm$ 14.14 <sup>b</sup>	-4.95 $\pm$ 1.26 <sup>ab</sup>	0.75 $\pm$ 0.01 <sup>cd</sup>	221.60 $\pm$ 1.55 <sup>d</sup>	2a7474.38 $\pm$ 453.80 <sup>b</sup>
25	244.57 $\pm$ 8.81 <sup>c</sup>	-6.03 $\pm$ 0.29 <sup>a</sup>	0.75 $\pm$ 0.00 <sup>cd</sup>	230.65 $\pm$ 0.73 <sup>e</sup>	27367.05 $\pm$ 287.48 <sup>b</sup>
30	282.79 $\pm$ 28.31 <sup>d</sup>	-6.05 $\pm$ 0.22 <sup>a</sup>	0.79 $\pm$ 0.01 <sup>d</sup>	255.38 $\pm$ 0.36 <sup>f</sup>	26687.52 $\pm$ 449.19 <sup>b</sup>

Note: the results were presented as SD of the means that were achieved by quadruplicate.

Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$



**Fig. 2: Wet noodles with hot water extract of pluchea leaf powder added at concentrations a. 0%; b. 5%; c. 10%; d. 15%; e. 20%; f. 25%; and g. 30% w/v**

### Cooking Quality

Cooking quality of wet noodles added with hot water extract from pluchea leaf powder at 0, 5, 10, 15, 20, 25 and 30% (w/v) was shown in Figure 2, Table 3 and Table 4. The addition of pluchea extract no significantly influenced the water content, cooking loss, swelling index, chroma, and hue of the produced wet noodles using statistical analysis by ANOVA at  $p \leq 5\%$ . Water content is one of the chemical properties of a food product determined shelf life of food products, because the water content measures the free and weakly bound water in foodstuffs.<sup>46,47</sup> This study identified that the moisture content of the cooked wet noodles ranged between 64-67% wb. Previous study showed that the water content of the cooked egg wet noodles was around 54-58% wb<sup>47</sup> and maximum of 65%.<sup>20</sup> Chairuni *et al.*<sup>46</sup> stated that the boiling process could cause a change in moisture content from about 35% to about 52%. The Indonesian National Standard<sup>48</sup> stipulates that the moisture content of cooked wet noodles is a maximum of 65%. This means that only control noodles (without treatment) exhibited a moisture content similar to the previous information. The obtained data showed a trend that an extract addition caused an increase in the water content of wet noodles, but statistical analysis at  $p \leq 5\%$  showed no significant difference. This phenomenon was in accordance with the experimental results of Juliana *et al.*<sup>49</sup> that the using of spenochlea

leaf extract for making wet noodles, as well as Hasmawati *et al.*<sup>20</sup> that the sweet potato leaf extract increased the moisture of fresh noodles. The water content of pluchea wet noodles was expected by reaction between many components in the dough that impacted to the swelling index and cooking loss. Mualim *et al.*,<sup>14</sup> Bilina *et al.*<sup>22</sup> and Setiyoko *et al.*<sup>31</sup> reported that the presence of amino in protein and hydroxyl groups in amylose and amylopectin fractions in wheat flour as raw material for making dough determines the moisture content, swelling index and cooking loss of wet noodles. The contribution of glutenin and gliadin proteins in wheat flour to form gluten networks determines the capability of noodles to swell and retain water in the system. Gliadin acts as an adhesive that causes dough to be elastic, while glutenin makes the dough to be firm and able to withstand  $\text{CO}_2$  gas thus, the dough can expand and form pores. Fadzil *et al.*<sup>32</sup> found that thermal treatment during the boiling process results in the denaturation of gluten and causes a monomer of proteins to determine other reactions at the disulfide or sulfhydryl chain. The existence of phenolic compounds from pluchea extract also increased the capacity of noodles to absorb water and determined water mobility. Widyawati *et al.*<sup>26</sup> confirmed that hydrophilic compounds of proteins, carbohydrates, and polyphenolic components determine water mobility due to their ability to bind with water molecules through hydrogen bonding.

Tuhumury *et al.*<sup>50</sup> informed that gluten formation can inhibit water absorption by starch granules so that can prevent gelatinization. Therefore, the addition of phenolic compounds from the hot extract of pluchea leaf powder can inhibit the formation of gluten so that stimulates gelatinization of starch granules.

