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Article

The Effect of κ-Carrageenan Proportion and Hot Water Extract of *Pluchea Indica* Less Leaf Tea to Quality and Sensory Properties of Stink Lily (*Amorphophallus Muelleri*) Wet Noodles

Paini Sri Widyawati[1,†,*], Thomas Indarto Putut Suseno[1], Anna Ingani Widjajaseputra[1], Theresia Endang Widoeri Widyastuti[1], Vincentia Wilhelmina Moeljadi[1], and Sherina Tandiono[1]

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Abstract : The study aimed to determine the effect of the proportion of κ-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles. The research design used was a Randomized Block Design with two factors, i.e. the difference in the proportion of κ-carrageenan (K) (0, 1, 2, and 3% b/b) and the addition of hot water extract of *Pluchea indica Less* leaf tea (L) (0, 15, and 30% b/v) with 12 treatment level (K0L0, K0L1, K0L2, K1L0, K1L1, K1L2, K2L0, K2L1, K2L2, K3L0, K3L1, K3L2). The data were analyzed by the Anova at α= 5% and continued with the Duncan's Multiple Range Test at α= 5% and the best treatment was determined by the Spider web method based on sensory assay by a hedonic method. The proportions of κ-carrageenan and the concentration of pluchea tea extract had a significant effect on cooking quality and sensory properties. However, the interaction of the two factors affected the swelling index, yellowness (b*), chroma (C), hue (h), total phenol content (TPC), total flavonoid content (TFC), and DPPH free radical scavenging assay (AOA). The best treatment of wet noodles was K2L0 with a preference score of 15.8. The binding of κ-carrageenan and phenolic compounds to make networking structure by intra- and inter-disulfide bind between glucomannan and gluten, was thought to affect the cooking quality, sensory properties, bioactive compounds (TPC and TFC), and AOA.

Keywords: *Amorphophallus muelleri*, *Pluchea indica* Less, wet noodles, quality and sensory properties

1. Introduction

Noodles are a rice substitute commodity that is much favored by the public [1], especially in China, Indonesia, India, Japan, Vietnam, and the United States. Basically, noodles are divided into wet noodles and dry noodles. Indonesia is the second country in the world that likes to consume noodles [2]. In 2017, the consumption of instant noodles achieves by 180.2 packets per head in the world, and in Indonesia, the consumption of wet noodles shows that all age groups and education levels like it [3]. Meanwhile, instant noodle consumption in 2020 reached 12,640 million portions [2]. Noodles are generally made from wheat flour, the use of local food ingredients based on carbohydrates, including stink lily flour, can reduce the consumption of wheat flour which is quite high in Indonesia, the average consumption of wheat flour for the Indonesian population in 2019 is 17.8 kg/capita/year [4].

Stink lily flour (*Amorphophallus* oncophyllus) is a group of *Araceae* that contains glucomannan oligosaccharides around 15-64% dry base [5] or more than 60% [6]. Glucomannan is a heteropolysaccharide consisting of 67% D-mannose and 33% D-glucose and has β-1,4 and β-1,6 glycoside bonds [7], which can reduce body weight, sugar content blood levels, LDL cholesterol levels and prolong gastric emptying time [8,9]. Stink lily flour has a glycemic index of 85 which is lower than the glycemic index of glucose which is considered to be 100 [7]. The use of stink lily flour in the manufacture of wet noodles is able to replace the role of gliadin and glutenin proteins in the formation of gluten with an elastic texture [10]. Polysaccharides in stink lily flour can dissolve in water to form a thick solution, form a gel, expand, and melt like agar [11], can increase the elasticity and cohesiveness [12,13] with increasing α-helix and β-sheet stuctures of wet noodles [13]. However, the higher the substitution of stink lily flour, the lower the texture preference because the noodles break easily and are sticky [12]. Therefore, it is necessary to add hydrocolloids, including carrageenan, because they can increase elasticity [14]. The combination of the use of glucomannan and carrageenan can form a strong and elastic gel [15].

The addition of hot water extract from pluchea leaf tea in making stink lily wet noodles is expected to increase the functional value of wet noodle products. Pluchea leaves contain nutrients, such as: protein 1.79 g/100 g, fat 0.49 g/100 g, ash 0.20 g/100 g, insoluble fiber 0.89 g/100 g, soluble fiber 0.45 g/100 g, total fiber 1.34 g/100 g, carbohydrates 8.65 g/100 g, calcium 251 g/100 g, β-carotene 1.225 mg/100 g and vitamin C 30.17 mg/100 g as well as bioactive compounds, such as: phenolic acid 28.48±0.67 mg/100 g wb (chlorogenic acid 20±0.24 mg/100 g wb, caffeic acid 8.65±0.46 mg/100 g wb), total flavonoids 6.39 mg/100 g wb (quercetin 5.21±0.26 mg/100 g wb, kaempferol 0.28±0.02 mg/100 g wb, myricetin 0.09± 0.03 mg/100 g wb), total anthocyanins 0.27±0.01 mg/100 g wb, β-carotene 1.70±0.05 mg/100 g wb, and total carotenoids 8.7±0.34 mg/100 g wb [16], 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, and 4,5-O-dicaffeoylquinic acid [17,18,19]. Meanwhile, hot water extract of 2% pluchea leaf tea (2 g/100 ml) contains a total phenolic content of 9.3 mg EAG/ g, total flavonoid content 22.0 mg EC/ g, DPPH free radical scavenging activity DPPH 27.2 mg EAG/ g, and reduced iron ion 10.2 mg EAG/ g [20], due to the presence of phytochemicals (alkaloids, flavonoids, phenolics, sterols, cardiac glycosides, phenol hydroquinone, tannins, terpenoids, and saponins) [20], which has been shown to have potential as an antioxidant [20,21] and antidiabetic [22]. The effect of using κ-carrageenan and water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles has not been studied in detail. Therefore, the purpose of this study was to determine the effect of the proportion of κ-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles.

2. Materials and Methods

2.1. Chemicals and Reagents.

The compounds 2,2-diphenyl1-picrylhydrazyl (DPPH), sodium carbonate, gallic acid, and (+)-catechin were purchased from Sigma-Aldrich (St. Louis, USA). Methanol, folin ciocalteus phenol, sodium nitric, aluminium chloride, κ-carrageenan, and sodium hydroxide were purchased from Merck (New Jersey, USA).

2.2. Preparation of Pluchea Leaf Tea.

Pluchea leaves on each branch number 1-6 from the shoot were collected, sorted, and dried at an ambient temperature for 7 days until moisture content 11.16±0.09% dry base. And then dried leaves were powdered to get 45 mesh size [23]. Futhermore the leaf powder was heated by drying oven (Binder, Merck KGaA, Darmstadt, Germany) at 120^oC for 10 min. Then dried powder of pluchea leaves was packed 2 g in tea bag that called pluchea leaf tea.

2.3. Preparation of Hot Water Extract of Pluchea Leaf Tea.

Pluchea leaf tea in tea bag was extracted by hot water at 95^oC for 1 min to get 15 and 30% (b/v) concentrations (Table 1). And then each concentration of extract was used to make stink lily wet noodles.

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

Materials	**Concentration of hot water extract of pluchea leaf tea (% b/v)**		
	0	15	30
Pluchea leaf tea (g)	0	4.5	9
Hot water (mL)	30	30	30

2.4. Stink Lily Wet Noodles Making.

Stink lily wet noodles were made with mixing of wheat and stink lily flour, and κ-carrageenan at 1, 2, and 3% (b/b) concentrations. And then the mixture was added egg, salt, baking powder, and hot water extract of pluchea leaf tea and kneaded to form a dough by a mixer machine. Then the dough was passed through a roller to make face bands the desired thickness and cut through rollers using cutting blades. The formula of stink lily wet noodle was showed at Table 2.

2.5. Stink Lily Wet Noodles Extraction.

125 g each sample from stink lily wet noodles was weighed (Ohaus, Ohaus Instruments (Shanghai) Co.,Ltd. RRT) and then they were dried by cabinet drying at 60^oC for 4 hours to get dried noodles. Next each sample was powdered by chopper machine at second speed for 35 seconds and then 20 g powdered sample was added 50 mL methanol by shaking water bath at 35^oC, 70 rpm for 1 hour. Filtrate was separated by Whatman filter paper grade 40 and residue was extracted again with same pattern way. Filtrate was collected and dried by rotary evaporator (Buchi Rotary Evaporator; Buchi Shanghai Ltd, RRT) at 0.2-0.3 atm, 50^oC for 60 min until getting 2 mL extract. Then extract was kept at 0^oC before further study.

2.6. Swelling Index Assay

Swelling index or water absorption is the ability of noodles to absorb water after gelatinization during the boiling process [24]. The principle of water absorption testing is to determine the amount of water absorbed in wet noodles at a certain temperature and time. The amount of water absorbed in wet noodles can be determined from the difference between the weight of the noodles after and before being boiled divided by the weight of the noodles before boiling [25].

2.7. Cooking Loss Assay

Cooking loss is one of the important quality parameters in wet noodles to determine the quality of wet noodles after cooking [26]. The cooking loss test for stink lily stink lily wet noodles was carried out to determine the number of solids that came out of the noodle strands during the cooking process, namely the release of a small portion of starch from the noodle strands.

2.8. Determination of Tensile Strength of Wet Noodles

The tensile strength (elongation) is one important parameter of texture analysis in noodle products. 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 principle of the texture analyzer is to prepare a suitable probe for the test, then place the noodle samples on the table under the probe. The elongation of the noodles was individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. The same procedure was done to tighten the other end of the strip to the upper roller arm. Elongation, which was the maximum force to deform and break noodles by extension, was measured using a test speed of 3.0 mm/s, with a 100 mm distance between two rollers. Deformations were recorded using the software during the extension and are expressed as a graph. The elongation at breaking was calculated per gram.

2.9. Color Measurement

The noodle samples were measured by a colorimeter (Minolta CM-3500D; Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab L*, a* and b* values were recorded as described by [27]. And then L*, a* and b* values were collected. The L* value was stated the position on the white/black axis, the a* value the position on the red/green axis, and the b* value the position on the yellow/blue axis. The measurements were done in triplicate and the readings were averaged.

2.10. Total Phenol Content Assay

Total phenol content (TPC) of stink lily wet noodles was analyzed by spectrophotometric method using folin ciocateus phenol reagent [28]. Principles assay of the TPC assay are interaction between phenolic compounds and phosphomolybdic/ phosphotungstic acid complexes based on the transfer of electrons in alkaline medium from phenolic compounds to form a blue chromophore constituted by a phosphotungstic/ phosphomolybdenum complex. The reduced folin ciocalteus phenol reagent is detected by a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 760 nm and gallic acid is used as the reference standard compound and results are expressed as gallic acid equivalents (mg/kg wet noodles).

2.11. Total Flavonoid Content Assay

Total flavonoid content of samples was measured by spectrophotometric method with reaction between $AlCl_3$ and $NaNO_2$ with aromatic ring of flavonoid compounds [29]. And then mixture was added aluminium chloride to result yellow solution. Next, addition of NaOH solution in mixture caused red solution that was measured by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 510 nm. As standard reference compound used was (+) catechin and results were expressed as catechin equivalents (mg/kg wet noodles).

2.12. DPPH Free Radical Scavenging Activity Assay

DPPH free radical scavenging activity was measured by the spectrophotometric method [30]. This method is used to determine the antioxidant capacity of a compound from an extract or other biological sources, based on transferring from the odd electron of a nitrogen atom in DPPH is reduced by receiving a hydrogen atom from antioxidants to result in DPPH-H with yellow-colored solution. Reaction between DPPH in methanol solution with samples was measured by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 517 nm. As standard reference compound used was gallic acid and results were expressed as gallic acid equivalents (mg/kg wet noodles).

2.13. Sensory Evaluation

Sensory assay was carried out to determine the level of panelist acceptance of wet noodles substituted with stink lily flour with the addition of carrageenan and hot water extract of pluchea leaf tea [31]. The test was carried out using the hedonic scale scoring method. This method is designed to measure the level of panelist preference for the product by rating the level of preference for the product being tested. Samples were served in dishes coded with random three-digit numbers that carried out using a completely randomized design (CRD) trial using 100 untrained panelists. Each panelist is faced with 15 (fifteen) samples and a questionnaire containing test instructions, and is asked to give each sample a score according to their level of preference. The parameters tested were taste, aroma, texture, color, and overall preference of wet noodles substituted with stink lily flour. The best treatment of samples was determined by spider web method that was correlated by the large area of graph [32].

2.14. Experiment Design and Statistical Analysis

The research design used was a randomized block design with two factors, i.e. differences in the proportion of κ-carrageenan (K) and differences in the concentration of pluchea tea extract (L) added to wet noodles. The proportion of κ-carrageenan consisted of 4 (four) treatment levels, including 0% (K0), 1% (K1), 2% (K2), 3% (K3) and the concentration of pluchea tea extract consisted of 3 (three) levels, i.e. 0% (L0), 15% (L1), and 30% (L2). Each treatment was repeated 3 (three) times in order to obtain 36 (thirty-six) experiment units. The experiment design of stink lily noodles can be seen in Table 2.

The data are presented as mean ± SD of the triplicate determinations and were analyzed using ANOVA, followed by Duncan multiple range test for significant differences using the SPSS 17.0 software (SPSS Inc. Chicago, IL, USA). Values were considered significant at p = 0.05.

3. Results

3.1. Cooking Quality

The evaluated cooking properties of the stink lily wet noodles were showed in Table 3 and the stink lily wet noodles product was showed at Figure 1. The level of cooking was estimated by the moisture content, swelling index, cooking loss and tensile strength from noodles. Based on statistically analysis by Anova at p=0.05, showed that the increasing of κ-carrageenan proportion went up significant difference of moisture content of wet noodles, but the addition of pluchea leaf hot water extract and the interaction effect of the proportion of κ-carrageenan and the addition of the extract no influenced to moisture content of wet noodles. The moisture content value was ranged from 62.83±0.58 to 65.83±0.22. The sample K3L0 had the highest moisture content and K0L2 had the lowest moisture content. Furthermore the addition of the κ-carrageenan proportion or pluchea tea extract had a significantly different effect such as the interaction effect of the addition of the two parameters, on the swelling index or water absorption value of wet noodles based on statistical analysis at p=0.05. The water absorption value was ranged from 142.25±0.39% to 162.21±0.25%. The treatment with the lowest swelling index was K0L2 and the highest was K3L0. Whereas the cooking loss of wet noodles decreased significantly with the addition of the proportion of κ–carrageenan but increased significantly with the addition of pluchea tea extract. The cooking loss of wet noodles was ranged 17.83±0.4% to 20.13±0.7%. K0L2 was treatment with the biggest cooking loss and K3L0 was treatment with the smallest cooking loss. Tensile strength value of stink lily noodles was significant different because there was an interaction effect of κ-carrageenan proportion and pluchea tea extract addition . Tensile strength wet noodles was ranged 0.096±0.004 N to 0.174±0.015 N. The analysis of stink lily noodles color showed that lightness had a significant increase in with an increasing proportion of carrageenan and decreased with increasing pluchea tea extract used because of the color effect of carrageenan and pluchea tea extract. The lightness of wet noodles was ranged 67.80±0.22 to 74.50±0.23. The effect of the κ-carrageenan and pluchea tea extract color also influenced significantly redness of wet noodles. The redness of wet noodles was ranged 1.20±0.04 to 3.30±0.23. The interaction effect of κ-carrageenan and pluchea tea extract addition was appeared on yellowness, chroma and hue values. The yellowness, chroma and hue values were ranged 16.90±0.27 to 30.00±0.07, 17.00±0.28 to 30.10±0.03, and 83.70±0.07 to 86.40±0.02, respectively.

Table 2. The formula of stink lily wet noodles

Material	K0L0	K0L1	K0L2	K1L0	K1L1	K1L2	K2L0	K2L1	K2L2	K3L0	K3L1	K3L2
Wheat flour (g)	120	120	120	120	120	120	120	120	120	120	120	120
Stink lily flour (g)	30	30	30	28.5	28.5	28.5	27	27	27	25.5	25.5	25.5
κ-Carrageenan (g)	0	0	0	1.5	1.5	1.5	3	3	3	4.5	4.5	4.5
Egg (g)	30	30	30	30	30	30	30	30	30	30	30	30
Salt (g)	3	3	3	3	3	3	3	3	3	3	3	3
Baking Powder (g)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water (mL)	30	0	0	30	0	0	30	0	0	30	0	0
Hot water extract of pluchea leaves 15% (mL)	0	30	0	0	30	0	0	30	0	0	30	0
Hot water extract of pluchea leaves 30% (mL)	0	0	30	0	0	30	0	0	30	0	0	30
Total (g)	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5

Note: K0 = wheat flour: stink lily flour: κ-carrageenan = 80 : 20 : 0
K1 = wheat flour: stink lily flour: κ-carrageenan = 80 : 19 : 1
K2 = wheat flour: stink lily flour: κ-carrageenan = 80 : 18 : 2
K3 = wheat flour: stink lily flour: κ-carrageenan = 80 : 17 : 3
L0 = concentration of hot water extract from pluchea leaf tea = 0%
L1 = concentration of hot water extract from pluchea leaf tea = 15%
L2 = concentration of hot water extract from pluchea leaf tea = 30%

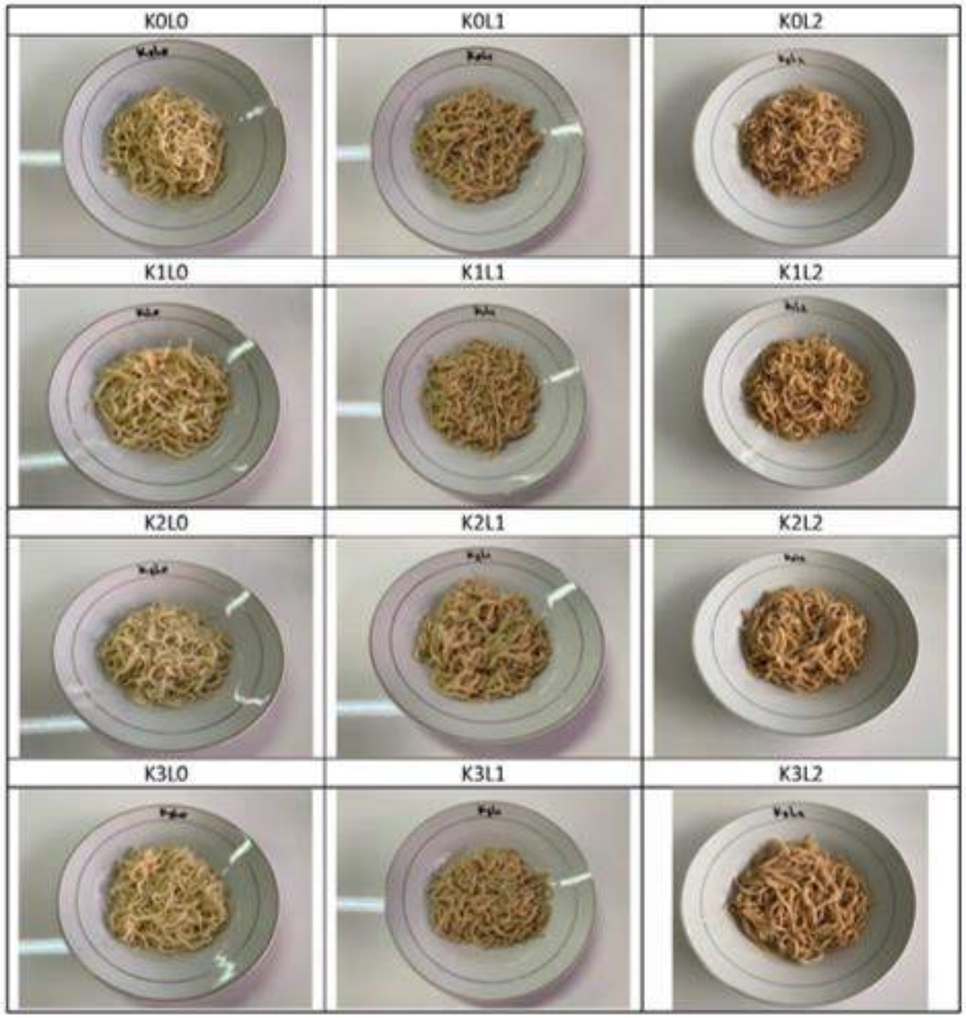

Figure 1. Stink Lily Noodles

Note: K0 = wheat flour: stink lily flour: κ-carrageenan = 80 : 20 : 0, K1 = wheat flour: stink lily flour: κ-carrageenan = 80 : 19 : 1 , K2 = wheat flour: stink lily flour: κ-carrageenan = 80 : 18 : 2 , K3 = wheat flour: stink lily flour: κ-carrageenan = 80 : 17 : 3, L0 = concentration of hot water extract from pluchea leaf tea = 0%, L1 = concentration of hot water extract from pluchea leaf tea = 15% , L2 = concentration of hot water extract from pluchea leaf tea = 30%

Table 3. Color, Moisture Content, Swelling Index, Cooking Loss, and Tensile Strength of Stink Lily Noodles

Samples	Color					Moisture Content (%)	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (N)
	L*	a*	b*	C	h				
K0L0	73.00 ± 0,06	1.20 ± 0.06	16.90 ± 0.25a	17.00±0.31a	86.40±0.00g	64.15±0.70	148.90±0.15c	18.83±0.44	0.106±0.002
K0L1	68.70 ± 0.35	2.60 ± 0.06	26.50 ± 0.32d	26.50±0.29c	84.40±0.21bc	63.66±0.38	146.36±0.27b	19.06±0.43	0.1051±0.001
K0L2	67.80 ± 0.20	2.80 ± 0.06	27.80 ± 0.46ef	27.80±0.45e	84.20±0.32abc	62.83±0.58	142.25±0.39a	20.13±0.71	0.116±0.006
K1L0	73.40 ± 0.25	1.30 ± 0.06	17.30 ± 0.15ab	17.30±0.15a	85.70±0.21f	64.42±0.80	149.63±0.34d	18.47±0.31	0.086±0.005
K1L1	69.00 ± 0.36	2.80 ± 0.12	27.30 ± 0.45e	27.40±0.50d	84.20±0.15a	62.95±0.68	146.65±0.43b	19.36±0.92	0.103±0.004
K1L2	68.30 ± 0.15	3.00 ± 0.12	28.60 ± 0.12g	28.70±0.15f	84.00±0.15abc	63.37±1.04	148.85±057c	19.76±0.90	0.108±0.005
K2L0	73.70 ± 0.10	1.50 ± 0.00	17.70 ± 0.26bc	17.80±.23a	85.20±0.06de	64.67±1.08	155.67±0.46h	18.18±0.45	0.098±0.002
K2L1	69.40± 0.15	3.00 ± 0.06	28.20 ± 0.15fg	28.40±0.15f	83.80±0.17ab	63.74±0.75	150.96±0.71e	18.62±0.41	0.106±0.005
K2L2	68.70 ± 0.06	3.10 ± 0.15	29.30 ± 0.00h	29.40±0.06g	84.00±0.15abc	64.25±1.60	154.82±0.44g	19.34±0.77	0.114±0.003
K3L0	74.50 ± 0.23	1.70 ± 0.12	18.10 ± 0.00c	18.10±0.06b	84.60±0.21cd	65.83±0.22	162.21±0.25i	17.83±0.41	0.110±0.003
K3L1	69.80 ± 0.50	3.20 ± 0.06	29.30 ± 0.12h	29.30±0.06g	83.80±0.53ab	64.57±1.78	153.35±0.15f	18.36±0.17	0.124±0.007
K3L2	69.00 ± 0.20	3.30 ± 0.26	30.00 ± 0.06i	30.10±0.06h	83.60±0.06a	65.49±1.04	159.59±0.52i	19.22±0.84	0.126±0.008

*The results were presented as SD of the means that were gotten by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different, $p<0.05$.

3.2. Bioactive Compounds and Antioxidant Activity

Bioactive compounds analyzed included total phenol content (TPC) and total flavonoid content (TFC). The analysis data showed that the TPC and TFC increased significantly due to the interaction effect between the proportion of κ-carrageenan and the addition of pluchea tea extract (Table 4). The results of the analysis showed that the control sample K0L0 had the lowest total phenol, i.e. 0.3409 ± 0.0338 mg GAE/kg dry noodles. The K2L2 sample had the highest total phenol, which was 1.1963 ± 0.0272 mg GAE/kg dry noodles. This result was suitable with the TFC value of wet noodles where K0L0 had the lowest TFC value and K2L2 had the highest value, i.e. 0.0534 ± 0.0036 and 1.3364 ± 0.04601 mg CE/kg dry noodles, respectively. The high and low values of TPC and TFC were correlated with AOA. The higher the TPC and TFC values, the higher the AOA value. The DPPH free radicals scavenging activity (AOA) of wet noodles was determined significantly by the interaction effect of adding the proportion of κ-carrageenan and pluchea tea extract. K0L0 had the lowest AOA value and K2L2 had the highest AOA value, i.e. 0.4143±0.0060 and 0.7576±0.0092 mg GAE/kg dry noodles, respectively.

3.3. Sensory Properties

The evaluated sensory properties of the stink lily noodles were shown in Table 5. Parameter sensory that analyzed included aroma, color, taste, texture, and overall acceptability. The method used for sensory assay of stink lily noodles was hedonic scale scoring or a test of the level of consumer preference for a product by giving an assessment or score on a certain trait [33]. Organoleptic testing of stink lily wet noodles was presented to 100 untrained panelists aged 17-25 years. Panelists are asked to give scores or numbers based on their level of preference for certain treatments. The value scale used was 1-15, where a value of 0-3.0 indicated "strongly dislike", a value of 3.1-6.0 "does not like", a value of 6.1-9.0 "neutral", a value of 9.1-12.0 “like”, and 12.1-15.0 “like very much”. The results of statistical tests by ANOVA at α=5% showed that interaction effect of each treatment significantly influenced the panelists' preference for noodle color. The preference value of stink lily noodles color was ranged from 9.12 to 12.02 (like). The highest color preference value was the control treatment (K0L0) and the treatment with the lowest color preference value was K0L1. The interaction effect of each treatment were significantly determined the panelists' preference for the aroma. The preference value for the aroma of wet noodles was ranged from 8.29 to 11.58 (neutral-like). The treatment with the highest preference value was stink lily noodles K1L0 and the treatment with the lowest preference value was K3L2 treatment. The preference value of noodles taste was only affected by κ-carrageenan proportion or extract concentration. The preference value for the wet noodle taste was ranged from 8.18 to 11.08 (neutral-like). The treatment with the highest taste preference value was K2L0 while the treatment with the lowest taste preference value was K0L2. Increasing the proportion of carrageenan to 2% increased the preference value for taste, after that it decreased with the addition of the proportion of 3% carrageenan. While increasing the concentration of pluchea leaf tea extract decreased the panelists' preference for taste. The results of statistical tests using ANOVA at p= 5% showed that the addition of extract only significantly influenced the panelists' preference for noodles texture. In this study, the preference for wet noodles texture was ranged from 9.46 to 11.66 (like).

Table 4. Total Phenol Content, Total Flavonoid Content, and DPPH Free Radical Scavenging Activity of Stink Lily Noodles

Samples	TPC (mg GAE/g dry noodles)	TFC (mg CE/g dry noodles)	DPPH Scavenging Activity (mg GAE/g dry noodles)
K0L0	0.3409±0.0338[a]	0.0571±0.0035[a]	0.4143±0.0060[a]
K0L1	0.9480±0.0273[d]	0.7044±0.0065[c]	0.7424±0.0159[c]
K0L2	1.0991±0.0466[e]	1.1087±0.0065[d]	0.7571±0.0013[c]
K1L0	0.4576±0.0396[b]	0.0821±0.0017[a]	0.5229±0.0259[b]
K1L1	0.9243±0.0774[d]	0.7348±0.0030[c]	0.7497±0.0055[c]
K1L2	1.0047±0.0704[d]	1.0910±0.0949[d]	0.7509±0.0012[c]
K2L0	0.4997±0.0450[b]	0.0888±0.0084[a]	0.5318±0.0052[b]
K2L1	0.9648±0.0248[d]	0.7181±0.0179[c]	0.7477±0.0043[c]
K2L2	1.1963±0.0272[f]	1.3364±0.0460[e]	0.7576±0.0092[c]
K3L0	0.5267±0.0070[b]	0.2181±0.0025[b]	0.5873±0.0197[b]
K3L1	0.8070±0.0307[c]	0.7264±0.0385[c]	0.7508±0.0077[c]
K3L2	1.1446±0.0636[ef]	1.0674±0.0627[d]	0.7505±0.0066[c]

*The results were presented as SD of the means that were gotten by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different, $p<0.05$.

The increasing the addition of extracts decreased the level of the texture preference of wet noodles. The overall preference value of wet noodles showed that there was the interaction effect between the proportion of κ-carrageenan and the addition of pluchea tea extract. The preference value for the overall of wet noodles was ranged from 8.62 to 11.24 (neutral-like). The treatment with the highest preference value was stink lily noodles K0L0 and the treatment with the lowest preference value was K3L2. Determination of the best treatment for differences in the proportions of κ-carrageenan and the addition of pluchea tea extract on wet noodles was determined using the spider web method based on organoleptic parameters (color, aroma, taste, texture and overall). The spider web graph can be seen in Figure 2. Data showed that the treatment with the largest area was K2L0, i.e. wet noodles with the proportion of κ-carrageenan 2 % with the addition of 0% pluchea tea extract. The area of the K2L0 treatment area was 79.16 cm^2 and had a preference score of 15.8 with a very like category.

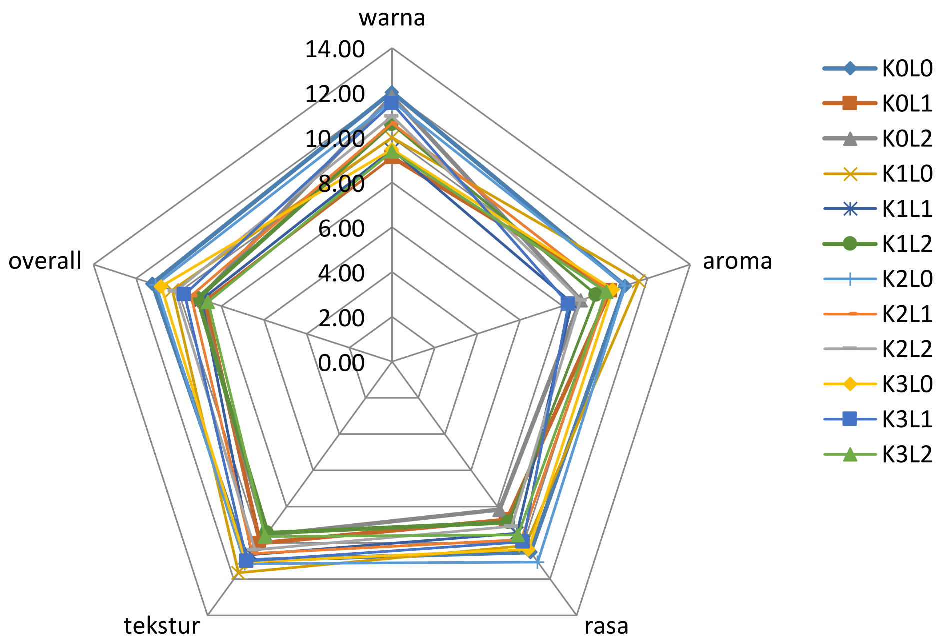

Figure 2. Spider web Graph to Determine The Best Treatment of Stink Lily Noodles

Table 5. Sensory Properties of Stink Lily Noodles

Samples	Hedonic Preference Score				
	Color	Aroma	Taste	Texture	Overall
K0L0	12.02f	10.93d	10.52	10.95	11.24f
K0L1	9.12a	10.26cd	8.72	10.03	8.79a
K0L2	11.83ef	8.86ab	8.18	9.58	9.04ab
K1L0	9.98bc	11.58e	10.15	11.66	10.3cde
K1L1	9.44ab	9.58bc	9.49	10.66	8.93ab
K1L2	10.59cd	8.45a	8.87	9.46	9.11ab
K2L0	11.62f	10.93de	11.08	11.15	11.07def
K2L1	10.63cd	10.14ab	9.82	10.61	9.42abc
K2L2	10.94de	8.84cd	9.09	10.38	10.16cde
K3L0	11.51ef	10.36cd	10.37	11.07	10.84def
K3L1	9.37ab	10.07a	9.95	11	9.72bc
K3L2	9.47ab	8.29cd	9.57	9.64	8.62a

4. Discussion

4.1. Cooking Quality

Moisture content is a major parameter of stinky silky wet noodles that shows the amount of water contained in food product that determines rheological characteristics, chemical, physical, and sensory properties, and shelf life of food product [34]. The κ-carrageenan addition gave a significant difference of moisture content to wet noodles. The κ-carrageenan is hydrocolloids that has a group of sulfate and water-soluble polysaccharides [35,36,37], composes an ester sulfate content about 25-30% and a 3,6-anhydro-galactose (3,6-AG) about 28 to 35% [38,36]. This anionic carrageenan can interact very tightly with water molecule [39] and can be collaborated with glucomannan from stink lily on gelation process [40] with making intra- and inter-disulfide bind at network structure of gluten [13,41]. The κ-carrageenan can bind with limited free water molecule, form complexes compounds with water, and interact with gluten network [13]. However, the mobility of water mainly depends on changes in the hydrogen bond structure. The presence of hydrophilic components such as proteins, carbohydrates, glucomannan, κ-carrageenan and polyphenolic compounds in wet noodles can be involved in hydrogen bonding with water molecules that determine water mobility [13,34,41,42]. Thus, increasing the proportion of k-carrageenan can increase the amount of free water and weakly bound water in the wet noodles.

The swelling index or water absorption is the ability of a product to absorb water which is influenced by particle size, chemical composition, and water content [43]. The swelling index of wet noodles was determined by the presence of κ-carrageenan, protein, starch, glucomannan, and bioactive compounds of pluchea tea extract in dough. [13] said that glutelin proteins of wheat flour can involve intra-and intermolecular disulfide bonds to result a fibrous shape, and then globular gliadin protein of wheat flour can be bound at the glutenin skeleton by non-covalent bonds to be a unique networks structure of gluten. The addition of the glucomannan of stinky silky flour as a non-ionic hydrocolloid has good water holding capacity and can be made a stronger three-dimensional network structure. [44] informed that the glucomannan can fill the number of holes of the network structure of gluten that make a structure dense and stable. [13] underlined that glucomannan has many hydroxyl group in the structure that can be bound tightly with water by electrostatic forces and hydrogen bond. [41] said that the presence of κ-carrageenan in dough can be synergist with glucomannan to change sulfhydryl groups to be disulfide bonds in protein. [20] informed that bioactive compounds of pluchea tea extract are alkaloids, flavonoids, phenolics, phenol hydroquinone, saponins, tannins, sterols, terpenoids, and cardiac glycosides. Meanwhile [16] informed that pluchea leaves contain 1.79 g/100 g protein, 0.49 g/100 g fat, 0.20 g/100 g ash, 0.89 g/100 g insoluble fiber, 0.45 g/100 g dissolved fiber, total fiber 1.34 g/100 g, carbohydrates 8.65 g/100 g, calcium 251 g/100 g, β-carotene 1.225 g/100 g and vitamin C 30.17 g/100 g, and phenolic acid bioactive compounds 28.48± 0.67 mg/100 g body weight (chlorogenic acid 20±0.24 mg/100 g body weight, caffeic acid 8.65±0.46 mg/100 g body weight), total flavonoids 6.39 mg/100 g body weight (quercetin 5.21± 0.26 mg/100 g body weight, kaempferol 0.28 ± 0.02 mg/100 g body weight, myrisetin 0.09 ± 0.03 mg/100 g body weight), total anthocyanins 0.27 ± mg/100 g body weight, β-carotene 1.70 ± 0.05 mg/100 g body weight and total carotenoids 8.7 ± 0.34 mg/100 g body weight. [17,18,19] proved that pluchea leaves contain 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, and 4,5- O-dicaffeoylquinic acid. [45] informed that phenolic acid can be bound with protein and carbohydrate by non-covalent interactions, i.e. hydrophobic interaction, hydrogen bonding, electrostatic interaction, van der Waals interaction, and π-π stacking. The presence of κ-carrageenan proportion and pluchea tea extract addition that differed caused change of composition and various interaction of compounds that determined different swelling index of wet noodles.

The phenomena was caused by κ-carrageenan and bioactive compounds of pluchea tea extract, especially phenolic compounds, that involved the interaction with protein and carbohydrate in dough. κ-carrageenan can stabilized and supported a rigid structure of gluten. The hydrocolloid can avoid starch gelatinization process because it can bind tightly with water molecule caused lower the water activity. Supported by [13,46,41], κ-carrageenan can trap the free water molecule that starch can't absorb the water molecule and require higher energy to break the energy barrier required for the starch gelatinization process. Whereas [42,47,45] clarified that starch can be bound with polyphenol, including hydrophobic and electrostatic interactions and hydrogen bond that the hydrogen bond is dominant binding forces. This interaction can support releasing of amylose of starch gelatinization process that the cooking loss increased at the higher pluchea tea extract addition. The presence of polyphenol compounds of pluchea tea extract caused water competition with glutenin and gliadin of wheat flour that inhibited interaction between glutenin and gliadin to form gluten. According to [47], gluten and gliadin in a random coil structure can be aggregated by phenolic compounds and starch easily undergoes a gelatinization process where amylose interacts with polyphenolic compounds, through hydrogen bonds and hydrophobic interactions. The more protein in the form of random coil structure causes the protein to easily interact with polyphenols and come out of the noodles during the cooking process that the cooking loss increases.

The increasing κ-carrageenan proportion grew up tensile strength because this hydrocolloid could be made strong cross linking through inter-molecular and intra-molecular bonds involving the glutenin and gliadin of wheat flour protein, and glucomannan of stink lily flour. The more networks that are formed between the components of the noodles have an effect on the tensile strength of wet noodles, and vice versa [13,48]. The synergism effect of the wet noodles component determined water bind capacity and water mobility that established texture properties of wet noodles, this statement is supported by [34,40,41]. [49] also informed that the addition of hydrocolloids in the noodles-making process increases the viscosity and water absorption because the water binding and holding properties of hydrocolloids that can form gel. However, the addition of pluchea tea extract caused the tensile strength to decline because the polyphenol compounds of pluchea tea extract induced breakdown of the networking structure among the components of dough because there was water competition among them. Furthermore, the polyphenol compounds could be reacted with starch and protein because the formation of the gluten network was disrupted that gliadin and glutenin in the form of random coils and starch could be underwent an excessive gelatinization process. This opinion is supported by [13,42,41]. κ-carrageenan has a yellowish white color and has the ability to bind water molecules that it increases the lightness of wet noodles, while the pluchea tea extract contains polyphenolic compounds, such as tannins which can give the noodles a brown color that the lightness level is reduced.

This opinion was supported by [20,38]. The increase in yellowness was in line with the increase in lightness because the higher the water content value was caused by the ability of κ-carrageenan to bind water molecules, thereby increasing the brightness and the brown color contribution of the pluchea tea extract gave a brownish-yellow color of the wet noodles that the intensity of this color increased as indicated by the increased chroma value.

