

Effect of Soaking and Boiling Time on the Functional Properties of Jack Bean Flour

ABSTRACT

Jack bean is a type of legume that is widely cultivated in Indonesia, but its use is still limited. The levels of protein and carbohydrates contained in the bean have the potential to be developed, so it is necessary to know its functional properties. The bean has a hard texture; therefore, it needs to be pre-treated by soaking and boiling. Soaking causes the structure of the bean to become soft due to the imbibition of water into the cells. Boiling causes starch gelatinization and protein hydrolysis. This study aimed to determine the profile of the functional properties of jack bean flour with variations in soaking and boiling time. The soaking times studied were 6, 12, and 24 h and the boiling times studied were 5, 10, and 15 min. Each treatment level was replicated three times. Data obtained were calculated the mean and standard deviation to determine and analyze jack bean flour functional properties profile. The results showed that soaking and boiling time increased moisture content, water absorption, oil absorption, emulsion stability, and foam stability, while protein solubility, emulsion capacity, and foam capacity decreased. Emulsification properties showed as the potential functional properties for further utilization of the jack beans.

Keywords: boiling, functional properties, jack bean flour, soaking

INTRODUCTION

Legumes are a food commodity that is widely cultivated in Indonesia. One of the most utilized legumes is soybean. Soybeans are commonly utilized to make *tempe*, tofu, *kecap*, and *oncom*. Domestic demand for soybeans is very high, reaching 2.2 million tons per year, so imports are necessary (Kementrian Pertanian, 2021). The level of soybean production in Indonesia itself has actually decreased, namely from 963,183 tons in 2015 to 424,189 tons in 2019 (Triyanti, 2020). The number of soybean imports is also large and there was an increase in imports in 2020-2021 from 2.475 tons to 2.489 tons (Badan Pusat Statistik, 2021). This large number of imports can be overcome by utilizing alternative legumes which is jack bean (*Canavalia ensiformis* (L) DC).

Utilization of jack beans are still done traditionally either by boiling or frying to be made as snacks. Jack beans can be used as an alternative since it is easy to cultivate. It can grow on elevations up to 2000 masl (meters above sea level) with temperatures around 20-32°C in tropic areas and 14-27°C in rainfed areas and are able to grow in high rainfall areas and dry areas (Safira et al., 2019).

Jack beans can become an alternative since its nutritional components, especially protein, is not much different from soybeans.

According to Susanti et al. (2013), jack beans have 28.6% protein, while soybean protein is 34.9%. Jack beans also have a high carbohydrate content (60.1%) which is composed mostly of starch (Ekafitri & Isworo, 2014). The protein and carbohydrate content makes the jack bean a potential to be developed, so it is necessary to know its functional properties. Functional properties are researched to determine the utilization of jack bean that can give certain characteristics to food (Awwaly et al., 2015).

Utilization of jack beans in the form of flour eases its application in food and lengthens its shelf life (Liadi et al., 2019). Its application is easy since it has a larger surface so it can interact with the components in food. Components such as carbohydrate, protein, fat, and other components affect the functional properties. Functional properties are physicochemical properties of foods that describe complex interaction between structure, molecular conformation, composition, and physicochemical properties of food components. Functional properties include water and oil absorption capacity, emulsion activity, emulsion stability, foaming capacity, foaming stability, *gelling*, and others (Awuchi et al., 2019).

Jack beans have a hard texture, causing the protein and starch in it to be difficult to

extract and process further. This causes the need for preliminary treatment (soaking and boiling). Soaking makes jack bean easier to peel and speeds up cooking process because the availability of water inside helps speed up starch gelatinization and protein denaturation (Zamindar et al., 2013). Soaking may also cause a decrease in protein levels due to leaching of water-soluble proteins from the beans to the soaking medium (Widjajaseputra et al., 2019). Variations in soaking time that will be studied are 6 hours, 12 hours, and 24 hours.

Boiling is a wet heat processing method because ingredients are directly in contact with water (Augustyn et al., 2017). According to Gilang et al. (2013), boiling causes the structure of jack bean to become more porous, increasing its ability to absorb water. Boiling also causes starch gelatinization and protein hydrolysis which will affect the functional properties of jack bean flour. Variations in boiling time that will be studied are 5 minutes, 10 minutes, and 15 minutes. Soaking and boiling times are thought to interact to influence the functional properties of jack bean flour, so it is necessary to perform this research.

MATERIALS AND METHODS

Material

The materials used in this research were jack beans which came from a group of farmers in Temanggung, Central Java. Materials used in analysis in this research were hydrochloric acid (Honeywell), sodium hydroxide (Merck), Bovine Serum Albumin and coomassie brilliant blue (Applichem), phosphoric acid and absolute ethanol (Supelco EMSURE Merck), aquades, aquabides. dan CCO brand corn oil.

Sample preparation

Jack beans (100 g) were prepared then soaked using soaking water with a ratio of beans 1:5 and boiled with same ratio of beans. The beans were peeled and crushed using a dry mill with the pulse function for 7 seconds. The crushed beans were then placed on a baking sheet to be dried in an oven at 60°C for 6 h. Dried beans were then further crushed and sieved (80-mesh) to achieve a homogenous sample. Jack bean flour was packed in plastic and kept in a freezer prior analysis. Combination of soaking time (6, 12, and 24 h)

and boiling time (5, 10, and 15 min) were performed in this research.

Parameters and data analysis

Moisture content of jack bean flour was determined following the procedure of AOAC. (1995). Soluble protein content was determined according to Utami et al. (2016). Water and oil absorption capacity, emulsion capacity and stability, foam capacity and stability, and gelling ability was referred to Khattab and Arntfield (2009) with some modifications. The analysis was carried out 3 times replication. The data obtained was calculated as the average and standard deviation.