As a result, the impact of increased the moisture content during boiling had an effect on the value of the swelling index and cooking loss of the wet noodles. Widyawati *et al.*<sup>26</sup> claimed that the swelling index is the capability to trap water which is dependent on the chemical composition, particle size, and water content. Gull *et al.*<sup>51</sup> further confirmed that the swelling index is an indicator to determine water absorption by starch and protein to make gelatinization and hydration. Setiyoko *et al.*<sup>31</sup> explained that cooking loss is the mass of noodle solids that come out of the noodle strands for boiling. Gull *et al.*<sup>51</sup> added that soluble starch and other soluble components leach out into the water during the cooking process, making the cooking water turned thicker. The moisture content results (64-67% wb) showed that the produced wet noodles exceeded the moisture content limit of wet noodles after cooking, which is between 54-58%,<sup>46</sup> while the cooking loss value of wet noodles should not be more than 10%.<sup>31</sup> In this study, the cooking loss value was 3-4.2%. The cooking loss of samples during boiling noodles were caused the breaking of the bonding network that the polysaccharides are released and the gluten network breaks because of the addition of pluchea leaf extract. Widyawati *et al.*<sup>26</sup> supported that polyphenol can be bound with protein and starch with many non-covalent interactions, such as hydrogen bonding, electrostatic interaction, hydrophobic interaction, Van der Waal's interaction, and  $\pi$ - $\pi$  stacking. This interaction can inhibit amylose and amylopectin from starch to undergo gelatinization and gliadin and glutelin from the protein of wheat flour to form gluten.

The swelling index value derived from this research was about 56-68 %. Based on the previous research, the swelling index of egg wet noodles incorporated with angkung (*Basella alba* L.) fruit was around 51%.<sup>51</sup> This means that the addition of pluchea leaf extract in wet noodles also affects the ability of noodles to absorb water. Widyawati *et al.*<sup>26</sup> and Suriyaphan<sup>6</sup>

noted that bioactive compounds in hot water extract of pluchea leaf tea include 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, 4,5-O-dicaffeoylquinic acid, chlorogenic acid, caffeic acid, quercetin, kaempferol, myricetin, total anthocyanins,  $\beta$ -carotene, and total carotenoids. The swelling index of pluchea wet noodles was higher than the addition of angkung fruit extract, due to the involvement of hydroxyl groups from extract in absorbing water, in inhibiting the formation of gluten and in increasing the ability of starch granules to absorb water so that the swelling index and cooking loss increased. Suriyaphan<sup>6</sup> informed that hot extract of pluchea leaf tea contains 1.79 g/100 g protein, 8.65 g/100 g carbohydrate, and fiber (0.45 g/100 g soluble and 0.89 g/100 g insoluble), these compounds can involve in increasing the swelling index from pluchea wet noodles.

Color is one of the physical characteristics possessed by wet noodles that becomes a benchmark for consumer acceptance. This research found that the color of wet noodles was influenced by the addition of pluchea extract. The addition of pluchea leaf extract no significant affected the redness ( $a^*$ ), chroma (C), and hue ( $^{\circ}h$ ) of the wet noodles, but it influenced the yellowness ( $b^*$ ) and lightness ( $L^*$ ) values. Using of pluchea leaf powder brewing decreased the brightness of wet noodles significantly, as the concentration of the extract increased. This is related to the bioactive compounds of pluchea leaves, especially tannins, carotenoids, and flavonoids that cause the wet noodles to experience color changes. According to Widyawati *et al.*<sup>8</sup> tannins are water-soluble compounds that can give a brown color. Suriyaphan<sup>6</sup> and Widyawati *et al.*<sup>26</sup> also stated that Khlu tea from pluchea leaves contained  $\beta$ -carotene, total carotenoids, and total flavonoids of  $1.70 \pm 0.05$ ,  $8.74 \pm 0.34$ , and  $6.39$  mg/100 g fresh weight, respectively. This pigment is a water-soluble pigment that gives a yellow color. Gull *et al.*<sup>51</sup> stated that this pigment was easily changed in the paste sample due to the swelling and discoloration of the pigment during cooking.