4.2. Bioactive Compounds and Antioxidant Activity

The stinky silky wet noodles K0L0 had the lowest TPC and TFC because there was contributed of phenolic content from wheat flour and egg. [50] said that wheat flour has phenolic acids including ferulic, caffeic, and p-coumaric acid. Moreover, the presence of TFC in the K0L0 sample is thought to be due to the presence of a thiol group in egg white which is able to chelate metal ions and is able to be conjugated with saccharides [51], as well as 3,5-diacetyltambulin compounds from stink lily flour [52]. While the TFC and TPC values in the K2L2 sample were dominantly contributed by the presence of phytochemical compounds in the pluchea tea extract. [20] explained that there are phytochemical compounds in the pluchea tea extract. [16, 17,18,19] also emphasized that pluchea leaves contain phenolic acids and flavonoids. The existence of a non-significant difference between treatments in the TPC and TFC assays indicated an interaction between the components in the dough that it affected the presence of free hydroxyl groups that could bind to the Folin Ciocalteus phenol reagent. as described by [13,41,42,45,47] glutenin, gliadin, glucomannan, κ-carrageenan, and polyphenol compounds are involved in the formation of networks structure in the dough so as to determine the quality of wet noodles. The interactions that occur involve various non-covalent interaction mechanisms that affect the presence of free hydroxyl groups. The TPC and TFC values of wet noodles in each treatment affected antioxidant activity (AOA). They determined AOA of wet noodles, usually positively correlated. [53] said that TPC and AOA were strongly correlated in seeds, sprouts and grasses of corn (Zea mays L.). [54] also informed that there is an excellent correlation coefficient between the TPC, TFC and antioxidant activities of *Phaleria macrocarpa* fruit. [55] explained that the high level of flavonoids and phenols in plant caused the antioxidant activity of *Grewia carpinifolia* extract. The antioxidant activity of phenolics is related to their redox properties which induced them to act as reducing agents, hydrogen donors, singlet oxygen quenchers and metal chelators. [56] underlined that DPPH free radical scavenging activity of polyphenol compounds of *T. pallida* extract was determined by hydrogen donating ability which it highly correlated. The potency of wet noodles as AOA was determined by reduced capability of DPPH free radical solution color from purple to be yellow color.

4.3. Sensory Properties

The analysis of sensory properties of the stink lily noodles was conducted by the hedonic scale scoring method with attribute the preference of color, taste, aroma, texture and overall. The result of the color preference test showed that the control treatment (K0L0) was the highest value because the treatment without the addition of pluchea tea extract not change the color of the wet noodles was yellowish-white. And then the treatment with the lowest color preference value was K0L1 due to the addition of this extract decreased the panelists' preference for the color because the noodles were darker and brownish color. [16,20] said that the color of the pluchea tea extract contributed to changing the color of this wet noodle originated from tannins, flavonoids, and chlorophyll. However, in this study, increasing the extract concentration did not significantly affect the panelists' preference for color when the proportion of κ-carrageenan increased, because the addition of stink lily flour and κ-carrageenan would increase the lightness of the wet noodles that the produced color of the wet noodles was brighter and preferred by panelists. This data was supported by the data from color rider analysis, where the results of the sensory test by the panelists were in line with the decrease in the lightness value, the increase in the reddish and yellowish values, the hue value showed the yellow-red color, and chroma value showed an increase in color intensity. The panelist preference of aroma from wet noodles was determined by the aroma from the material used to make wet noodles or the interaction of aroma produced from the reaction among the material composition. According to [57], stink lily flour has a musty aroma, and all wet noodles produced have a musty smell. Meanwhile, according to [58], κ-carrageenan is unscented that not contribute to wet noodles. The addition of pluchea tea extract decreased the panelists' preference for the aroma of wet noodles because the addition of the extract caused the wet noodles to smell like leaves (floral) and unpleasant and the panelists did not like it. Fragrant or unpleasant aroma comes from volatile compounds contained in pluchea leaves. According to [59], pluchea leaves have 66 volatile compounds, these volatile compounds play a role in forming the aroma in the hot water extract of pluchea leaf tea. According to [60], pluchea leaves contain volatile compounds contributed by aliphatic aldehyde group compounds or aromatic compounds that give a distinctive aroma, therefore the presence of these compounds in steeping water can give a specific aroma, i.e. fragrant (floral) in wet noodles. There was a difference in the effect of the proportion of κ-carrageenan and pluchea leaf tea extract on taste due to the contribution of taste produced by carrageenan and extract. According to [57,61], stink lily flour and κ-carrageenan do not have a distinctive or neutral taste, increasing the concentration of κ-carrageenan gives a higher preference value because noodles are considered to have a better texture that contributes to the assessment of taste. The increase in the concentration of pluchea tea extract caused the taste preference value of noodles to decrease significantly, this is due to the presence of tannins, catechins, and phenolic compounds in the pluchea tea extract which determined bitter and slightly astringent. The effect of κ-carrageenan proportion and tea extract to make wet noodles influenced panelist preference of texture because this hydrocolloid can be make strong cross linking through inter-molecular and intra-molecular bonds involving the glutenin and gliadin of wheat flour protein, and glucomannan of stink lily flour that determined water bind capacity and water mobility [34,40,41]. Presence of the polyphenol compounds of pluchea tea extract can be breakdown of the networking structure among the components of dough because of water competition of them. [13,42,41] said that the polyphenol compounds could be reacted with starch and protein to disrupt the gluten network and cause starch to undergo an excessive gelatinization process. The difference in the proportion of κ-carrageenan change the overall preference value of wet noodles to be significantly different overall compared to the control, this was because the proportion of κ-carrageenan influenced the all sensory attribute (color, aroma, and taste). The addition of pluchea tea extract in wet noodles decreased the overall preference value because the addition of extract affected the organoleptic characters tested due to the content of secondary metabolites of pluchea leaves, such as flavonoids, phenols, and tannins that could affect the taste, aroma, the color, and texture of the noodles. Based on spider web graph showed that K2L0 was the best treatment of stink lily wet noodles. It was also supported by better physicochemical properties than the control, including yellowish white wet noodles, better swelling index, lower cooking loss, higher tensile strength value, and lower moisture content. However, this K2L0 treatment did not have the highest TPC, TFC, and AOA, i.e. 0.4997±0.0450; 0.0888±0.0084; and 0.5318±0.0052, respectively.

5. Conclusions

The use of κ-carrageenan proportions and pluchea leaf tea extract had a significant effect on the cooking quality and sensory properties of stink lily wet noodles. Statistical analysis at p=5% showed that there was an interaction effect of the proportion of κ-carrageenan and pluchea leaf tea extract on the swelling index, yellowness, chroma, hue, TPC, TFC, AOA, the preference value for color, aroma, and overall. While the moisture content of wet noodles was only affected by the proportion of κ-carrageenan, for tensile strength, cooking loss, lightness, and redness, and the preference value for texture and taste were influenced by the proportions of κ-carrageenan and the concentration of pluchea leaf tea extract, respectively. The best treatment based on the spider web graph showed that the K0L2 treatment had the largest area 79.16 cm^2 and a preference score of 15.8 with a very like category, this is in accordance with the results of physicochemical and sensory tests, but it was no correlated with the highest bioactive content (TPC and TFC) and antioxidant activity.

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Sample Availability: Samples of stink lily wet noodles and pluchea leaf tea are available from the authors.

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Indonesia, June 30th, 2022

Dear the Editorial Board of the Molecules Journal

Greetings,

I, the undersigned below:

Name : Dr. Paini Sri Widyawati, S.Si., M.Si.

Institution : Food Technology Department, Agricultural Technology Faculty, Widya Mandala Surabaya, Catholic University, Indonesia

has submitted a manuscript with the title "**The Effect of κ-Carrageenan Proportion and Hot Water Extract of *Pluchea Indica* Less Leaf Tea to Quality and Sensory Properties of Stink Lily (*Amorphophallus Muelleri*) Wet Noodles**" in the Molecules journal for publication.

Thank you for your attention

Sincerely,

Dr. Paini Sri Widyawati, S.Si., M.Si.

Indonesia, June 30th, 2022

Dear the Editorial Board of the Molecules Journal

Greetings,

I, the undersigned below:

Name : Dr. Paini Sri Widyawati, S.Si., M.Si.

Institution : Food Technology Department, Agricultural Technology Faculty, Widya Mandala Surabaya, Catholic University, Indonesia

submit an application to be able to copyrights to the publication entitled "**The Effect of κ-Carrageenan Proportion and Hot Water Extract of *Pluchea Indica* Less Leaf Tea to Quality and Sensory Properties of Stink Lily (*Amorphophallus Muelleri*) Wet Noodles**" based on the applicable provisions of the Molecules journal.

Thank you for your attention

Sincerely,

Dr. Paini Sri Widyawati, S.Si., M.Si.

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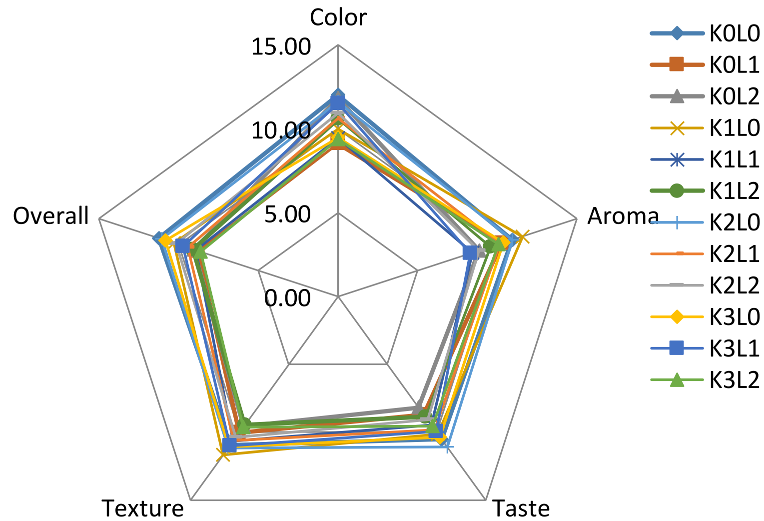

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2. Manuscript Information Overview (4-7-2022)
-Correspondence
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[Molecules] Manuscript ID: molecules-1821369 - Assistant Editor Assigned

Jasna Sotirovic <sotirovic@mdpi.com> Fri, Jul 1, 2022 at 5:15 PM
Reply-To: sotirovic@mdpi.com
To: Paini Sri Widyawati <paini@ukwms.ac.id>
Cc: Jasna Sotirovic <sotirovic@mdpi.com>, Thomas Indarto Putut Suseno <thomasindartoftp@gmail.com>, Theresia Endang Widoeri Widyastuti <widoeri@ukwms.ac.id>, Anna Ingani Widjajaseputra <anna27july@yahoo.com>, Vincentia Wilhelmina Moeljadi <vincentiawilhelmina@gmail.com>, Sherina Tandiono <sherinatandiono@gmail.com>, Molecules Editorial Office <molecules@mdpi.com>

Dear Dr. Widyawati,

Your paper has been assigned to Jasna Sotirovic, who will be your main point of contact as your paper is processed further.

Journal: Molecules
Manuscript ID: molecules-1821369
Title: The Effect of k-Carrageenan Proportion and Hot Water Extract of Pluchea Indica Less Leaf Tea to Quality and Sensory Properties of Stink Lily (Amorphophallus Muelleri) Wet Noodles
Authors: Paini Sri Widyawati *, Thomas Indarto Putut Suseno, Theresia Endang Widoeri Widyastuti, Anna Ingani Widjajaseputra, Vincentia Wilhelmina Moeljadi, Sherina Tandiono

Received: 01 July 2022
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Best regards,
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[Molecules] Manuscript ID: molecules-1821369 - Ethical Questions Confirmation

Molecules Editorial Office <molecules@mdpi.com> Fri, Jul 1, 2022 at 5:11 PM
Reply-To: sotirovic@mdpi.com
To: Paini Sri Widyawati <paini@ukwms.ac.id>
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Dear Dr. Widyawati,

I am writing to you because your manuscript, The Effect of k-Carrageenan Proportion and Hot Water Extract of Pluchea Indica Less Leaf Tea to Quality and Sensory Properties of Stink Lily (Amorphophallus Muelleri) Wet Noodles of molecules-1821369, describes the use of cell lines or non-model plant species but does not include relevant source information.

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[Molecules] Manuscript ID: molecules-1821369 - Ethical Questions Confirmation

Paini Sri Widyawati <paini@ukwms.ac.id> Fri, Jul 1, 2022 at 7:45 PM
To: sotirovic@mdpi.com

Dear Ms. Jasna Sotirovic

I inform you about the plant species that I use in my research
a. Database Name: *Pluchea indica* (L.) Less.
Accession Numbers:https://www.gbif.org/species/3132728

b. Database Name :*Amorphophallus muelleri Blume*
Accession Numbers: https://www.gbif.org/species/2871712

Thanks for attention

The Best Regards

Paini Sri Widyawati
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Manuscript Information Overview

Manuscript ID	**molecules-1821369**
Status	Under review
Article type	Article
Title	The Effect of k-Carrageenan Proportion and Hot Water Extract of Pluchea Indica Less Leaf Tea to Quality and Sensory Properties of Stink Lily (Amorphophallus Muelleri) Wet Noodles
Journal	*Molecules* (https://www.mdpi.com/journal/molecules)
Section	Food Chemistry (https://www.mdpi.com/journal/molecules/sections/food_chemistry)
Special Issue	Advances in Functional Foods (https://www.mdpi.com/journal/molecules/special_issues/adv_func_food)
Abstract	The study aimed to determine the effect of the proportion of k-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles. The research design used was a Randomized Block Design with two factors, i.e. the difference in the proportion of k-carrageenan (K) (0, 1, 2, and 3% b/b) and the addition of hot water extract of Pluchea indica Less leaf tea (L) (0, 15, and 30% b/v) with 12 treatment level (K0L0, K0L1, K0L2, K1L0, K1L1, K1L2, K2L0, K2L1, K2L2, K3L0, K3L1, K3L2). The data were analyzed by the Anova at = 5% and continued with the Duncan's Multiple Range Test at p= 5% and the best treatment was determined by the Spider web method based on sensory assay by a hedonic method. The proportions of -carrageenan and the concentration of pluchea tea extract had a significant effect on cooking quality and sensory properties. However, the interaction of the two factors affected the swelling index, yellowness (b*), chroma (C), hue (h), total phenol content (TPC), total flavonoid content (TFC), and DPPH free radical scavenging assay (AOA). The best treatment of wet noodles was K2L0 with a preference score of 15.8. The binding of -carrageenan and phenolic compounds to make networking structure by intra- and inter-disulfide bind between glucomannan and gluten, was thought to affect the cooking quality, sensory properties, bioactive compounds (TPC and TFC), and AOA.
Keywords	Amorphophallus muelleri, Pluchea indica Less, wet noodles, quality and sensory properties
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Article

The Effect of κ-Carrageenan Proportion and Hot Water Extract of *Pluchea Indica* Less Leaf Tea to Quality and Sensory Properties of Stink Lily (*Amorphophallus Muelleri*) Wet Noodles

Paini Sri Widyawati[1,†,*], Thomas Indarto Putut Suseno[1], Anna Ingani Widjajaseputra[1], Theresia Endang Widoeri Widyastuti[1], Vincentia Wilhelmina Moeljadi[1], and Sherina Tandiono[1]

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Abstract : The study aimed to determine the effect of the proportion of κ-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles. The research design used was a Randomized Block Design with two factors, i.e. the difference in the proportion of κ-carrageenan (K) (0, 1, 2, and 3% b/b) and the addition of hot water extract of *Pluchea indica Less* leaf tea (L) (0, 15, and 30% b/v) with 12 treatment level (K0L0, K0L1, K0L2, K1L0, K1L1, K1L2, K2L0, K2L1, K2L2, K3L0, K3L1, K3L2). The data were analyzed by the Anova at α= 5% and continued with the Duncan's Multiple Range Test at α= 5% and the best treatment was determined by the Spider web method based on sensory assay by a hedonic method. The proportions of κ-carrageenan and the concentration of pluchea tea extract had a significant effect on cooking quality and sensory properties. However, the interaction of the two factors affected the swelling index, yellowness (b*), chroma (C), hue (h), total phenol content (TPC), total flavonoid content (TFC), and DPPH free radical scavenging assay (AOA). The best treatment of wet noodles was K2L0 with a preference score of 15.8. The binding of κ-carrageenan and phenolic compounds to make networking structure by intra- and inter-disulfide bind between glucomannan and gluten, was thought to affect the cooking quality, sensory properties, bioactive compounds (TPC and TFC), and AOA.

Keywords: *Amorphophallus muelleri*, *Pluchea indica* Less, wet noodles, quality and sensory properties

1. Introduction

Noodles are a rice substitute commodity that is much favored by the public [1], especially in China, Indonesia, India, Japan, Vietnam, and the United States. Basically, noodles are divided into wet noodles and dry noodles. Indonesia is the second country in the world that likes to consume noodles [2]. In 2017, the consumption of instant noodles achieves by 180.2 packets per head in the world, and in Indonesia, the consumption of wet noodles shows that all age groups and education levels like it [3]. Meanwhile, instant noodle consumption in 2020 reached 12,640 million portions [2]. Noodles are generally made from wheat flour, the use of local food ingredients based on carbohydrates, including stink lily flour, can reduce the consumption of wheat flour which is quite high in Indonesia, the average consumption of wheat flour for the Indonesian population in 2019 is 17.8 kg/capita/year [4].

Stink lily flour (*Amorphophallus* oncophyllus) is a group of *Araceae* that contains glucomannan oligosaccharides around 15-64% dry base [5] or more than 60% [6]. Glucomannan is a heteropolysaccharide consisting of 67% D-mannose and 33% D-glucose and has β-1,4 and β-1,6 glycoside bonds [7], which can reduce body weight, sugar content blood levels, LDL cholesterol levels and prolong gastric emptying time [8,9]. Stink lily flour has a glycemic index of 85 which is lower than the glycemic index of glucose which is considered to be 100 [7]. The use of stink lily flour in the manufacture of wet noodles is able to replace the role of gliadin and glutenin proteins in the formation of gluten with an elastic texture [10]. Polysaccharides in stink lily flour can dissolve in water to form a thick solution, form a gel, expand, and melt like agar [11], can increase the elasticity and cohesiveness [12,13] with increasing α-helix and β-sheet stuctures of wet noodles [13]. However, the higher the substitution of stink lily flour, the lower the texture preference because the noodles break easily and are sticky [12]. Therefore, it is necessary to add hydrocolloids, including carrageenan, because they can increase elasticity [14]. The combination of the use of glucomannan and carrageenan can form a strong and elastic gel [15].

The addition of hot water extract from pluchea leaf tea in making stink lily wet noodles is expected to increase the functional value of wet noodle products. Pluchea leaves contain nutrients, such as: protein 1.79 g/100 g, fat 0.49 g/100 g, ash 0.20 g/100 g, insoluble fiber 0.89 g/100 g, soluble fiber 0.45 g/100 g, total fiber 1.34 g/100 g, carbohydrates 8.65 g/100 g, calcium 251 g/100 g, β-carotene 1.225 mg/100 g and vitamin C 30.17 mg/100 g as well as bioactive compounds, such as: phenolic acid 28.48±0.67 mg/100 g wb (chlorogenic acid 20±0.24 mg/100 g wb, caffeic acid 8.65±0.46 mg/100 g wb), total flavonoids 6.39 mg/100 g wb (quercetin 5.21±0.26 mg/100 g wb, kaempferol 0.28±0.02 mg/100 g wb, myricetin 0.09± 0.03 mg/100 g wb), total anthocyanins 0.27±0.01 mg/100 g wb, β-carotene 1.70±0.05 mg/100 g wb, and total carotenoids 8.7±0.34 mg/100 g wb [16], 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, and 4,5-O-dicaffeoylquinic acid [17,18,19]. Meanwhile, hot water extract of 2% pluchea leaf tea (2 g/100 ml) contains a total phenolic content of 9.3 mg EAG/ g, total flavonoid content 22.0 mg EC/ g, DPPH free radical scavenging activity DPPH 27.2 mg EAG/ g, and reduced iron ion 10.2 mg EAG/ g [20], due to the presence of phytochemicals (alkaloids, flavonoids, phenolics, sterols, cardiac glycosides, phenol hydroquinone, tannins, terpenoids, and saponins) [20], which has been shown to have potential as an antioxidant [20,21] and antidiabetic [22]. The effect of using κ-carrageenan and water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles has not been studied in detail. Therefore, the purpose of this study was to determine the effect of the proportion of κ-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles.

2. Materials and Methods

2.1. Chemicals and Reagents.

The compounds 2,2-diphenyl1-picrylhydrazyl (DPPH), sodium carbonate, gallic acid, and (+)-catechin were purchased from Sigma-Aldrich (St. Louis, USA). Methanol, folin ciocalteus phenol, sodium nitric, aluminium chloride, κ-carrageenan, and sodium hydroxide were purchased from Merck (New Jersey, USA).

2.2. Preparation of Pluchea Leaf Tea.

Pluchea leaves on each branch number 1-6 from the shoot were collected, sorted, and dried at an ambient temperature for 7 days until moisture content 11.16±0.09% dry base. And then dried leaves were powdered to get 45 mesh size [23]. Futhermore the leaf powder was heated by drying oven (Binder, Merck KGaA, Darmstadt, Germany) at 120^{o}C for 10 min. Then dried powder of pluchea leaves was packed 2 g in tea bag that called pluchea leaf tea.

2.3. Preparation of Hot Water Extract of Pluchea Leaf Tea.

Pluchea leaf tea in tea bag was extracted by hot water at 95^{o}C for 1 min to get 15 and 30% (b/v) concentrations (Table 1). And then each concentration of extract was used to make stink lily wet noodles.

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

Materials	Concentration of hot water extract of pluchea leaf tea (% b/v)		
	0	15	30
Pluchea leaf tea (g)	0	4.5	9
Hot water (mL)	30	30	30

2.4. Stink Lily Wet Noodles Making.

Stink lily wet noodles were made with mixing of wheat and stink lily flour, and κ-carrageenan at 1, 2, and 3% (b/b) concentrations. And then the mixture was added egg, salt, baking powder, and hot water extract of pluchea leaf tea and kneaded to form a dough by a mixer machine. Then the dough was passed through a roller to make face bands the desired thickness and cut through rollers using cutting blades. The formula of stink lily wet noodle was showed at Table 2.

2.5. Stink Lily Wet Noodles Extraction.

125 g each sample from stink lily wet noodles was weighed (Ohaus, Ohaus Instruments (Shanghai) Co.,Ltd. RRT) and then they were dried by cabinet drying at 60^{o}C for 4 hours to get dried noodles. Next each sample was powdered by chopper machine at second speed for 35 seconds and then 20 g powdered sample was added 50 mL methanol by shaking water bath at 35^{o}C, 70 rpm for 1 hour. Filtrate was separated by Whatman filter paper grade 40 and residue was extracted again with same pattern way. Filtrate was collected and dried by rotary evaporator (Buchi Rotary Evaporator; Buchi Shanghai Ltd, RRT) at 0.2-0.3 atm, 50^{o}C for 60 min until getting 2 mL extract. Then extract was kept at 0^{o}C before further study.

2.6. Swelling Index Assay

Swelling index or water absorption is the ability of noodles to absorb water after gelatinization during the boiling process [24]. The principle of water absorption testing is to determine the amount of water absorbed in wet noodles at a certain temperature and time. The amount of water absorbed in wet noodles can be determined from the difference between the weight of the noodles after and before being boiled divided by the weight of the noodles before boiling [25].

2.7. Cooking Loss Assay

Cooking loss is one of the important quality parameters in wet noodles to determine the quality of wet noodles after cooking [26]. The cooking loss test for stink lily stink lily wet noodles was carried out to determine the number of solids that came out of the noodle strands during the cooking process, namely the release of a small portion of starch from the noodle strands.

2.8. Determination of Tensile Strength of Wet Noodles

The tensile strength (elongation) is one important parameter of texture analysis in noodle products. 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 principle of the texture analyzer is to prepare a suitable probe for the test, then place the noodle samples on the table under the probe. The elongation of the noodles was individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. The same procedure was done to tighten the other end of the strip to the upper roller arm. Elongation, which was the maximum force to deform and break noodles by extension, was measured using a test speed of 3.0 mm/s, with a 100 mm distance between two rollers. Deformations were recorded using the software during the extension and are expressed as a graph. The elongation at breaking was calculated per gram.

2.9. Color Measurement

The noodle samples were measured by a colorimeter (Minolta CM-3500D; Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab L*, a* and b* values were recorded as described by [27]. And then L*, a* and b* values were collected. The L* value was stated the position on the white/black axis, the a* value the position on the red/green axis, and the b* value the position on the yellow/blue axis. The measurements were done in triplicate and the readings were averaged.

2.10. Total Phenol Content Assay

Total phenol content (TPC) of stink lily wet noodles was analyzed by spectrophotometric method using folin ciocateus phenol reagent [28]. Principles assay of the TPC assay are interaction between phenolic compounds and phosphomolybdic/ phosphotungstic acid complexes based on the transfer of electrons in alkaline medium from phenolic compounds to form a blue chromophore constituted by a phosphotungstic/ phosphomolybdenum complex. The reduced folin ciocalteus phenol reagent is detected by a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 760 nm and gallic acid is used as the reference standard compound and results are expressed as gallic acid equivalents (mg/kg wet noodles).

2.11. Total Flavonoid Content Assay

Total flavonoid content of samples was measured by spectrophotometric method with reaction between $AlCl_3$ and $NaNO_2$ with aromatic ring of flavonoid compounds [29]. And then mixture was added aluminium chloride to result yellow solution. Next, addition of NaOH solution in mixture caused red solution that was measured by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 510 nm. As standard reference compound used was (+) catechin and results were expressed as catechin equivalents (mg/kg wet noodles).

2.12. DPPH Free Radical Scavenging Activity Assay

DPPH free radical scavenging activity was measured by the spectrophotometric method [30]. This method is used to determine the antioxidant capacity of a compound from an extract or other biological sources, based on transferring from the odd electron of a nitrogen atom in DPPH is reduced by receiving a hydrogen atom from antioxidants to result in DPPH-H with yellow-colored solution. Reaction between DPPH in methanol solution with samples was measured by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 517 nm. As standard reference compound used was gallic acid and results were expressed as gallic acid equivalents (mg/kg wet noodles).

2.13. Sensory Evaluation

Sensory assay was carried out to determine the level of panelist acceptance of wet noodles substituted with stink lily flour with the addition of carrageenan and hot water extract of pluchea leaf tea [31]. The test was carried out using the hedonic scale scoring method. This method is designed to measure the level of panelist preference for the product by rating the level of preference for the product being tested. Samples were served in dishes coded with random three-digit numbers that carried out using a completely randomized design (CRD) trial using 100 untrained panelists. Each panelist is faced with 15 (fifteen) samples and a questionnaire containing test instructions, and is asked to give each sample a score according to their level of preference. The parameters tested were taste, aroma, texture, color, and overall preference of wet noodles substituted with stink lily flour. The best treatment of samples was determined by spider web method that was correlated by the large area of graph [32].

2.14. Experiment Design and Statistical Analysis

The research design used was a randomized block design with two factors, i.e. differences in the proportion of κ-carrageenan (K) and differences in the concentration of pluchea tea extract (L) added to wet noodles. The proportion of κ-carrageenan consisted of 4 (four) treatment levels, including 0% (K0), 1% (K1), 2% (K2), 3% (K3) and the concentration of pluchea tea extract consisted of 3 (three) levels, i.e. 0% (L0), 15% (L1), and 30% (L2). Each treatment was repeated 3 (three) times in order to obtain 36 (thirty-six) experiment units. The experiment design of stink lily noodles can be seen in Table 2.

The data are presented as mean ± SD of the triplicate determinations and were analyzed using ANOVA, followed by Duncan multiple range test for significant differences using the SPSS 17.0 software (SPSS Inc. Chicago, IL, USA). Values were considered significant at p = 0.05.

3. Results

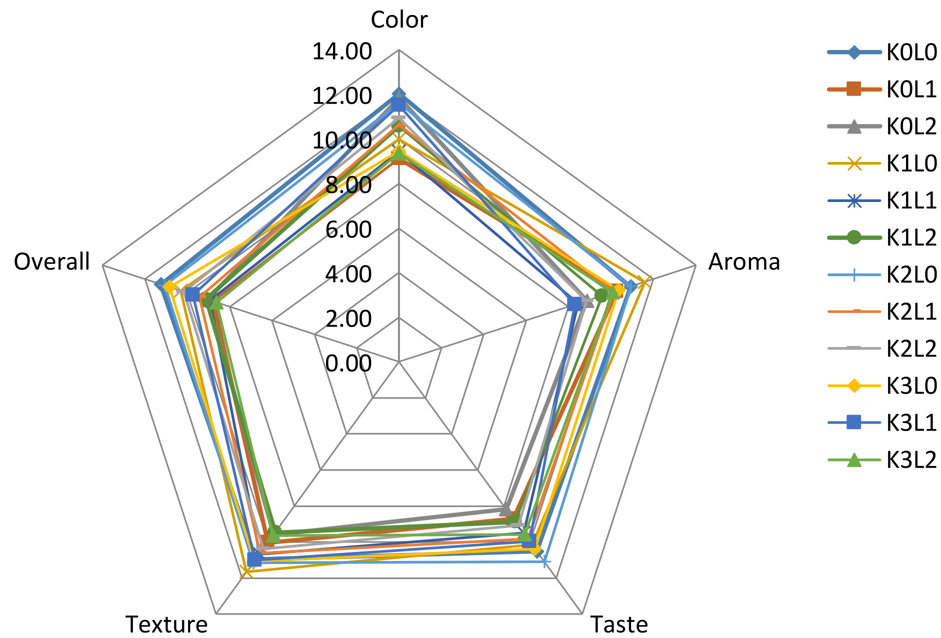
3.1. Cooking Quality

The evaluated cooking properties of the stink lily wet noodles were showed in Table 3 and the stink lily wet noodles product was showed at Figure 1. The level of cooking was estimated by the moisture content, swelling index, cooking loss and tensile strength from noodles. Based on statistically analysis by Anova at p=0.05, showed that the increasing of κ-carrageenan proportion went up significant difference of moisture content of wet noodles, but the addition of pluchea leaf hot water extract and the interaction effect of the proportion of κ-carrageenan and the addition of the extract no influenced to moisture content of wet noodles. The moisture content value was ranged from 62.83±0.58 to 65.83±0.22. The sample K3L0 had the highest moisture content and K0L2 had the lowest moisture content. Furthermore the addition of the κ-carrageenan proportion or pluchea tea extract had a significantly different effect such as the interaction effect of the addition of the two parameters, on the swelling index or water absorption value of wet noodles based on statistical analysis at p=0.05. The water absorption value was ranged from 142.25±0.39% to 162.21±0.25%. The treatment with the lowest swelling index was K0L2 and the highest was K3L0. Whereas the cooking loss of wet noodles decreased significantly with the addition of the proportion of κ–carrageenan but increased significantly with the addition of pluchea tea extract. The cooking loss of wet noodles was ranged 17.83±0.4% to 20.13±0.7%. K0L2 was treatment with the biggest cooking loss and K3L0 was treatment with the smallest cooking loss. Tensile strength value of stink lily noodles was significant different because there was an interaction effect of κ-carrageenan proportion and pluchea tea extract addition . Tensile strength wet noodles was ranged 0.096±0.004 N to 0.174±0.015 N. The analysis of stink lily noodles color showed that lightness had a significant increase in with an increasing proportion of carrageenan and decreased with increasing pluchea tea extract used because of the color effect of carrageenan and pluchea tea extract. The lightness of wet noodles was ranged 67.80±0.22 to 74.50±0.23. The effect of the κ-carrageenan and pluchea tea extract color also influenced significantly redness of wet noodles. The redness of wet noodles was ranged 1.20±0.04 to 3.30±0.23. The interaction effect of κ-carrageenan and pluchea tea extract addition was appeared on yellowness, chroma and hue values. The yellowness, chroma and hue values were ranged 16.90±0.27 to 30.00±0.07, 17.00±0.28 to 30.10±0.03, and 83.70±0.07 to 86.40±0.02, respectively.

Table 2. The formula of stink lily wet noodles

Material	K0L0	K0L1	K0L2	K1L0	K1L1	K1L2	K2L0	K2L1	K2L2	K3L0	K3L1	K3L2
Wheat flour (g)	120	120	120	120	120	120	120	120	120	120	120	120
Stink lily flour (g)	30	30	30	28.5	28.5	28.5	27	27	27	25.5	25.5	25.5
κ-Carrageenan (g)	0	0	0	1.5	1.5	1.5	3	3	3	4.5	4.5	4.5
Egg (g)	30	30	30	30	30	30	30	30	30	30	30	30
Salt (g)	3	3	3	3	3	3	3	3	3	3	3	3
Baking Powder (g)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water (mL)	30	0	0	30	0	0	30	0	0	30	0	0
Hot water extract of pluchea leaves 15% (mL)	0	30	0	0	30	0	0	30	0	0	30	0
Hot water extract of pluchea leaves 30% (mL)	0	0	30	0	0	30	0	0	30	0	0	30
Total (g)	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5

Note: K0 = wheat flour: stink lily flour: κ-carrageenan = 80 : 20 : 0
K1 = wheat flour: stink lily flour: κ-carrageenan = 80 : 19 : 1
K2 = wheat flour: stink lily flour: κ-carrageenan = 80 : 18 : 2
K3 = wheat flour: stink lily flour: κ-carrageenan = 80 : 17 : 3
L0 = concentration of hot water extract from pluchea leaf tea = 0%
L1 = concentration of hot water extract from pluchea leaf tea = 15%
L2 = concentration of hot water extract from pluchea leaf tea = 30%


Color
14.00
12.00
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8.00
6.00
4.00
2.00
0.00
Aroma
Taste
Texture
Overall
K0L0
K0L1
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K3L1
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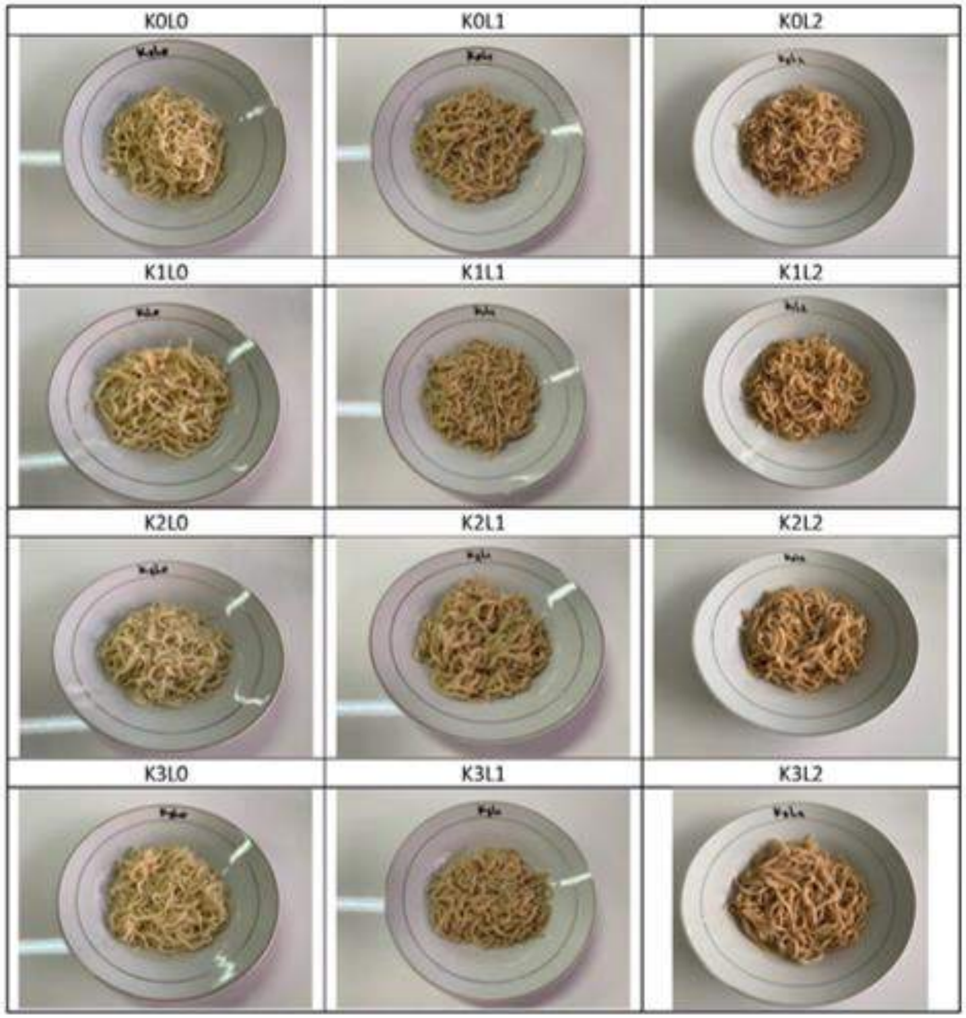

Figure 1. Stink Lily Noodles

Note: K0 = wheat flour: stink lily flour: κ-carrageenan = 80 : 20 : 0, K1 = wheat flour: stink lily flour: κ-carrageenan = 80 : 19 : 1 , K2 = wheat flour: stink lily flour: κ-carrageenan = 80 : 18 : 2 , K3 = wheat flour: stink lily flour: κ-carrageenan = 80 : 17 : 3, L0 = concentration of hot water extract from pluchea leaf tea = 0%, L1 = concentration of hot water extract from pluchea leaf tea = 15% , L2 = concentration of hot water extract from pluchea leaf tea = 30%

Table 3. Color, Moisture Content, Swelling Index, Cooking Loss, and Tensile Strength of Stink Lily Noodles

Samples	Color					Moisture Content (%)	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (N)
	L*	a*	b*	C	h				
K0L0	73.00 ± 0,06	1.20 ± 0.06	16.90 ± 0.25a	17.00±0.31a	86.40±0.00g	64.15±0.70	148.90±0.15c	18.83±0.44	0.106±0.002
K0L1	68.70 ± 0.35	2.60 ± 0.06	26.50 ± 0.32d	26.50±0.29c	84.40±0.21bc	63.66±0.38	146.36±0.27b	19.06±0.43	0.1051±0.001
K0L2	67.80 ± 0.20	2.80 ± 0.06	27.80 ± 0.46ef	27.80±0.45e	84.20±0.32abc	62.83±0.58	142.25±0.39a	20.13±0.71	0.116±0.006
K1L0	73.40 ± 0.25	1.30 ± 0.06	17.30 ± 0.15ab	17.30±0.15a	85.70±0.21f	64.42±0.80	149.63±0.34d	18.47±0.31	0.086±0.005
K1L1	69.00 ± 0.36	2.80 ± 0.12	27.30 ± 0.45e	27.40±0.50d	84.20±0.15a	62.95±0.68	146.65±0.43b	19.36±0.92	0.103±0.004
K1L2	68.30 ± 0.15	3.00 ± 0.12	28.60 ± 0.12g	28.70±0.15f	84.00±0.15abc	63.37±1.04	148.85±057c	19.76±0.90	0.108±0.005
K2L0	73.70 ± 0.10	1.50 ± 0.00	17.70 ± 0.26bc	17.80±.23a	85.20±0.06de	64.67±1.08	155.67±0.46h	18.18±0.45	0.098±0.002
K2L1	69.40± 0.15	3.00 ± 0.06	28.20 ± 0.15fg	28.40±0.15f	83.80±0.17ab	63.74±0.75	150.96±0.71e	18.62±0.41	0.106±0.005
K2L2	68.70 ± 0.06	3.10 ± 0.15	29.30 ± 0.00h	29.40±0.06g	84.00±0.15abc	64.25±1.60	154.82±0.44g	19.34±0.77	0.114±0.003
K3L0	74.50 ± 0.23	1.70 ± 0.12	18.10 ± 0.00c	18.10±0.06b	84.60±0.21cd	65.83±0.22	162.21±0.25i	17.83±0.41	0.110±0.003
K3L1	69.80 ± 0.50	3.20 ± 0.06	29.30 ± 0.12h	29.30±0.06g	83.80±0.53ab	64.57±1.78	153.35±0.15f	18.36±0.17	0.124±0.007
K3L2	69.00 ± 0.20	3.30 ± 0.26	30.00 ± 0.06i	30.10±0.06h	83.60±0.06a	65.49±1.04	159.59±0.52i	19.22±0.84	0.126±0.008

*The results were presented as SD of the means that were gotten by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different, $p<0.05$.