Thus, the addition of hot water extract of pluchea leaf powder significantly reduced the brightness of wet noodles, because brown-colored noodles



were produced as the concentrations of added pluchea leaf extract increased. However, increasing the concentration of this extract had no influence on the redness, hue, and chroma values in ANOVA at  $p \leq 5\%$ . The results showed that the redness value of wet noodles revolved from  $0.97 \pm 0.30$  to  $2.18 \pm 0.93$ , whereas the hue value of wet noodles ranged from  $82.12 \pm 3.05$  to  $86.47 \pm 1.04$ . Based on this value, the color of wet noodles is in the yellow to the red color range,<sup>53</sup> thus the visible color of the wet noodle product was yellow to brown (Figure 2). Yellowness increased significantly with the addition of pluchea leaf extract and the value ranged from  $16.18 \pm 0.62$  to  $19.72 \pm 3.50$ . This was due to the availability of tannins and chlorophyll compounds from pluchea leaf extract. The chroma value of wet noodles was obtained within the range of  $15.6 \pm 1.5$  to  $19.8 \pm 3.4$ . This means that the brewing of pluchea leaf powder did not change the intensity of the brown color in the resulting wet noodles.

Texture analysis of pluchea wet noodles added with various concentrations of hot water extract from pluchea leaf powder was showed at Table 4, including hardness, adhesiveness, cohesiveness, elongation, and elasticity. Hardness is the maximum force given to a product until deformation.<sup>54,55</sup> From the texture analyzer graph, hardness is measured from the highest height of the peak. The higher peak of graph shows the harder product.<sup>32</sup> Adhesiveness is force or tackiness that is required to pull the product from its surface, its value is obtained from the area between the first and second compressions.<sup>56,57</sup> Adhesiveness values show negative value, the bigger negative value means the product is stickier. Cohesiveness or compactness is the ratio of the positive force area to the first and second compressions.<sup>55,57</sup> This is an indication of the internal forces that make up the product.<sup>58</sup> Elongation is the change in length of noodles when being exposed to a tensile force until the noodles break.<sup>59</sup> Elasticity is the time required for the product to withstand the load until it breaks. The more elastic a product, the longer the holding time. The data showed that the higher concentration of pluchea leaf powder within the hot water extract caused a significant increase in the hardness, stickiness, compactness, elasticity, and elongation of the resulting wet noodles. Widyawati *et al.*<sup>26</sup> informed that the polyphenols contained in pluchea leaf extract can be weakly interacted either

covalently or non-covalently (hydrogen bonds, van der Waals forces, and hydrophobic interactions) with starch and protein. Phenolic compounds can be dissolved in water because they have several hydroxyl groups that are polar. Amoako and Akiwa<sup>60</sup> and Zhu *et al.*<sup>61</sup> have also proven that polyphenolic compounds can be interacted with carbohydrates through the interaction of two hydrophobic and hydrophilic functional groups with amylose. Diez-Sánchez *et al.*<sup>62</sup> stated that polyphenolic compounds can be reacted with amylose and protein helical structures and largely determined by molecular weight, conformational mobility, and flexibility, as well as by the relationship between hydrogen donor/acceptor groups in protein, amylose, and polyphenols. The interactions between polyphenolic compounds, amylose and amylopectin can affect the gelatinization process in the amylose helical structure and interfere with the interaction between gliadin, glutenin, and water to form gluten, so that the distance of the network that functions to trap water and gas decreases. This phenomenon is in line with the trend of moisture content, swelling index and cooking losses. As a result, the wet noodles' texture increased. Based on the high cooking loss ( $> 98\%$ ) and swelling index (56.2 to 67.7%) data, it can be concluded that the interaction that occurs between the phenol group in pluchea leaf extract with amylose and protein was weak. The bioactive components of pluchea leaf extract are thought to affect the formation of disulfide cross-links (S-S) and turn into to form sulfhydryl groups (-SH) under the influence of heat. Ananingsih and Zhou<sup>63</sup> said that antioxidant compounds are a reducing agent that can have an impact on reducing S-S bonds and increasing the number of SH groups in the dough to produce a harder texture. According to Rahardjo *et al.*<sup>56</sup> phenolic compounds are hydroxyl compounds that influence the strength of the dough, where the higher the component of phenol compounds will weaken the gluten matrix and the dough thus becoming unstable. The instability of the dough can cause the texture to become hard.

Many researchers also find that tannins and phenols influence the networking S-S bond in the dough of wet noodles. Wang *et al.*<sup>64</sup> showed that tannins increase the relative amount of large, medium polymers in the gluten protein network so as to improve the dough quality. Zhang *et al.*<sup>65</sup> claimed that these polymer compounds are the

results of interactions or combinations of protein-tannin compounds that form bonds with the type of covalent, hydrogen, or ionic bonds. Rauf and Andini<sup>66</sup> also added that phenol compounds can reduce S-S bonds to SH bonds. SH is a type of thiol compound group, where the thiol group can influence the stickiness, viscosity, cohesiveness, elongation, and extensibility of the dough. Wang *et al.*<sup>67</sup> discovered the effect of phenolic compounds from green tea extract to increase the stickiness of wheat bread. The cohesiveness of the dough is formed due to a large number of thiol bonds formed, thus increasing the viscosity of the dough. The increased viscosity of the dough is thought to be due to the formation of polyphenolic compounds with thiol groups, as in the research of Ananingsih and Zhou<sup>63</sup> that the formation of catechin-thiol can increase the viscosity of the dough and the stability

of the dough. Zhu *et al.*<sup>68</sup> mentioned that the addition of phenolic compounds from green tea was able to increase the PV (peak viscosity) of wheat flour. Wang *et al.*<sup>64</sup> also found that the cohesiveness of the dough is influenced by tannins, where tannins can produce micro-glutens so as to produce a compact dough and increase the gluten network. The addition of pluchea leaf extract in making wet noodles could influence the elongation of wet noodles due to the components of polyphenol compounds such as tannins that can reduce the number of free amino groups. This is supported by Zhang *et al.*<sup>32</sup> and Wang *et al.*<sup>64</sup> that the formation of other types of covalent bonds, such as bonds between amino and hydroxyl groups, by forming hydrogen bonds between phenolic compounds and protein gluten so as to improve the quality of dough strength and dough extensibility.

**Table 5: Total phenol content, total flavonoid content, the DPPH free radical scavenging activity, and iron ion reducing power of the pluchea wet noodles.**

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	TPC (mg GAE/kg Dried Noodles)	TFC (mg CE/kg Dried Noodles)	DPPH (mg GAE/kg Dried Noodles)	FRAP (mg GAE/kg Dried noodles)
0	39.26±0.66 <sup>a</sup>	32.36±1.47 <sup>a</sup>	96.75±4.26 <sup>a</sup>	25.96±0.25 <sup>a</sup>
5	61.09±3.80 <sup>b</sup>	46.31±2.15 <sup>b</sup>	121.36±3.58 <sup>b</sup>	34.50±1.71 <sup>b</sup>
10	82.84±3.11 <sup>c</sup>	62.44±0.55 <sup>c</sup>	130.68±4.82 <sup>c</sup>	51.33±2.19 <sup>c</sup>
15	101.48±2.16 <sup>d</sup>	84.67±1.22 <sup>d</sup>	142.48±2.14 <sup>d</sup>	58.69±2.14 <sup>d</sup>
20	114.94±4.20 <sup>e</sup>	100.14±1.50 <sup>e</sup>	148.84±3.20 <sup>e</sup>	67.26±0.06 <sup>e</sup>
25	128.06±1.38 <sup>f</sup>	107.93±0.89 <sup>f</sup>	157.51±7.69 <sup>f</sup>	69.53±1.06 <sup>f</sup>
30	136.35±1.16 <sup>g</sup>	131.69±1.56 <sup>g</sup>	166.97±1.53 <sup>g</sup>	84.98±0.11 <sup>g</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate.

Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

#### Bioactive Compounds and Antioxidant Activity

Wet noodles added with pluchea leaf powder were analyzed based on its bioactive compounds and antioxidant activities. The analysis was conducted to determine the functional properties of wet noodles. Data analysis of the bioactive compound contents and antioxidant activity of wet noodles were presented in Table 5. The measured bioactive compounds (BC) involved total phenolic content (TPC) and total flavonoid content (TFC) and antioxidant activity (AA), including DPPH free radical

scavenging activity/DPPH and iron ion reducing power/FRAP). The higher the concentration of the added pluchea leaf powder extract, the higher the BC and AA of wet noodles. Statistical analysis at  $p \leq 5\%$  showed that the addition of pluchea extract had a significant effect on BC and AA wet noodles. There was a tendency for the increase in BC in line with the increase in AA. Pearson correlation (PC) test showed that there was a positive and strong correlation between TPC and DPPH ( $r = 0.990$ ), TPC and FRAP ( $r = 0.986$ ), TFC and DPPH