3.2. Bioactive Compounds and Antioxidant Activity

Bioactive compounds analyzed included total phenol content (TPC) and total flavonoid content (TFC). The analysis data showed that the TPC and TFC increased significantly due to the interaction effect between the proportion of κ-carrageenan and the addition of pluchea tea extract (Table 4). The results of the analysis showed that the control sample K0L0 had the lowest total phenol, i.e. 0.3409 ± 0.0338 mg GAE/kg dry noodles. The K2L2 sample had the highest total phenol, which was 1.1963 ± 0.0272 mg GAE/kg dry noodles. This result was suitable with the TFC value of wet noodles where K0L0 had the lowest TFC value and K2L2 had the highest value, i.e. 0.0534 ± 0.0036 and 1.3364 ± 0.04601 mg CE/kg dry noodles, respectively. The high and low values of TPC and TFC were correlated with AOA. The higher the TPC and TFC values, the higher the AOA value. The DPPH free radicals scavenging activity (AOA) of wet noodles was determined significantly by the interaction effect of adding the proportion of κ-carrageenan and pluchea tea extract. K0L0 had the lowest AOA value and K2L2 had the highest AOA value, i.e. 0.4143±0.0060 and 0.7576±0.0092 mg GAE/kg dry noodles, respectively.

3.3. Sensory Properties

The evaluated sensory properties of the stink lily noodles were shown in Table 5. Parameter sensory that analyzed included aroma, color, taste, texture, and overall acceptability. The method used for sensory assay of stink lily noodles was hedonic scale scoring or a test of the level of consumer preference for a product by giving an assessment or score on a certain trait [33]. Organoleptic testing of stink lily wet noodles was presented to 100 untrained panelists aged 17-25 years. Panelists are asked to give scores or numbers based on their level of preference for certain treatments. The value scale used was 1-15, where a value of 0-3.0 indicated "strongly dislike", a value of 3.1-6.0 "does not like", a value of 6.1-9.0 "neutral", a value of 9.1-12.0 “like”, and 12.1-15.0 “like very much”. The results of statistical tests by ANOVA at α=5% showed that interaction effect of each treatment significantly influenced the panelists' preference for noodle color. The preference value of stink lily noodles color was ranged from 9.12 to 12.02 (like). The highest color preference value was the control treatment (K0L0) and the treatment with the lowest color preference value was K0L1. The interaction effect of each treatment were significantly determined the panelists' preference for the aroma. The preference value for the aroma of wet noodles was ranged from 8.29 to 11.58 (neutral-like). The treatment with the highest preference value was stink lily noodles K1L0 and the treatment with the lowest preference value was K3L2 treatment. The preference value of noodles taste was only affected by κ-carrageenan proportion or extract concentration. The preference value for the wet noodle taste was ranged from 8.18 to 11.08 (neutral-like). The treatment with the highest taste preference value was K2L0 while the treatment with the lowest taste preference value was K0L2. Increasing the proportion of carrageenan to 2% increased the preference value for taste, after that it decreased with the addition of the proportion of 3% carrageenan. While increasing the concentration of pluchea leaf tea extract decreased the panelists' preference for taste. The results of statistical tests using ANOVA at p= 5% showed that the addition of extract only significantly influenced the panelists' preference for noodles texture. In this study, the preference for wet noodles texture was ranged from 9.46 to 11.66 (like).

Table 4. Total Phenol Content, Total Flavonoid Content, and DPPH Free Radical Scavenging Activity of Stink Lily Noodles

Samples	TPC (mg GAE/g dry noodles)	TFC (mg CE/g dry noodles)	DPPH Scavenging Activity (mg GAE/g dry noodles)
K0L0	0.3409 ± 0.0338^{a}	0.0571 ± 0.0035^{a}	0.4143 ± 0.0060^{a}
K0L1	0.9480 ± 0.0273^{d}	0.7044 ± 0.0065^{c}	0.7424 ± 0.0159^{c}
K0L2	1.0991 ± 0.0466^{e}	1.1087 ± 0.0065^{d}	0.7571 ± 0.0013^{c}
K1L0	0.4576 ± 0.0396^{b}	0.0821 ± 0.0017^{a}	0.5229 ± 0.0259^{b}
K1L1	0.9243 ± 0.0774^{d}	0.7348 ± 0.0030^{c}	0.7497 ± 0.0055^{c}
K1L2	1.0047 ± 0.0704^{d}	1.0910 ± 0.0949^{d}	0.7509 ± 0.0012^{c}
K2L0	0.4997 ± 0.0450^{b}	0.0888 ± 0.0084^{a}	0.5318 ± 0.0052^{b}
K2L1	0.9648 ± 0.0248^{d}	0.7181 ± 0.0179^{c}	0.7477 ± 0.0043^{c}
K2L2	1.1963 ± 0.0272^{f}	1.3364 ± 0.0460^{e}	0.7576 ± 0.0092^{c}
K3L0	0.5267 ± 0.0070^{b}	0.2181 ± 0.0025^{b}	0.5873 ± 0.0197^{b}
K3L1	0.8070 ± 0.0307^{c}	0.7264 ± 0.0385^{c}	0.7508 ± 0.0077^{c}
K3L2	1.1446 ± 0.0636^{ef}	1.0674 ± 0.0627^{d}	0.7505 ± 0.0066^{c}

*The results were presented as SD of the means that were gotten by quadruplicate. Means with different superscripts (alphabets) in the same column are significantly different, $p<0.05$.

The increasing the addition of extracts decreased the level of the texture preference of wet noodles. The overall preference value of wet noodles showed that there was the interaction effect between the proportion of κ-carrageenan and the addition of pluchea tea extract. The preference value for the overall of wet noodles was ranged from 8.62 to 11.24 (neutral-like). The treatment with the highest preference value was stink lily noodles K0L0 and the treatment with the lowest preference value was K3L2. Determination of the best treatment for differences in the proportions of κ-carrageenan and the addition of pluchea tea extract on wet noodles was determined using the spider web method based on organoleptic parameters (color, aroma, taste, texture and overall). The spider web graph can be seen in Figure 2. Data showed that the treatment with the largest area was K2L0, i.e. wet noodles with the proportion of κ-carrageenan 2 % with the addition of 0% pluchea tea extract. The area of the K2L0 treatment area was 79.16 cm^2 and had a preference score of 15.8 with a very like category.

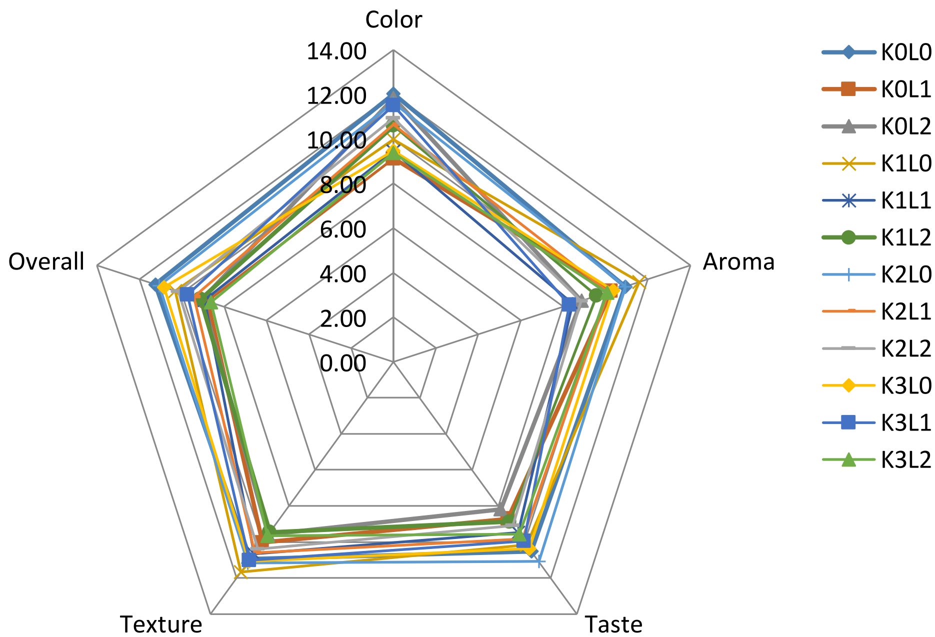

Figure 2. Spider web Graph to Determine The Best Treatment of Stink Lily Noodles

Table 5. Sensory Properties of Stink Lily Noodles

Samples	Hedonic Preference Score				
	Color	Aroma	Taste	Texture	Overall
K0L0	12.02f	10.93d	10.52	10.95	11.24f
K0L1	9.12a	10.26cd	8.72	10.03	8.79a
K0L2	11.83ef	8.86ab	8.18	9.58	9.04ab
K1L0	9.98bc	11.58e	10.15	11.66	10.3cde
K1L1	9.44ab	9.58bc	9.49	10.66	8.93ab
K1L2	10.59cd	8.45a	8.87	9.46	9.11ab
K2L0	11.62f	10.93de	11.08	11.15	11.07def
K2L1	10.63cd	10.14ab	9.82	10.61	9.42abc
K2L2	10.94de	8.84cd	9.09	10.38	10.16cde
K3L0	11.51ef	10.36cd	10.37	11.07	10.84def
K3L1	9.37ab	10.07a	9.95	11	9.72bc
K3L2	9.47ab	8.29cd	9.57	9.64	8.62a

4. Discussion

4.1. Cooking Quality

Moisture content is a major parameter of stinky silky wet noodles that shows the amount of water contained in food product that determines rheological characteristics, chemical, physical, and sensory properties, and shelf life of food product [34]. The κ-carrageenan addition gave a significant difference of moisture content to wet noodles. The κ-carrageenan is hydrocolloids that has a group of sulfate and water-soluble polysaccharides [35,36,37], composes an ester sulfate content about 25-30% and a 3,6-anhydro-galactose (3,6-AG) about 28 to 35% [38,36]. This anionic carrageenan can interact very tightly with water molecule [39] and can be collaborated with glucomannan from stink lily on gelation process [40] with making intra- and inter-disulfide bind at network structure of gluten [13,41]. The κ-carrageenan can bind with limited free water molecule, form complexes compounds with water, and interact with gluten network [13]. However, the mobility of water mainly depends on changes in the hydrogen bond structure. The presence of hydrophilic components such as proteins, carbohydrates, glucomannan, κ-carrageenan and polyphenolic compounds in wet noodles can be involved in hydrogen bonding with water molecules that determine water mobility [13,34,41,42]. Thus, increasing the proportion of k-carrageenan can increase the amount of free water and weakly bound water in the wet noodles.

The swelling index or water absorption is the ability of a product to absorb water which is influenced by particle size, chemical composition, and water content [43]. The swelling index of wet noodles was determined by the presence of κ-carrageenan, protein, starch, glucomannan, and bioactive compounds of pluchea tea extract in dough. [13] said that glutelin proteins of wheat flour can involve intra-and intermolecular disulfide bonds to result a fibrous shape, and then globular gliadin protein of wheat flour can be bound at the glutenin skeleton by non-covalent bonds to be a unique networks structure of gluten. The addition of the glucomannan of stinky silky flour as a non-ionic hydrocolloid has good water holding capacity and can be made a stronger three-dimensional network structure. [44] informed that the glucomannan can fill the number of holes of the network structure of gluten that make a structure dense and stable. [13] underlined that glucomannan has many hydroxyl group in the structure that can be bound tightly with water by electrostatic forces and hydrogen bond. [41] said that the presence of κ-carrageenan in dough can be synergist with glucomannan to change sulfhydryl groups to be disulfide bonds in protein. [20] informed that bioactive compounds of pluchea tea extract are alkaloids, flavonoids, phenolics, phenol hydroquinone, saponins, tannins, sterols, terpenoids, and cardiac glycosides. Meanwhile [16] informed that pluchea leaves contain 1.79 g/100 g protein, 0.49 g/100 g fat, 0.20 g/100 g ash, 0.89 g/100 g insoluble fiber, 0.45 g/100 g dissolved fiber, total fiber 1.34 g/100 g, carbohydrates 8.65 g/100 g, calcium 251 g/100 g, β-carotene 1.225 g/100 g and vitamin C 30.17 g/100 g, and phenolic acid bioactive compounds 28.48± 0.67 mg/100 g body weight (chlorogenic acid 20±0.24 mg/100 g body weight, caffeic acid 8.65±0.46 mg/100 g body weight), total flavonoids 6.39 mg/100 g body weight (quercetin 5.21± 0.26 mg/100 g body weight, kaempferol 0.28 ± 0.02 mg/100 g body weight, myrisetin 0.09 ± 0.03 mg/100 g body weight), total anthocyanins 0.27 ± mg/100 g body weight, β-carotene 1.70 ± 0.05 mg/100 g body weight and total carotenoids 8.7 ± 0.34 mg/100 g body weight. [17,18,19] proved that pluchea leaves contain 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, and 4,5- O-dicaffeoylquinic acid. [45] informed that phenolic acid can be bound with protein and carbohydrate by non-covalent interactions, i.e. hydrophobic interaction, hydrogen bonding, electrostatic interaction, van der Waals interaction, and π-π stacking. The presence of κ-carrageenan proportion and pluchea tea extract addition that differed caused change of composition and various interaction of compounds that determined different swelling index of wet noodles.

The phenomena was caused by κ-carrageenan and bioactive compounds of pluchea tea extract, especially phenolic compounds, that involved the interaction with protein and carbohydrate in dough. κ-carrageenan can stabilized and supported a rigid structure of gluten. The hydrocolloid can avoid starch gelatinization process because it can bind tightly with water molecule caused lower the water activity. Supported by [13,46,41], κ-carrageenan can trap the free water molecule that starch can't absorb the water molecule and require higher energy to break the energy barrier required for the starch gelatinization process. Whereas [42,47,45] clarified that starch can be bound with polyphenol, including hydrophobic and electrostatic interactions and hydrogen bond that the hydrogen bond is dominant binding forces. This interaction can support releasing of amylose of starch gelatinization process that the cooking loss increased at the higher pluchea tea extract addition. The presence of polyphenol compounds of pluchea tea extract caused water competition with glutenin and gliadin of wheat flour that inhibited interaction between glutenin and gliadin to form gluten. According to [47], gluten and gliadin in a random coil structure can be aggregated by phenolic compounds and starch easily undergoes a gelatinization process where amylose interacts with polyphenolic compounds, through hydrogen bonds and hydrophobic interactions. The more protein in the form of random coil structure causes the protein to easily interact with polyphenols and come out of the noodles during the cooking process that the cooking loss increases.

The increasing κ-carrageenan proportion grew up tensile strength because this hydrocolloid could be made strong cross linking through inter-molecular and intra-molecular bonds involving the glutenin and gliadin of wheat flour protein, and glucomannan of stink lily flour. The more networks that are formed between the components of the noodles have an effect on the tensile strength of wet noodles, and vice versa [13,48]. The synergism effect of the wet noodles component determined water bind capacity and water mobility that established texture properties of wet noodles, this statement is supported by [34,40,41]. [49] also informed that the addition of hydrocolloids in the noodles-making process increases the viscosity and water absorption because the water binding and holding properties of hydrocolloids that can form gel. However, the addition of pluchea tea extract caused the tensile strength to decline because the polyphenol compounds of pluchea tea extract induced breakdown of the networking structure among the components of dough because there was water competition among them. Furthermore, the polyphenol compounds could be reacted with starch and protein because the formation of the gluten network was disrupted that gliadin and glutenin in the form of random coils and starch could be underwent an excessive gelatinization process. This opinion is supported by [13,42,41]. κ-carrageenan has a yellowish white color and has the ability to bind water molecules that it increases the lightness of wet noodles, while the pluchea tea extract contains polyphenolic compounds, such as tannins which can give the noodles a brown color that the lightness level is reduced.

This opinion was supported by [20,38]. The increase in yellowness was in line with the increase in lightness because the higher the water content value was caused by the ability of κ-carrageenan to bind water molecules, thereby increasing the brightness and the brown color contribution of the pluchea tea extract gave a brownish-yellow color of the wet noodles that the intensity of this color increased as indicated by the increased chroma value.

4.2. Bioactive Compounds and Antioxidant Activity

The stinky silky wet noodles K0L0 had the lowest TPC and TFC because there was contributed of phenolic content from wheat flour and egg. [50] said that wheat flour has phenolic acids including ferulic, caffeic, and p-coumaric acid. Moreover, the presence of TFC in the K0L0 sample is thought to be due to the presence of a thiol group in egg white which is able to chelate metal ions and is able to be conjugated with saccharides [51], as well as 3,5-diacetyltambulin compounds from stink lily flour [52]. While the TFC and TPC values in the K2L2 sample were dominantly contributed by the presence of phytochemical compounds in the pluchea tea extract. [20] explained that there are phytochemical compounds in the pluchea tea extract. [16, 17,18,19] also emphasized that pluchea leaves contain phenolic acids and flavonoids. The existence of a non-significant difference between treatments in the TPC and TFC assays indicated an interaction between the components in the dough that it affected the presence of free hydroxyl groups that could bind to the Folin Ciocalteus phenol reagent. as described by [13,41,42,45,47] glutenin, gliadin, glucomannan, κ-carrageenan, and polyphenol compounds are involved in the formation of networks structure in the dough so as to determine the quality of wet noodles. The interactions that occur involve various non-covalent interaction mechanisms that affect the presence of free hydroxyl groups. The TPC and TFC values of wet noodles in each treatment affected antioxidant activity (AOA). They determined AOA of wet noodles, usually positively correlated. [53] said that TPC and AOA were strongly correlated in seeds, sprouts and grasses of corn (Zea mays L.). [54] also informed that there is an excellent correlation coefficient between the TPC, TFC and antioxidant activities of *Phaleria macrocarpa* fruit. [55] explained that the high level of flavonoids and phenols in plant caused the antioxidant activity of *Grewia carpinifolia* extract. The antioxidant activity of phenolics is related to their redox properties which induced them to act as reducing agents, hydrogen donors, singlet oxygen quenchers and metal chelators. [56] underlined that DPPH free radical scavenging activity of polyphenol compounds of *T. pallida* extract was determined by hydrogen donating ability which it highly correlated. The potency of wet noodles as AOA was determined by reduced capability of DPPH free radical solution color from purple to be yellow color.

4.3. Sensory Properties

The analysis of sensory properties of the stink lily noodles was conducted by the hedonic scale scoring method with attribute the preference of color, taste, aroma, texture and overall. The result of the color preference test showed that the control treatment (K0L0) was the highest value because the treatment without the addition of pluchea tea extract not change the color of the wet noodles was yellowish-white. And then the treatment with the lowest color preference value was K0L1 due to the addition of this extract decreased the panelists' preference for the color because the noodles were darker and brownish color. [16,20] said that the color of the pluchea tea extract contributed to changing the color of this wet noodle originated from tannins, flavonoids, and chlorophyll. However, in this study, increasing the extract concentration did not significantly affect the panelists' preference for color when the proportion of κ-carrageenan increased, because the addition of stink lily flour and κ-carrageenan would increase the lightness of the wet noodles that the produced color of the wet noodles was brighter and preferred by panelists. This data was supported by the data from color rider analysis, where the results of the sensory test by the panelists were in line with the decrease in the lightness value, the increase in the reddish and yellowish values, the hue value showed the yellow-red color, and chroma value showed an increase in color intensity. The panelist preference of aroma from wet noodles was determined by the aroma from the material used to make wet noodles or the interaction of aroma produced from the reaction among the material composition. According to [57], stink lily flour has a musty aroma, and all wet noodles produced have a musty smell. Meanwhile, according to [58], κ-carrageenan is unscented that not contribute to wet noodles. The addition of pluchea tea extract decreased the panelists' preference for the aroma of wet noodles because the addition of the extract caused the wet noodles to smell like leaves (floral) and unpleasant and the panelists did not like it. Fragrant or unpleasant aroma comes from volatile compounds contained in pluchea leaves. According to [59], pluchea leaves have 66 volatile compounds, these volatile compounds play a role in forming the aroma in the hot water extract of pluchea leaf tea. According to [60], pluchea leaves contain volatile compounds contributed by aliphatic aldehyde group compounds or aromatic compounds that give a distinctive aroma, therefore the presence of these compounds in steeping water can give a specific aroma, i.e. fragrant (floral) in wet noodles. There was a difference in the effect of the proportion of κ-carrageenan and pluchea leaf tea extract on taste due to the contribution of taste produced by carrageenan and extract. According to [57,61], stink lily flour and κ-carrageenan do not have a distinctive or neutral taste, increasing the concentration of κ-carrageenan gives a higher preference value because noodles are considered to have a better texture that contributes to the assessment of taste. The increase in the concentration of pluchea tea extract caused the taste preference value of noodles to decrease significantly, this is due to the presence of tannins, catechins, and phenolic compounds in the pluchea tea extract which determined bitter and slightly astringent. The effect of κ-carrageenan proportion and tea extract to make wet noodles influenced panelist preference of texture because this hydrocolloid can be make strong cross linking through inter-molecular and intra-molecular bonds involving the glutenin and gliadin of wheat flour protein, and glucomannan of stink lily flour that determined water bind capacity and water mobility [34,40,41]. Presence of the polyphenol compounds of pluchea tea extract can be breakdown of the networking structure among the components of dough because of water competition of them. [13,42,41] said that the polyphenol compounds could be reacted with starch and protein to disrupt the gluten network and cause starch to undergo an excessive gelatinization process. The difference in the proportion of κ-carrageenan change the overall preference value of wet noodles to be significantly different overall compared to the control, this was because the proportion of κ-carrageenan influenced the all sensory attribute (color, aroma, and taste). The addition of pluchea tea extract in wet noodles decreased the overall preference value because the addition of extract affected the organoleptic characters tested due to the content of secondary metabolites of pluchea leaves, such as flavonoids, phenols, and tannins that could affect the taste, aroma, the color, and texture of the noodles. Based on spider web graph showed that K2L0 was the best treatment of stink lily wet noodles. It was also supported by better physicochemical properties than the control, including yellowish white wet noodles, better swelling index, lower cooking loss, higher tensile strength value, and lower moisture content. However, this K2L0 treatment did not have the highest TPC, TFC, and AOA, i.e. 0.4997±0.0450; 0.0888±0.0084; and 0.5318±0.0052, respectively.

5. Conclusions

The use of κ-carrageenan proportions and pluchea leaf tea extract had a significant effect on the cooking quality and sensory properties of stink lily wet noodles. Statistical analysis at p=5% showed that there was an interaction effect of the proportion of κ-carrageenan and pluchea leaf tea extract on the swelling index, yellowness, chroma, hue, TPC, TFC, AOA, the preference value for color, aroma, and overall. While the moisture content of wet noodles was only affected by the proportion of κ-carrageenan, for tensile strength, cooking loss, lightness, and redness, and the preference value for texture and taste were influenced by the proportions of κ-carrageenan and the concentration of pluchea leaf tea extract, respectively. The best treatment based on the spider web graph showed that the K0L2 treatment had the largest area 79.16 cm^2 and a preference score of 15.8 with a very like category, this is in accordance with the results of physicochemical and sensory tests, but it was no correlated with the highest bioactive content (TPC and TFC) and antioxidant activity.

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

[Molecules] Manuscript ID: molecules-1821369 - Article Processing Charge Confirmation

Molecules Editorial Office <molecules@mdpi.com> Fri, Jul 15, 2022 at 1:54 PM
Reply-To: sotirovic@mdpi.com
To: Paini Sri Widyawati <paini@ukwms.ac.id>
Cc: Thomas Indarto Putut Suseno <thomasindartoftp@gmail.com>, Theresia Endang Widoeri Widyastuti <widoeri@ukwms.ac.id>, Anna Ingani Widjajaseputra <anna27july@yahoo.com>, Vincentia Wilhelmina Moeljadi <vincentiawilhelmina@gmail.com>, Sherina Tandiono <sherinatandiono@gmail.com>, Molecules Editorial Office <molecules@mdpi.com>

Dear Dr. Widyawati,

Thank you very much for submitting your manuscript to Molecules:

Journal name: Molecules
Manuscript ID: molecules-1821369
Type of manuscript: Article
Title: The Effect of k-Carrageenan Proportion and Hot Water Extract of
Pluchea Indica Less Leaf Tea to Quality and Sensory Properties of Stink Lily
(Amorphophallus Muelleri) Wet Noodles
Authors: Paini Sri Widyawati *, Thomas Indarto Putut Suseno, Theresia Endang
Widoeri Widyastuti, Anna Ingani Widjajaseputra, Vincentia Wilhelmina
Moeljadi, Sherina Tandiono
Received: 1 July 2022
E-mails: paini@ukwms.ac.id, thomasindartoftp@gmail.com, widoeri@ukwms.ac.id,
anna27july@yahoo.com, vincentiawilhelmina@gmail.com, sherinatandiono@gmail.com
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Name: Paini Sri Widyawati
Address: Dr. Paini Sri Widyawati
Academic
FTP UKWMS Jl. Dinoyo 42-44
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Kind regards,
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E-Mail: sotirovic@mdpi.com

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Newly Released Impact Factor for /Molecules/ (2021): 4.927
Newly released CiteScore for /Molecules/ (2021): 5.9 - Q1 (Chemistry (miscellaneous))

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

[Molecules] Manuscript ID: molecules-1821369 - Acknowledgement - Article Processing Charge Confirmation Received

molecules@mdpi.com <molecules@mdpi.com> Fri, Jul 15, 2022 at 2:45 PM
Reply-To: molecules@mdpi.com
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Cc: paini@ukwms.ac.id, molecules@mdpi.com, sotirovic@mdpi.com

Dear Dr. Widyawati,

Thank you very much for your confirmation of the Article Processing Charge of 2000 CHF for the following manuscript:

Journal name: Molecules
Manuscript ID: molecules-1821369
Type of manuscript: Article
Title: The Effect of k-Carrageenan Proportion and Hot Water Extract of Pluchea Indica Less Leaf Tea to Quality and Sensory Properties of Stink Lily (Amorphophallus Muelleri) Wet Noodles
Authors: Paini Sri Widyawati *, Thomas Indarto Putut Suseno, Theresia Endang Widoeri Widyastuti, Anna Ingani Widjajaseputra, Vincentia Wilhelmina Moeljadi, Sherina Tandiono
Received: 1 July 2022
E-mails: paini@ukwms.ac.id, thomasindartoftp@gmail.com, widoeri@ukwms.ac.id, anna27july@yahoo.com, vincentiawilhelmina@gmail.com, sherinatandiono@gmail.com

Please note that the invoice will be sent to the below address immediately after your paper is accepted.

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Address:Dr. Paini Sri Widyawati
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FTP UKWMS Jl. Dinoyo 42-44
60265 Surabaya
Indonesia
E-Mail:paini@ukwms.ac.id

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Manuscript Information Overview

Manuscript ID	**molecules-1821369**
Status	Under review
Article type	Article
Title	The Effect of k-Carrageenan Proportion and Hot Water Extract of Pluchea Indica Less Leaf Tea to Quality and Sensory Properties of Stink Lily (Amorphophallus Muelleri) Wet Noodles
Journal	*Molecules* (https://www.mdpi.com/journal/molecules)
Section	Food Chemistry (https://www.mdpi.com/journal/molecules/sections/food_chemistry)
Special Issue	Advances in Functional Foods (https://www.mdpi.com/journal/molecules/special_issues/adv_func_food)
Abstract	The study aimed to determine the effect of the proportion of k-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles. The research design used was a Randomized Block Design with two factors, i.e. the difference in the proportion of k-carrageenan (K) (0, 1, 2, and 3% b/b) and the addition of hot water extract of Pluchea indica Less leaf tea (L) (0, 15, and 30% b/v) with 12 treatment level (K0L0, K0L1, K0L2, K1L0, K1L1, K1L2, K2L0, K2L1, K2L2, K3L0, K3L1, K3L2). The data were analyzed by the Anova at = 5% and continued with the Duncan's Multiple Range Test at p= 5% and the best treatment was determined by the Spider web method based on sensory assay by a hedonic method. The proportions of - carrageenan and the concentration of pluchea tea extract had a significant effect on cooking quality and sensory properties. However, the interaction of the two factors affected the swelling index, yellowness (b*), chroma (C), hue (h), total phenol content (TPC), total flavonoid content (TFC), and DPPH free radical scavenging assay (AOA). The best treatment of wet noodles was K2L0 with a preference score of 15.8. The binding of - carrageenan and phenolic compounds to make networking structure by intra- and inter-disulfide bind between glucomannan and gluten, was thought to affect the cooking quality, sensory properties, bioactive compounds (TPC and TFC), and AOA.
Keywords	Amorphophallus muelleri, Pluchea indica Less, wet noodles, quality and sensory properties
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Paini Sri Widyawati <paini@ukwms.ac.id>

[Molecules] Manuscript ID: molecules-1821369 - Major Revisions

Molecules Editorial Office <molecules@mdpi.com> Mon, Jul 18, 2022 at 2:02 PM
Reply-To: sotirovic@mdpi.com
To: Paini Sri Widyawati <paini@ukwms.ac.id>
Cc: Thomas Indarto Putut Suseno <thomasindartoftp@gmail.com>, Theresia Endang Widoeri Widyastuti <widoeri@ukwms.ac.id>, Anna Ingani Widjajaseputra <anna27july@yahoo.com>, Vincentia Wilhelmina Moeljadi <vincentiawilhelmina@gmail.com>, Sherina Tandiono <sherinatandiono@gmail.com>, Molecules Editorial Office <molecules@mdpi.com>

Dear Dr. Widyawati,

Thank you again for your manuscript submission:

Manuscript ID: molecules-1821369
Type of manuscript: Article
Title: The Effect of k-Carrageenan Proportion and Hot Water Extract of Pluchea Indica Less Leaf Tea to Quality and Sensory Properties of Stink Lily (Amorphophallus Muelleri) Wet Noodles
Authors: Paini Sri Widyawati *, Thomas Indarto Putut Suseno, Theresia Endang Widoeri Widyastuti, Anna Ingani Widjajaseputra, Vincentia Wilhelmina Moeljadi, Sherina Tandiono
Received: 1 July 2022
E-mails: paini@ukwms.ac.id, thomasindartoftp@gmail.com, widoeri@ukwms.ac.id, anna27july@yahoo.com, vincentiawilhelmina@gmail.com, sherinatandiono@gmail.com
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(I) Please check that all references are relevant to the contents of the manuscript.
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Kind regards,
Ms. Jasna Sotirovic,
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Paini Sri Widyawati <paini@ukwms.ac.id>

[Molecules] Manuscript ID: molecules-1821369 - Major Revisions

Paini Sri Widyawati <paini@ukwms.ac.id> Mon, Jul 18, 2022 at 3:30 PM
To: sotirovic@mdpi.com

Dear Journal Editor

In connection with my previous letter to Ms. Julien that I will publish my manuscript in the molecular journal for the regular edition and not in the special edition.
Therefore, if I revise this manuscript, how can I be sure that it is not published in a special edition?
Because I would have a hard time paying the journal APC if this manuscript was published in a special issue.

Please help so that this manuscript can be published regularly. Thank you for your attention.

Regards

Paini Sri Widyawati
[Quoted text hidden]

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

[Molecules] Manuscript ID: molecules-1821369 - Major Revisions

Jasna Sotirović <sotirovic@mdpi.com> Tue, Jul 19, 2022 at 4:16 PM
To: Paini Sri Widyawati <paini@ukwms.ac.id>
Cc: Molecules Editorial Office <molecules@mdpi.com>

Dear Dr. Widyawati,

Thank you very much for your letter.

I apologize for a delay in response. Your manuscript has been moved from Special Issue to a regular submission in Journal Molecules, as requested.

Should you have any further questions or concerns, please let me know.

Have a nice day.

Kind regards,

Ms. Jasna Sotirovic,
Assistant Editor, MDPI Belgrade
E-Mail: sotirovic@mdpi.com

MDPI Branch Office, Belgrade
Bulevar Mihajla Pupina 115
11070 New Belgrade, Serbia
Tel.: +381 11 414 75 49

Newly Released Impact Factor for /Molecules/ (2021): 4.927

On 2022-07-18 10:30, Paini Sri Widyawati wrote:
> Dear Dr. Widyawati,

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

[Molecules] Manuscript ID: molecules-1821369 - Major Revisions

Paini Sri Widyawati <paini@ukwms.ac.id> Tue, Jul 19, 2022 at 7:16 PM
To: Jasna Sotirović <sotirovic@mdpi.com>

Dear Ms Jasna Sotirovic

Thanks for attention

The Best Regards

Paini Sri W

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Journal	Molecules (https://www.mdpi.com/journal/molecules) (ISSN 1420-3049)
Manuscript ID	molecules-1821369
Type	Article
Title	The Effect of k-Carrageenan Proportion and Hot Water Extract of Pluchea Indica Less Leaf Tea to Quality and Sensory Properties of Stink Lily (Amorphophallus Muelleri) Wet Noodles (https://www.mdpi.com/1420-3049/27/16/5062)

Authors: Paini Sri Widyawati * (https://sciprofiles.com/profile/2124526) , Thomas Indarto Putut Suseno , Theresia Endang Widoeri Widyastuti , Anna Ingani Widjajaseputra , Vincentia Wilhelmina Moeljadi , Sherina Tandiono

Abstract: The study aimed to determine the effect of the proportion of k-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles. The research design used was a Randomized Block Design with two factors, i.e. the difference in the proportion of k-carrageenan (K) (0, 1, 2, and 3% b/b) and the addition of hot water extract of Pluchea indica Less leaf tea (L) (0, 15, and 30% b/v) with 12 treatment level (K0L0, K0L1, K0L2, K1L0, K1L1, K1L2, K2L0, K2L1, K2L2, K3L0, K3L1, K3L2). The data were analyzed by the Anova at □= 5% and continued with the Duncan's Multiple Range Test at p= 5% and the best treatment was determined by the Spider web method based on sensory assay by a hedonic method. The proportions of □-carrageenan and the concentration of pluchea tea extract had a significant effect on cooking quality and sensory properties. However, the interaction of the two factors affected the swelling index, yellowness (b*), chroma (C), hue (h), total phenol content (TPC), total flavonoid content (TFC), and DPPH free radical scavenging assay (AOA). The best treatment of wet noodles was K2L0 with a preference score of 15.8. The binding of □-carrageenan and phenolic compounds to make networking structure by intra- and inter-disulfide bind between glucomannan and gluten, was thought to affect the cooking quality, sensory properties, bioactive compounds (TPC and TFC), and AOA.

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Authors' Responses to Reviewer's Comments (Reviewer 1)

Author's Notes

Dear Reviewer

Thank you for your suggestions to improve our manuscript.
Attached I send the manuscript that I have revised. The sections I am revising are marked in yellow in the manuscript.
There are several explanations regarding reviewer questions
1. The maximum amount of k-carrageenan allowed is not clear, but the concentration of k-carrageenan for noodle products is a maximum of 3%
2. Testing of the bioactive compound content and antioxidant activity (DPPH) was only carried out on cooked noodles, while raw wet noodles were not carried out, so it is not known the number loss of bioactive compounds and antioxidant activity.

The Best Regards

Paini Sri Widyawati

Author's Notes File

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	Yes	Can be improved	Must be improved	Not applicable
Does the introduction provide sufficient background and include all relevant references?	( )	(x)	( )	( )
Is the research design appropriate?	( )	(x)	( )	( )
Are the methods adequately described?	(x)	( )	( )	( )
Are the results clearly presented?	( )	(x)	( )	( )
Are the conclusions supported by the results?	(x)	( )	( )	( )

Comments and

Suggestions for Authors

The study has some interesting information. However, it needs to be clear in the introduction why k-carrageenan and the extract are added to the noodles, what defects of the noodles are to be improved, and what functions the addition of the extract makes edible, not simply the determination of the antioxidant properties in the noodles.

1. L 205-206 revise the sentence.
2. 3. Is there a standard for the maximum allowable amount of k-carrageenan in noodles?
3. 4.1. Cooking Quality provides an extensive discussion of the effects of k- carrageenan, including its use in other studies, but fails to provide a focused account of what was seen in the different samples in this study, and it is recommended that an analysis specific to the results of this study be included in the discussion.
4. Bioactive Compounds and Antioxidant Activity

   What is the significance of this section on TPC, TFC and DPPH of stink lily wet noodles? Is there any loss of activity after boiling? Is it still meaningful to eat after the loss?

Submission Date: 01 July 2022

Date of this review: 07 Jul 2022 02:16:26

Journal	Molecules (https://www.mdpi.com/journal/molecules) (ISSN 1420-3049)
Manuscript ID	molecules-1821369
Type	Article
Title	The Effect of k-Carrageenan Proportion and Hot Water Extract of Pluchea Indica Less Leaf Tea to Quality and Sensory Properties of Stink Lily (Amorphophallus Muelleri) Wet Noodles (https://www.mdpi.com/1420-3049/27/16/5062)
Authors	Paini Sri Widyawati * (https://sciprofiles.com/profile/2124526) , Thomas Indarto Putut Suseno , Theresia Endang Widoeri Widyastuti , Anna Ingani Widjajaseputra , Vincentia Wilhelmina Moeljadi , Sherina Tandiono
Abstract	The study aimed to determine the effect of the proportion of k-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles. The research design used was a Randomized Block Design with two factors, i.e. the difference in the proportion of k-carrageenan (K) (0, 1, 2, and 3% b/b) and the addition of hot water extract of Pluchea indica Less leaf tea (L) (0, 15, and 30% b/v) with 12 treatment level (K0L0, K0L1, K0L2, K1L0, K1L1, K1L2, K2L0, K2L1, K2L2, K3L0, K3L1, K3L2). The data were analyzed by the Anova at = 5% and continued with the Duncan's Multiple Range Test at p= 5% and the best treatment was determined by the Spider web method based on sensory assay by a hedonic method. The proportions of -carrageenan and the concentration of pluchea tea extract had a significant effect on cooking quality and sensory properties. However, the interaction of the two factors affected the swelling index, yellowness (b*), chroma (C), hue (h), total phenol content (TPC), total flavonoid content (TFC), and DPPH free radical scavenging assay (AOA). The best treatment of wet noodles was K2L0 with a preference score of 15.8. The binding of -carrageenan and phenolic compounds to make networking structure by intra- and inter-disulfide bind between glucomannan and gluten, was thought to affect the cooking quality, sensory properties, bioactive compounds (TPC and TFC), and AOA.