( $r=0.974$ ), and TFC and FRAP ( $r=0.991$ ). This means that the antioxidant activity of wet pluchea noodles was strongly influenced by TPC and TFC. Muflihah *et al.*<sup>69</sup> informed that the PC ( $r$ ) > 0.699 indicates the strength and linear correlation between antioxidant activity (AA) and TPC, and also shows a strong positive relationship but PC ( $r$ ) < 0.699 obtains a moderately positive relationship. If the  $r$  value of TFC and AA is lower than TPC and AA, it indicates that the contribution of TPC to AA is greater than TFC to AA. PC is lower than 1 and there are other components that affect AA. The PC of TPC and TFC is  $r > 0.913$  showing a strong positive relationship which is expected because both classes contributed to AA plants. Aryal *et al.*<sup>70</sup> and Muflihah *et al.*<sup>69</sup> informed that phenolic compounds are soluble natural antioxidants and potential donating electrons depend on their number and position of hydroxyl groups contributed to antioxidant action. Consequently, these groups are responsible to scavenge the free radicals which is expressed as TPC of pluchea wet noodles. DPPH free radical can accept electrons from phenolic compounds to change the stable purple-colored to the yellow-

colored solution. Based on FRAP analysis, it was showed that the bioactive compounds contained in pluchea wet noodles were a potential source of antioxidants because they can transform  $\text{Fe}^{3+}$ /ferricyanide complex to  $\text{Fe}^{2+}$ /ferrous. Therefore, the bioactive compounds in pluchea wet noodles can function as primary and secondary antioxidants. Research data showed that the cooking quality of wet noodles tends to increase along with the increase in the values of TPC, TFC, DPPH and FRAP.

### Sensory Evaluation

Sensory assay of pluchea wet noodles, namely color, aroma, taste, texture, and overall acceptance, was carried out using a hedonic test to determine the level of consumer preference for the product. This test was conducted to determine the quality differences between the products and to provide an assessment on certain properties.<sup>44</sup> The hedonic test is the most widely used assessment to determine the level of preference for product.<sup>71</sup> The results of the sensory evaluation of pluchea wet noodles were presented in Table 6.

**Table 6: Effect of hot water extract from pluchea leaf powder to preferences for color, aroma, taste, texture, and overall acceptance of wet noodles at various concentrations**

Concentration of Hot Extract from Pluchea Leaf Powder (% w/v)	Hedonic Score				
	Color	Aroma	Taste	Texture	Overall acceptance
0	6.19±1.25 <sup>d</sup>	5.52±1.08	5.50±1.18 <sup>c</sup>	6.20±1.13 <sup>b</sup>	6.63±1.49 <sup>c</sup>
5	5.62±1.28 <sup>c</sup>	5.52±0.83	5.51±1.29 <sup>c</sup>	6.37±1.14 <sup>bc</sup>	6.40±1.52 <sup>c</sup>
10	5.62±1.21 <sup>c</sup>	5.45±0.85	5.46±1.12 <sup>c</sup>	6.53±1.14 <sup>c</sup>	6.53±1.64 <sup>c</sup>
15	5.14±1.25 <sup>b</sup>	4.81±1.04	4.61±1.11 <sup>b</sup>	6.13±1.09 <sup>b</sup>	5.78±1.67 <sup>b</sup>
20	4.91±1.32 <sup>b</sup>	4.54±1.18	4.47±1.15 <sup>ab</sup>	5.80±1.06 <sup>a</sup>	5.17±1.70 <sup>a</sup>
25	4.54±1.40 <sup>a</sup>	4.26±1.23	4.20±1.24 <sup>a</sup>	5.50±1.04 <sup>a</sup>	5.23±1.75 <sup>a</sup>
30	4.47±1.33 <sup>a</sup>	4.05±1.34	4.15±1.40 <sup>a</sup>	5.59±1.05 <sup>a</sup>	5.37±1.91 <sup>a</sup>

Note the results were presented as SD of the means that were achieved by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

The results of the sensory evaluation for color preference ranged from  $4.47 \pm 1.33$  to  $6.19 \pm 1.26$  (neutral-like). The statistical analysis showed that the higher concentration of hot water extract addition decreased lower color preference of wet noodles.