The coverletter for this review report has been saved in the database. You can safely close this window.

Authors' Responses to Reviewer's Comments (Reviewer 2)

Author's Notes

Dear Reviewer

Thank you for your suggestions to improve our manuscript.
Attached I send the manuscript that I have revised. The sections I am revising are marked in yellow in the manuscript.
We have changed, corrected, and added information according to the reviewer's suggestions

The Best Regards

Paini Sri Widyawati

Author's Notes File

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Quality of English Language

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( ) Moderate English changes required.
(x) English language and style are fine/minor spell check required.
( ) I am not qualified to assess the quality of English in this paper.

	Yes	Can be improved	Must be improved	Not applicable
Does the introduction provide sufficient background and include all relevant references?	(x)	( )	( )	( )
Is the research design appropriate?	(x)	( )	( )	( )
Are the methods adequately described?	( )	( )	(x)	( )
Are the results clearly presented?	( )	( )	(x)	( )
Are the conclusions supported by the results?	( )	(x)	( )	( )

Comments and Suggestions for Authors

I think that the topic is very interesting for the journal fits perfectly in the *Special Issue* to which it has been submitted, since it provides the possibility of increase the functional value of wet noodle products.

However, there are important aspects that must be clarified to be published:

- LINE 3. Replace "to" with "on".

- LINES 13 and 14. What do you mean with "b/b" and "b/v"? Review it throughout the text.

- LINE 15. Put Anova in capital letters.

- LINE 21. The DPPH free radical scavenging assay is usually associated with the acronym DPPH and not with AOA.

- LINE 76. The figures included in the non-published material could be included in the manuscript to better understand the elaboration process.

- LINE 101. The information included in the manuscript seems misplaced. Introduce tables and figures as close as possible to where they are cited in the text.

- LINE 121. Remove repeated words.

- LINE 141. Include the name of the authors, replacing “by [27]” with “by Rathorel et al. [27]”. Review it throughout the text.

- LINE 173-185. The experimental design should be explained in more detail: Detail hedonic scale scoring method.

- LINES 194-197. Explain better the statistical analysis. Were you do a pre-treatment of the data (normal distribution and variance homogeneity)? Were the values considered significant when $P = 0.05$ or when $P < 0.05$?

- LINE 238. Figure 1b is not clear. Please replace it with a higher quality one. Moreover, reflect in the legend that there is Figure 1a and 1b.

- LINE 243. Please, use superscripts in the table. The same in Table 5.

- LINE 289. Revise the number of significant decimals.

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Submission Date: 01 July 2022

Date of this review: 17 Jul 2022 13:33:02

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

[Molecules] Manuscript ID: molecules-1821369 - Manuscript Resubmitted

Molecules Editorial Office <molecules@mdpi.com> Sun, Jul 24, 2022 at 11:08 PM
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The Effect of κ-Carrageenan Proportion and Hot Water Extract of *Pluchea Indica* Less Leaf Tea on Quality and Sensory Properties of Stink Lily (*Amorphophallus Muelleri*) Wet Noodles

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Abstract : The study aimed to determine the effect of the proportion of κ-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles. The research design used was a Randomized Block Design with two factors, i.e. the difference in the proportion of κ-carrageenan (K) (0, 1, 2, and 3% w/w) and the addition of hot water extract of *Pluchea indica Less* leaf tea (L) (0, 15, and 30% w/v) with 12 treatment level (K0L0, K0L1, K0L2, K1L0, K1L1, K1L2, K2L0, K2L1, K2L2, K3L0, K3L1, K3L2). The data were analyzed by the ANOVA at p< 5% and continued with the Duncan's Multiple Range Test at p< 5% and the best treatment was determined by the Spider web method based on sensory assay by a hedonic method. The proportions of κ-carrageenan and the concentration of pluchea tea extract had a significant effect on cooking quality and sensory properties. However, the interaction of the two factors affected the swelling index, yellowness (b*), chroma (C), hue (h), total phenol content (TPC), total flavonoid content (TFC), and DPPH free radical scavenging assay (DPPH). The best treatment of wet noodles was K2L0 with a preference score of 15.8. The binding of κ-carrageenan and phenolic compounds to make networking structure by intra- and inter-disulfide bind between glucomannan and gluten, was thought to affect the cooking quality, sensory properties, bioactive compounds (TPC and TFC), and DPPH

Keywords: *Amorphophallus muelleri*; *Pluchea indica* Less; wet noodles; quality and sensory properties

1. Introduction

Noodles are a rice substitute commodity that is much favored by the public [1], especially in China, Indonesia, India, Japan, Vietnam, and the United States. Basically, noodles are divided into wet noodles and dry noodles. Indonesia is the second country in the world that likes to consume noodles [2]. In 2017, the consumption of instant noodles achieves by 180.2 packets per head in the world, and in Indonesia, the consumption of wet noodles shows that all age groups and education levels like it [3]. Meanwhile, instant noodle consumption in 2020 reached 12,640 million portions [2]. Noodles are generally made from wheat flour, the use of local food ingredients based on carbohydrates, including stink lily flour, can reduce the consumption of wheat flour which is quite high in Indonesia, the average consumption of wheat flour for the Indonesian population in 2019 is 17.8 kg/capita/year [4].

Stink lily flour (*Amorphophallus muelleri*) is a group of *Araceae* that contains glucomannan oligosaccharides around 15-64% dry base [5] or more than 60% [6]. Glucomannan is a heteropolysaccharide consisting of 67% D-mannose and 33% D-glucose and has β-1,4 and β-1,6 glycoside bonds [7], which can reduce body weight, sugar content blood levels,

LDL cholesterol levels and prolong gastric emptying time [8,9]. Stink lily flour has a glycemic index of 85 which is lower than the glycemic index of glucose which is considered to be 100 [7]. The use of stink lily flour in the manufacture of wet noodles is able to replace the role of gliadin and glutenin proteins in the formation of gluten with an elastic texture [10]. Polysaccharides in stink lily flour can dissolve in water to form a thick solution, form a gel, expand, and melt like agar [11], can increase the elasticity and cohesiveness [12,13] with increasing α-helix and β-sheet structures of wet noodles [13]. However, the higher the substitution of stink lily flour, the lower the texture preference because the noodles break easily and are sticky [12]. Therefore, it is necessary to add hydrocolloids, including carrageenan, because they can increase elasticity [14]. The combination of the use of glucomannan and carrageenan can form a strong and elastic gel [15].

The addition of hot water extract from pluchea leaf tea in making stink lily wet noodles is expected to increase the functional value of wet noodle products. Pluchea leaves contain nutrients, such as: protein 1.79 g/100 g, fat 0.49 g/100 g, ash 0.20 g/100 g, insoluble fiber 0.89 g/100 g, soluble fiber 0.45 g/100 g, total fiber 1.34 g/100 g, carbohydrates 8.65 g/100 g, calcium 251 g/100 g, β-carotene 1.225 mg/100 g and vitamin C 30.17 mg/100 g as well as bioactive compounds, such as: phenolic acid 28.48±0.67 mg/100 g wb (chlorogenic acid 20±0.24 mg/100 g wb, caffeic acid 8.65±0.46 mg/100 g wb), total flavonoids 6.39 mg/100 g wb (quercetin 5.21±0.26 mg/100 g wb, kaempferol 0.28±0.02 mg/100 g wb, myricetin 0.09± 0.03 mg/100 g wb), total anthocyanins 0.27±0.01 mg/100 g wb, β-carotene 1.70±0.05 mg/100 g wb, and total carotenoids 8.7±0.34 mg/100 g wb [16], 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, and 4,5-O-dicaffeoylquinic acid [17,18,19]. Meanwhile, hot water extract of 2% pluchea leaf tea (2 g/100 ml) contains a total phenolic content of 9.3 mg EAG/ g, total flavonoid content 22.0 mg EC/ g, DPPH free radical scavenging activity DPPH 27.2 mg EAG/ g, and reduced iron ion 10.2 mg EAG/ g [20], due to the presence of phytochemicals (alkaloids, flavonoids, phenolics, sterols, cardiac glycosides, phenol hydroquinone, tannins, terpenoids, and saponins) [20], which has been shown to have potential as an antioxidant [20,21] and antidiabetic [22]. The effect of using κ-carrageenan and water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles has not been studied in detail. Therefore, the purpose of this study was to determine the effect of the proportion of κ-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles.

2. Materials and Methods

2.1. Reagents and Materials

The compounds 2,2-diphenyl1-picrylhydrazyl (DPPH), sodium carbonate, gallic acid, and (+)-catechin were purchased from Sigma-Aldrich (St. Louis, USA). Methanol, folin ciocalteus phenol, sodium nitric, aluminium chloride, κ-carrageenan, and sodium hydroxide were purchased from Merck (New Jersey, USA).

Pluchea leaves as raw material for making pluchea leaf tea are collected from gardens around the city of Surabaya. Specification of pluchea plant is according to the GBIF taxon ID number database: 3132728. Stink lily flour is obtained from the stink lily flour processing industry in East Java. Specification of Stink lily plant is according to the GBIF taxon ID number database: 735493731. The wheat flour used is high protein flour obtained from the wheat flour processing industry in Indonesia.

2.2. Preparation of Pluchea Leaf Tea.

Pluchea leaves on each branch number 1-6 from the shoot were collected, sorted, and dried at an ambient temperature for 7 days until moisture content 11.16±0.09% dry base. And then dried leaves were powdered to get 45 mesh size [23]. Futhermore the leaf powder was heated by drying oven (Binder, Merck KGaA, Darmstadt, Germany) at 120 °C for

10 min. Then dried powder of pluchea leaves was packed 2 g in tea bag that called pluchea leaf tea.

2.3. Preparation of Hot Water Extract of Pluchea Leaf Tea.

Pluchea leaf tea in tea bag was extracted by hot water at 95 °C for 1 min to get 15 and 30% (b/v) concentrations (Table 1). And then each concentration of extract was used to make stink lily wet noodles.

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

Materials	Concentration of hot water extract of pluchea leaf tea (% b/v)		
	0	15	30
Pluchea leaf tea (g)	0	4.5	9
Hot water (mL)	30	30	30

2.4. Stink Lily Wet Noodles Making.

Stink lily wet noodles were made with mixing of wheat and stink lily flour, and κ-carrageenan at 1, 2, and 3% (b/b) concentrations. And then the mixture was added egg, salt, baking powder, and hot water extract of pluchea leaf tea and kneaded to form a dough by a mixer machine. Then the dough was passed through a roller to make face bands the desired thickness and cut through rollers using cutting blades. The formula of stink lily wet noodle was showed at Table 2.

2.5. Stink Lily Wet Noodles Extraction.

125 g each sample from stink lily wet noodles was weighed (Ohaus, Ohaus Instruments (Shanghai) Co., Ltd., RRT) and then they were dried by cabinet drying at 60 °C for 4 hours to get dried noodles. Next each sample was powdered by chopper machine at second speed for 35 seconds and then 20 g powdered sample was added 50 mL methanol by shaking water bath at 35 °C, 70 rpm for 1 hour. Filtrate was separated by Whatman filter paper grade 40 and residue was extracted again with same pattern way. Filtrate was collected and dried by rotary evaporator (Buchi Rotary Evaporator; Buchi Shanghai Ltd, RRT) at 0.2-0.3 atm, 50 °C for 60 min until getting 2 mL extract. Then extract was kept at 0 °C before further study.

2.6. Swelling Index Assay

Swelling index or water absorption is the ability of noodles to absorb water after gelatinization during the boiling process [24]. The principle of water absorption testing is to determine the amount of water absorbed in wet noodles at a certain temperature and time. The amount of water absorbed in wet noodles can be determined from the difference between the weight of the noodles after and before being boiled divided by the weight of the noodles before boiling [25].

2.7. Cooking Loss Assay

Cooking loss is one of the important quality parameters in wet noodles to determine the quality of wet noodles after cooking [26]. The cooking loss test for stink lily wet noodles was carried out to determine the number of solids that came out of the noodle strands during the cooking process, namely the release of a small portion of starch from the noodle strands.

2.8. Determination of Tensile Strength of Wet Noodles

The tensile strength (elongation) is one important parameter of texture analysis in noodle products. 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 principle of the texture analyzer is to prepare a suitable probe for the test, then place the noodle samples on the table under the probe. The elongation of the noodles was individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. The same procedure was done to tighten the other end of the strip to the upper roller arm. Elongation, which was the maximum force to deform and break noodles by extension, was measured using a test speed of 3.0 mm/s, with a 100 mm distance between two rollers. Deformations were recorded using the software during the extension and are expressed as a graph. The elongation at breaking was calculated per gram.

2.9. Color Measurement

The noodle samples were measured by a colorimeter (Minolta CM-3500D; Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab L*, a* and b* values were recorded as described by Rathorel et al.[27]. And then L*, a* and b* values were collected. The L* value was stated the position on the white/black axis, the a* value the position on the red/green axis, and the b* value the position on the yellow/blue axis. The measurements were done in triplicate and the readings were averaged.

2.10. Total Phenol Content Assay

Total phenol content (TPC) of stink lily wet noodles was analyzed by spectrophotometric method using folin ciocateus phenol reagent [28]. Principles assay of the TPC assay are interaction between phenolic compounds and phosphomolybdic/ phosphotungstic acid complexes based on the transfer of electrons in alkaline medium from phenolic compounds to form a blue chromophore constituted by a phosphotungstic/ phosphomolybdenum complex. The reduced folin ciocalteus phenol reagent is detected by a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 760 nm and gallic acid is used as the reference standard compound and results are expressed as gallic acid equivalents (mg/kg wet noodles).

2.11. Total Flavonoid Content Assay

Total flavonoid content of samples was measured by spectrophotometric method with reaction between $AlCl_3$ and $NaNO_2$ with aromatic ring of flavonoid compounds [29]. And then mixture was added aluminium chloride to result yellow solution. Next, addition of NaOH solution in mixture caused red solution that was measured by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 510 nm. As standard reference compound used was (+) catechin and results were expressed as catechin equivalents (mg/kg wet noodles).

2.12. DPPH Free Radical Scavenging Activity Assay

DPPH free radical scavenging activity was measured by the spectrophotometric method [30]. This method is used to determine the antioxidant capacity of a compound from an extract or other biological sources, based on transferring from the odd electron of a nitrogen atom in DPPH is reduced by receiving a hydrogen atom from antioxidants to result in DPPH-H with yellow-colored solution. Reaction between DPPH in methanol solution with samples was measured by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 517 nm. As standard reference compound used was gallic acid and results were expressed as gallic acid equivalents (mg/kg wet noodles).

2.13. Sensory Evaluation

Sensory assay was carried out to determine the level of panelist acceptance of wet noodles substituted with stink lily flour with the addition of carrageenan and hot water extract of pluchea leaf tea [31]. The test was carried out using the hedonic scale scoring method. This method is designed to measure the level of panelist preference for the product by rating the level of preference for the product being tested. Samples were served in dishes coded with random three-digit numbers that carried out using a completely randomized design (CRD) trial using 100 untrained panelists with an age range of 17 to 25 years. The hedonic method used in this study is the hedonic scoring method, the panelists were asked to give a preference score for each sample. The hedonic score used was a value of 1-15 given by the panelists according to the level of preference for the product. Values 0-3.0 indicate "strongly dislike", values 3.1-6.0 "dislike", values 6.1-9.0 "neutral", values 9.1-12.0 "like", and a value of 12.1-15.0 "very much like".

Each panelist is faced with 12 (twelve) samples and a questionnaire containing test instructions and is asked to give each sample a score according to their level of preference. The parameters tested were taste, aroma, texture, color, and overall acceptance of wet noodles substituted with stink lily flour. The best treatment of samples was determined by spider web method that was correlated by the large area of graph [32].

2.14. Experiment Design and Statistical Analysis

The research design of physicochemical assay used was a randomized block design with two factors, i.e. differences in the proportion of κ-carrageenan (K) and differences in the concentration of pluchea tea extract (L) added to wet noodles. The proportion of κ-carrageenan consisted of 4 (four) treatment levels, including 0% (K0), 1% (K1), 2% (K2), 3% (K3) and the concentration of pluchea tea extract consisted of 3 (three) levels, i.e., 0% (L0), 15% (L1), and 30% (L2). Each treatment was repeated 3 (three) times in order to obtain 36 (thirty-six) experiment units. The sensory test used a completely randomized design (CRD) on 100 untrained panelists.

The data before further analysis was determined by the normal distribution and homogeneity tests. And then the data are presented as mean ± SD of the triplicate determinations and were analyzed using ANOVA at $p < 5\%$, if the results of the ANOVA test had a significant effect, then proceed with the DMRT (Duncan Multiple Range Test) test at $p < 5\%$ to determine the level of treatment that gave significantly different results. The analysis used SPSS 17.0 software (SPSS Inc. Chicago, IL, USA).

3. Results

3.1. Cooking Quality

The evaluated cooking properties of the stink lily wet noodles were showed in Table 3 and the stink lily wet noodles product was showed at Figure 1. The level of cooking was estimated by the moisture content, swelling index, cooking loss and tensile strength from noodles. Based on statistically analysis by ANOVA at $p < 5\%$, showed that the increasing of κ-carrageenan proportion went up significant difference of moisture content of wet noodles, but the addition of pluchea leaf hot water extract and the interaction effect of the proportion of κ-carrageenan and the addition of the extract no influenced to moisture content of wet noodles. The moisture content value was ranged from 62.83±0.58 to 65.83±0.22. The sample K3L0 had the highest moisture content and K0L2 had the lowest moisture content. Furthermore, the addition of the κ-carrageenan proportion or pluchea tea extract had a significantly different effect such as the interaction effect of the addition of the two parameters, on the swelling index or water absorption value of wet noodles based on statistical analysis at $p < 5\%$. The water absorption value was ranged from 142.25±0.39% to 162.21±0.25%. The treatment with the lowest swelling index was K0L2 and the highest was K3L0. Whereas the cooking loss of wet noodles decreased significantly with the addition of the proportion of κ–carrageenan but increased significantly with the addition of pluchea tea extract. The cooking loss of wet noodles was ranged 17.83±0.4% to 20.13±0.7%. K0L2 was treatment with the biggest cooking loss and K3L0 was treatment with the smallest cooking loss. Tensile strength value of stink lily noodles was significant different because there was an interaction effect of κ-carrageenan proportion and pluchea tea extract addition. Tensile strength wet noodles were ranged 0.096±0.004 N to 0.174±0.015 N. The analysis of stink lily noodles color showed that lightness had a significant increase in with an increasing proportion of carrageenan and decreased with increasing pluchea tea extract used because of the color effect of carrageenan and pluchea tea extract. The lightness of wet noodles was ranged 67.80±0.22 to 74.50±0.23. The effect of the κ-carrageenan and pluchea tea extract color also influenced significantly redness of wet noodles. The redness of wet noodles was ranged 1.20±0.04 to 3.30±0.23. The interaction effect of κ-carrageenan and pluchea tea extract addition was appeared on yellowness, chroma and hue values. The yellowness, chroma and hue values were ranged 16.90±0.27 to 30.00±0.07, 17.00±0.28 to 30.10±0.03, and 83.70±0.07 to 86.40±0.02, respectively.

Table 2. The formula of stink lily wet noodles.

Material	K0L0	K0L1	K0L2	K1L0	K1L1	K1L2	K2L0	K2L1	K2L2	K3L0	K3L1	K3L2
Wheat flour (g)	120	120	120	120	120	120	120	120	120	120	120	120
Stink lily flour (g)	30	30	30	28.5	28.5	28.5	27	27	27	25.5	25.5	25.5
κ-Carrageenan (g)	0	0	0	1.5	1.5	1.5	3	3	3	4.5	4.5	4.5
Egg (g)	30	30	30	30	30	30	30	30	30	30	30	30
Salt (g)	3	3	3	3	3	3	3	3	3	3	3	3
Baking Powder (g)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water (mL)	30	0	0	30	0	0	30	0	0	30	0	0
Hot water extract of pluchea leaves 15% (mL)	0	30	0	0	30	0	0	30	0	0	30	0
Hot water extract of pluchea leaves 30% (mL)	0	0	30	0	0	30	0	0	30	0	0	30
Total (g)	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5

Note: K0 = wheat flour: stink lily flour: κ-carrageenan = 80 : 20 : 0.
K1 = wheat flour: stink lily flour: κ-carrageenan = 80 : 19 : 1.
K2 = wheat flour: stink lily flour: κ-carrageenan = 80 : 18 : 2.
K3 = wheat flour: stink lily flour: κ-carrageenan = 80 : 17 : 3.
L0 = concentration of hot water extract from pluchea leaf tea = 0%.
L1 = concentration of hot water extract from pluchea leaf tea = 15%.
L2 = concentration of hot water extract from pluchea leaf tea = 30%.

Figure 1. Stink Lily Noodles. Note K0 = wheat flour: stink lily flour: κ-carrageenan = 80 : 20 : 0, K1 = wheat flour: stink lily flour: κ-carrageenan = 80 : 19 : 1 , K2 = wheat flour: stink lily flour: κ-carrageenan = 80 : 18 : 2 , K3 = wheat flour: stink lily flour: κ-carrageenan = 80 : 17 : 3, L0 = concentration of hot water extract from pluchea leaf tea = 0%, L1 = concentration of hot water extract from pluchea leaf tea = 15% , L2 = concentration of hot water extract from pluchea leaf tea = 30%.

Table 3. Color, Moisture Content, Swelling Index, Cooking Loss, and Tensile Strength of Stink Lily Noodles.

Samples	Color					Moisture Content (%)	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (N)
	L*	a*	b*	C	h				
K0L0	73.00 ± 0,06	1.20 ± 0.06	16.90 ± 0.25^{a}	17.00±0.31^{a}	86.40±0.00^{g}	64.15±0.70	148.90±0.15^{c}	18.83±0.44	0.106±0.002
K0L1	68.70 ± 0.35	2.60 ± 0.06	26.50 ± 0.32^{d}	26.50±0.29^{c}	84.40±0.21^{bc}	63.66±0.38	146.36±0.27^{b}	19.06±0.43	0.105±0.001
K0L2	67.80 ± 0.20	2.80 ± 0.06	27.80 ± 0.46^{ef}	27.80±0.45^{e}	84.20±0.32^{abc}	62.83±0.58	142.25±0.39^{a}	20.13±0.71	0.116±0.006
K1L0	73.40 ± 0.25	1.30 ± 0.06	17.30 ± 0.15^{ab}	17.30±0.15^{a}	85.70±0.21^{f}	64.42±0.80	149.63±0.34^{d}	18.47±0.31	0.086±0.005
K1L1	69.00 ± 0.36	2.80 ± 0.12	27.30 ± 0.45^{e}	27.40±0.50^{d}	84.20±0.15^{a}	62.95±0.68	146.65±0.43^{b}	19.36±0.92	0.103±0.004
K1L2	68.30 ± 0.15	3.00 ± 0.12	28.60 ± 0.12^{g}	28.70±0.15^{f}	84.00±0.15^{abc}	63.37±1.04	148.85±057^{c}	19.76±0.90	0.108±0.005
K2L0	73.70 ± 0.10	1.50 ± 0.00	17.70 ± 0.26^{bc}	17.80±.23^{a}	85.20±0.06^{de}	64.67±1.08	155.67±0.46^{h}	18.18±0.45	0.098±0.002
K2L1	69.40± 0.15	3.00 ± 0.06	28.20 ± 0.15^{fg}	28.40±0.15^{f}	83.80±0.17^{ab}	63.74±0.75	150.96±0.71^{e}	18.62±0.41	0.106±0.005
K2L2	68.70 ± 0.06	3.10 ± 0.15	29.30 ± 0.00^{h}	29.40±0.06^{g}	84.00±0.15^{abc}	64.25±1.60	154.82±0.44^{g}	19.34±0.77	0.114±0.003
K3L0	74.50 ± 0.23	1.70 ± 0.12	18.10 ± 0.00^{c}	18.10±0.06^{b}	84.60±0.21^{cd}	65.83±0.22	162.21±0.25^{i}	17.83±0.41	0.110±0.003
K3L1	69.80 ± 0.50	3.20 ± 0.06	29.30 ± 0.12^{h}	29.30±0.06^{g}	83.80±0.53^{ab}	64.57±1.78	153.35±0.15^{f}	18.36±0.17	0.124±0.007
K3L2	69.00 ± 0.20	3.30 ± 0.26	30.00 ± 0.06^{i}	30.10±0.06^{h}	83.60±0.06^{a}	65.49±1.04	159.59±0.52^{i}	19.22±0.84	0.126±0.008

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

3.2. Bioactive Compounds and DPPH Free Radical Scavenging Activity (DPPH)

Bioactive compounds analyzed included total phenol content (TPC) and total flavonoid content (TFC). The analysis data showed that the TPC and TFC increased significantly due to the interaction effect between the proportion of κ-carrageenan and the addition of pluchea tea extract (Table 4). The results of the analysis showed that the control sample K0L0 had the lowest total phenol, i.e. 0.3409 ± 0.0338 mg GAE/kg dry noodles. The K2L2 sample had the highest total phenol, which was 1.1963 ± 0.0272 mg GAE/kg dry noodles. This result was suitable with the TFC value of wet noodles where K0L0 had the lowest TFC value and K2L2 had the highest value, i.e., 0.0534 ± 0.0036 and 1.3364 ± 0.04601 mg CE/kg dry noodles, respectively. The high and low values of TPC and TFC were correlated with AOA. The higher the TPC and TFC values, the higher the DPPH value. The DPPH free radicals scavenging activity of wet noodles was determined significantly by the interaction effect of adding the proportion of κ-carrageenan and pluchea tea extract. K0L0 had the lowest DPPH value and K2L2 had the highest DPPH value, i.e. 0.4143±0.0060 and 0.7576±0.0092 mg GAE/kg dry noodles, respectively.

3.3. Sensory Properties

The evaluated sensory properties of the stink lily noodles were shown in Table 5. Parameter sensory that analyzed included aroma, color, taste, texture, and overall acceptability. The method used for sensory assay of stink lily noodles was hedonic scale scoring or a test of the level of consumer preference for a product by giving an assessment or score on a certain trait [33]. Organoleptic testing of stink lily wet noodles was presented to 100 untrained panelists aged 17-25 years. Panelists are asked to give scores or numbers based on their level of preference for certain treatments. The value score used was 1-15, where a value of 0-3.0 indicated "strongly dislike", a value of 3.1-6.0 "does not like", a value of 6.1-9.0 "neutral", a value of 9.1-12.0 “like”, and 12.1-15.0 “like very much”. The results of statistical tests by ANOVA at $p < 5\%$ showed that interaction effect of each treatment significantly influenced the panelists' preference for noodle color. The preference value of stink lily noodles color was ranged from 9.12 to 12.02 (like). The highest color preference value was the control treatment (K0L0) and the treatment with the lowest color preference value was K0L1. The interaction effect of each treatment were significantly determined the panelists' preference for the aroma. The preference value for the aroma of wet noodles was ranged from 8.29 to 11.58 (neutral-like). The treatment with the highest preference value was stink lily noodles K1L0 and the treatment with the lowest preference value was K3L2 treatment. The preference value of noodles taste was only affected by κ-carrageenan proportion or extract concentration. The preference value for the wet noodle taste was ranged from 8.18 to 11.08 (neutral-like). The treatment with the highest taste preference value was K2L0 while the treatment with the lowest taste preference value was K0L2. Increasing the proportion of carrageenan to 2% increased the preference value for taste, after that it decreased with the addition of the proportion of 3% carrageenan. While increasing the concentration of pluchea leaf tea extract decreased the panelists' preference for taste. The results of statistical tests using ANOVA at $p < 5\%$ showed that the addition of extract only significantly influenced the panelists' preference for noodles texture. In this study, the preference for wet noodles texture was ranged from 9.46 to 11.66 (like).

Table 4. Total Phenol Content, Total Flavonoid Content, and DPPH Free Radical Scavenging Activity of Stink Lily Noodles.

Samples	TPC (mg GAE/g dry noodles)	TFC (mg CE/g dry noodles)	DPPH Scavenging Activity (mg GAE/g dry noodles)
K0L0	$0.3409{\pm}0.0338^{a}$	$0.0571{\pm}0.0035^{a}$	$0.4143{\pm}0.0060^{a}$
K0L1	$0.9480{\pm}0.0273^{d}$	$0.7044{\pm}0.0065^{c}$	$0.7424{\pm}0.0159^{c}$
K0L2	$1.0991{\pm}0.0466^{e}$	$1.1087{\pm}0.0065^{d}$	$0.7571{\pm}0.0013^{c}$
K1L0	$0.4576{\pm}0.0396^{b}$	$0.0821{\pm}0.0017^{a}$	$0.5229{\pm}0.0259^{b}$
K1L1	$0.9243{\pm}0.0774^{d}$	$0.7348{\pm}0.0030^{c}$	$0.7497{\pm}0.0055^{c}$
K1L2	$1.0047{\pm}0.0704^{d}$	$1.0910{\pm}0.0949^{d}$	$0.7509{\pm}0.0012^{c}$
K2L0	$0.4997{\pm}0.0450^{b}$	$0.0888{\pm}0.0084^{a}$	$0.5318{\pm}0.0052^{b}$
K2L1	$0.9648{\pm}0.0248^{d}$	$0.7181{\pm}0.0179^{c}$	$0.7477{\pm}0.0043^{c}$
K2L2	$1.1963{\pm}0.0272^{f}$	$1.3364{\pm}0.0460^{e}$	$0.7576{\pm}0.0092^{c}$
K3L0	$0.5267{\pm}0.0070^{b}$	$0.2181{\pm}0.0025^{b}$	$0.5873{\pm}0.0197^{b}$
K3L1	$0.8070{\pm}0.0307^{c}$	$0.7264{\pm}0.0385^{c}$	$0.7508{\pm}0.0077^{c}$
K3L2	$1.1446{\pm}0.0636^{ef}$	$1.0674{\pm}0.0627^{d}$	$0.7505{\pm}0.0066^{c}$

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

The increasing the addition of extracts decreased the level of the texture preference of wet noodles. The overall preference value of wet noodles showed that there was the interaction effect between the proportion of κ-carrageenan and the addition of pluchea tea extract. The preference value for the overall of wet noodles was ranged from 8.62 to 11.24 (neutral-like). The treatment with the highest preference value was stink lily noodles K0L0 and the treatment with the lowest preference value was K3L2. Determination of the best treatment for differences in the proportions of κ-carrageenan and the addition of pluchea tea extract on wet noodles was determined using the spider web method based on organoleptic parameters (color, aroma, taste, texture and overall). The spider web graph can be seen in Figure 2. Data showed that the treatment with the largest area was K2L0, i.e. wet noodles with the proportion of κ-carrageenan 2 % with the addition of 0% pluchea tea extract. The area of the K2L0 treatment area was 79.16 cm^2 and had a preference score of 15.8 with a very like category.

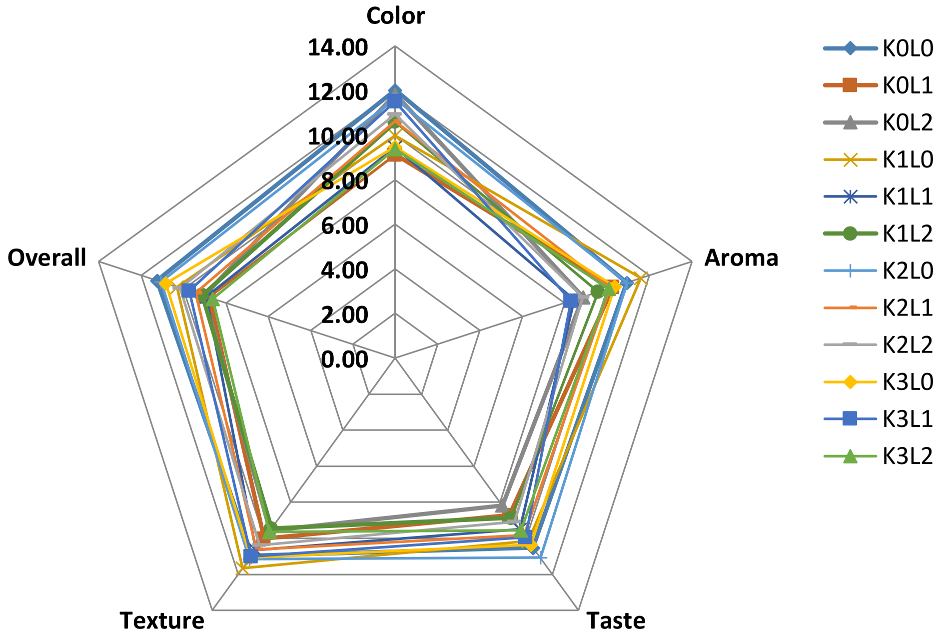

Figure 2. Spider web Graph to Determine the Best Treatment of Stink Lily Noodles.

Table 5. Sensory Properties of Stink Lily Noodles.

Samples	Hedonic Preference Score				
	Color	Aroma	Taste	Texture	Overall Acceptance
K0L0	12.02^{f}	10.93^{d}	10.52	10.95	11.24^{f}
K0L1	9.12^{a}	10.26^{cd}	8.72	10.03	8.79^{a}
K0L2	11.83^{ef}	8.86^{ab}	8.18	9.58	9.04^{ab}
K1L0	9.98^{bc}	11.58^{e}	10.15	11.66	10.3^{cde}
K1L1	9.44^{ab}	9.58^{bc}	9.49	10.66	8.93^{ab}
K1L2	10.59^{cd}	8.45^{a}	8.87	9.46	9.11^{ab}
K2L0	11.62^{f}	10.93^{de}	11.08	11.15	11.07^{def}
K2L1	10.63^{cd}	10.14^{ab}	9.82	10.61	9.42^{abc}
K2L2	10.94^{de}	8.84^{cd}	9.09	10.38	10.16^{cde}
K3L0	11.51^{ef}	10.36^{cd}	10.37	11.07	10.84^{def}
K3L1	9.37^{ab}	10.07^{a}	9.95	11	9.72^{bc}
K3L2	9.47^{ab}	8.29^{cd}	9.57	9.64	8.62^{a}

4. Discussion

4.1. Cooking Quality

Moisture content is a major parameter of stinky silky wet noodles that shows the amount of water contained in food product that determines rheological characteristics, chemical, physical, and sensory properties, and shelf life of food product [34]. The result showed that the κ-carrageenan addition gave a significant difference of moisture content to wet noodles. The κ-carrageenan is hydrocolloids that has a group of sulfate and water-soluble polysaccharides [35,36,37], composes an ester sulfate content about 25-30% and a 3,6-anhydro-galactose (3,6-AG) about 28 to 35% [38,36]. This anionic carrageenan can interact very tightly with water molecule [39] and can be collaborated with glucomannan from stink lily on gelation process [40] with making intra- and inter-disulfide bind at network structure of gluten [13,41]. The κ-carrageenan can bind with limited free water molecule, form complexes compounds with water, and interact with gluten network [13]. However, the mobility of water mainly depends on changes in the hydrogen bond structure. The presence of hydrophilic components such as proteins, carbohydrates, glucomannan, κ-carrageenan and polyphenolic compounds in wet noodles can be involved in hydrogen bonding with water molecules that determine water mobility [13,34,41,42]. Thus, increasing the proportion of k-carrageenan used in the manufacture of stink lily noodles can increase the amount of free water and weakly bound water in wet noodles. the interaction between the hydroxyl functional groups in carrageenan and water molecules supports an increase in the water content of wet noodles.

The swelling index or water absorption is the ability of a product to absorb water which is influenced by particle size, chemical composition, and water content [43]. The research showed that the interaction of κ-carrageenan proportion and hot water extract of pluchea leaf tea addition gave a significant effect of the swelling index properties from wet noodles. The swelling index of wet noodles was determined by the presence of κ-carrageenan, protein, starch, glucomannan, and bioactive compounds of pluchea tea extract in dough. [13] said that glutelin proteins of wheat flour can involve intra-and intermolecular disulfide bonds to result a fibrous shape, and then globular gliadin protein of wheat flour can be bound at the glutenin skeleton by non-covalent bonds to be a unique networks structure of gluten. The addition of the glucomannan of stinky silky flour as a non-ionic hydrocolloid has good water holding capacity and can be made a stronger three-dimensional network structure. [44] informed that the glucomannan can fill the number of holes of the network structure of gluten that make a structure dense and stable. [13] underlined that glucomannan has many hydroxyl group in the structure that can be bound tightly with water by electrostatic forces and hydrogen bond. [41] said that the presence of κ-carrageenan in dough can be synergist with glucomannan to change sulfhydryl groups to be disulfide bonds in protein. [20] informed that bioactive compounds of pluchea tea extract are alkaloids, flavonoids, phenolics, phenol hydroquinone, saponins, tannins, sterols, terpenoids, and cardiac glycosides. Meanwhile [16] informed that pluchea leaves contain 1.79 g/100 g protein, 0.49 g/100 g fat, 0.20 g/100 g ash, 0.89 g/100 g insoluble fiber, 0.45 g/100 g dissolved fiber, total fiber 1.34 g/100 g, carbohydrates 8.65 g/100 g, calcium 251 g/100 g, β-carotene 1.225 g/100 g and vitamin C 30.17 g/100 g, and phenolic acid bioactive compounds 28.48± 0.67 mg/100 g body weight (chlorogenic acid 20±0.24 mg/100 g body weight, caffeic acid 8.65±0.46 mg/100 g body weight), total flavonoids 6.39 mg/100 g body weight (quercetin 5.21± 0.26 mg/100 g body weight, kaempferol 0.28 ± 0.02 mg/100 g body weight, myrisetin 0.09 ± 0.03 mg/100 g body weight), total anthocyanins 0.27 ± mg/100 g body weight, β-carotene 1.70 ± 0.05 mg/100 g body weight and total carotenoids 8.7 ± 0.34 mg/100 g body weight. [17,18,19] proved that pluchea leaves contain 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, and 4,5- O-dicaffeoylquinic acid. [45] informed that phenolic acid can be bound with protein and carbohydrate by non-covalent interactions, i.e. hydrophobic interaction, hydrogen bonding, electrostatic interaction, van der Waals interaction, and π-π stacking. The presence of κ-carrageenan proportion and pluchea tea extract addition that differed caused change of composition and various interaction of compounds that determined different swelling index of wet noodles.

The cooking loss of stink lily noodles was influenced significantly by κ-carrageenan proportion nor extract addition, but interaction of two factors was insignificant difference. The phenomena was caused by κ-carrageenan and bioactive compounds of pluchea tea extract, especially phenolic compounds, that involved the interaction with protein and carbohydrate in dough. κ-carrageenan can stabilized and supported a rigid structure of gluten. The hydrocolloid can avoid starch gelatinization process because it can bind tightly with water molecule caused lower the water activity. Supported by [13,46,41], κ-carrageenan can trap the free water molecule that starch can't absorb the water molecule and require higher energy to break the energy barrier required for the starch gelatinization process. Whereas [42,47,45] clarified that starch can be bound with polyphenol, including hydrophobic and electrostatic interactions and hydrogen bond that the hydrogen bond is dominant binding forces. This interaction can support releasing of amylose of starch gelatinization process that the cooking loss increased at the higher pluchea tea extract addition. The presence of polyphenol compounds of pluchea tea extract caused water competition with glutenin and gliadin of wheat flour that inhibited interaction between glutenin and gliadin to form gluten. According to [47], gluten and gliadin in a random coil structure can be aggregated by phenolic compounds and starch easily undergoes a gelatinization process where amylose interacts with polyphenolic compounds, through hydrogen bonds and hydrophobic interactions. The more protein in the form of random coil structure causes the protein to easily interact with polyphenols and come out of the noodles during the cooking process that the cooking loss increases.

The tensile strength of stink lily was influenced significantly by κ-carrageenan proportion nor extract addition. The increasing κ-carrageenan proportion grew up tensile strength because this hydrocolloid could be made strong cross linking through inter-molecular and intra-molecular bonds involving the glutenin and gliadin of wheat flour protein, and glucomannan of stink lily flour. The more networks that are formed between the components of the noodles have an effect on the tensile strength of wet noodles, and vice versa [13,48]. The synergism effect of the wet noodles component determined water bind capacity and water mobility that established texture properties of wet noodles, this statement is supported by [34,40,41]. [49] also informed that the addition of hydrocolloids in the noodles-making process increases the viscosity and water absorption because the water binding and holding properties of hydrocolloids that can form gel. However, the addition of pluchea tea extract caused the tensile strength to decline because the polyphenol compounds of pluchea tea extract induced breakdown of the networking structure among the components of dough because there was water competition among them. Furthermore, the polyphenol compounds could be reacted with starch and protein because the formation of the gluten network was disrupted that gliadin and glutenin in the form of random coils and starch could be underwent an excessive gelatinization process. This opinion is supported by [13,42,41]. κ-carrageenan has a yellowish white color and has the ability to bind water molecules that it increases the lightness of wet noodles, while the pluchea tea extract contains polyphenolic compounds, such as tannins which can give the noodles a brown color that the lightness level is reduced. This opinion was supported by [20,38]. The increase in yellowness was in line with the increase in lightness because the higher the water content value was caused by the ability of κ-carrageenan to bind water molecules, thereby increasing the brightness and the brown color contribution of the pluchea tea extract gave a brownish-yellow color of the wet noodles that the intensity of this color increased as indicated by the increased chroma value.

4.2. Bioactive Compounds and DPPH Free Radical Scavenging Activity

The stinky silky wet noodles K0L0 had the lowest TPC and TFC because there was contributed of phenolic content from wheat flour and egg. [50] said that wheat flour has phenolic acids including ferulic, caffeic, and p-coumaric acid. Moreover, the presence of TFC in the K0L0 sample is thought to be due to the presence of a thiol group in egg white which is able to chelate metal ions and is able to be conjugated with saccharides [51], as well as 3,5-diacetyltambulin compounds from stink lily flour [52]. While the TFC and TPC values in the K2L2 sample were dominantly contributed by the presence of phytochemical compounds in the pluchea tea extract. [20] explained that there are phytochemical compounds in the pluchea tea extract. [16, 17,18,19] also emphasized that pluchea leaves contain phenolic acids and flavonoids. The existence of a non-significant difference between treatments in the TPC and TFC assays indicated an interaction between the components in the dough that it affected the presence of free hydroxyl groups that could bind to the Folin Ciocalteus phenol reagent. as described by [13,41,42,45,47] glutenin, gliadin, glucomannan, κ-carrageenan, and polyphenol compounds are involved in the formation of networks structure in the dough so as to determine the quality of wet noodles. The interactions that occur involve various non-covalent interaction mechanisms that affect the presence of free hydroxyl groups. The TPC and TFC values of wet noodles in each treatment affected DPPH free radical scavenging activity (DPPH). They determined DPPH of wet noodles, usually positively correlated. [53] said that TPC and DPPH were strongly correlated in seeds, sprouts and grasses of corn (*Zea mays* L.). [54] also informed that there is an excellent correlation coefficient between the TPC, TFC and antioxidant activities of *Phaleria macrocarpa* fruit. [55] explained that the high level of flavonoids and phenols in plant caused the antioxidant activity of *Grewia carpinifolia* extract. The antioxidant activity of phenolics is related to their redox properties which induced them to act as reducing agents, hydrogen donors, singlet oxygen quenchers and metal chelators. [56] underlined that DPPH free radical scavenging activity of polyphenol compounds of *T. pallida* extract was determined by hydrogen donating ability which it highly correlated. The potency of wet noodles as AOA was determined by reduced capability of DPPH free radical solution color from purple to be yellow color.

4.3. Sensory Properties

The analysis of sensory properties of the stink lily noodles was conducted by the hedonic scale scoring method with attribute the preference of color, taste, aroma, texture and overall. The result of the color preference test showed that the control treatment (K0L0) was the highest value because the treatment without the addition of pluchea tea extract not change the color of the wet noodles was yellowish-white. And then the treatment with the lowest color preference value was K0L1 due to the addition of this extract decreased the panelists' preference for the color because the noodles were darker and brownish color. [16,20] said that the color of the pluchea tea extract contributed to changing the color of this wet noodle originated from tannins, flavonoids, and chlorophyll. However, in this study, increasing the extract concentration did not significantly affect the panelists' preference for color when the proportion of κ-carrageenan increased, because the addition of stink lily flour and κ-carrageenan would increase the lightness of the wet noodles that the produced color of the wet noodles was brighter and preferred by panelists. This data was supported by the data from color rider analysis, where the results of the sensory test by the panelists were in line with the decrease in the lightness value, the increase in the reddish and yellowish values, the hue value showed the yellow-red color, and chroma value showed an increase in color intensity. The panelist preference of aroma from wet noodles was determined by the aroma from the material used to make wet noodles or the interaction of aroma produced from the reaction among the material composition. According to [57], stink lily flour has a musty aroma, and all wet noodles produced have a musty smell. Meanwhile, according to [58], κ-carrageenan is unscented that not contribute to wet noodles. The addition of pluchea tea extract decreased the panelists' preference for the aroma of wet noodles because the addition of the extract caused the wet noodles to smell like leaves (floral) and unpleasant and the panelists did not like it. Fragrant or unpleasant aroma comes from volatile compounds contained in pluchea leaves. According to [59], pluchea leaves have 66 volatile compounds, these volatile compounds play a role in forming the aroma in the hot water extract of pluchea leaf tea. According to [60], pluchea leaves contain volatile compounds contributed by aliphatic aldehyde group compounds or aromatic compounds that give a distinctive aroma, therefore the presence of these compounds in steeping water can give a specific aroma, i.e. fragrant (floral) in wet noodles. There was a difference in the effect of the proportion of κ-carrageenan and pluchea leaf tea extract on taste due to the contribution of taste produced by carrageenan and extract. According to [57,61], stink lily flour and κ-carrageenan do not have a distinctive or neutral taste, increasing the concentration of κ-carrageenan gives a higher preference value because noodles are considered to have a better texture that contributes to the assessment of taste. The increase in the concentration of pluchea tea extract caused the taste preference value of noodles to decrease significantly, this is due to the presence of tannins, catechins, and phenolic compounds in the pluchea tea extract which determined bitter and slightly astringent. The effect of κ-carrageenan proportion and tea extract to make wet noodles influenced panelist preference of texture because this hydrocolloid can be make strong cross linking through inter-molecular and intra-molecular bonds involving the glutenin and gliadin of wheat flour protein, and glucomannan of stink lily flour that determined water bind capacity and water mobility [34,40,41]. Presence of the polyphenol compounds of pluchea tea extract can be breakdown of the networking structure among the components of dough because of water competition of them. [13,42,41] said that the polyphenol compounds could be reacted with starch and protein to disrupt the gluten network and cause starch to undergo an excessive gelatinization process. The difference in the proportion of κ-carrageenan change the overall preference value of wet noodles to be significantly different overall compared to the control, this was because the proportion of κ-carrageenan influenced the all sensory attribute (color, aroma, and taste). The addition of pluchea tea extract in wet noodles decreased the overall preference value because the addition of extract affected the organoleptic characters tested due to the content of secondary metabolites of pluchea leaves, such as flavonoids, phenols, and tannins that could affect the taste, aroma, the color, and texture of the noodles. Based on spider web graph showed that K2L0 was the best treatment of stink lily wet noodles. It was also supported by better physicochemical properties than the control, including yellowish white wet noodles, better swelling index, lower cooking loss, higher tensile strength value, and lower moisture content. However, this K2L0 treatment did not have the highest TPC, TFC, and AOA, i.e. 0.4997±0.0450; 0.0888±0.0084; and 0.5318±0.0052, respectively.

5. Conclusions

The use of κ-carrageenan proportions and pluchea leaf tea extract had a significant effect on the cooking quality and sensory properties of stink lily wet noodles. Statistical analysis at $p < 5\%$ showed that there was an interaction effect of the proportion of κ-carrageenan and pluchea leaf tea extract on the swelling index, yellowness, chroma, hue, TPC, TFC, DPPH, the preference value for color, aroma, and overall acceptance. While the moisture content of wet noodles was only affected by the proportion of κ-carrageenan, for tensile strength, cooking loss, lightness, and redness, and the preference value for texture and taste were influenced by the proportions of κ-carrageenan and the concentration of pluchea leaf tea extract, respectively. The best treatment based on the spider web graph showed that the K0L2 treatment had the largest area 79.16 cm^2 and a preference score of 15.8 with a very like category, this is in accordance with the results of physicochemical and sensory tests, but it was no correlated with the highest bioactive content (TPC and TFC) and DPPH.

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Sample Availability: Samples of stink lily wet noodles and pluchea leaf tea are available from the authors.

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4. Second Review: Minor Revision (4-7-2022)
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Dear Dr. Widyawati,

Thank you very much for providing the revised version of your paper:

Manuscript ID: molecules-1821369
Type of manuscript: Article
Title: The Effect of k-Carrageenan Proportion and Hot Water Extract of
Pluchea Indica Less Leaf Tea to Quality and Sensory Properties of Stink Lily
(Amorphophallus Muelleri) Wet Noodles
Authors: Paini Sri Widyawati *, Thomas Indarto Putut Suseno, Theresia Endang
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Journal	Molecules (https://www.mdpi.com/journal/molecules) (ISSN 1420-3049)
Manuscript ID	molecules-1821369
Type	Article
Title	The Effect of k-Carrageenan Proportion and Hot Water Extract of Pluchea Indica Less Leaf Tea to Quality and Sensory Properties of Stink Lily (Amorphophallus Muelleri) Wet Noodles (https://www.mdpi.com/1420-3049/27/16/5062)

Authors: Paini Sri Widyawati * (https://sciprofiles.com/profile/2124526) , Thomas Indarto Putut Suseno , Theresia Endang Widoeri Widyastuti , Anna Ingani Widjajaseputra , Vincentia Wilhelmina Moeljadi , Sherina Tandiono

Abstract: The study aimed to determine the effect of the proportion of k-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles. The research design used was a Randomized Block Design with two factors, i.e. the difference in the proportion of k-carrageenan (K) (0, 1, 2, and 3% b/b) and the addition of hot water extract of Pluchea indica Less leaf tea (L) (0, 15, and 30% b/v) with 12 treatment level (K0L0, K0L1, K0L2, K1L0, K1L1, K1L2, K2L0, K2L1, K2L2, K3L0, K3L1, K3L2). The data were analyzed by the Anova at □= 5% and continued with the Duncan's Multiple Range Test at p= 5% and the best treatment was determined by the Spider web method based on sensory assay by a hedonic method. The proportions of □-carrageenan and the concentration of pluchea tea extract had a significant effect on cooking quality and sensory properties. However, the interaction of the two factors affected the swelling index, yellowness (b*), chroma (C), hue (h), total phenol content (TPC), total flavonoid content (TFC), and DPPH free radical scavenging assay (AOA). The best treatment of wet noodles was K2L0 with a preference score of 15.8. The binding of □-carrageenan and phenolic compounds to make networking structure by intra- and inter-disulfide bind between glucomannan and gluten, was thought to affect the cooking quality, sensory properties, bioactive compounds (TPC and TFC), and AOA.

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Authors' Responses to Reviewer's Comments (Reviewer 1)

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Author's Notes	Dear Reviewer Thanks for attention The Best Regards Paini Sri Widyawati

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Title: The Effect of k-Carrageenan Proportion and Hot Water Extract of Pluchea Indica Less Leaf Tea to Quality and Sensory Properties of Stink Lily (Amorphophallus Muelleri) Wet Noodles (https://www.mdpi.com/1420-3049/27/16/5062)

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Authors' Responses to Reviewer's Comments (Reviewer 2)

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Dear Reviewer

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Comments and Suggestions for Authors

Although the manuscript has been considerably improved, the authors have not taken into account all the suggestions made by the reviewer. Moreover, it continues to have quite a few formatting errors. Therefore, there are still important aspects that must be clarified to be published:

- LINE 76. The figures included in the previous non-published material version could be included in the manuscript to better understand the elaboration process. Include a flowchart of the

Stink Lily (*Amorphophallus Muelleri*) wet noodles making process.

- LINE 107. The information included in the manuscript seems misplaced. Put tables and figures as close as possible to where they are cited in the text. For example, Table 2 is cited on line 107, but does not appear until line 244.

- LINE 304. Revise the number of significant decimals in Table 4.

- LINE 350. Include the name of the authors, replacing "[13]" with "by Li et al. [13]". Review it throughout the text (LINES 355, 356, 358, 360, 362, 373, 394, 408, 434, 445, 446, 448, 451, 476, 477, 481, 483).

- LINE 385. Begin the sentence as "k-carrageenan can trap the free water molecule…", and move [13,46,41] to the end of the sentence.

- LINE 388. Include "other authors" after "Whereas".

- LINE 408. Include "other authors" after "by". The same in LINE 417, 439.

- LINE 435. Include "other authors" before "[16, 17,18,19]". The same in LINE 464, 501.

- LINE 489. Include "other authors" after "to".

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The Effect of κ-Carrageenan Proportion and Hot Water Extract of *Pluchea Indica* Less Leaf Tea on Quality and Sensory Properties of Stink Lily (*Amorphophallus Muelleri*) Wet Noodles

Paini Sri Widyawati [†,*], Thomas Indarto Putut Suseno , Anna Ingani Widjajaseputra , Theresia Endang Widoeri Widyastuti, Vincentia Wilhelmina Moeljadi and Sherina Tandiono

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Abstract : The study aimed to determine the effect of the proportion of κ-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles. The research design used was a Randomized Block Design with two factors, i.e. the difference in the proportion of κ-carrageenan (K) (0, 1, 2, and 3% w/w) and the addition of hot water extract of *Pluchea indica Less* leaf tea (L) (0, 15, and 30% w/v) with 12 treatment level (K0L0, K0L1, K0L2, K1L0, K1L1, K1L2, K2L0, K2L1, K2L2, K3L0, K3L1, K3L2). The data were analyzed by the ANOVA at p< 5% and continued with the Duncan's Multiple Range Test at p< 5% and the best treatment was determined by the Spider web method based on sensory assay by a hedonic method. The proportions of κ-carrageenan and the concentration of pluchea tea extract had a significant effect on cooking quality and sensory properties. However, the interaction of the two factors affected the swelling index, yellowness (b*), chroma (C), hue (h), total phenol content (TPC), total flavonoid content (TFC), and DPPH free radical scavenging assay (DPPH). The best treatment of wet noodles was K2L0 with a preference score of 15.8. The binding of κ-carrageenan and phenolic compounds to make networking structure by intra- and inter-disulfide bind between glucomannan and gluten, was thought to affect the cooking quality, sensory properties, bioactive compounds (TPC and TFC), and DPPH

Keywords: *Amorphophallus muelleri*; *Pluchea indica* Less; wet noodles; quality and sensory properties

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1. Introduction

Noodles are a rice substitute commodity that is much favored by the public [1], especially in China, Indonesia, India, Japan, Vietnam, and the United States. Basically, noodles are divided into wet noodles and dry noodles. Indonesia is the second country in the world that likes to consume noodles [2]. In 2017, the consumption of instant noodles achieves by 180.2 packets per head in the world, and in Indonesia, the consumption of wet noodles shows that all age groups and education levels like it [3]. Meanwhile, instant noodle consumption in 2020 reached 12,640 million portions [2]. Noodles are generally made from wheat flour, the use of local food ingredients based on carbohydrates, including stink lily flour, can reduce the consumption of wheat flour which is quite high in Indonesia, the average consumption of wheat flour for the Indonesian population in 2019 is 17.8 kg/capita/year [4].

Stink lily flour (*Amorphophallus muelleri*) is a group of *Araceae* that contains glucomannan oligosaccharides around 15-64% dry base [5] or more than 60% [6]. Glucomannan is a heteropolysaccharide consisting of 67% D-mannose and 33% D-glucose and has β-1,4 and β-1,6 glycoside bonds [7], which can reduce body weight, sugar content blood levels,

LDL cholesterol levels and prolong gastric emptying time [8,9]. Stink lily flour has a glycemic index of 85 which is lower than the glycemic index of glucose which is considered to be 100 [7]. The use of stink lily flour in the manufacture of wet noodles is able to replace the role of gliadin and glutenin proteins in the formation of gluten with an elastic texture [10]. Polysaccharides in stink lily flour can dissolve in water to form a thick solution, form a gel, expand, and melt like agar [11], can increase the elasticity and cohesiveness [12,13] with increasing α-helix and β-sheet structures of wet noodles [13]. However, the higher the substitution of stink lily flour, the lower the texture preference because the noodles break easily and are sticky [12]. Therefore, it is necessary to add hydrocolloids, including carrageenan, because they can increase elasticity [14]. The combination of the use of glucomannan and carrageenan can form a strong and elastic gel [15].

The addition of hot water extract from pluchea leaf tea in making stink lily wet noodles is expected to increase the functional value of wet noodle products. Pluchea leaves contain nutrients, such as: protein 1.79 g/100 g, fat 0.49 g/100 g, ash 0.20 g/100 g, insoluble fiber 0.89 g/100 g, soluble fiber 0.45 g/100 g, total fiber 1.34 g/100 g, carbohydrates 8.65 g/100 g, calcium 251 g/100 g, β-carotene 1.225 mg/100 g and vitamin C 30.17 mg/100 g as well as bioactive compounds, such as: phenolic acid 28.48±0.67 mg/100 g wb (chlorogenic acid 20±0.24 mg/100 g wb, caffeic acid 8.65±0.46 mg/100 g wb), total flavonoids 6.39 mg/100 g wb (quercetin 5.21±0.26 mg/100 g wb, kaempferol 0.28±0.02 mg/100 g wb, myricetin 0.09± 0.03 mg/100 g wb), total anthocyanins 0.27±0.01 mg/100 g wb, β-carotene 1.70±0.05 mg/100 g wb, and total carotenoids 8.7±0.34 mg/100 g wb [16], 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, and 4,5-O-dicaffeoylquinic acid [17,18,19]. Meanwhile, hot water extract of 2% pluchea leaf tea (2 g/100 ml) contains a total phenolic content of 9.3 mg EAG/ g, total flavonoid content 22.0 mg EC/ g, DPPH free radical scavenging activity DPPH 27.2 mg EAG/ g, and reduced iron ion 10.2 mg EAG/ g [20], due to the presence of phytochemicals (alkaloids, flavonoids, phenolics, sterols, cardiac glycosides, phenol hydroquinone, tannins, terpenoids, and saponins) [20], which has been shown to have potential as an antioxidant [20,21] and antidiabetic [22]. The effect of using κ-carrageenan and water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles has not been studied in detail. Therefore, the purpose of this study was to determine the effect of the proportion of κ-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles.

2. Materials and Methods

2.1. Reagents and Materials

The compounds 2,2-diphenyl-1-picrylhydrazyl (DPPH), sodium carbonate, gallic acid, and (+)-catechin were purchased from Sigma-Aldrich (St. Louis, USA). Methanol, folin ciocalteus phenol, sodium nitric, aluminium chloride, κ-carrageenan, and sodium hydroxide were purchased from Merck (New Jersey, USA).

Pluchea leaves as raw material for making pluchea leaf tea are collected from gardens around the city of Surabaya. Specification of pluchea plant is according to the GBIF taxon ID number database: 3132728. Stink lily flour is obtained from the stink lily flour processing industry in East Java. Specification of Stink lily plant is according to the GBIF taxon ID number database: 735493731. The wheat flour used is high protein flour obtained from the wheat flour processing industry in Indonesia.

2.2. Preparation of Pluchea Leaf Tea.

Pluchea leaves on each branch number 1-6 from the shoot were collected, sorted, and dried at an ambient temperature for 7 days until moisture content 11.16±0.09% dry base. And then dried leaves were powdered to get 45 mesh size [23]. Futhermore the leaf powder was heated by drying oven (Binder, Merck KGaA, Darmstadt, Germany) at 120 °C for

10 min. Then dried powder of pluchea leaves was packed 2 g in tea bag that called pluchea leaf tea.

2.3. Preparation of Hot Water Extract of Pluchea Leaf Tea.

Pluchea leaf tea in tea bag was extracted by hot water at 95 °C for 1 min to get 15 and 30% (b/v) concentrations (Table 1). And then each concentration of extract was used to make stink lily wet noodles.

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

Materials	**Concentration of hot water extract of pluchea leaf tea (% b/v)**		
	0	**15**	**30**
Pluchea leaf tea (g)	0	4.5	9
Hot water (mL)	30	30	30

2.4. Stink Lily Wet Noodles Making.

Stink lily wet noodles were made with mixing of wheat and stink lily flour, and κ-carrageenan at 1, 2, and 3% (b/b) concentrations. And then the mixture was added egg, salt, baking powder, and hot water extract of pluchea leaf tea and kneaded to form a dough by a mixer machine. Then the dough was passed through a roller to make face bands the desired thickness and cut through rollers using cutting blades. The formula of stink lily wet noodle was showed at Table 2.

Table 2. The formula of stink lily wet noodles.

Material	**K0L0**	**K0L1**	**K0L2**	**K1L0**	**K1L1**	**K1L2**	**K2L0**	**K2L1**	**K2L2**	**K3L0**	**K3L1**	**K3L2**
Wheat flour (g)	120	120	120	120	120	120	120	120	120	120	120	120
Stink lily flour (g)	30	30	30	28.5	28.5	28.5	27	27	27	25.5	25.5	25.5
κ-Carrageenan (g)	0	0	0	1.5	1.5	1.5	3	3	3	4.5	4.5	4.5
Egg (g)	30	30	30	30	30	30	30	30	30	30	30	30
Salt (g)	3	3	3	3	3	3	3	3	3	3	3	3
Baking Powder (g)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water (mL)	30	0	0	30	0	0	30	0	0	30	0	0
Hot water extract of pluchea leaves 15% (mL)	0	30	0	0	30	0	0	30	0	0	30	0
Hot water extract of pluchea leaves 30% (mL)	0	0	30	0	0	30	0	0	30	0	0	30
Total (g)	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5

Note: K0 = wheat flour: stink lily flour: κ-carrageenan = 80 : 20 : 0.
K1 = wheat flour: stink lily flour: κ-carrageenan = 80 : 19 : 1.
K2 = wheat flour: stink lily flour: κ-carrageenan = 80 : 18 : 2.
K3 = wheat flour: stink lily flour: κ-carrageenan = 80 : 17 : 3.
L0 = concentration of hot water extract from pluchea leaf tea = 0%.
L1 = concentration of hot water extract from pluchea leaf tea = 15%.
L2 = concentration of hot water extract from pluchea leaf tea = 30%.

2.5. Stink Lily Wet Noodles Extraction.

125 g each sample from stink lily wet noodles was weighed (Ohaus, Ohaus Instruments (Shanghai) Co., Ltd., RRT) and then they were dried by cabinet drying at 60 °C for 4 hours to get dried noodles. Next each sample was powdered by chopper machine at second speed for 35 seconds and then 20 g powdered sample was added 50 mL methanol by shaking water bath at 35 °C, 70 rpm for 1 hour. Filtrate was separated by Whatman filter paper grade 40 and residue was extracted again with same pattern way. Filtrate was collected and dried by rotary evaporator (Buchi Rotary Evaporator; Buchi Shanghai Ltd, RRT) at 0.2-0.3 atm, 50 °C for 60 min until getting 2 mL extract. Then extract was kept at 0 °C before further study.

2.6. Swelling Index Assay

Swelling index or water absorption is the ability of noodles to absorb water after gelatinization during the boiling process [24]. The principle of water absorption testing is to determine the amount of water absorbed in wet noodles at a certain temperature and time. The amount of water absorbed in wet noodles can be determined from the difference between the weight of the noodles after and before being boiled divided by the weight of the noodles before boiling [25].

2.7. Cooking Loss Assay

Cooking loss is one of the important quality parameters in wet noodles to determine the quality of wet noodles after cooking [26]. The cooking loss test for stink lily wet noodles was carried out to determine the number of solids that came out of the noodle strands during the cooking process, namely the release of a small portion of starch from the noodle strands.

2.8. Determination of Tensile Strength of Wet Noodles

The tensile strength (elongation) is one important parameter of texture analysis in noodle products. 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 principle of the texture analyzer is to prepare a suitable probe for the test, then place the noodle samples on the table under the probe. The elongation of the noodles was individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. The same procedure was done to tighten the other end of the strip to the upper roller arm. Elongation, which was the maximum force to deform and break noodles by extension, was measured using a test speed of 3.0 mm/s, with a 100 mm distance between two rollers. Deformations were recorded using the software during the extension and are expressed as a graph. The elongation at breaking was calculated per gram.

2.9. Color Measurement

The noodle samples were measured by a colorimeter (Minolta CM-3500D; Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab L*, a* and b* values were recorded as described by Rathorel et al.[27]. And then L*, a* and b* values were collected. The L* value was stated the position on the white/black axis, the a* value the position on the red/green axis, and the b* value the position on the yellow/blue axis. The measurements were done in triplicate and the readings were averaged.

2.10. Total Phenol Content Assay

Total phenol content (TPC) of stink lily wet noodles was analyzed by spectrophotometric method using folin ciocateus phenol reagent [28]. Principles assay of the TPC assay are interaction between phenolic compounds and phosphomolybdic/ phosphotungstic acid complexes based on the transfer of electrons in alkaline medium from phenolic compounds to form a blue chromophore constituted by a phosphotungstic/ phosphomolybdenum complex. The reduced folin ciocalteus phenol reagent is detected by a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 760 nm and gallic acid is used as the reference standard compound and results are expressed as gallic acid equivalents (mg/kg wet noodles).

2.11. Total Flavonoid Content Assay

Total flavonoid content of samples was measured by spectrophotometric method with reaction between $AlCl_3$ and $NaNO_2$ with aromatic ring of flavonoid compounds [29]. And then mixture was added aluminium chloride to result yellow solution. Next, addition of NaOH solution in mixture caused red solution that was measured by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 510 nm. As standard reference compound used was (+) catechin and results were expressed as catechin equivalents (mg/kg wet noodles).

2.12. DPPH Free Radical Scavenging Activity Assay

DPPH free radical scavenging activity was measured by the spectrophotometric method [30]. This method is used to determine the antioxidant capacity of a compound from an extract or other biological sources, based on transferring from the odd electron of a nitrogen atom in DPPH is reduced by receiving a hydrogen atom from antioxidants to result in DPPH-H with yellow-colored solution. Reaction between DPPH in methanol solution with samples was measured by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 517 nm. As standard reference compound used was gallic acid and results were expressed as gallic acid equivalents (mg/kg wet noodles).

2.13. Sensory Evaluation

Sensory assay was carried out to determine the level of panelist acceptance of wet noodles substituted with stink lily flour with the addition of carrageenan and hot water extract of pluchea leaf tea [31]. The test was carried out using the hedonic scale scoring method. This method is designed to measure the level of panelist preference for the product by rating the level of preference for the product being tested. Samples were served in dishes coded with random three-digit numbers that carried out using a completely randomized design (CRD) trial using 100 untrained panelists with an age range of 17 to 25 years. The hedonic method used in this study is the hedonic scoring method, the panelists were asked to give a preference score for each sample. The hedonic score used was a value of 1-15 given by the panelists according to the level of preference for the product. Values 0-3.0 indicate "strongly dislike", values 3.1-6.0 "dislike", values 6.1-9.0 "neutral", values 9.1-12.0 "like", and a value of 12.1-15.0 "very much like".

Each panelist is faced with 12 (twelve) samples and a questionnaire containing test instructions and is asked to give each sample a score according to their level of preference. The parameters tested were taste, aroma, texture, color, and overall acceptance of wet noodles substituted with stink lily flour. The best treatment of samples was determined by spider web method that was correlated by the large area of graph [32].

2.14. Experiment Design and Statistical Analysis

The research design of physicochemical assay used was a randomized block design with two factors, i.e. differences in the proportion of κ-carrageenan (K) and differences in the concentration of pluchea tea extract (L) added to wet noodles. The proportion of κ-carrageenan consisted of 4 (four) treatment levels, including 0% (K0), 1% (K1), 2% (K2), 3% (K3) and the concentration of pluchea tea extract consisted of 3 (three) levels, i.e., 0%

(L0), 15% (L1), and 30% (L2). Each treatment was repeated 3 (three) times in order to obtain 36 (thirty-six) experiment units. The sensory test used a completely randomized design (CRD) on 100 untrained panelists.

The data before further analysis was determined by the normal distribution and homogeneity tests. And then the data are presented as mean ± SD of the triplicate determinations and were analyzed using ANOVA at $p < 5\%$, if the results of the ANOVA test had a significant effect, then proceed with the DMRT (Duncan Multiple Range Test) test at $p < 5\%$ to determine the level of treatment that gave significantly different results. The analysis used SPSS 17.0 software (SPSS Inc. Chicago, IL, USA).

3. Results

3.1. Cooking Quality

The evaluated cooking properties of the stink lily wet noodles were showed in Table 3 and the stink lily wet noodles product was showed at Figure 1. The level of cooking was estimated by the moisture content, swelling index, cooking loss and tensile strength from noodles. Based on statistically analysis by ANOVA at $p < 5\%$, showed that the increasing of κ-carrageenan proportion went up significant difference of moisture content of wet noodles, but the addition of pluchea leaf hot water extract and the interaction effect of the proportion of κ-carrageenan and the addition of the extract no influenced to moisture content of wet noodles. The moisture content value was ranged from 62.83±0.58 %wb to 65.83±0.22 %wb. The sample K3L0 had the highest moisture content and K0L2 had the lowest moisture content. Furthermore, the addition of the κ-carrageenan proportion or pluchea tea extract had a significantly different effect such as the interaction effect of the addition of the two parameters, on the swelling index or water absorption value of wet noodles based on statistical analysis at $p < 5\%$. The water absorption value was ranged from 142.25±0.39% to 162.21±0.25%. The treatment with the lowest swelling index was K0L2 and the highest was K3L0. Whereas the cooking loss of wet noodles decreased significantly with the addition of the proportion of κ–carrageenan but increased significantly with the addition of pluchea tea extract. The cooking loss of wet noodles was ranged 17.83±0.4% to 20.13±0.7%. K0L2 was treatment with the biggest cooking loss and K3L0 was treatment with the smallest cooking loss. Tensile strength value of stink lily noodles was significant different because there was an interaction effect of κ-carrageenan proportion and pluchea tea extract addition. Tensile strength wet noodles were ranged 0.096±0.004 N to 0.174±0.015 N. The analysis of stink lily noodles color showed that lightness had a significant increase in with an increasing proportion of carrageenan and decreased with increasing pluchea tea extract used because of the color effect of carrageenan and pluchea tea extract. The lightness of wet noodles was ranged 67.80±0.22 to 74.50±0.23. The effect of the κ-carrageenan and pluchea tea extract color also influenced significantly redness of wet noodles. The redness of wet noodles was ranged 1.20±0.04 to 3.30±0.23. The interaction effect of κ-carrageenan and pluchea tea extract addition was appeared on yellowness, chroma and hue values. The yellowness, chroma and hue values were ranged 16.90±0.27 to 30.00±0.07, 17.00±0.28 to 30.10±0.03, and 83.70±0.07 to 86.40±0.02, respectively.

Figure 1. Stink Lily Noodles. Note K0 = wheat flour: stink lily flour: κ-carrageenan = 80 : 20 : 0, K1 = wheat flour: stink lily flour: κ-carrageenan = 80 : 19 : 1 , K2 = wheat flour: stink lily flour: κ-carrageenan = 80 : 18 : 2 , K3 = wheat flour: stink lily flour: κ-carrageenan = 80 : 17 : 3, L0 = concentration of hot water extract from pluchea leaf tea = 0%, L1 = concentration of hot water extract from pluchea leaf tea = 15% , L2 = concentration of hot water extract from pluchea leaf tea = 30%.

Table 3. Color, Moisture Content, Swelling Index, Cooking Loss, and Tensile Strength of Stink Lily Noodles.

Samples	Color					Moisture Content (%wb)	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (N)
	L*	a*	b*	C	h				
K0L0	73.00 ± 0,06	1.20 ± 0.06	16.90 ± 0.25^{a}	17.00±0.31^{a}	86.40±0.00^{g}	64.15±0.70	148.90±0.15^{c}	18.83±0.44	0.106±0.002
K0L1	68.70 ± 0.35	2.60 ± 0.06	26.50 ± 0.32^{d}	26.50±0.29^{c}	84.40±0.21^{bc}	63.66±0.38	146.36±0.27^{b}	19.06±0.43	0.105±0.001
K0L2	67.80 ± 0.20	2.80 ± 0.06	27.80 ± 0.46^{ef}	27.80±0.45^{e}	84.20±0.32^{abc}	62.83±0.58	142.25±0.39^{a}	20.13±0.71	0.116±0.006
K1L0	73.40 ± 0.25	1.30 ± 0.06	17.30 ± 0.15^{ab}	17.30±0.15^{a}	85.70±0.21^{f}	64.42±0.80	149.63±0.34^{d}	18.47±0.31	0.086±0.005
K1L1	69.00 ± 0.36	2.80 ± 0.12	27.30 ± 0.45^{e}	27.40±0.50^{d}	84.20±0.15^{a}	62.95±0.68	146.65±0.43^{b}	19.36±0.92	0.103±0.004
K1L2	68.30 ± 0.15	3.00 ± 0.12	28.60 ± 0.12^{g}	28.70±0.15^{f}	84.00±0.15^{abc}	63.37±1.04	148.85±057^{c}	19.76±0.90	0.108±0.005
K2L0	73.70 ± 0.10	1.50 ± 0.00	17.70 ± 0.26^{bc}	17.80±.23^{a}	85.20±0.06^{de}	64.67±1.08	155.67±0.46^{h}	18.18±0.45	0.098±0.002
K2L1	69.40± 0.15	3.00 ± 0.06	28.20 ± 0.15^{fg}	28.40±0.15^{f}	83.80±0.17^{ab}	63.74±0.75	150.96±0.71^{e}	18.62±0.41	0.106±0.005
K2L2	68.70 ± 0.06	3.10 ± 0.15	29.30 ± 0.00^{h}	29.40±0.06^{g}	84.00±0.15^{abc}	64.25±1.60	154.82±0.44^{g}	19.34±0.77	0.114±0.003
K3L0	74.50 ± 0.23	1.70 ± 0.12	18.10 ± 0.00^{c}	18.10±0.06^{b}	84.60±0.21^{cd}	65.83±0.22	162.21±0.25^{i}	17.83±0.41	0.110±0.003
K3L1	69.80 ± 0.50	3.20 ± 0.06	29.30 ± 0.12^{h}	29.30±0.06^{g}	83.80±0.53^{ab}	64.57±1.78	153.35±0.15^{f}	18.36±0.17	0.124±0.007
K3L2	69.00 ± 0.20	3.30 ± 0.26	30.00 ± 0.06^{i}	30.10±0.06^{h}	83.60±0.06^{a}	65.49±1.04	159.59±0.52^{i}	19.22±0.84	0.126±0.008

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

3.2. Bioactive Compounds and DPPH Free Radical Scavenging Activity (DPPH)

Bioactive compounds analyzed included total phenol content (TPC) and total flavonoid content (TFC). The analysis data showed that the TPC and TFC increased significantly due to the interaction effect between the proportion of κ-carrageenan and the addition of pluchea tea extract (Table 4). The results of the analysis showed that the control sample K0L0 had the lowest total phenol, i.e. 0.341 ± 0.034 mg GAE/kg dry noodles. The K2L2 sample had the highest total phenol, which was 1.196 ± 0.027 mg GAE/kg dry noodles. This result was suitable with the TFC value of wet noodles where K0L0 had the lowest TFC value and K2L2 had the highest value, i.e., 0.057 ± 0.004 and 1.336 ± 0.046 mg CE/kg dry noodles, respectively. The high and low values of TPC and TFC were correlated with AOA. The higher the TPC and TFC values, the higher the DPPH value. The DPPH free radicals scavenging activity of wet noodles was determined significantly by the interaction effect of adding the proportion of κ-carrageenan and pluchea tea extract. K0L0 had the lowest DPPH value and K2L2 had the highest DPPH value, i.e. 0.414±0.006 and 0.758±0.009 mg GAE/kg dry noodles, respectively.

Table 4. Total Phenol Content, Total Flavonoid Content, and DPPH Free Radical Scavenging Activity of Stink Lily Noodles.

Samples	TPC (mg GAE/g dry noodles)	TFC (mg CE/g dry noodles)	DPPH Scavenging Activity (mg GAE/g dry noodles)
K0L0	0.341±0.034^{a}	0.057±0.004^{a}	0.414±0.006^{a}
K0L1	0.948±0.027^{d}	0.704±0.007^{c}	0.742±0.016^{c}
K0L2	1.099±0.047^{e}	1.109±0.007^{d}	0.757±0.001^{c}
K1L0	0.458±0.040^{b}	0.082±0.002^{a}	0.523±0.026^{b}
K1L1	0.924±0.077^{d}	0.735±0.003^{c}	0.750±0.006^{c}
K1L2	1.005±0.070^{d}	1.091±0.095^{d}	0.751±0.001^{c}
K2L0	0.500±0.045^{b}	0.089±0.008^{a}	0.532±0.005^{b}
K2L1	0.965±0.025^{d}	0.718±0.018^{c}	0.748±0.004^{c}
K2L2	1.196±0.027^{f}	1.336±0.046^{e}	0.758±0.009^{c}
K3L0	0.527±0.007^{b}	0.218±0.003^{b}	0.587±0.020^{b}
K3L1	0.807±0.031^{c}	0.726±0.039^{c}	0.751±0.008^{c}
K3L2	1.145±0.064^{ef}	1.067±0.063^{d}	0.751±0.007^{c}

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

3.3. Sensory Properties

The evaluated sensory properties of the stink lily noodles were shown in Table 5. Parameter sensory that analyzed included aroma, color, taste, texture, and overall acceptability. The method used for sensory assay of stink lily noodles was hedonic scale scoring or a test of the level of consumer preference for a product by giving an assessment or score on a certain trait [33]. Organoleptic testing of stink lily wet noodles was presented to 100 untrained panelists aged 17-25 years. Panelists are asked to give scores or numbers based on their level of preference for certain treatments. The value score used was 1-15, where a value of 0-3.0 indicated "strongly dislike", a value of 3.1-6.0 "does not like", a value of 6.1-9.0 "neutral", a value of 9.1-12.0 “like”, and 12.1-15.0 “like very much”. The results of statistical tests by ANOVA at p < 5% showed that interaction effect of each treatment significantly influenced the panelists' preference for noodle color. The preference value of stink lily noodles color was ranged from 9.12 to 12.02 (like). The highest color preference value was the control treatment (K0L0) and the treatment with the lowest color preference value was K0L1. The interaction effect of each treatment were significantly determined the panelists' preference for the aroma. The preference value for the aroma of wet noodles was ranged from 8.29 to 11.58 (neutral-like). The treatment with the highest preference value was stink lily noodles K1L0 and the treatment with the lowest preference value was K3L2 treatment. The preference value of noodles taste was only affected by κ-carrageenan proportion or extract concentration. The preference value for the wet noodle taste was ranged from 8.18 to 11.08 (neutral-like). The treatment with the highest taste preference value was K2L0 while the treatment with the lowest taste preference value was K0L2. Increasing the proportion of carrageenan to 2% increased the preference value for taste, after that it decreased with the addition of the proportion of 3% carrageenan. While increasing the concentration of pluchea leaf tea extract decreased the panelists' preference for taste. The results of statistical tests using ANOVA at p < 5% showed that the addition of extract only significantly influenced the panelists' preference for noodles texture. In this study, the preference for wet noodles texture was ranged from 9.46 to 11.66 (like).