The higher concentration of pluchea extract could reduce the level of color preference because the color of the wet noodles was darker than control and turned to dark brown. This color change was due to the pluchea extract containing several components,



including chlorophyll and tannins, which can alter the of wet noodles' color to be browner along with the increase in the concentration of pluchea extract. This result was in accordance to the effect of color analysis performed using color reader where the pluchea wet noodles' brightness declined, yellowness increased, and the color intensity increased with an increased concentration of pluchea extract. The occurrence of this process is related to the effect of light and heat on pluchea leaf powder which causes the degradation of chlorophyll into brown pheophytin due to drying, where the nature of chlorophyll itself is sensitive to light, heat, oxygen, and chemicals.<sup>72,73</sup>

Aroma is one of the parameters in sensory evaluation using the sense of smell and an indicator of the assessment of a product.<sup>74</sup> The results of the preference values for aroma were ranged from  $4.05 \pm 1.34$  to  $5.52 \pm 1.23$  (neutral-slightly like). Higher concentration of pluchea extract in wet noodles reduced the preference score for aroma due to distinct dry leaves (green) aroma. According to Lee *et al.*<sup>75</sup> the unpleasant aroma on leaves comes from a group of aliphatic aldehyde compounds. The appearance of a distinctive leaf aroma in noodles is due to aromatic compounds. According to Martiyanti and Vita<sup>76</sup> aromatic compounds are chemical compounds that have an aroma or odor when the conditions are met, which is volatile, while Widyawati *et al.*<sup>77</sup> informed that pluchea leaves were detected to have 66 volatile compounds. The appearance of the aroma is due to the volatile compounds in the raw material reacting with water vapor when boiling the noodles. In addition, there is also an oxidation process of polyphenolic compounds such as catechins or tannins that can produce an aroma in pluchea wet noodles.

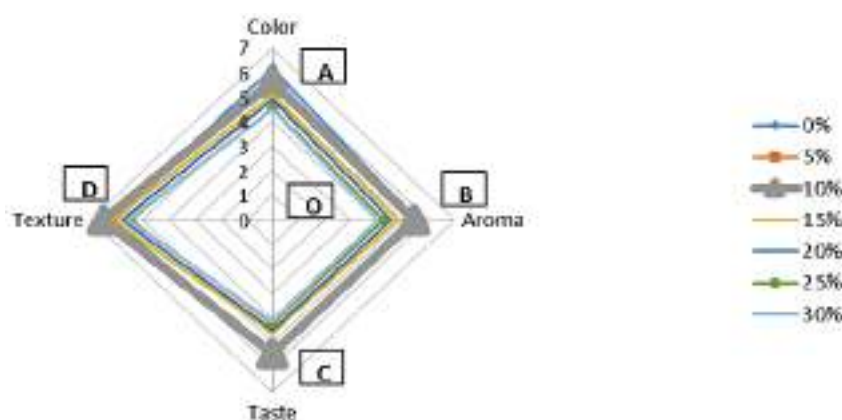
According to Martiyanti and Vita<sup>3</sup> taste attribute is one important sensory aspect in food products and has a great impact on the food selection by consumers. Tongue is able to detect basic tastes, such as sweet, salty, sour, and bitter, at different points. Lamusu<sup>73</sup> declared that taste is a component of flavor and an important criterion in assessing a product that is accepted by the tongue. The preference test of the taste of pluchea wet noodles resulted in values ranging from  $4.15 \pm 1.40$  to  $5.50 \pm 1.28$  (neutral-slightly like). The increase in concentrations of pluchea extract was negatively correlated to the preference level of the taste

of pluchea wet noodles assessed by the panelists. The statistical analysis results showed that the difference in the concentration of the extract significant influenced on the preference score for the taste of pluchea wet noodles. The increased concentration of pluchea extract produced a distinctive taste on wet noodles, such as a bitter and astringent tastes, due to the presence of compounds such as tannins and alkaloids from the pluchea leaves. Susetyarini<sup>78</sup> said that pluchea leaves contain tannins (2.35%), and alkaloids (0.32%). According to Pertiwi<sup>79</sup> tannin compounds dominate the bitter and astringent taste, while alkaloid compounds cause a bitter taste. The high level of taste preference for wet noodles was found in noodles with lower content of pluchea extract.