Table 5. Sensory Properties of Stink Lily Noodles.

Samples	Hedonic Preference Score				
	Color	Aroma	Taste	Texture	Overall Acceptance
K0L0	12.02^{f}	10.93^{d}	10.52	10.95	11.24^{f}
K0L1	9.12^{a}	10.26^{cd}	8.72	10.03	8.79^{a}
K0L2	11.83^{ef}	8.86^{ab}	8.18	9.58	9.04^{ab}
K1L0	9.98^{bc}	11.58^{e}	10.15	11.66	10.3^{cde}
K1L1	9.44^{ab}	9.58^{bc}	9.49	10.66	8.93^{ab}
K1L2	10.59^{cd}	8.45^{a}	8.87	9.46	9.11^{ab}
K2L0	11.62^{f}	10.93^{de}	11.08	11.15	11.07^{def}
K2L1	10.63^{cd}	10.14^{ab}	9.82	10.61	9.42^{abc}
K2L2	10.94^{de}	8.84^{cd}	9.09	10.38	10.16^{cde}
K3L0	11.51^{ef}	10.36^{cd}	10.37	11.07	10.84^{def}
K3L1	9.37^{ab}	10.07^{a}	9.95	11	9.72^{bc}
K3L2	9.47^{ab}	8.29^{cd}	9.57	9.64	8.62^{a}

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

The increasing the addition of extracts decreased the level of the texture preference of wet noodles. The overall preference value of wet noodles showed that there was the interaction effect between the proportion of κ-carrageenan and the addition of pluchea tea extract. The preference value for the overall of wet noodles was ranged from 8.62 to 11.24 (neutral-like). The treatment with the highest preference value was stink lily noodles K0L0 and the treatment with the lowest preference value was K3L2. Determination of the best treatment for differences in the proportions of κ-carrageenan and the addition of pluchea tea extract on wet noodles was determined using the spider web method based on organoleptic parameters (color, aroma, taste, texture and overall). The spider web graph can be seen in Figure 2. Data showed that the treatment with the largest area was K2L0, i.e. wet noodles with the proportion of κ-carrageenan 2 % with the addition of 0% pluchea tea extract. The area of the K2L0 treatment area was 79.16 cm^2 and had a preference score of 15.8 with a very like category.

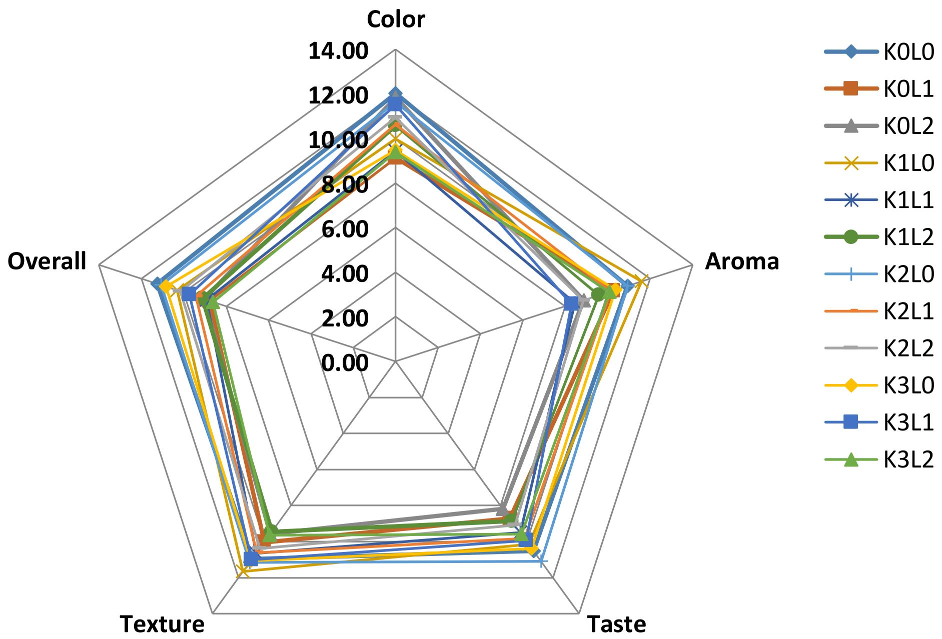

Figure 2. Spider web Graph to Determine the Best Treatment of Stink Lily Noodles.

4. Discussion

4.1. Cooking Quality

Moisture content is a major parameter of stinky silky wet noodles that shows the amount of water contained in food product that determines rheological characteristics, chemical, physical, and sensory properties, and shelf life of food product [34]. The result showed that the κ-carrageenan addition gave a significant difference of moisture content to wet noodles. The κ-carrageenan is hydrocolloids that has a group of sulfate and water-soluble polysaccharides [35,36,37], composes an ester sulfate content about 25-30% and a 3,6-anhydro-galactose (3,6-AG) about 28 to 35% [38,36]. This anionic carrageenan can interact very tightly with water molecule [39] and can be collaborated with glucomannan from stink lily on gelation process [40] with making intra- and inter-disulfide bind at network structure of gluten [13,41]. The κ-carrageenan can bind with limited free water molecule, form complexes compounds with water, and interact with gluten network [13]. However, the mobility of water mainly depends on changes in the hydrogen bond structure. The presence of hydrophilic components such as proteins, carbohydrates, glucomannan, κ-carrageenan and polyphenolic compounds in wet noodles can be involved in hydrogen bonding with water molecules that determine water mobility [13,34,41,42]. Thus, increasing the proportion of k-carrageenan used in the manufacture of stink lily noodles can increase the amount of free water and weakly bound water in wet noodles. the interaction between the hydroxyl functional groups in carrageenan and water molecules supports an increase in the water content of wet noodles.

The swelling index or water absorption is the ability of a product to absorb water which is influenced by particle size, chemical composition, and water content [43]. The research showed that the interaction of κ-carrageenan proportion and hot water extract of pluchea leaf tea addition gave a significant effect of the swelling index properties from wet noodles. The swelling index of wet noodles was determined by the presence of κ-carrageenan, protein, starch, glucomannan, and bioactive compounds of pluchea tea extract in dough. Li et al. [13] said that glutelin proteins of wheat flour can involve intra-and intermolecular disulfide bonds to result a fibrous shape, and then globular gliadin protein of wheat flour can be bound at the glutenin skeleton by non-covalent bonds to be a unique networks structure of gluten. The addition of the glucomannan of stinky silky flour as a non-ionic hydrocolloid has good water holding capacity and can be made a stronger three-dimensional network structure. Chen et al. [44] informed that the glucomannan can fill the number of holes of the network structure of gluten that make a structure dense and stable. Li et al. [13] underlined that glucomannan has many hydroxyl group in the structure that can be bound tightly with water by electrostatic forces and hydrogen bond. Huang et al. [41] said that the presence of κ-carrageenan in dough can be synergist with glucomannan to change sulfhydryl groups to be disulfide bonds in protein. Widyawati et al. [20] informed that bioactive compounds of pluchea tea extract are alkaloids, flavonoids, phenolics, phenol hydroquinone, saponins, tannins, sterols, terpenoids, and cardiac glycosides. Meanwhile Suriyaphan [16] informed that pluchea leaves contain 1.79 g/100 g protein, 0.49 g/100 g fat, 0.20 g/100 g ash, 0.89 g/100 g insoluble fiber, 0.45 g/100 g dissolved fiber, total fiber 1.34 g/100 g, carbohydrates 8.65 g/100 g, calcium 251 g/100 g, β-carotene 1.225 g/100 g and vitamin C 30.17 g/100 g, and phenolic acid bioactive compounds 28.48± 0.67 mg/100 g body weight (chlorogenic acid 20±0.24 mg/100 g body weight, caffeic acid 8.65±0.46 mg/100 g body weight), total flavonoids 6.39 mg/100 g body weight (quercetin 5.21± 0.26 mg/100 g body weight, kaempferol 0.28 ± 0.02 mg/100 g body weight, myricetin 0.09 ± 0.03 mg/100 g body weight), total anthocyanins 0.27 ± mg/100 g body weight, β-carotene 1.70 ± 0.05 mg/100 g body weight and total carotenoids 8.7 ± 0.34 mg/100 g body weight. Vongsak et al. [17]; Ruan et al. [18]; Chan et al. [19] proved that pluchea leaves contain 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, and 4,5- O-dicaffeoylquinic acid. Schefer at al. [45] informed that phenolic acid can be bound with protein and carbohydrate by non-covalent interactions, i.e. hydrophobic interaction, hydrogen bonding, electrostatic interaction, van der Waals interaction, and π-π stacking. The presence of κ-carrageenan proportion and pluchea tea extract addition that differed caused change of composition and various interaction of compounds that determined different swelling index of wet noodles.

The cooking loss of stink lily noodles was influenced significantly by κ-carrageenan proportion nor extract addition, but interaction of two factors was insignificant difference. The phenomena was caused by κ-carrageenan and bioactive compounds of pluchea tea extract, especially phenolic compounds, that involved the interaction with protein and carbohydrate in dough. κ-carrageenan can stabilized and supported a rigid structure of gluten. The hydrocolloid can avoid starch gelatinization process because it can bind tightly with water molecule caused lower the water activity. Supported by Li et al.[13]; Herawati [46]; Huang et al. [41], κ-carrageenan can trap the free water molecule that starch can't absorb the water molecule and require higher energy to break the energy barrier required for the starch gelatinization process. Whereas Zhu [42]; Amoako and Awika [47];

Schefer et al. [45] clarified that starch can be bound with polyphenol, including hydrophobic and electrostatic interactions and hydrogen bond that the hydrogen bond is dominant binding forces. This interaction can support releasing of amylose of starch gelatinization process that the cooking loss increased at the higher pluchea tea extract addition. The presence of polyphenol compounds of pluchea tea extract caused water competition with glutenin and gliadin of wheat flour that inhibited interaction between glutenin and gliadin to form gluten. According to Amoako and Awika [47], gluten and gliadin in a random coil structure can be aggregated by phenolic compounds and starch easily undergoes a gelatinization process where amylose interacts with polyphenolic compounds, through hydrogen bonds and hydrophobic interactions. The more protein in the form of random coil structure causes the protein to easily interact with polyphenols and come out of the noodles during the cooking process that the cooking loss increases.

The tensile strength of stink lily was influenced significantly by κ-carrageenan proportion nor extract addition. The increasing κ-carrageenan proportion grew up tensile strength because this hydrocolloid could be made strong cross linking through inter-molecular and intra-molecular bonds involving the glutenin and gliadin of wheat flour protein, and glucomannan of stink lily flour. The more networks that are formed between the components of the noodles have an effect on the tensile strength of wet noodles, and vice versa [13,48]. The synergism effect of the wet noodles component determined water bind capacity and water mobility that established texture properties of wet noodles, this statement is supported by Li et al.[34]; Saha and Bhattacharya [40]; Huang et al. [41]. Diniyah et al.[49] also informed that the addition of hydrocolloids in the noodles-making process increases the viscosity and water absorption because the water binding and holding properties of hydrocolloids that can form gel. However, the addition of pluchea tea extract caused the tensile strength to decline because the polyphenol compounds of pluchea tea extract induced breakdown of the networking structure among the components of dough because there was water competition among them. Furthermore, the polyphenol compounds could be reacted with starch and protein because the formation of the gluten network was disrupted that gliadin and glutenin in the form of random coils and starch could be underwent an excessive gelatinization process. This opinion is supported by Li et al. [13]; Zhu [42]; Huang et al. [41]. κ-carrageenan has a yellowish white color and has the ability to bind water molecules that it increases the lightness of wet noodles, while the pluchea tea extract contains polyphenolic compounds, such as tannins which can give the noodles a brown color that the lightness level is reduced. This opinion was supported by Widyawati et al. [20]; Necas et al. [38]. The increase in yellowness was in line with the increase in lightness because the higher the water content value was caused by the ability of κ-carrageenan to bind water molecules, thereby increasing the brightness and the brown color contribution of the pluchea tea extract gave a brownish-yellow color of the wet noodles that the intensity of this color increased as indicated by the increased chroma value.

4.2. Bioactive Compounds and DPPH Free Radical Scavenging Activity

The stinky silky wet noodles K0L0 had the lowest TPC and TFC because there was contributed of phenolic content from wheat flour and egg. Punia et al. [50] said that wheat flour has phenolic acids including ferulic, caffeic, and p-coumaric acid. Moreover, the presence of TFC in the K0L0 sample is thought to be due to the presence of a thiol group in egg white which is able to chelate metal ions and is able to be conjugated with saccharides [51], as well as 3,5-diacetyltambulin compounds from stink lily flour [52]. While the TFC and TPC values in the K2L2 sample were dominantly contributed by the presence of phytochemical compounds in the pluchea tea extract.Widyawati et al. [20] explained that there are phytochemical compounds in the pluchea tea extract. Suriyaphan [16]; Vongsak et al. [17]; Ruan et al. [18]; Chan et al. [19] also emphasized that pluchea leaves contain phenolic acids and flavonoids. The existence of a non-significant difference between treatments in the TPC and TFC assays indicated an interaction between the components in the dough that it affected the presence of free hydroxyl groups that could bind to the Folin Ciocalteus phenol reagent. as described by Li et al. [13]; Herawati [41]; Zhu [42]; Schefer et al. [45]; Amoako and Awika [47] glutenin, gliadin, glucomannan, κ-carrageenan, and polyphenol compounds are involved in the formation of networks structure in the dough so as to determine the quality of wet noodles. The interactions that occur involve various non-covalent interaction mechanisms that affect the presence of free hydroxyl groups. The TPC and TFC values of wet noodles in each treatment affected DPPH free radical scavenging activity (DPPH). They determined DPPH of wet noodles, usually positively correlated. Niroula et al. [53] said that TPC and DPPH were strongly correlated in seeds, sprouts and grasses of corn (*Zea mays* L.). Lim et al. [54] also informed that there is an excellent correlation coefficient between the TPC, TFC and antioxidant activities of *Phaleria macrocarpa* fruit. Adebiyi et al. [55] explained that the high level of flavonoids and phenols in plant caused the antioxidant activity of *Grewia carpinifolia* extract. The antioxidant activity of phenolics is related to their redox properties which induced them to act as reducing agents, hydrogen donors, singlet oxygen quenchers and metal chelators. Rahman et al. [56] underlined that DPPH free radical scavenging activity of polyphenol compounds of *T. pallida* extract was determined by hydrogen donating ability which it highly correlated. The potency of wet noodles as AOA was determined by reduced capability of DPPH free radical solution color from purple to be yellow color.

4.3. Sensory Properties

The analysis of sensory properties of the stink lily noodles was conducted by the hedonic scale scoring method with attribute the preference of color, taste, aroma, texture and overall. The result of the color preference test showed that the control treatment (K0L0) was the highest value because the treatment without the addition of pluchea tea extract not change the color of the wet noodles was yellowish-white. And then the treatment with the lowest color preference value was K0L1 due to the addition of this extract decreased the panelists' preference for the color because the noodles were darker and brownish color. Suriyaphan [16]; Widyawati et al. [20] said that the color of the pluchea tea extract contributed to changing the color of this wet noodle originated from tannins, flavonoids, and chlorophyll. However, in this study, increasing the extract concentration did not significantly affect the panelists' preference for color when the proportion of κ-carrageenan increased, because the addition of stink lily flour and κ-carrageenan would increase the lightness of the wet noodles that the produced color of the wet noodles was brighter and preferred by panelists. This data was supported by the data from color rider analysis, where the results of the sensory test by the panelists were in line with the decrease in the lightness value, the increase in the reddish and yellowish values, the hue value showed the yellow-red color, and chroma value showed an increase in color intensity. The panelist preference of aroma from wet noodles was determined by the aroma from the material used to make wet noodles or the interaction of aroma produced from the reaction among the material composition. According to Ramdani et al. [57], stink lily flour has a musty aroma, and all wet noodles produced have a musty smell. Meanwhile, according to Fitantri et al. [58], κ-carrageenan is unscented that not contribute to wet noodles. The addition of pluchea tea extract decreased the panelists' preference for the aroma of wet noodles because the addition of the extract caused the wet noodles to smell like leaves (floral) and unpleasant and the panelists did not like it. Fragrant or unpleasant aroma comes from volatile compounds contained in pluchea leaves. According to Widyawati et al. [59], pluchea leaves have 66 volatile compounds, these volatile compounds play a role in forming the aroma in the hot water extract of pluchea leaf tea. According to Lee et al. [60], pluchea leaves contain volatile compounds contributed by aliphatic aldehyde group compounds or aromatic compounds that give a distinctive aroma, therefore the presence of these compounds in steeping water can give a specific aroma, i.e. fragrant (floral) in wet noodles. There was a difference in the effect of the proportion of κ-carrageenan and pluchea leaf tea extract on taste due to the contribution of taste produced by carrageenan and extract.

According to Ramdani et al. [57]; Haryu et al. [61], stink lily flour and κ-carrageenan do not have a distinctive or neutral taste, increasing the concentration of κ-carrageenan gives a higher preference value because noodles are considered to have a better texture that contributes to the assessment of taste. The increase in the concentration of pluchea tea extract caused the taste preference value of noodles to decrease significantly, this is due to the presence of tannins, catechins, and phenolic compounds in the pluchea tea extract which determined bitter and slightly astringent. The effect of κ-carrageenan proportion and tea extract to make wet noodles influenced panelist preference of texture because this hydrocolloid can be make strong cross linking through inter-molecular and intra-molecular bonds involving the glutenin and gliadin of wheat flour protein, and glucomannan of stink lily flour that determined water bind capacity and water mobility [34,40,41]. Presence of the polyphenol compounds of pluchea tea extract can be breakdown of the networking structure among the components of dough because of water competition of them. Li et al. [13]; Zhu [42]; Huang et al. [41] said that the polyphenol compounds could be reacted with starch and protein to disrupt the gluten network and cause starch to undergo an excessive gelatinization process. The difference in the proportion of κ-carrageenan change the overall preference value of wet noodles to be significantly different overall compared to the control, this was because the proportion of κ-carrageenan influenced the all sensory attribute (color, aroma, and taste). The addition of pluchea tea extract in wet noodles decreased the overall preference value because the addition of extract affected the organoleptic characters tested due to the content of secondary metabolites of pluchea leaves, such as flavonoids, phenols, and tannins that could affect the taste, aroma, the color, and texture of the noodles. Based on spider web graph showed that K2L0 was the best treatment of stink lily wet noodles. It was also supported by better physicochemical properties than the control, including yellowish white wet noodles, better swelling index, lower cooking loss, higher tensile strength value, and lower moisture content. However, this K2L0 treatment did not have the highest TPC, TFC, and AOA, i.e. 0.500±0.045; 0.089±0.008; and 0.532±0.005, respectively.

5. Conclusions

The use of κ-carrageenan proportions and pluchea leaf tea extract had a significant effect on the cooking quality and sensory properties of stink lily wet noodles. Statistical analysis at $p < 5\%$ showed that there was an interaction effect of the proportion of κ-carrageenan and pluchea leaf tea extract on the swelling index, yellowness, chroma, hue, TPC, TFC, DPPH, the preference value for color, aroma, and overall acceptance. While the moisture content of wet noodles was only affected by the proportion of κ-carrageenan, for tensile strength, cooking loss, lightness, and redness, and the preference value for texture and taste were influenced by the proportions of κ-carrageenan and the concentration of pluchea leaf tea extract, respectively. The best treatment based on the spider web graph showed that the K0L2 treatment had the largest area 79.16 cm^2 and a preference score of 15.8 with a very like category, this is in accordance with the results of physicochemical and sensory tests, but it was no correlated with the highest bioactive content (TPC and TFC) and DPPH.

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Sample Availability: Samples of stink lily wet noodles and pluchea leaf tea are available from the authors.

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The Effect of κ-Carrageenan Proportion and Hot Water Extract of *Pluchea Indica* Less Leaf Tea on Quality and Sensory Properties of Stink Lily (*Amorphophallus Muelleri*) Wet Noodles

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Abstract : The study aimed to determine the effect of the proportion of κ-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles. The research design used was a Randomized Block Design with two factors, i.e. the difference in the proportion of κ-carrageenan (K) (0, 1, 2, and 3% w/w) and the addition of hot water extract of *Pluchea indica Less* leaf tea (L) (0, 15, and 30% w/v) with 12 treatment level (K0L0, K0L1, K0L2, K1L0, K1L1, K1L2, K2L0, K2L1, K2L2, K3L0, K3L1, K3L2). The data were analyzed by the ANOVA at $p < 5\%$ and continued with the Duncan's Multiple Range Test at $p < 5\%$ and the best treatment was determined by the Spider web method based on sensory assay by a hedonic method. The proportions of κ-carrageenan and the concentration of pluchea tea extract had a significant effect on cooking quality and sensory properties. However, the interaction of the two factors affected the swelling index, yellowness (b*), chroma (C), hue (h), total phenol content (TPC), total flavonoid content (TFC), and DPPH free radical scavenging assay (DPPH). The best treatment of wet noodles was K2L0 with a preference score of 15.8. The binding of κ-carrageenan and phenolic compounds to make networking structure by intra- and inter-disulfide bind between glucomannan and gluten, was thought to affect the cooking quality, sensory properties, bioactive compounds (TPC and TFC), and DPPH

Keywords: *Amorphophallus muelleri*; *Pluchea indica* Less; wet noodles; quality and sensory properties

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1. Introduction

Noodles are a rice substitute commodity that is much favored by the public [1], especially in China, Indonesia, India, Japan, Vietnam, and the United States. Basically, noodles are divided into wet noodles and dry noodles. Indonesia is the second country in the world that likes to consume noodles [2]. In 2017, the consumption of instant noodles achieves by 180.2 packets per head in the world, and in Indonesia, the consumption of wet noodles shows that all age groups and education levels like it [3]. Meanwhile, instant noodle consumption in 2020 reached 12,640 million portions [2]. Noodles are generally made from wheat flour, the use of local food ingredients based on carbohydrates, including stink lily flour, can reduce the consumption of wheat flour which is quite high in Indonesia, the average consumption of wheat flour for the Indonesian population in 2019 is 17.8 kg/capita/year [4].

Stink lily flour (*Amorphophallus muelleri*) is a group of *Araceae* that contains glucomannan oligosaccharides around 15-64% dry base [5] or more than 60% [6]. Glucomannan is a heteropolysaccharide consisting of 67% D-mannose and 33% D-glucose and has β-1,4 and β-1,6 glycoside bonds [7], which can reduce body weight, sugar content blood levels,

LDL cholesterol levels and prolong gastric emptying time [8,9]. Stink lily flour has a glycemic index of 85 which is lower than the glycemic index of glucose which is considered to be 100 [7]. The use of stink lily flour in the manufacture of wet noodles is able to replace the role of gliadin and glutenin proteins in the formation of gluten with an elastic texture [10]. Polysaccharides in stink lily flour can dissolve in water to form a thick solution, form a gel, expand, and melt like agar [11], can increase the elasticity and cohesiveness [12,13] with increasing α-helix and β-sheet structures of wet noodles [13]. However, the higher the substitution of stink lily flour, the lower the texture preference because the noodles break easily and are sticky [12]. Therefore, it is necessary to add hydrocolloids, including carrageenan, because they can increase elasticity [14]. The combination of the use of glucomannan and carrageenan can form a strong and elastic gel [15].

The addition of hot water extract from pluchea leaf tea in making stink lily wet noodles is expected to increase the functional value of wet noodle products. Pluchea leaves contain nutrients, such as: protein 1.79 g/100 g, fat 0.49 g/100 g, ash 0.20 g/100 g, insoluble fiber 0.89 g/100 g, soluble fiber 0.45 g/100 g, total fiber 1.34 g/100 g, carbohydrates 8.65 g/100 g, calcium 251 g/100 g, β-carotene 1.225 mg/100 g and vitamin C 30.17 mg/100 g as well as bioactive compounds, such as: phenolic acid 28.48±0.67 mg/100 g wb (chlorogenic acid 20±0.24 mg/100 g wb, caffeic acid 8.65±0.46 mg/100 g wb), total flavonoids 6.39 mg/100 g wb (quercetin 5.21±0.26 mg/100 g wb, kaempferol 0.28±0.02 mg/100 g wb, myricetin 0.09± 0.03 mg/100 g wb), total anthocyanins 0.27±0.01 mg/100 g wb, β-carotene 1.70±0.05 mg/100 g wb, and total carotenoids 8.7±0.34 mg/100 g wb [16], 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, and 4,5-O-dicaffeoylquinic acid [17,18,19]. Meanwhile, hot water extract of 2% pluchea leaf tea (2 g/100 ml) contains a total phenolic content of 9.3 mg EAG/ g, total flavonoid content 22.0 mg EC/ g, DPPH free radical scavenging activity DPPH 27.2 mg EAG/ g, and reduced iron ion 10.2 mg EAG/ g [20], due to the presence of phytochemicals (alkaloids, flavonoids, phenolics, sterols, cardiac glycosides, phenol hydroquinone, tannins, terpenoids, and saponins) [20], which has been shown to have potential as an antioxidant [20,21] and antidiabetic [22]. The effect of using κ-carrageenan and water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles has not been studied in detail. Therefore, the purpose of this study was to determine the effect of the proportion of κ-carrageenan and hot water extract of pluchea leaf tea on the quality and sensory of stink lily wet noodles.

2. Materials and Methods

2.1. Reagents and Materials

The compounds 2,2-diphenyl-1-picrylhydrazyl (DPPH), sodium carbonate, gallic acid, and (+)-catechin were purchased from Sigma-Aldrich (St. Louis, USA). Methanol, folin ciocalteus phenol, sodium nitric, aluminium chloride, κ-carrageenan, and sodium hydroxide were purchased from Merck (New Jersey, USA).

Pluchea leaves as raw material for making pluchea leaf tea are collected from gardens around the city of Surabaya. Specification of pluchea plant is according to the GBIF taxon ID number database: 3132728. Stink lily flour is obtained from the stink lily flour processing industry in East Java. Specification of Stink lily plant is according to the GBIF taxon ID number database: 735493731. The wheat flour used is high protein flour obtained from the wheat flour processing industry in Indonesia.

2.2. Preparation of Pluchea Leaf Tea.

Pluchea leaves on each branch number 1-6 from the shoot were collected, sorted, and dried at an ambient temperature for 7 days until moisture content 11.16±0.09% dry base. And then dried leaves were powdered to get 45 mesh size [23]. Futhermore the leaf powder was heated by drying oven (Binder, Merck KGaA, Darmstadt, Germany) at 120 °C for

10 min. Then dried powder of pluchea leaves was packed 2 g in tea bag that called pluchea leaf tea.

2.3. Preparation of Hot Water Extract of Pluchea Leaf Tea.

Pluchea leaf tea in tea bag was extracted by hot water at 95 °C for 1 min to get 15 and 30% (b/v) concentrations (Table 1). And then each concentration of extract was used to make stink lily wet noodles.

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

Materials	Concentration of hot water extract of pluchea leaf tea (% b/v)		
	0	**15**	**30**
Pluchea leaf tea (g)	0	4.5	9
Hot water (mL)	30	30	30

2.4. Stink Lily Wet Noodles Making.

Stink lily wet noodles were made with mixing of wheat and stink lily flour, and κ-carrageenan at 1, 2, and 3% (b/b) concentrations. And then the mixture was added egg, salt, baking powder, and hot water extract of pluchea leaf tea and kneaded to form a dough by a mixer machine. Then the dough was passed through a roller to make face bands the desired thickness and cut through rollers using cutting blades. The formula of stink lily wet noodle was showed at Table 2.

Table 2. The formula of stink lily wet noodles.

Material	K0L0	K0L1	K0L2	K1L0	K1L1	K1L2	K2L0	K2L1	K2L2	K3L0	K3L1	K3L2
Wheat flour (g)	120	120	120	120	120	120	120	120	120	120	120	120
Stink lily flour (g)	30	30	30	28.5	28.5	28.5	27	27	27	25.5	25.5	25.5
κ-Carrageenan (g)	0	0	0	1.5	1.5	1.5	3	3	3	4.5	4.5	4.5
Egg (g)	30	30	30	30	30	30	30	30	30	30	30	30
Salt (g)	3	3	3	3	3	3	3	3	3	3	3	3
Baking Powder (g)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water (mL)	30	0	0	30	0	0	30	0	0	30	0	0
Hot water extract of pluchea leaves 15% (mL)	0	30	0	0	30	0	0	30	0	0	30	0
Hot water extract of pluchea leaves 30% (mL)	0	0	30	0	0	30	0	0	30	0	0	30
Total (g)	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5

Note: K0 = wheat flour: stink lily flour: κ-carrageenan = 80 : 20 : 0.
K1 = wheat flour: stink lily flour: κ-carrageenan = 80 : 19 : 1.
K2 = wheat flour: stink lily flour: κ-carrageenan = 80 : 18 : 2.
K3 = wheat flour: stink lily flour: κ-carrageenan = 80 : 17 : 3.
L0 = concentration of hot water extract from pluchea leaf tea = 0%.
L1 = concentration of hot water extract from pluchea leaf tea = 15%.
L2 = concentration of hot water extract from pluchea leaf tea = 30%.

2.5. Stink Lily Wet Noodles Extraction.

125 g each sample from stink lily wet noodles was weighed (Ohaus, Ohaus Instruments (Shanghai) Co., Ltd., RRT) and then they were dried by cabinet drying at 60 °C for 4 hours to get dried noodles. Next each sample was powdered by chopper machine at second speed for 35 seconds and then 20 g powdered sample was added 50 mL methanol by shaking water bath at 35 °C, 70 rpm for 1 hour. Filtrate was separated by Whatman filter paper grade 40 and residue was extracted again with same pattern way. Filtrate was collected and dried by rotary evaporator (Buchi Rotary Evaporator; Buchi Shanghai Ltd, RRT) at 0.2-0.3 atm, 50 °C for 60 min until getting 2 mL extract. Then extract was kept at 0 °C before further study.

2.6. Swelling Index Assay

Swelling index or water absorption is the ability of noodles to absorb water after gelatinization during the boiling process [24]. The principle of water absorption testing is to determine the amount of water absorbed in wet noodles at a certain temperature and time. The amount of water absorbed in wet noodles can be determined from the difference between the weight of the noodles after and before being boiled divided by the weight of the noodles before boiling [25].

2.7. Cooking Loss Assay

Cooking loss is one of the important quality parameters in wet noodles to determine the quality of wet noodles after cooking [26]. The cooking loss test for stink lily wet noodles was carried out to determine the number of solids that came out of the noodle strands during the cooking process, namely the release of a small portion of starch from the noodle strands.

2.8. Determination of Tensile Strength of Wet Noodles

The tensile strength (elongation) is one important parameter of texture analysis in noodle products. 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 principle of the texture analyzer is to prepare a suitable probe for the test, then place the noodle samples on the table under the probe. The elongation of the noodles was individually tested by putting one end into the lower roller arm slot and sufficiently winding the loosened arm to fasten the noodle end. The same procedure was done to tighten the other end of the strip to the upper roller arm. Elongation, which was the maximum force to deform and break noodles by extension, was measured using a test speed of 3.0 mm/s, with a 100 mm distance between two rollers. Deformations were recorded using the software during the extension and are expressed as a graph. The elongation at breaking was calculated per gram.

2.9. Color Measurement

The noodle samples were measured by a colorimeter (Minolta CM-3500D; Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab L*, a* and b* values were recorded as described by Rathorel et al.[27]. And then L*, a* and b* values were collected. The L* value was stated the position on the white/black axis, the a* value the position on the red/green axis, and the b* value the position on the yellow/blue axis. The measurements were done in triplicate and the readings were averaged.

2.10. Total Phenol Content Assay

Total phenol content (TPC) of stink lily wet noodles was analyzed by spectrophotometric method using folin ciocateus phenol reagent [28]. Principles assay of the TPC assay are interaction between phenolic compounds and phosphomolybdic/ phosphotungstic acid complexes based on the transfer of electrons in alkaline medium from phenolic compounds to form a blue chromophore constituted by a phosphotungstic/ phosphomolybdenum complex. The reduced folin ciocalteus phenol reagent is detected by a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 760 nm and gallic acid is used as the reference standard compound and results are expressed as gallic acid equivalents (mg/kg wet noodles).

2.11. Total Flavonoid Content Assay

Total flavonoid content of samples was measured by spectrophotometric method with reaction between $AlCl_3$ and $NaNO_2$ with aromatic ring of flavonoid compounds [29]. And then mixture was added aluminium chloride to result yellow solution. Next, addition of NaOH solution in mixture caused red solution that was measured by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 510 nm. As standard reference compound used was (+) catechin and results were expressed as catechin equivalents (mg/kg wet noodles).

2.12. DPPH Free Radical Scavenging Activity Assay

DPPH free radical scavenging activity was measured by the spectrophotometric method [30]. This method is used to determine the antioxidant capacity of a compound from an extract or other biological sources, based on transferring from the odd electron of a nitrogen atom in DPPH is reduced by receiving a hydrogen atom from antioxidants to result in DPPH-H with yellow-colored solution. Reaction between DPPH in methanol solution with samples was measured by spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 517 nm. As standard reference compound used was gallic acid and results were expressed as gallic acid equivalents (mg/kg wet noodles).

2.13. Sensory Evaluation

Sensory assay was carried out to determine the level of panelist acceptance of wet noodles substituted with stink lily flour with the addition of carrageenan and hot water extract of pluchea leaf tea [31]. The test was carried out using the hedonic scale scoring method. This method is designed to measure the level of panelist preference for the product by rating the level of preference for the product being tested. Samples were served in dishes coded with random three-digit numbers that carried out using a completely randomized design (CRD) trial using 100 untrained panelists with an age range of 17 to 25 years. The hedonic method used in this study is the hedonic scoring method, the panelists were asked to give a preference score for each sample. The hedonic score used was a value of 1-15 given by the panelists according to the level of preference for the product. Values 0-3.0 indicate "strongly dislike", values 3.1-6.0 "dislike", values 6.1-9.0 "neutral", values 9.1-12.0 "like", and a value of 12.1-15.0 "very much like".

Each panelist is faced with 12 (twelve) samples and a questionnaire containing test instructions and is asked to give each sample a score according to their level of preference. The parameters tested were taste, aroma, texture, color, and overall acceptance of wet noodles substituted with stink lily flour. The best treatment of samples was determined by spider web method that was correlated by the large area of graph [32].

2.14. Experiment Design and Statistical Analysis

The research design of physicochemical assay used was a randomized block design with two factors, i.e. differences in the proportion of κ-carrageenan (K) and differences in the concentration of pluchea tea extract (L) added to wet noodles. The proportion of κ-carrageenan consisted of 4 (four) treatment levels, including 0% (K0), 1% (K1), 2% (K2), 3% (K3) and the concentration of pluchea tea extract consisted of 3 (three) levels, i.e., 0%

(L0), 15% (L1), and 30% (L2). Each treatment was repeated 3 (three) times in order to obtain 36 (thirty-six) experiment units. The sensory test used a completely randomized design (CRD) on 100 untrained panelists.

The data before further analysis was determined by the normal distribution and homogeneity tests. And then the data are presented as mean ± SD of the triplicate determinations and were analyzed using ANOVA at $p< 5\%$, if the results of the ANOVA test had a significant effect, then proceed with the DMRT (Duncan Multiple Range Test) test at $p< 5\%$ to determine the level of treatment that gave significantly different results. The analysis used SPSS 17.0 software (SPSS Inc. Chicago, IL, USA).

3. Results

3.1. Cooking Quality

The evaluated cooking properties of the stink lily wet noodles were showed in Table 3 and the stink lily wet noodles product was showed at Figure 1. The level of cooking was estimated by the moisture content, swelling index, cooking loss and tensile strength from noodles. Based on statistically analysis by ANOVA at $p < 5\%$, showed that the increasing of κ-carrageenan proportion went up significant difference of moisture content of wet noodles, but the addition of pluchea leaf hot water extract and the interaction effect of the proportion of κ-carrageenan and the addition of the extract no influenced to moisture content of wet noodles. The moisture content value was ranged from 62.83±0.58 %wb to 65.83±0.22 %wb. The sample K3L0 had the highest moisture content and K0L2 had the lowest moisture content. Furthermore, the addition of the κ-carrageenan proportion or pluchea tea extract had a significantly different effect such as the interaction effect of the addition of the two parameters, on the swelling index or water absorption value of wet noodles based on statistical analysis at $p < 5\%$. The water absorption value was ranged from 142.25±0.39% to 162.21±0.25%. The treatment with the lowest swelling index was K0L2 and the highest was K3L0. Whereas the cooking loss of wet noodles decreased significantly with the addition of the proportion of κ–carrageenan but increased significantly with the addition of pluchea tea extract. The cooking loss of wet noodles was ranged 17.83±0.4% to 20.13±0.7%. K0L2 was treatment with the biggest cooking loss and K3L0 was treatment with the smallest cooking loss. Tensile strength value of stink lily noodles was significant different because there was an interaction effect of κ-carrageenan proportion and pluchea tea extract addition. Tensile strength wet noodles were ranged 0.096±0.004 N to 0.174±0.015 N. The analysis of stink lily noodles color showed that lightness had a significant increase in with an increasing proportion of carrageenan and decreased with increasing pluchea tea extract used because of the color effect of carrageenan and pluchea tea extract. The lightness of wet noodles was ranged 67.80±0.22 to 74.50±0.23. The effect of the κ-carrageenan and pluchea tea extract color also influenced significantly redness of wet noodles. The redness of wet noodles was ranged 1.20±0.04 to 3.30±0.23. The interaction effect of κ-carrageenan and pluchea tea extract addition was appeared on yellowness, chroma and hue values. The yellowness, chroma and hue values were ranged 16.90±0.27 to 30.00±0.07, 17.00±0.28 to 30.10±0.03, and 83.70±0.07 to 86.40±0.02, respectively.

Figure 1. Stink Lily Noodles. Note K0 = wheat flour: stink lily flour: κ-carrageenan = 80 : 20 : 0, K1 = wheat flour: stink lily flour: κ-carrageenan = 80 : 19 : 1 , K2 = wheat flour: stink lily flour: κ-carrageenan = 80 : 18 : 2 , K3 = wheat flour: stink lily flour: κ-carrageenan = 80 : 17 : 3, L0 = concentration of hot water extract from pluchea leaf tea = 0%, L1 = concentration of hot water extract from pluchea leaf tea = 15% , L2 = concentration of hot water extract from pluchea leaf tea = 30%.

Table 3. Color, Moisture Content, Swelling Index, Cooking Loss, and Tensile Strength of Stink Lily Noodles.

Samples	Color					Moisture Content (%wb)	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (N)
	L*	a*	b*	C	h				
K0L0	73.00 ± 0,06	1.20 ± 0.06	16.90 ± 0.25^{a}	17.00±0.31^{a}	86.40±0.00^{g}	64.15±0.70	148.90±0.15^{c}	18.83±0.44	0.106±0.002
K0L1	68.70 ± 0.35	2.60 ± 0.06	26.50 ± 0.32^{d}	26.50±0.29^{c}	84.40±0.21^{bc}	63.66±0.38	146.36±0.27^{b}	19.06±0.43	0.105±0.001
K0L2	67.80 ± 0.20	2.80 ± 0.06	27.80 ± 0.46^{ef}	27.80±0.45^{e}	84.20±0.32^{abc}	62.83±0.58	142.25±0.39^{a}	20.13±0.71	0.116±0.006
K1L0	73.40 ± 0.25	1.30 ± 0.06	17.30 ± 0.15^{ab}	17.30±0.15^{a}	85.70±0.21^{f}	64.42±0.80	149.63±0.34^{d}	18.47±0.31	0.086±0.005
K1L1	69.00 ± 0.36	2.80 ± 0.12	27.30 ± 0.45^{e}	27.40±0.50^{d}	84.20±0.15^{a}	62.95±0.68	146.65±0.43^{b}	19.36±0.92	0.103±0.004
K1L2	68.30 ± 0.15	3.00 ± 0.12	28.60 ± 0.12^{g}	28.70±0.15^{f}	84.00±0.15^{abc}	63.37±1.04	148.85±057^{c}	19.76±0.90	0.108±0.005
K2L0	73.70 ± 0.10	1.50 ± 0.00	17.70 ± 0.26^{bc}	17.80±.23^{a}	85.20±0.06^{de}	64.67±1.08	155.67±0.46^{h}	18.18±0.45	0.098±0.002
K2L1	69.40± 0.15	3.00 ± 0.06	28.20 ± 0.15^{fg}	28.40±0.15^{f}	83.80±0.17^{ab}	63.74±0.75	150.96±0.71^{e}	18.62±0.41	0.106±0.005
K2L2	68.70 ± 0.06	3.10 ± 0.15	29.30 ± 0.00^{h}	29.40±0.06^{g}	84.00±0.15^{abc}	64.25±1.60	154.82±0.44^{g}	19.34±0.77	0.114±0.003
K3L0	74.50 ± 0.23	1.70 ± 0.12	18.10 ± 0.00^{c}	18.10±0.06^{b}	84.60±0.21^{cd}	65.83±0.22	162.21±0.25^{i}	17.83±0.41	0.110±0.003
K3L1	69.80 ± 0.50	3.20 ± 0.06	29.30 ± 0.12^{h}	29.30±0.06^{g}	83.80±0.53^{ab}	64.57±1.78	153.35±0.15^{f}	18.36±0.17	0.124±0.007
K3L2	69.00 ± 0.20	3.30 ± 0.26	30.00 ± 0.06^{i}	30.10±0.06^{h}	83.60±0.06^{a}	65.49±1.04	159.59±0.52^{i}	19.22±0.84	0.126±0.008

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

3.2. Bioactive Compounds and DPPH Free Radical Scavenging Activity (DPPH)

Bioactive compounds analyzed included total phenol content (TPC) and total flavonoid content (TFC). The analysis data showed that the TPC and TFC increased significantly due to the interaction effect between the proportion of κ-carrageenan and the addition of pluchea tea extract (Table 4). The results of the analysis showed that the control sample K0L0 had the lowest total phenol, i.e. 0.341 ± 0.034 mg GAE/kg dry noodles. The K2L2 sample had the highest total phenol, which was 1.196 ± 0.027 mg GAE/kg dry noodles. This result was suitable with the TFC value of wet noodles where K0L0 had the lowest TFC value and K2L2 had the highest value, i.e., 0.057 ± 0.004 and 1.336 ± 0.046 mg CE/kg dry noodles, respectively. The high and low values of TPC and TFC were correlated with AOA. The higher the TPC and TFC values, the higher the DPPH value. The DPPH free radicals scavenging activity of wet noodles was determined significantly by the interaction effect of adding the proportion of κ-carrageenan and pluchea tea extract. K0L0 had the lowest DPPH value and K2L2 had the highest DPPH value, i.e. 0.414±0.006 and 0.758±0.009 mg GAE/kg dry noodles, respectively.

Table 4. Total Phenol Content, Total Flavonoid Content, and DPPH Free Radical Scavenging Activity of Stink Lily Noodles.

Samples	TPC (mg GAE/g dry noodles)	TFC (mg CE/g dry noodles)	DPPH Scavenging Activity (mg GAE/g dry noodles)
K0L0	0.341±0.034^{a}	0.057±0.004^{a}	0.414±0.006^{a}
K0L1	0.948±0.027^{d}	0.704±0.007^{c}	0.742±0.016^{c}
K0L2	1.099±0.047^{e}	1.109±0.007^{d}	0.757±0.001^{c}
K1L0	0.458±0.040^{b}	0.082±0.002^{a}	0.523±0.026^{b}
K1L1	0.924±0.077^{d}	0.735±0.003^{c}	0.750±0.006^{c}
K1L2	1.005±0.070^{d}	1.091±0.095^{d}	0.751±0.001^{c}
K2L0	0.500±0.045^{b}	0.089±0.008^{a}	0.532±0.005^{b}
K2L1	0.965±0.025^{d}	0.718±0.018^{c}	0.748±0.004^{c}
K2L2	1.196±0.027^{f}	1.336±0.046^{e}	0.758±0.009^{c}
K3L0	0.527±0.007^{b}	0.218±0.003^{b}	0.587±0.020^{b}
K3L1	0.807±0.031^{c}	0.726±0.039^{c}	0.751±0.008^{c}
K3L2	1.145±0.064^{ef}	1.067±0.063^{d}	0.751±0.007^{c}

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

3.3. Sensory Properties

The evaluated sensory properties of the stink lily noodles were shown in Table 5. Parameter sensory that analyzed included aroma, color, taste, texture, and overall acceptability. The method used for sensory assay of stink lily noodles was hedonic scale scoring or a test of the level of consumer preference for a product by giving an assessment or score on a certain trait [33]. Organoleptic testing of stink lily wet noodles was presented to 100 untrained panelists aged 17-25 years. Panelists are asked to give scores or numbers based on their level of preference for certain treatments. The value score used was 1-15, where a value of 0-3.0 indicated "strongly dislike", a value of 3.1-6.0 "does not like", a value of 6.1-9.0 "neutral", a value of 9.1-12.0 “like”, and 12.1-15.0 “like very much”. The results of statistical tests by ANOVA at p < 5% showed that interaction effect of each treatment significantly influenced the panelists' preference for noodle color. The preference value of stink lily noodles color was ranged from 9.12 to 12.02 (like). The highest color preference value was the control treatment (K0L0) and the treatment with the lowest color preference value was K0L1. The interaction effect of each treatment were significantly determined the panelists' preference for the aroma. The preference value for the aroma of wet noodles was ranged from 8.29 to 11.58 (neutral-like). The treatment with the highest preference value was stink lily noodles K1L0 and the treatment with the lowest preference value was K3L2 treatment. The preference value of noodles taste was only affected by κ-carrageenan proportion or extract concentration. The preference value for the wet noodle taste was ranged from 8.18 to 11.08 (neutral-like). The treatment with the highest taste preference value was K2L0 while the treatment with the lowest taste preference value was K0L2. Increasing the proportion of carrageenan to 2% increased the preference value for taste, after that it decreased with the addition of the proportion of 3% carrageenan. While increasing the concentration of pluchea leaf tea extract decreased the panelists' preference for taste. The results of statistical tests using ANOVA at p < 5% showed that the addition of extract only significantly influenced the panelists' preference for noodles texture. In this study, the preference for wet noodles texture was ranged from 9.46 to 11.66 (like).

Table 5. Sensory Properties of Stink Lily Noodles.

Samples	Hedonic Preference Score				
	Color	Aroma	Taste	Texture	Overall Acceptance
K0L0	12.02^{f}	10.93^{d}	10.52	10.95	11.24^{f}
K0L1	9.12^{a}	10.26^{cd}	8.72	10.03	8.79^{a}
K0L2	11.83^{ef}	8.86^{ab}	8.18	9.58	9.04^{ab}
K1L0	9.98^{bc}	11.58^{e}	10.15	11.66	10.3^{cde}
K1L1	9.44^{ab}	9.58^{bc}	9.49	10.66	8.93^{ab}
K1L2	10.59^{cd}	8.45^{a}	8.87	9.46	9.11^{ab}
K2L0	11.62^{f}	10.93^{de}	11.08	11.15	11.07^{def}
K2L1	10.63^{cd}	10.14^{ab}	9.82	10.61	9.42^{abc}
K2L2	10.94^{de}	8.84^{cd}	9.09	10.38	10.16^{cde}
K3L0	11.51^{ef}	10.36^{cd}	10.37	11.07	10.84^{def}
K3L1	9.37^{ab}	10.07^{a}	9.95	11	9.72^{bc}
K3L2	9.47^{ab}	8.29^{cd}	9.57	9.64	8.62^{a}

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

The increasing the addition of extracts decreased the level of the texture preference of wet noodles. The overall preference value of wet noodles showed that there was the interaction effect between the proportion of κ-carrageenan and the addition of pluchea tea extract. The preference value for the overall of wet noodles was ranged from 8.62 to 11.24 (neutral-like). The treatment with the highest preference value was stink lily noodles K0L0 and the treatment with the lowest preference value was K3L2. Determination of the best treatment for differences in the proportions of κ-carrageenan and the addition of pluchea tea extract on wet noodles was determined using the spider web method based on organoleptic parameters (color, aroma, taste, texture and overall). The spider web graph can be seen in Figure 2. Data showed that the treatment with the largest area was K2L0, i.e. wet noodles with the proportion of κ-carrageenan 2 % with the addition of 0% pluchea tea extract. The area of the K2L0 treatment area was 79.16 cm^2 and had a preference score of 15.8 with a very like category.

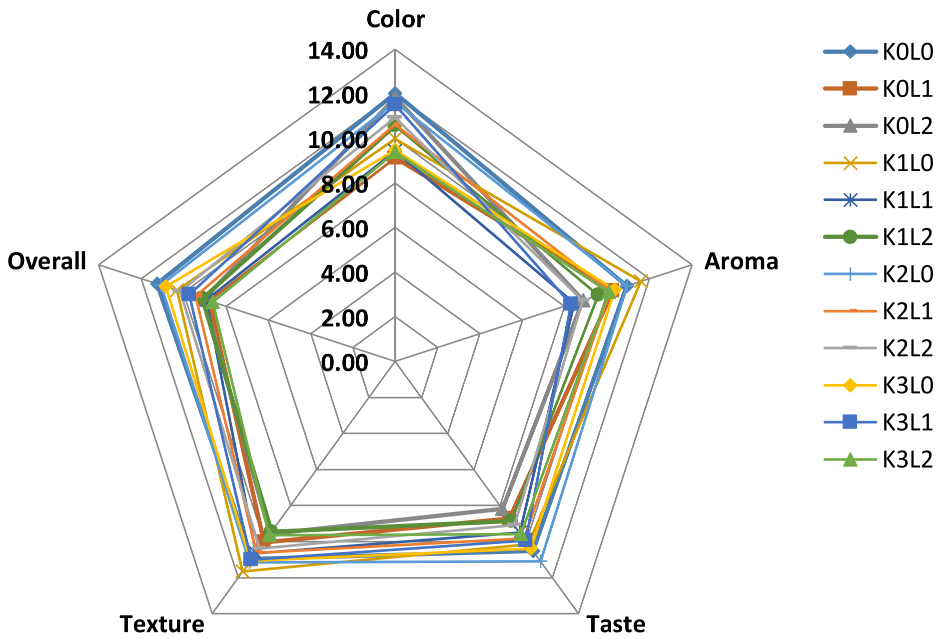

Figure 2. Spider web Graph to Determine the Best Treatment of Stink Lily Noodles.

4. Discussion

4.1. Cooking Quality

Moisture content is a major parameter of stinky silky wet noodles that shows the amount of water contained in food product that determines rheological characteristics, chemical, physical, and sensory properties, and shelf life of food product [34]. The result showed that the κ-carrageenan addition gave a significant difference of moisture content to wet noodles. The κ-carrageenan is hydrocolloids that has a group of sulfate and water-soluble polysaccharides [35,36,37], composes an ester sulfate content about 25-30% and a 3,6-anhydro-galactose (3,6-AG) about 28 to 35% [38,36]. This anionic carrageenan can interact very tightly with water molecule [39] and can be collaborated with glucomannan from stink lily on gelation process [40] with making intra- and inter-disulfide bind at network structure of gluten [13,41]. The κ-carrageenan can bind with limited free water molecule, form complexes compounds with water, and interact with gluten network [13]. However, the mobility of water mainly depends on changes in the hydrogen bond structure. The presence of hydrophilic components such as proteins, carbohydrates, glucomannan, κ-carrageenan and polyphenolic compounds in wet noodles can be involved in hydrogen bonding with water molecules that determine water mobility [13,34,41,42]. Thus, increasing the proportion of k-carrageenan used in the manufacture of stink lily noodles can increase the amount of free water and weakly bound water in wet noodles. the interaction between the hydroxyl functional groups in carrageenan and water molecules supports an increase in the water content of wet noodles.

The swelling index or water absorption is the ability of a product to absorb water which is influenced by particle size, chemical composition, and water content [43]. The research showed that the interaction of κ-carrageenan proportion and hot water extract of pluchea leaf tea addition gave a significant effect of the swelling index properties from wet noodles. The swelling index of wet noodles was determined by the presence of κ-carrageenan, protein, starch, glucomannan, and bioactive compounds of pluchea tea extract in dough. Li et al. [13] said that glutelin proteins of wheat flour can involve intra-and intermolecular disulfide bonds to result a fibrous shape, and then globular gliadin protein of wheat flour can be bound at the glutenin skeleton by non-covalent bonds to be a unique networks structure of gluten. The addition of the glucomannan of stinky silky flour as a non-ionic hydrocolloid has good water holding capacity and can be made a stronger three-dimensional network structure. Chen et al. [44] informed that the glucomannan can fill the number of holes of the network structure of gluten that make a structure dense and stable. Li et al. [13] underlined that glucomannan has many hydroxyl group in the structure that can be bound tightly with water by electrostatic forces and hydrogen bond. Huang et al. [41] said that the presence of κ-carrageenan in dough can be synergist with glucomannan to change sulfhydryl groups to be disulfide bonds in protein. Widyawati et al. [20] informed that bioactive compounds of pluchea tea extract are alkaloids, flavonoids, phenolics, phenol hydroquinone, saponins, tannins, sterols, terpenoids, and cardiac glycosides. Meanwhile Suriyaphan [16] informed that pluchea leaves contain 1.79 g/100 g protein, 0.49 g/100 g fat, 0.20 g/100 g ash, 0.89 g/100 g insoluble fiber, 0.45 g/100 g dissolved fiber, total fiber 1.34 g/100 g, carbohydrates 8.65 g/100 g, calcium 251 g/100 g, β-carotene 1.225 g/100 g and vitamin C 30.17 g/100 g, and phenolic acid bioactive compounds 28.48± 0.67 mg/100 g body weight (chlorogenic acid 20±0.24 mg/100 g body weight, caffeic acid 8.65±0.46 mg/100 g body weight), total flavonoids 6.39 mg/100 g body weight (quercetin 5.21± 0.26 mg/100 g body weight, kaempferol 0.28 ± 0.02 mg/100 g body weight, myricetin 0.09 ± 0.03 mg/100 g body weight), total anthocyanins 0.27 ± mg/100 g body weight, β-carotene 1.70 ± 0.05 mg/100 g body weight and total carotenoids 8.7 ± 0.34 mg/100 g body weight. Vongsak et al. [17]; Ruan et al. [18]; Chan et al. [19] proved that pluchea leaves contain 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, and 4,5- O-dicaffeoylquinic acid. Schefer at al. [45] informed that phenolic acid can be bound with protein and carbohydrate by non-covalent interactions, i.e. hydrophobic interaction, hydrogen bonding, electrostatic interaction, van der Waals interaction, and π-π stacking. The presence of κ-carrageenan proportion and pluchea tea extract addition that differed caused change of composition and various interaction of compounds that determined different swelling index of wet noodles.

The cooking loss of stink lily noodles was influenced significantly by κ-carrageenan proportion nor extract addition, but interaction of two factors was insignificant difference. The phenomena was caused by κ-carrageenan and bioactive compounds of pluchea tea extract, especially phenolic compounds, that involved the interaction with protein and carbohydrate in dough. κ-carrageenan can stabilized and supported a rigid structure of gluten. The hydrocolloid can avoid starch gelatinization process because it can bind tightly with water molecule caused lower the water activity. Supported by Li et al.[13]; Herawati [46]; Huang et al. [41], κ-carrageenan can trap the free water molecule that starch can't absorb the water molecule and require higher energy to break the energy barrier required for the starch gelatinization process. Whereas Zhu [42]; Amoako and Awika [47];

Schefer et al. [45] clarified that starch can be bound with polyphenol, including hydrophobic and electrostatic interactions and hydrogen bond that the hydrogen bond is dominant binding forces. This interaction can support releasing of amylose of starch gelatinization process that the cooking loss increased at the higher pluchea tea extract addition. The presence of polyphenol compounds of pluchea tea extract caused water competition with glutenin and gliadin of wheat flour that inhibited interaction between glutenin and gliadin to form gluten. According to Amoako and Awika [47], gluten and gliadin in a random coil structure can be aggregated by phenolic compounds and starch easily undergoes a gelatinization process where amylose interacts with polyphenolic compounds, through hydrogen bonds and hydrophobic interactions. The more protein in the form of random coil structure causes the protein to easily interact with polyphenols and come out of the noodles during the cooking process that the cooking loss increases.

The tensile strength of stink lily was influenced significantly by κ-carrageenan proportion nor extract addition. The increasing κ-carrageenan proportion grew up tensile strength because this hydrocolloid could be made strong cross linking through inter-molecular and intra-molecular bonds involving the glutenin and gliadin of wheat flour protein, and glucomannan of stink lily flour. The more networks that are formed between the components of the noodles have an effect on the tensile strength of wet noodles, and vice versa [13,48]. The synergism effect of the wet noodles component determined water bind capacity and water mobility that established texture properties of wet noodles, this statement is supported by Li et al.[34]; Saha and Bhattacharya [40]; Huang et al. [41]. Diniyah et al.[49] also informed that the addition of hydrocolloids in the noodles-making process increases the viscosity and water absorption because the water binding and holding properties of hydrocolloids that can form gel. However, the addition of pluchea tea extract caused the tensile strength to decline because the polyphenol compounds of pluchea tea extract induced breakdown of the networking structure among the components of dough because there was water competition among them. Furthermore, the polyphenol compounds could be reacted with starch and protein because the formation of the gluten network was disrupted that gliadin and glutenin in the form of random coils and starch could be underwent an excessive gelatinization process. This opinion is supported by Li et al. [13]; Zhu [42]; Huang et al. [41]. κ-carrageenan has a yellowish white color and has the ability to bind water molecules that it increases the lightness of wet noodles, while the pluchea tea extract contains polyphenolic compounds, such as tannins which can give the noodles a brown color that the lightness level is reduced. This opinion was supported by Widyawati et al. [20]; Necas et al. [38]. The increase in yellowness was in line with the increase in lightness because the higher the water content value was caused by the ability of κ-carrageenan to bind water molecules, thereby increasing the brightness and the brown color contribution of the pluchea tea extract gave a brownish-yellow color of the wet noodles that the intensity of this color increased as indicated by the increased chroma value.

4.2. Bioactive Compounds and DPPH Free Radical Scavenging Activity

The stinky silky wet noodles K0L0 had the lowest TPC and TFC because there was contributed of phenolic content from wheat flour and egg. Punia et al. [50] said that wheat flour has phenolic acids including ferulic, caffeic, and p-coumaric acid. Moreover, the presence of TFC in the K0L0 sample is thought to be due to the presence of a thiol group in egg white which is able to chelate metal ions and is able to be conjugated with saccharides [51], as well as 3,5-diacetyltambulin compounds from stink lily flour [52]. While the TFC and TPC values in the K2L2 sample were dominantly contributed by the presence of phytochemical compounds in the pluchea tea extract.Widyawati et al. [20] explained that there are phytochemical compounds in the pluchea tea extract. Suriyaphan [16]; Vongsak et al. [17]; Ruan et al. [18]; Chan et al. [19] also emphasized that pluchea leaves contain phenolic acids and flavonoids. The existence of a non-significant difference between treatments in the TPC and TFC assays indicated an interaction between the components in the dough that it affected the presence of free hydroxyl groups that could bind to the Folin Ciocalteus phenol reagent. as described by Li et al. [13]; Herawati [41]; Zhu [42]; Schefer et al. [45]; Amoako and Awika [47] glutenin, gliadin, glucomannan, κ-carrageenan, and polyphenol compounds are involved in the formation of networks structure in the dough so as to determine the quality of wet noodles. The interactions that occur involve various non-covalent interaction mechanisms that affect the presence of free hydroxyl groups. The TPC and TFC values of wet noodles in each treatment affected DPPH free radical scavenging activity (DPPH). They determined DPPH of wet noodles, usually positively correlated. Niroula et al. [53] said that TPC and DPPH were strongly correlated in seeds, sprouts and grasses of corn (*Zea mays* L.). Lim et al. [54] also informed that there is an excellent correlation coefficient between the TPC, TFC and antioxidant activities of *Phaleria macrocarpa* fruit. Adebiyi et al. [55] explained that the high level of flavonoids and phenols in plant caused the antioxidant activity of *Grewia carpinifolia* extract. The antioxidant activity of phenolics is related to their redox properties which induced them to act as reducing agents, hydrogen donors, singlet oxygen quenchers and metal chelators. Rahman et al. [56] underlined that DPPH free radical scavenging activity of polyphenol compounds of *T. pallida* extract was determined by hydrogen donating ability which it highly correlated. The potency of wet noodles as AOA was determined by reduced capability of DPPH free radical solution color from purple to be yellow color.

4.3. Sensory Properties

The analysis of sensory properties of the stink lily noodles was conducted by the hedonic scale scoring method with attribute the preference of color, taste, aroma, texture and overall. The result of the color preference test showed that the control treatment (K0L0) was the highest value because the treatment without the addition of pluchea tea extract not change the color of the wet noodles was yellowish-white. And then the treatment with the lowest color preference value was K0L1 due to the addition of this extract decreased the panelists' preference for the color because the noodles were darker and brownish color. Suriyaphan [16]; Widyawati et al. [20] said that the color of the pluchea tea extract contributed to changing the color of this wet noodle originated from tannins, flavonoids, and chlorophyll. However, in this study, increasing the extract concentration did not significantly affect the panelists' preference for color when the proportion of κ-carrageenan increased, because the addition of stink lily flour and κ-carrageenan would increase the lightness of the wet noodles that the produced color of the wet noodles was brighter and preferred by panelists. This data was supported by the data from color rider analysis, where the results of the sensory test by the panelists were in line with the decrease in the lightness value, the increase in the reddish and yellowish values, the hue value showed the yellow-red color, and chroma value showed an increase in color intensity. The panelist preference of aroma from wet noodles was determined by the aroma from the material used to make wet noodles or the interaction of aroma produced from the reaction among the material composition. According to Ramdani et al. [57], stink lily flour has a musty aroma, and all wet noodles produced have a musty smell. Meanwhile, according to Fitantri et al. [58], κ-carrageenan is unscented that not contribute to wet noodles. The addition of pluchea tea extract decreased the panelists' preference for the aroma of wet noodles because the addition of the extract caused the wet noodles to smell like leaves (floral) and unpleasant and the panelists did not like it. Fragrant or unpleasant aroma comes from volatile compounds contained in pluchea leaves. According to Widyawati et al. [59], pluchea leaves have 66 volatile compounds, these volatile compounds play a role in forming the aroma in the hot water extract of pluchea leaf tea. According to Lee et al. [60], pluchea leaves contain volatile compounds contributed by aliphatic aldehyde group compounds or aromatic compounds that give a distinctive aroma, therefore the presence of these compounds in steeping water can give a specific aroma, i.e. fragrant (floral) in wet noodles. There was a difference in the effect of the proportion of κ-carrageenan and pluchea leaf tea extract on taste due to the contribution of taste produced by carrageenan and extract.

According to Ramdani et al. [57]; Haryu et al. [61], stink lily flour and κ-carrageenan do not have a distinctive or neutral taste, increasing the concentration of κ-carrageenan gives a higher preference value because noodles are considered to have a better texture that contributes to the assessment of taste. The increase in the concentration of pluchea tea extract caused the taste preference value of noodles to decrease significantly, this is due to the presence of tannins, catechins, and phenolic compounds in the pluchea tea extract which determined bitter and slightly astringent. The effect of κ-carrageenan proportion and tea extract to make wet noodles influenced panelist preference of texture because this hydrocolloid can be make strong cross linking through inter-molecular and intra-molecular bonds involving the glutenin and gliadin of wheat flour protein, and glucomannan of stink lily flour that determined water bind capacity and water mobility [34,40,41]. Presence of the polyphenol compounds of pluchea tea extract can be breakdown of the networking structure among the components of dough because of water competition of them. Li et al. [13]; Zhu [42]; Huang et al. [41] said that the polyphenol compounds could be reacted with starch and protein to disrupt the gluten network and cause starch to undergo an excessive gelatinization process. The difference in the proportion of κ-carrageenan change the overall preference value of wet noodles to be significantly different overall compared to the control, this was because the proportion of κ-carrageenan influenced the all sensory attribute (color, aroma, and taste). The addition of pluchea tea extract in wet noodles decreased the overall preference value because the addition of extract affected the organoleptic characters tested due to the content of secondary metabolites of pluchea leaves, such as flavonoids, phenols, and tannins that could affect the taste, aroma, the color, and texture of the noodles. Based on spider web graph showed that K2L0 was the best treatment of stink lily wet noodles. It was also supported by better physicochemical properties than the control, including yellowish white wet noodles, better swelling index, lower cooking loss, higher tensile strength value, and lower moisture content. However, this K2L0 treatment did not have the highest TPC, TFC, and AOA, i.e. 0.500±0.045; 0.089±0.008; and 0.532±0.005, respectively.

5. Conclusions

The use of κ-carrageenan proportions and pluchea leaf tea extract had a significant effect on the cooking quality and sensory properties of stink lily wet noodles. Statistical analysis at $p < 5\%$ showed that there was an interaction effect of the proportion of κ-carrageenan and pluchea leaf tea extract on the swelling index, yellowness, chroma, hue, TPC, TFC, DPPH, the preference value for color, aroma, and overall acceptance. While the moisture content of wet noodles was only affected by the proportion of κ-carrageenan, for tensile strength, cooking loss, lightness, and redness, and the preference value for texture and taste were influenced by the proportions of κ-carrageenan and the concentration of pluchea leaf tea extract, respectively. The best treatment based on the spider web graph showed that the K0L2 treatment had the largest area 79.16 cm^2 and a preference score of 15.8 with a very like category, this is in accordance with the results of physicochemical and sensory tests, but it was no correlated with the highest bioactive content (TPC and TFC) and DPPH.

Author Contributions: P.S.W., T.I.P.S., A.I.W., and T.E.W.W. conceived the research; P.S.W., T.I.P.S., I.W., and T.E.W.W carried out the literature search and designed the methodology of lab analyses; P.S.W., V.W.M. and S.T. implemented the fieldwork; P.S.W., V.W.M. and S.T. performed the experiments and processed raw data; P.S.W., V.W.M. and S.T. processed the data and performed data analyses; P.S.W. wrote the manuscript. All authors have read and agreed to the published version of the manuscript.

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(Amorphophallus Muelleri) Wet Noodles
Authors: Paini Sri Widyawati *, Thomas Indarto Putut Suseno, Theresia Endang
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Dear Dr. Widyawati,

Thank you very much for resubmitting the modified version of the following manuscript:

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Article

The Effect of κ-Carrageenan Proportion and Hot Water Extract of the *Pluchea indica* Less Leaf Tea on the Quality and Sensory Properties of Stink Lily (*Amorphophallus muelleri*) Wet Noodles

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Abstract: The study aims to determine the effect of the proportion of κ-carrageenan and the hot water extract of pluchea leaf tea on the quality and sensory properties of stink lily wet noodles. The research design is a randomized block design with two factors, i.e., the difference in the proportion of κ-carrageenan (K) (0, 1, 2, and 3% *w*/*w*) and the addition of the hot water extract of the *Pluchea indica* Less leaf tea (L) (0, 15, and 30% *w*/*v*), with 12 treatment levels (K0L0, K0L1, K0L2, K1L0, K1L1, K1L2, K2L0, K2L1, K2L2, K3L0, K3L1, K3L2). The data are analyzed by the ANOVA at $p < 5\%$ and continued with the Duncan's multiple range test at $p < 5\%$, and the best treatment was determined by the spider web method based on sensory assay by a hedonic method. The proportions of κ-carrageenan and the concentration of pluchea tea extract had a significant effect on the cooking quality and sensory properties. However, the interaction of the two factors affected the swelling index, yellowness (b*), chroma (C), hue (h), total phenol content (TPC), total flavonoid content (TFC), and DPPH free radical scavenging assay (DPPH). The best treatment of wet noodles was K2L0, with a preference score of 15.8. The binding of κ-carrageenan and phenolic compounds to make a networking structure by intra- and inter-disulfide bind between glucomannan and gluten was thought to affect the cooking quality, sensory properties, bioactive compounds (TPC and TFC), and DPPH.

Keywords: *Amorphophallus muelleri*; *Pluchea indica* Less; wet noodles; quality and sensory properties

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1. Introduction

Noodles are a rice-substitute commodity that are much favored by the public [1], especially in China, Indonesia, India, Japan, Vietnam, and the United States. Basically, noodles are divided into wet noodles and dry noodles. Indonesia is the country that consumes the second-highest amount of noodles in the world [2]. In 2017, the consumption of instant noodles became 180.2 packets per head in the world, and in Indonesia, the consumption of wet noodles shows that all age groups and education levels enjoy them [3]. Meanwhile, instant noodle consumption in 2020 reached 12,640 million portions [2]. Noodles are generally made from wheat flour; however, the use of local food ingredients based on carbohydrates, including stink lily flour, can reduce the consumption of wheat flour, which is quite high in Indonesia, with the average consumption of wheat flour for the Indonesian population in 2019 being 17.8 kg/capita/year [4].

Stink lily flour (*Amorphophallus muelleri*) is a group of *Araceae* that contains glucomannan oligosaccharides of around 15–64% dry base [5], or more than 60% [6]. Glucomannan is a heteropolysaccharide consisting of 67% D-mannose and 33% D-glucose, and has β-1,4 and β-1,6 glycoside bonds [7] which can reduce body weight, blood sugar content levels, LDL cholesterol levels, and prolong gastric emptying time [8,9]. Stink lily flour has a glycemic index of 85, which is lower than the glycemic index of glucose (which is considered to be 100 [7]). The use of stink lily flour in the manufacture of wet noodles is able to replace the role of the gliadin and glutenin proteins in the formation of gluten with an elastic texture [10]. Polysaccharides in stink lily flour can dissolve in water to form a thick solution, form a gel, expand, melt like agar [11], and can increase the elasticity and cohesiveness [12,13] with increasing α-helix and β-sheet structures of wet noodles [13]. However, the higher the substitution of stink lily flour, the lower the texture preference, because the noodles break easily and are sticky [12]. Therefore, it is necessary to add hydrocolloids, including carrageenan, because they can increase elasticity [14]. The combination of the use of glucomannan and carrageenan can form a strong and elastic gel [15].

The addition of the hot water extract from pluchea leaf tea in making stink lily wet noodles is expected to increase the functional value of wet noodle products. Pluchea leaves contain nutrients, such as: protein 1.79 g/100 g, fat 0.49 g/100 g, ash 0.20 g/100 g, insoluble fiber 0.89 g/100 g, soluble fiber 0.45 g/100 g, total fiber 1.34 g/100 g, carbohydrates 8.65 g/100 g, calcium 251 g/100 g, β-carotene 1.225 mg/100 g, and vitamin C 30.17 mg/100 g, as well as bioactive compounds, such as: phenolic acid 28.48 ± 0.67 mg/100 g wb (chlorogenic acid 20 ± 0.24 mg/100 g wb, caffeic acid 8.65 ± 0.46 mg/100 g wb), total flavonoids 6.39 mg/100 g wb (quercetin 5.21 ± 0.26 mg/100 g wb, kaempferol 0.28 ± 0.02 mg/100 g wb, myricetin 0.09 ± 0.03 mg/100 g wb), total anthocyanins 0.27 ± 0.01 mg/100 g wb, β-carotene 1.70 ± 0.05 mg/100 g wb, and total carotenoids 8.7 ± 0.34 mg/100 g wb [16], 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, and 4,5-O-dicaffeoylquinic acid [17–19]. Meanwhile, the hot water extract of 2% pluchea leaf tea (2 g/100 mL) contains a total phenolic content of 9.3 mg EAG/g, total flavonoid content 22.0 mg EC/g, DPPH free radical scavenging activity DPPH 27.2 mg EAG/g, and reduced iron ion 10.2 mg EAG/g [20], due to the presence of phytochemicals (alkaloids, flavonoids, phenolics, sterols, cardiac glycosides, phenol hydroquinone, tannins, terpenoids, and saponins) [20], which has been shown to have potential as antioxidants [20,21] and antidiabetics [22]. The effect of using κ-carrageenan and the water extract of pluchea leaf tea on the quality and sensory properties of stink lily wet noodles has not been studied in detail. Therefore, the purpose of this study is to determine the effect of the proportion of κ-carrageenan and the hot water extract of pluchea leaf tea on the quality and sensory properties of stink lily wet noodles.

2. Materials and Methods

2.1. Reagents and Materials

The compounds 2,2-diphenyl-1-picrylhydrazyl (DPPH), sodium carbonate, gallic acid, and (+)-catechin were purchased from Sigma-Aldrich (St. Louis, MO, USA). Methanol, Folin–Ciocalteu's phenol, sodium nitric, aluminum chloride, κ-carrageenan, and sodium hydroxide were purchased from Merck (Kenilworth, NJ, USA).

The pluchea leaves as a raw material for making the pluchea leaf tea were collected from gardens around the city of Surabaya. The specification of the pluchea plant was according to the GBIF taxon ID number database: 3132728. The stink lily flour was obtained from the stink lily flour processing industry in East Java. The specification of the ttink lily plant was according to the GBIF taxon ID number database: 735493731. The wheat flour used was a high-protein flour obtained from the wheat flour processing industry in Indonesia.

2.2. Preparation of the Pluchea Leaf Tea

The pluchea leaves on each branch (number 1–6 from) the shoot was collected, sorted, and dried at an ambient temperature for 7 days, until the moisture content was 11.16 ± 0.09% dry base. Then, the dried leaves were powdered to achieve a 45 mesh size [23]. Furthermore, the leaf powder was heated by a drying oven (Binder, Merck KGaA, Darmstadt, Germany) at 120 °C for 10 min. Then, the dried powder of the pluchea leaves was packed as 2 g per tea bag, which was then called pluchea leaf tea.

2.3. Preparation of the Hot Water Extract of Pluchea Leaf Tea

The pluchea leaf tea in a tea bag was extracted by hot water at 95 °C for 1 min to achieve 15 and 30% (*b*/*v*) concentrations (Table 1). Then, each concentration of the extract was used to make stink lily wet noodles.

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

Materials	**Concentration of Hot Water Extract of Pluchea Leaf Tea (% *b*/*v*)**		
	0	**15**	**30**
Pluchea leaf tea (g)	0	4.5	9
Hot water (mL)	30	30	30

2.4. Stink Lily Wet Noodles Making

The stink lily wet noodles were made with a mixture of wheat and stink lily flour and κ-carrageenan at 1, 2, and 3% (*b*/*b*) concentrations. Then, the mixture was added to egg, salt, baking powder, and the hot water extract of the pluchea leaf tea, and kneaded to form a dough by a mixer machine. The dough was then passed through a roller to make face bands of the desired thickness, and was cut through rollers using cutting blades. The formula of the stink lily wet noodle is showed in Table 2.

Table 2. The formula of the stink lily wet noodles.

Material	**K0L0**	**K0L1**	**K0L2**	**K1L0**	**K1L1**	**K1L2**	**K2L0**	**K2L1**	**K2L2**	**K3L0**	**K3L1**	**K3L2**
Wheat flour (g)	120	120	120	120	120	120	120	120	120	120	120	120
Stink lily flour (g)	30	30	30	28.5	28.5	28.5	27	27	27	25.5	25.5	25.5
κ-Carrageenan (g)	0	0	0	1.5	1.5	1.5	3	3	3	4.5	4.5	4.5
Egg (g)	30	30	30	30	30	30	30	30	30	30	30	30
Salt (g)	3	3	3	3	3	3	3	3	3	3	3	3
Baking powder (g)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Water (mL)	30	0	0	30	0	0	30	0	0	30	0	0
Hot water extract of the pluchea leaves 15% (mL)	0	30	0	0	30	0	0	30	0	0	30	0
Hot water extract of the pluchea leaves 30% (mL)	0	0	30	0	0	30	0	0	30	0	0	30
Total (g)	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5	214.5

Note: K0 = wheat flour: stink lily flour: κ-carrageenan = 80:20:0. K1 = wheat flour: stink lily flour: κ-carrageenan = 80:19:1. K2 = wheat flour: stink lily flour: κ-carrageenan = 80:18:2. K3 = wheat flour: stink lily flour: κ-carrageenan = 80:17:3. L0 = concentration of the hot water extract from the pluchea leaf tea = 0%. L1 = concentration of the hot water extract from the pluchea leaf tea = 15%. L2 = concentration of the hot water extract from the pluchea leaf tea = 30%.

2.5. Stink Lily Wet Noodles Extraction

125 g of each sample of the stink lily wet noodles was weighed (Ohaus, Ohaus Instruments (Shanghai) Co., Ltd., Shanghai, China), and then they were dried by cabinet drying at 60 °C for 4 h to get dried noodles. Next, each sample was powdered by a chopper machine at a second speed for 35 s, and then 20 g of each powdered sample was added to 50 mL methanol by a shaking water bath at 35 °C, 70 rpm, for 1 h. The filtrate was separated by Whatman filter paper grade 40, and the residue was extracted again with same pattern method. The filtrate was collected and dried by a rotary evaporator (Buchi Rotary Evaporator; Buchi Shanghai Ltd., RRT, Shanghai, China) at 0.2–0.3 atm, 50 °C, for 60 min, until a 2 mL extract was achieved. Then, the extract was kept at 0 °C before further study.