Texture is a sensation of pressure that can be observed by mouth (when bitten, chewed, and swallowed) or touched with fingers.<sup>80</sup> Texture testing performed by the panelist is called mouthfeel testing. According to Martiyanti and Vita,<sup>76</sup> mouthfeel is the kinesthetic effect of chewing food in the mouth. In this study, the preference test results on the texture of pluchea wet noodles revolved from  $5.50 \pm 1.04$  to  $6.53 \pm 1.13$  (rather like). The higher concentration of pluchea extract resulted in chewy and hard wet noodles, which reduced the panelists' preference level. Changes in the texture of wet noodles are influenced by polyphenolic compounds' contents, as well as several processing steps that can determine textures of wet noodles, such as mixing ingredients, developing dough, boiling, and draining noodles. Subjective testing results based on sensory evaluation were in line with the objective testing the texture analyzer. The noodles' texture that was getting harder, sticky, compact, not easy to break, and tough were not preferred by the panelists. Therefore, mentioned final texture of pluchea wet noodles was influenced by the fiber and protein components. According to Shabrina,<sup>81</sup> the components of fiber, protein, and starch complete to bind water. Texture changes are also influenced by the polyphenol compositions in the pluchea extract which is able to reduce S-S bonds to SH bonds, where the increase in SH (thiol) groups can cause a hard, sticky, and compact texture.<sup>64,66,67</sup> Besides, a high concentration of tannins capable of binding to proteins to form complex compounds into tannins-proteins are also able to build noodles' texture.

The interaction between color, aroma, taste, and texture created an overall taste of the food product and was assessed as the overall preference. The highest value on the overall preference was derived from control wet noodles, i.e., 6.63 (slightly like it), while the wet noodles added with 20% (w/v) concentration of pluchea extract had a low overall preference i.e., 5.17 (neutral-rather like). The addition of pluchea extract at 0% (w/v) concentration produced an overall preference value closed to 10% (w/v) concentration with scores

of 6.63 and 6.53, respectively. The area of the spider web chart for each treatment with the various concentrations of pluchea extract was seen in Figure 3. The best treatment of the wet noodles was the addition of 10% (w/v) of pluchea extract with an area of 66.37 cm<sup>2</sup> based on an average sensory value of color, aroma, taste, texture, and overall acceptance with the scores of 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), 6.53 (like), and 6.53 (like), respectively.



**Fig. 3: Spider web graph of sensory evaluation on wet noodles at various concentrations of hot water extract from pluchea leaf powder**

The use of pluchea leaf extract in the making of wet noodles was able to increase the functional values of wet noodles, based on the levels of bioactive compounds and antioxidant activity without changing the quality of cooking, which included water content, swelling index and cooking loss. Besides that, the use of pluchea leaf extract did not significantly change the color and color intensity of the resulting wet noodles, only slightly decreased the brightness level of the noodles. However, the wet noodles produced were still acceptable to the panelists, the addition of pluchea leaf extract as much as 10% (w/v) was the best treatment with an assessment that was almost closed to the control wet noodles (without treatment).

### Conclusion

Addition of hot water extract of pluchea leaf powder influenced physical, chemical and sensory properties of wet noodles. Lightness, texture, bioactive compound content, antioxidant

activity, and sensory properties of samples underwent significant difference. The higher concentration of pluchea extract caused the bigger these parameters of pluchea wet noodles. Using 10% (w/v) of hot water extract from pluchea leaf powder was the best treatment with color, aroma, taste, and texture scores 5.62 (slightly like), 5.45 (slightly like), 5.46 (somewhat like), and 6.53 (like), respectively. Utilization of hot water extract of pluchea leaf powder at 10% (w/v) resulted functional wet noodles with TPC, TFC, DPPH free radical scavenging and iron ion reducing power were 82.84 mg GAE/kg dried samples, 62.44 mg CE/kg dried samples, 130.68 mg GAE/kg dried samples and 51.33 mg GAE/kg dried samples, respectively.

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### Conflict of Interest

The authors declare no conflict of interest.

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8. Paper Published (8-7-2023)  
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Mon, Aug 21, 2023 at 5:51 PM

To: Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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