2.6. Swelling Index Assay

Swelling index, or water absorption, is the ability of noodles to absorb water after gelatinization during the boiling process [24]. The principle of water absorption testing is to determine the amount of water absorbed in wet noodles at a certain temperature and time. The amount of water absorbed in wet noodles can be determined from the difference between the weight of the noodles after and before being boiled divided by the weight of the noodles before boiling [25].

2.7. Cooking Loss Assay

Cooking loss is one of the important quality parameters in wet noodles to determine the quality of wet noodles after cooking [26]. The cooking loss test for stink lily wet noodles was carried out to determine the number of solids that came out of the noodle strands during the cooking process, namely, the release of a small portion of starch from the noodle strands.

2.8. Determination of the Tensile Strength of Wet Noodles

The tensile strength (elongation) is one important parameter of texture analysis in noodle products. The texture was determined using a 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 principle of the texture analyzer was to prepare a suitable probe for the test, then place the noodle samples on the table under the probe. The elongations 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. The same procedure was performed to tighten the other end of the strip to the upper roller arm. Elongation, which was the maximum force to deform and break the noodles by extension, was measured using a test speed of 3.0 mm/s, with a 100 mm distance between the two rollers. Deformations were recorded using the software during the extension, and are expressed as a graph. The elongation at breaking was calculated per gram.

2.9. Color Measurement

The noodle samples were measured by a colorimeter (Minolta CM-3500D; Minolta Co. Ltd., Osaka, Japan), and the CIE-Lab L*, a*, and b* values were recorded as described by Rathorel et al. [27]. Then, the L*, a*, and b* values were collected. The L* value was stated as the position on the white/black axis, the a* value the position on the red/green axis, and the b* value the position on the yellow/blue axis. The measurements were carried out in triplicate, and the readings were averaged.

2.10. Total Phenol Content Assay

The total phenol content (TPC) of the stink lily wet noodles was analyzed by the spectrophotometric method using the Folin–Ciocateu's phenol reagent [28]. Principles assay of the TPC assay are the interactions between phenolic compounds and phosphomolybdic/phosphotungstic acid complexes, based on the transfer of electrons in an alkaline medium from the phenolic compounds to form a blue chromophore constituted by a phosphotungstic/phosphomolybdenum complex. The reduced Folin–Ciocalteu's phenol reagent was detected by a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 760 nm and gallic acid was used as the reference standard compound, and the results are expressed as gallic acid equivalents (mg/kg wet noodles).

2.11. Total Flavonoid Content Assay

The total flavonoid content of the samples was measured by the spectrophotometric method, with a reaction between $AlCl_3$ and $NaNO_2$ with an aromatic ring of flavonoid compounds [29]. Then, the mixture was added to aluminum chloride, resulting in a yellow solution. Next, the addition of the NaOH solution in the mixture caused a red solution, that was measured by a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 510 nm. A standard reference compound of (+) catechin was used, and the results were expressed as catechin equivalents (mg/kg wet noodles).

2.12. DPPH Free Radical Scavenging Activity Assay

The DPPH free radical scavenging activity was measured by the spectrophotometric method [30]. This method is used to determine the antioxidant capacity of a compound from an extract or other biological sources, based on the transferring from the odd electron of a nitrogen atom in DPPH being reduced by receiving a hydrogen atom from antioxidants, to result in DPPH-H with a yellow-colored solution. The reaction between the DPPH in methanol solution with the samples was measured by a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ 517 nm. The standard reference compound used was gallic acid, and the results were expressed as gallic acid equivalents (mg/kg wet noodles).

2.13. Sensory Evaluation

Sensory assay was carried out to determine the level of panelist acceptance of wet noodles substituted with stink lily flour with the addition of carrageenan and the hot water extract of pluchea leaf tea [31]. The test was carried out using the hedonic scale scoring method. This method is designed to measure the level of panelist preference for the product by rating the level of preference for the product being tested. Samples were served in dishes coded with random three-digit numbers that allowed for a completely-randomized design (CRD) trial to be carried out, using 100 untrained panelists with an age range of 17 to 25 years. The hedonic method used in this study was the hedonic scoring method, and the panelists were asked to give a preference score for each sample. The hedonic score used was a value of 1–15, given by the panelists according to the level of preference for the product. Values 0–3.0 indicated "strongly dislike", values 3.1–6.0 indicated "dislike", values 6.1–9.0 indicated "neutral", values 9.1–12.0 indicated "like", and a value of 12.1–15.0 indicated "very much like".

Each panelist was faced with 12 (twelve) samples and a questionnaire containing test instructions, and was asked to give each sample a score according to their level of preference. The parameters tested were taste, aroma, texture, color, and overall acceptance of wet noodles substituted with stink lily flour. The best treatment of the samples was determined by the spider web method, that was correlated by the large area of graph [32].

2.14. Experiment Design and Statistical Analysis

The research design of the physicochemical assay used was a randomized block design with two factors, i.e., differences in the proportion of the κ-carrageenan (K) and differences in the concentration of the pluchea tea extract (L) added to the wet noodles. The proportion of κ-carrageenan consisted of four treatment levels, including 0% (K0), 1% (K1), 2% (K2), and 3% (K3), and the concentration of pluchea tea extract consisted of three levels, i.e., 0% (L0), 15% (L1), and 30% (L2). Each treatment was repeated three times in order to obtain 36 experiment units. The sensory test used a completely randomized design (CRD) on 100 untrained panelists.

The data, before further analysis, was determined by the normal distribution and homogeneity tests. Then, the data were presented as the mean ± SD of the triplicate determinations, and were analyzed using ANOVA at $p < 5\%$. If the results of the ANOVA test had a significant effect, then the DMRT (Duncan Multiple Range Test) was proceed with at $p < 5\%$ to determine the level of treatment that gave significantly different results. The analysis used SPSS 17.0 software (SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Cooking Quality

The evaluated cooking properties of the stink lily wet noodles were shown in Table 3, and the stink lily wet noodles product was shown in Figure 1. The level of cooking was estimated by the moisture content, swelling index, cooking loss, and tensile strength from the noodles. Based on the statistical analysis by ANOVA at $p < 5\%$, the increasing κ-carrageenan proportion was shown to have created a significant difference of moisture content of the wet noodles, but the addition of the pluchea leaf hot water extract, and the interaction effect of the proportion of κ-carrageenan and the addition of the extract, had no influence on the moisture content of the wet noodles. The moisture content value ranged from 62.83 ± 0.58 %wb to 65.83 ± 0.22 %wb. The sample K3L0 had the highest moisture content, and K0L2 had the lowest moisture content. Furthermore, the addition of the κ-carrageenan proportion or the pluchea tea extract had significantly different effects, such as the interaction effect of the addition of the two parameters, on the swelling index or water absorption value of the wet noodles, based on the statistical analysis at $p < 5\%$. The water absorption value ranged from 142.25 ± 0.39% to 162.21 ± 0.25%. The treatment with the lowest swelling index was K0L2, and the highest was K3L0. Contrary to this, the cooking loss of the wet noodles decreased significantly with the addition of the proportion of κ–carrageenan, but increased significantly with the addition of the pluchea tea extract. The cooking loss of the wet noodles ranged 17.83 ± 0.4% to 20.13 ± 0.7%. K0L2 was the treatment with the biggest cooking loss, and K3L0 was the treatment with the smallest cooking loss. The tensile strength value of the stink lily noodles was significant different because there was an interaction effect of the κ-carrageenan proportion and the pluchea tea extract addition. The tensile strengths of the wet noodles ranged 0.096 ± 0.004 N to 0.174 ± 0.015 N. The analysis of the stink lily noodles color showed that lightness had a significant increase with an increasing proportion of carrageenan and decreased with the increase in the amount of pluchea tea extract used, because of the color effect of the carrageenan and pluchea tea extracts. The lightness of the wet noodles ranged from 67.80 ± 0.22 to 74.50 ± 0.23. The effect of the κ-carrageenan and the pluchea tea extract color also significantly influenced the redness of wet noodles. The redness of the wet noodles ranged from 1.20 ± 0.04 to 3.30 ± 0.23. The interaction effect of the κ-carrageenan and the pluchea tea extract addition appeared on the yellowness, chroma, and hue values. The yellowness, chroma, and hue values ranged 16.90 ± 0.27 to 30.00 ± 0.07, 17.00 ± 0.28 to 30.10 ± 0.03, and 83.70 ± 0.07 to 86.40 ± 0.02, respectively.

Table 3. Color, moisture content, swelling index, cooking loss, and tensile strength of the stink lily noodles.

Samples	Color					Moisture Content (%wb)	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (N)
	L*	a*	b*	C	h				
K0L0	73.00 ± 0.06	1.20 ± 0.06	16.90 ± 0.25 ^{a}	17.00 ± 0.31 ^{a}	86.40 ± 0.00 ^{g}	64.15 ± 0.70	148.90 ± 0.15 ^{c}	18.83 ± 0.44	0.106 ± 0.002
K0L1	68.70 ± 0.35	2.60 ± 0.06	26.50 ± 0.32 ^{d}	26.50 ± 0.29 ^{c}	84.40 ± 0.21 ^{bc}	63.66 ± 0.38	146.36 ± 0.27 ^{b}	19.06 ± 0.43	0.105 ± 0.001
K0L2	67.80 ± 0.20	2.80 ± 0.06	27.80 ± 0.46 ^{ef}	27.80 ± 0.45 ^{e}	84.20 ± 0.32 ^{abc}	62.83 ± 0.58	142.25 ± 0.39 ^{a}	20.13 ± 0.71	0.116 ± 0.006
K1L0	73.40 ± 0.25	1.30 ± 0.06	17.30 ± 0.15 ^{ab}	17.30 ± 0.15 ^{a}	85.70 ± 0.21 ^{f}	64.42 ± 0.80	149.63 ± 0.34 ^{d}	18.47 ± 0.31	0.086 ± 0.005
K1L1	69.00 ± 0.36	2.80 ± 0.12	27.30 ± 0.45 ^{e}	27.40 ± 0.50 ^{d}	84.20 ± 0.15 ^{a}	62.95 ± 0.68	146.65 ± 0.43 ^{b}	19.36 ± 0.92	0.103 ± 0.004
K1L2	68.30 ± 0.15	3.00 ± 0.12	28.60 ± 0.12 ^{g}	28.70 ± 0.15 ^{f}	84.00 ± 0.15 ^{abc}	63.37 ± 1.04	148.85 ± 0.57 ^{c}	19.76 ± 0.90	0.108 ± 0.005
K2L0	73.70 ± 0.10	1.50 ± 0.00	17.70 ± 0.26 ^{bc}	17.80 ± 0.23 ^{a}	85.20 ± 0.06 ^{de}	64.67 ± 1.08	155.67 ± 0.46 ^{h}	18.18 ± 0.45	0.098 ± 0.002
K2L1	69.40± 0.15	3.00 ± 0.06	28.20 ± 0.15 ^{fg}	28.40 ± 0.15 ^{f}	83.80 ± 0.17 ^{ab}	63.74 ± 0.75	150.96 ± 0.71 ^{e}	18.62 ± 0.41	0.106 ± 0.005
K2L2	68.70 ± 0.06	3.10 ± 0.15	29.30 ± 0.00 ^{h}	29.40 ± 0.06 ^{g}	84.00 ± 0.15 ^{abc}	64.25 ± 1.60	154.82 ± 0.44 ^{g}	19.34 ± 0.77	0.114 ± 0.003
K3L0	74.50 ± 0.23	1.70 ± 0.12	18.10 ± 0.00 ^{c}	18.10 ± 0.06 ^{b}	84.60 ± 0.21 ^{cd}	65.83 ± 0.22	162.21 ± 0.25 ^{i}	17.83 ± 0.41	0.110 ± 0.003
K3L1	69.80 ± 0.50	3.20 ± 0.06	29.30 ± 0.12 ^{h}	29.30 ± 0.06 ^{g}	83.80 ± 0.53 ^{ab}	64.57 ± 1.78	153.35 ± 0.15 ^{f}	18.36 ± 0.17	0.124 ± 0.007
K3L2	69.00 ± 0.20	3.30 ± 0.26	30.00 ± 0.06 ^{i}	30.10 ± 0.06 ^{h}	83.60 ± 0.06 ^{a}	65.49 ± 1.04	159.59 ± 0.52 ^{i}	19.22 ± 0.84	0.126 ± 0.008

* 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. Stink lily noodles. Note that K0 = wheat flour: stink lily flour: κ-carrageenan = 80:20:0, K1 = wheat flour: stink lily flour: κ-carrageenan = 80:19:1, K2 = wheat flour: stink lily flour: κ-carrageenan = 80:18:2, K3 = wheat flour: stink lily flour: κ-carrageenan = 80:17:3, L0 = concentration of the hot water extract from the pluchea leaf tea = 0%, L1 = concentration of the hot water extract from the pluchea leaf tea = 15%, L2 = concentration of the hot water extract from the pluchea leaf tea = 30%.

3.2. Bioactive Compounds and DPPH Free Radical Scavenging Activity (DPPH)

The bioactive compounds analyzed include the total phenol content (TPC) and the total flavonoid content (TFC). The analysis data shows that the TPC and TFC increased significantly due to the interaction effect between the proportion of κ-carrageenan and the addition of the pluchea tea extract (Table 4). The results of the analysis show that the control sample K0L0 had the lowest total phenol, i.e., 0.341 ± 0.034 mg GAE/kg of dry noodles. The K2L2 sample had the highest total phenol, which was 1.196 ± 0.027 mg GAE/kg of dry noodles. This result is suitable with the TFC value of wet noodles, where K0L0 had the lowest TFC value and K2L2 had the highest value, i.e., 0.057 ± 0.004 and 1.336 ± 0.046 mg CE/kg of dry noodles, respectively. The high and low values of TPC and TFC were correlated with AOA. The higher the TPC and TFC values, the higher the DPPH value. The DPPH free radicals scavenging activity of the wet noodles was determined to be significant by the interaction effect of adding the proportion of κ-carrageenan and the pluchea tea extract. K0L0 had the lowest DPPH value and K2L2 had the highest DPPH value, i.e., 0.414 ± 0.006 and 0.758 ± 0.009 mg GAE/kg of dry noodles, respectively.

Table 4. Total phenol content, total flavonoid content, and the DPPH free radical scavenging activity of the stink lily noodles.

Samples	TPC (mg GAE/g Dry Noodles)	TFC (mg CE/g Dry Noodles)	DPPH Scavenging Activity (mg GAE/g Dry Noodles)
K0L0	0.341 ± 0.034 [a]	0.057 ± 0.004 [a]	0.414 ± 0.006 [a]
K0L1	0.948 ± 0.027 [d]	0.704 ± 0.007 [c]	0.742 ± 0.016 [c]
K0L2	1.099 ± 0.047 [e]	1.109 ± 0.007 [d]	0.757 ± 0.001 [c]
K1L0	0.458 ± 0.040 [b]	0.082 ± 0.002 [a]	0.523 ± 0.026 [b]
K1L1	0.924 ± 0.077 [d]	0.735 ± 0.003 [c]	0.750 ± 0.006 [c]
K1L2	1.005 ± 0.070 [d]	1.091 ± 0.095 [d]	0.751 ± 0.001 [c]
K2L0	0.500 ± 0.045 [b]	0.089 ± 0.008 [a]	0.532 ± 0.005 [b]
K2L1	0.965 ± 0.025 [d]	0.718 ± 0.018 [c]	0.748 ± 0.004 [c]
K2L2	1.196 ± 0.027 [f]	1.336 ± 0.046 [e]	0.758 ± 0.009 [c]
K3L0	0.527 ± 0.007 [b]	0.218 ± 0.003 [b]	0.587 ± 0.020 [b]
K3L1	0.807 ± 0.031 [c]	0.726 ± 0.039 [c]	0.751 ± 0.008 [c]
K3L2	1.145 ± 0.064 [ef]	1.067 ± 0.063 [d]	0.751 ± 0.007 [c]

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, $p < 5\%$.

3.3. Sensory Properties

The evaluated sensory properties of the stink lily noodles are shown in Table 5. The sensory parameters that were analyzed included aroma, color, taste, texture, and overall acceptability. The method used for the sensory assay of the stink lily noodles was a hedonic scale scoring, or a test of the level of consumer preference for a product by giving an assessment or score on a certain trait [33]. The organoleptic testing of the stink lily wet noodles was presented to 100 untrained panelists aged 17–25 years. The panelists were asked to give scores or numbers based on their level of preference for certain treatments. The value score used was 1–15, where a value of 0–3.0 indicated “strongly dislike”, a value of 3.1–6.0 indicated “does not like”, a value of 6.1–9.0 indicated “neutral”, a value of 9.1–12.0 indicated “like”, and a value of 12.1–15.0 indicated “like very much”. The results of the statistical tests by ANOVA at $p < 5\%$ show that the interaction effect of each treatment significantly influenced the panelists’ preference for noodle color. The preference value of the stink lily noodles’ color was ranged from 9.12 to 12.02 (like). The highest color preference value was the control treatment (K0L0), and the treatment with the lowest color preference value was K0L1. The interaction effect of each treatment had a significant impact on the panelists’ preference for the aroma. The preference value for the aroma of the wet noodles was ranged from 8.29 to 11.58 (neutral–like). The treatment with the highest preference value was the stink lily noodles K1L0, and the treatment with the lowest preference value was the K3L2 treatment. The preference value of noodles taste was only affected by the κ-carrageenan proportion or the extract concentration. The preference value for the wet noodle taste ranged from 8.18 to 11.08 (neutral–like). The treatment with the highest taste preference value was K2L0, while the treatment with the lowest taste preference value was K0L2. Increasing the proportion of carrageenan to 2% increased the preference value for taste, however after that it decreased with the addition of the proportion of 3% carrageenan. Meanwhile, increasing the concentration of the pluchea leaf tea extract decreased the panelists’ preference for taste. The results of the statistical tests using ANOVA at $p < 5\%$ show that the addition of the extract only significantly influenced the panelists’ preference for the noodles texture. In this study, the preference for the wet noodles texture ranged from 9.46 to 11.66 (like).

Table 5. Sensory properties of the stink lily noodles.

Samples	Hedonic Preference Score				
	Color	Aroma	Taste	Texture	Overall Acceptance
K0L0	12.02 [f]	10.93 [d]	10.52	10.95	11.24 [f]
K0L1	9.12 [a]	10.26 [cd]	8.72	10.03	8.79 [a]
K0L2	11.83 [ef]	8.86 [ab]	8.18	9.58	9.04 [ab]
K1L0	9.98 [bc]	11.58 [e]	10.15	11.66	10.3 [cde]
K1L1	9.44 [ab]	9.58 [bc]	9.49	10.66	8.93 [ab]
K1L2	10.59 [cd]	8.45 [a]	8.87	9.46	9.11 [ab]
K2L0	11.62 [f]	10.93 [de]	11.08	11.15	11.07 [def]
K2L1	10.63 [cd]	10.14 [ab]	9.82	10.61	9.42 [abc]
K2L2	10.94 [de]	8.84 [cd]	9.09	10.38	10.16 [cde]
K3L0	11.51 [ef]	10.36 [cd]	10.37	11.07	10.84 [def]
K3L1	9.37 [ab]	10.07 [a]	9.95	11	9.72 [bc]
K3L2	9.47 [ab]	8.29 [cd]	9.57	9.64	8.62 [a]

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, $p < 5\%$.

Increasing the addition of the extracts decreased the level of texture preference of the wet noodles. The overall preference value of the wet noodles shows that there is an interaction effect between the proportion of κ-carrageenan and the addition of the pluchea tea extract. The overall preference value of the wet noodles ranged from 8.62 to 11.24 (neutral–like). The treatment with the highest preference value was stink lily noodles K0L0, and the treatment with the lowest preference value was K3L2. The determination of the best treatment for the differences in the proportions of κ-carrageenan and the addition of the pluchea tea extract on the wet noodles was determined using the spider web method, based on organoleptic parameters (color, aroma, taste, texture, and overall). The spider web graph can be seen in Figure 2. The data shows that the treatment with the largest area was K2L0, i.e., wet noodles with the proportion of κ-carrageenan 2% and with the addition of 0% pluchea tea extract. The area of the K2L0 treatment area was 79.16 cm^2, and had a preference score of 15.8 (very like).

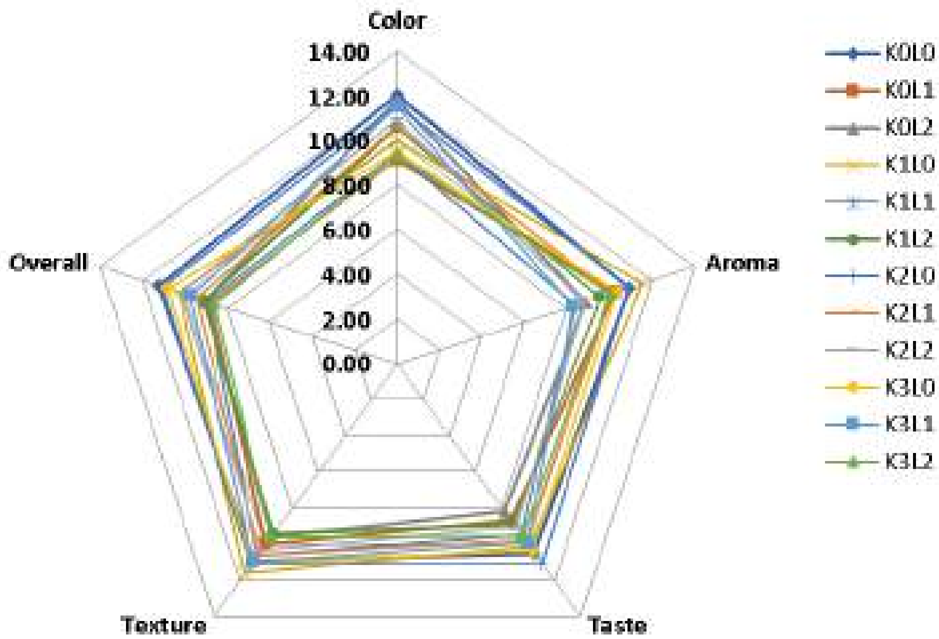

Figure 2. Spider web graph to determine the best treatment of the stink lily noodles.

4. Discussion

4.1. Cooking Quality

Moisture content is a major parameter of the stinky silky wet noodles that shows the amount of water contained in food product that determines rheological characteristics, the chemical, physical, and sensory properties, and the shelf life of the food product [34]. The result show that the κ-carrageenan addition gave a significant difference of moisture content to the wet noodles. The κ-carrageenan is a hydrocolloid that has a group of sulfate- and water-soluble polysaccharides [35–37], and composes an ester sulfate content of about 25–30% and a 3,6-anhydro-galactose (3,6-AG) of about 28 to 35% [36,38]. This anionic carrageenan can interact very tightly with water molecules [39], and can collaborate with the glucomannan from the stink lily on the gelation process [40] by making intra- and inter-disulfide binds at the network structure of gluten [13,41]. The κ-carrageenan can bind with limited free water molecules, form complex compounds with water, and interact with gluten networks [13]. However, the mobility of water mainly depends on changes in the hydrogen bond structure. The presence of hydrophilic components such as proteins, carbohydrates, glucomannan, κ-carrageenan, and polyphenolic compounds in the wet noodles can be involved in hydrogen bonding with the water molecules that determine water mobility [13,34,41,42]. Thus, increasing the proportion of k-carrageenan used in the manufacture of stink lily noodles can increase the amount of free water and weakly bound water in the wet noodles. The interaction between the hydroxyl functional groups in carrageenan and water molecules supports an increase in the water content of wet noodles.

The swelling index, or water absorption, is the ability of a product to absorb water, which is influenced by particle size, chemical composition, and water content [43]. The research shows that the interaction of the κ-carrageenan proportion and the hot water extract of the pluchea leaf tea addition had a significant impact on the swelling index properties of wet noodles. The swelling index of the wet noodles was determined by the presence of κ-carrageenan, protein, starch, glucomannan, and bioactive compounds of the pluchea tea extract in the dough. Li et al. [13] stated that the glutelin proteins of wheat flour can allow intra- and inter-molecular disulfide bonds to create a fibrous shape, and that then the globular gliadin protein of the wheat flour can be bound at the glutenin skeleton by non-covalent bonds to be a unique networks structure of gluten. The addition of the glucomannan of the stinky silky flour as a non-ionic hydrocolloid has good water holding capacity, and can be made into a stronger three-dimensional network structure. Chen et al. [44] stated that the glucomannan can fill the number of holes of the network structure of gluten that make a structure dense and stable. Li et al. [13] underlined that glucomannan has many hydroxyl groups in the structure that can be bound tightly with water by electrostatic forces and hydrogen bonds. Huang et al. [41] stated that the presence of κ-carrageenan in dough can be synergist with glucomannan to change sulfhydryl groups into disulfide bonds in protein. Widyawati et al. [20] stated that the bioactive compounds of pluchea tea extract are alkaloids, flavonoids, phenolics, phenol hydroquinone, saponins, tannins, sterols, terpenoids, and cardiac glycosides. Meanwhile, Suriyaphan [16] noted that pluchea leaves contain 1.79 g/100 g protein, 0.49 g/100 g fat, 0.20 g/100 g ash, 0.89 g/100 g insoluble fiber, 0.45 g/100 g dissolved fiber, total fiber 1.34 g/100 g, carbohydrates 8.65 g/100 g, calcium 251 g/100 g, β-carotene 1.225 g/100 g, and vitamin C 30.17 g/100 g, as well as phenolic acid bioactive compounds 28.48± 0.67 mg/100 g body weight (chlorogenic acid 20 ± 0.24 mg/100 g body weight, caffeic acid 8.65 ± 0.46 mg/100 g body weight), total flavonoids 6.39 mg/100 g body weight (quercetin 5.21± 0.26 mg/100 g body weight, kaempferol 0.28 ± 0.02 mg/100 g body weight, myricetin 0.09 ± 0.03 mg/100 g body weight), total anthocyanins 0.27 ± mg/100 g body weight, β-carotene 1.70 ± 0.05 mg/100 g body weight, and total carotenoids 8.7 ± 0.34 mg/100 g body weight. Vongsak et al. [17], Ruan et al. [18], and Chan et al. [19] proved that pluchea leaves contain 3-O-caffeoylquinic acid, 4-O-caffeoylquinic acid, 5-O-caffeoylquinic acid, 3,4-O-dicaffeoylquinic acid, 3,5-O-dicaffeoylquinic acid, and 4,5-O-dicaffeoylquinic acid. Schefer at al. [45] noted that phenolic acid can be bound with proteins and carbohydrates by non-covalent interactions, i.e., hydrophobic interaction, hydrogen bonding, electrostatic interaction, Van der Waals interaction, and π-π stacking. The presence of the κ-carrageenan proportion and the pluchea tea extract addition that differed caused a change of composition and various interactions of compounds that determined different swelling indexes of the wet noodles.

The cooking loss of the stink lily noodles was influenced significantly by the κ-carrageenan proportion and the extract addition, but interaction of two factors had an insignificant difference. The phenomena were caused by the κ-carrageenan and bioactive compounds of the pluchea tea extract, especially phenolic compounds, that involved the interaction with proteins and carbohydrates in dough. κ-carrageenan can stabilize and supported a rigid structure of gluten. The hydrocolloid can avoid the starch gelatinization process because it can bind tightly with water molecules, causing lower water activity. According to Li et al. [13], Herawati [14], and Huang et al. [41], κ-carrageenan can trap the free water molecules that starch can't absorb, and require higher energy to break the energy barrier required for the starch gelatinization process. However, Zhu [42], Amoako and Awika [46], and Schefer et al. [45] clarified that starch can be bound with polyphenol, including hydrophobic and electrostatic interactions and hydrogen bonds, and that the hydrogen bond is dominant binding forces. This interaction can support the releasing of the amylose of the starch gelatinization process that the cooking loss increased at the higher pluchea tea extract addition. The presence of the polyphenol compounds of the pluchea tea extract causes water competition with the glutenin and gliadin of wheat flour that inhibited interaction between glutenin and gliadin to form gluten. According to Amoako and Awika [46], gluten and gliadin in a random coil structure can easily be aggregated by phenolic compounds and starch when undergoing a gelatinization process where amylose interacts with polyphenolic compounds through hydrogen bonds and hydrophobic interactions. More protein in the form of random coil structures causes the protein to easily interact with polyphenols and come out of the noodles during the cooking process, meaning that the cooking loss increases.

The tensile strength of the stink lily was influenced significantly by the κ-carrageenan proportion and the extract addition. The increasing κ-carrageenan proportion increased the tensile strength because this hydrocolloid could be made strong by cross linking through the inter-molecular and intra-molecular bonds involving the glutenin and gliadin of wheat flour protein and the glucomannan of stink lily flour. The more networks that are formed between the components of the noodles, the greater the effect on the tensile strength of wet noodles, and vice versa [13,47]. The synergism effect of the wet noodles component determined the water bind capacity and water mobility, that in turn established texture properties of wet noodles; this statement is supported by Li et al. [34], Saha and Bhattacharya [40], and Huang et al. [41]. Diniyah et al. [48] also reported that the addition of hydrocolloids in the noodles-making process increases their viscosity and water absorption, due to the water binding and holding properties of hydrocolloids that can form gel. However, the addition of the pluchea tea extract caused the tensile strength to decline, because the polyphenol compounds of the pluchea tea extract induced a breakdown of the networking structure among the components of the dough because there was water competition among them. Furthermore, the polyphenol compounds could react with starch and protein because the formation of the gluten network was disrupted, and also gliadin and glutenin in the form of random coils and starch could have undergone an excessive gelatinization process. This opinion is supported by Li et al. [13], Zhu [42], and Huang et al. [41]. κ-carrageenan has a yellowish white color, and has the ability to bind water molecules so that it increases the lightness of wet noodles, while the pluchea tea extract contains polyphenolic compounds, such as tannins, which can give the noodles a brown color so that the lightness level is reduced. This opinion is supported by Widyawati et al. [20] and Necas et al. [38]. The increase in yellowness was in line with the increase in lightness, because the higher water content value was caused by the ability of κ-carrageenan to bind water molecules, thereby increasing the brightness; meanwhile. the brown color contribution of the pluchea tea extract gave a brownish–yellow color to the wet noodles, the intensity of which increased as indicated by the increased chroma value.

4.2. Bioactive Compounds and the DPPH Free Radical Scavenging Activity

The stinky silky wet noodles K0L0 had the lowest TPC and TFC because there was a contribution of phenolic content from the wheat flour and egg. Punia et al. [49] said that wheat flour had phenolic acids including ferulic, caffeic, and p-coumaric acid. Moreover, the presence of TFC in the K0L0 sample is thought to be due to the presence of a thiol group in egg white, which is able to chelate metal ions and is able to be conjugated with saccharides [50], as well as the 3,5-diacetyltambulin compounds from stink lily flour [51]. Meanwhile, the TFC and TPC values in the K2L2 sample were dominantly contributed to by the presence of phytochemical compounds in the pluchea tea extract. Widyawati et al. [20] explained that there are phytochemical compounds in the pluchea tea extract. Suriyaphan [16], Vongsak et al. [17], Ruan et al. [18], and Chan et al. [19] also emphasized that pluchea leaves contain phenolic acids and flavonoids. The existence of a non-significant difference between treatments in the TPC and TFC assays indicated an interaction between the components in the dough, and that it affected the presence of free hydroxyl groups that could bind to the Folin–Ciocalteu's phenol reagent. As described by Li et al. [13], Huang et al. [41], Zhu [42], Schefer et al. [45], and Amoako and Awika [46], glutenin, gliadin, glucomannan, κ-carrageenan, and polyphenol compounds are involved in the formation of network structures in the dough so as to determine the quality of the wet noodles. The interactions that occur involve various non-covalent interaction mechanisms that affect the presence of free hydroxyl groups. The TPC and TFC values of wet noodles in each treatment affected the DPPH free radical scavenging activity (DPPH). They determined the DPPH of wet noodles, and were usually positively correlated. Niroula et al. [52] said that TPC and DPPH were strongly correlated in seeds, sprouts, and grasses of corn (*Zea mays* L.). Lim et al. [53] also stated that there is an excellent correlation coefficient between the TPC, TFC, and antioxidant activities of the *Phaleria macrocarpa* fruit. Adebiyi et al. [54] explained that the high level of flavonoids and phenols in plants caused the antioxidant activity of the *Grewia carpinifolia* extract. The antioxidant activity of phenolics is related to their redox properties, which induced them to act as reducing agents, hydrogen donors, singlet oxygen quenchers, and metal chelators. Rahman et al. [55] underlined that the DPPH free radical scavenging activity of the polyphenol compounds of the *T. pallida* extract was determined by the hydrogen donating ability, with which it highly correlated. The potency of wet noodles as AOA was determined by the reduced capability of the DPPH free radical solution color from purple to yellow color.

4.3. Sensory Properties

The analysis of the sensory properties of the stink lily noodles was conducted by the hedonic scale scoring method, with attributes including the preferences of color, taste, aroma, texture, and overall. The result of the color preference test shows that the control treatment (K0L0) was the highest value, because the treatment without the addition of pluchea tea extract did not change the color of the wet noodles, meaning that they remained a yellowish–white. Then, the treatment with the lowest color preference value was K0L1, due to the addition of this extract decreasing the panelists' preference for the color because the noodles were darker and a brownish color. Suriyaphan [16] and Widyawati et al. [20] said that the color of the pluchea tea extract contributed to the changing of the color of this wet noodle due to its tannins, flavonoids, and chlorophyll. However, in this study, increasing the extract concentration did not significantly affect the panelists' preference for color when the proportion of κ-carrageenan increased, because the addition of the stink lily flour and the κ-carrageenan would increase the lightness of the wet noodles, so that the produced color of the wet noodles was brighter and preferred by panelists. This data is supported by the data from color rider analysis, where the results of the sensory test by the panelists are in line with the decrease in the lightness value, the increase in the reddish and yellowish values, the hue value that showed the yellow–red color, and the chroma value that showed an increase in color intensity. The panelist's preference of the aroma from the wet noodles was determined to be due to the aroma from the material used to make the wet noodles or the interaction of the aroma produced from the reaction among the material composition. According to Ramdani et al. [56], stink lily flour has a musty aroma, and all of the wet noodles produced had a musty smell. Meanwhile, according to Fitantri et al. [57], κ-carrageenan is unscented, meaning that it has no aroma to contribute to the wet noodles. The addition of the pluchea tea extract decreased the panelists' preference for the aroma of the wet noodles because the addition of the extract caused the wet noodles to smell like leaves (floral), which was unpleasant and so the panelists did not like it. Fragrant or unpleasant aromas come from volatile compounds contained in the pluchea leaves. According to Widyawati et al. [58], pluchea leaves have 66 volatile compounds, and these volatile compounds play a role in forming the aroma in the hot water extract of the pluchea leaf tea. According to Lee et al. [59], pluchea leaves contain volatile compounds contributed to by aliphatic aldehyde group compounds, or aromatic compounds, that give a distinctive aroma, therefore the presence of these compounds in steeping water can give a specific aroma, i.e., fragrant (floral) in wet noodles. There was a difference in the effect of the proportion of the κ-carrageenan and pluchea leaf tea extract on taste due to the contribution of taste produced by the carrageenan and the extract. According to Ramdani et al. [56] and Haryu et al. [60], stink lily flour and κ-carrageenan do not have a distinctive or neutral taste, so increasing the concentration of κ-carrageenan gives a higher preference value because noodles are considered to have a better texture that contributes to the assessment of taste. The increase in the concentration of pluchea tea extract caused the taste preference value of the noodles to decrease significantly, which was due to the presence of tannins, catechins, and phenolic compounds in the pluchea tea extract, which were determined to be bitter and slightly astringent. The effect of the κ-carrageenan proportion and tea extract to make wet noodles influenced the panelist's preference of texture because this hydrocolloid can cause strong cross linking through inter-molecular and intra-molecular bonds involving the glutenin and gliadin of wheat flour protein and the glucomannan of stink lily flour, which determined the water bind capacity and water mobility [34,40,41]. The presence of the polyphenol compounds of the pluchea tea extract can cause a breakdown of the networking structure among the components of the dough because of water competition of them. Li et al. [13], Huang et al. [41] and Zhu [42] reported that the polyphenol compounds could react with starch and protein to disrupt the gluten network and cause starch to undergo an excessive gelatinization process. The difference in the proportion of the κ-carrageenan changes the overall preference value of wet noodles to be significantly different overall compared to the control, because the proportion of the κ-carrageenan influenced the all-sensory attribute (color, aroma, and taste). The addition of the pluchea tea extract in the wet noodles decreased the overall preference value because the addition of the extract affected the organoleptic characters tested due to the content of secondary metabolites of the pluchea leaves, such as flavonoids, phenols, and tannins that could affect the taste, aroma, color, and texture of the noodles. The spider web graph showed that K2L0 was the best treatment of the stink lily wet noodles. This was also supported by it containing better physicochemical properties than the control, including yellowish–white wet noodles, better swelling index, lower cooking loss, higher tensile strength value, and lower moisture content. However, this K2L0 treatment did not have the highest TPC, TFC, and AOA, i.e., 0.500 ± 0.045; 0.089 ± 0.008; and 0.532 ± 0.005, respectively.

5. Conclusions

The use of κ-carrageenan proportions and pluchea leaf tea extract have a significant effect on the cooking quality and sensory properties of stink lily wet noodles. Statistical analysis at $p < 5\%$ showed that there was an interaction effect of the proportion of the κ-carrageenan and the pluchea leaf tea extract on the swelling index, yellowness, chroma, hue, TPC, TFC, DPPH, the preference value for color, aroma, and overall acceptance.

While the moisture content of the wet noodles was only affected by the proportion of κ-carrageenan, the tensile strength, cooking loss, lightness, redness, and the preference value for texture and taste were influenced by the proportions of κ-carrageenan and the concentration of the pluchea leaf tea extract, respectively. The spider web graph showed that the K0L2 treatment had the largest area at 79.16 cm^2 and a preference score of 15.8 (which can be assigned to the very like category), suggesting that this is the best treatment; this is in accordance with the results of the physicochemical and sensory tests, but it did not correlate with the highest bioactive content (TPC and TFC) and DPPH.

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Sample Availability: Samples of stink lily wet noodles and pluchea leaf tea are available from the authors.

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Kind regards,
Yuxin Zhou
MDPI Billing Team

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收件人: "yuxin zhou" <yuxin.zhou@mdpi.com>
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Article Title:	"The Effect of k-Carrageenan Proportion and Hot Water Extract of Pluchea Indica Less Leaf Tea to Quality and Sensory Properties of Stink Lily (Amorphophallus Muelleri) Wet Noodles"
Name of co-authors:	Paini Sri Widyawati, Thomas Indarto Putut Suseno, Theresia Endang Widoeri Widyastuti, Anna Ingani Widjajaseputra, Vincentia Wilhelmina Moeljadi and Sherina Tandiono Additional Author Information
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Article Processing Charges	CHF	2 300.00
Author Voucher discount code (29ad06afbf065051)	CHF	(300.00)
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