RESULTS AND DISCUSSION

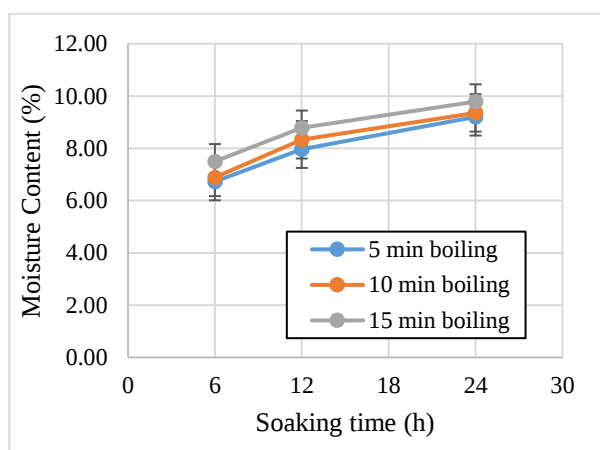
Moisture Content

The water content of jack bean flour increased with increasing soaking time and boiling time (Figure 1.). The highest water content was shown in the combination of 24 h soaking and 15 min boiling. According to Chigwedere et al. (2019), imbibition caused water to enter the intracellular matrix of the bean and other components diffused out. Longer boiling caused the proteins of the bean denatured, become exposed and caused polar groups on proteins to bind with more water (Aguilera et al., 2009). Starch also affected because it bound with water when gelatinization occurs during boiling (deMan et al., 2018). In the 15 min boiling treatment, the gelatinization level was higher so more water was trapped. When drying under the same conditions before flouring, the trapped water will evaporate and more water will remain in the flour, resulting in a higher water content.

Protein Solubility

Protein solubility testing is carried out to determine protein solubility in the pH range 2-12. Figure 2. showed that the protein solubility of jack bean flour decreased with increasing soaking time and boiling time. In the neutral pH range (pH 6-8), 6 h soaking treatment produces higher soluble protein levels than 12 and 24 h soaking.

Figure 4.1. Moisture content of jack bean flour with combination of soaking time (6, 12, 24 h) and boiling time (5, 10 15 min)



Boiling longer reduced the soluble protein content of jack bean flour (Figure 2.). Boiling caused the protein structure to open due to denaturation. According to Fennema (2017), opening the protein structure will increase the hydrophobicity of the protein surface. Longer boiling caused more denaturation of the protein structure and reduce solubility. Starch gelatinization also affects the level of protein solubility. As starch gelatinization during boiling, amylose was released during boiling. Sutedja et al. (2022) stated that amylose released from starch

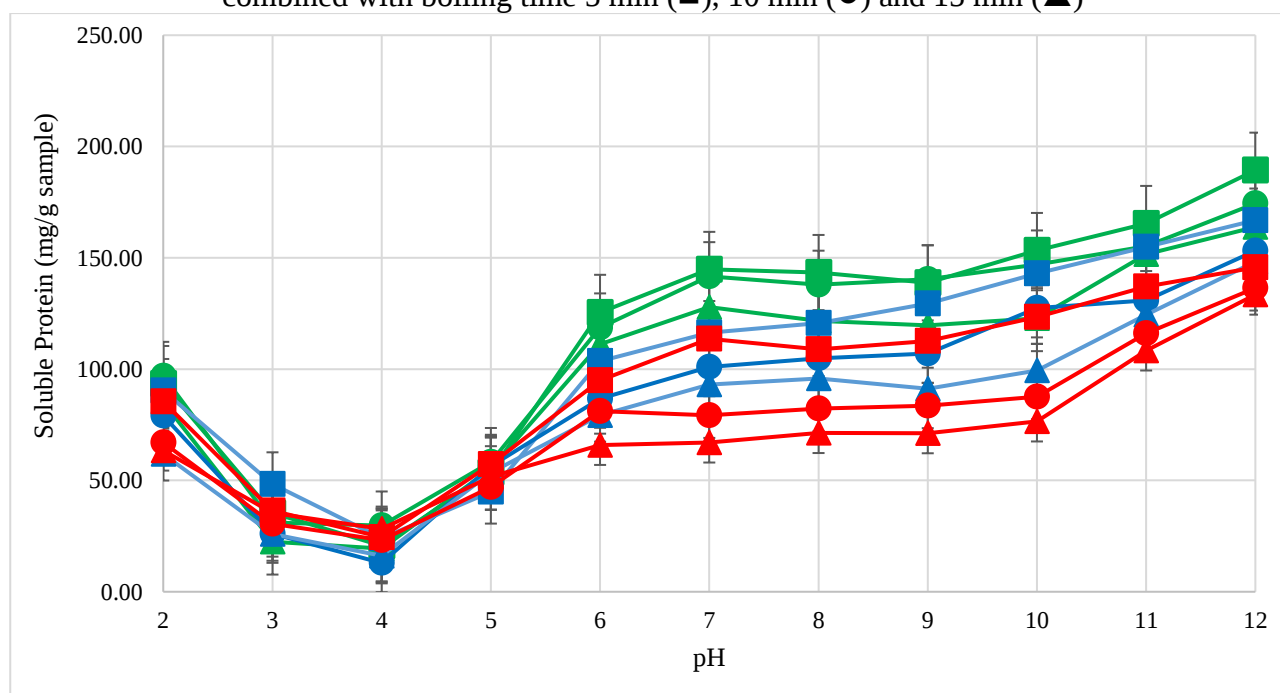
granules can bind to proteins to form a complex matrix, thereby inhibiting and reducing protein solubility.

The lowest protein solubility was found at pH 4 for all treatments. The jack bean protein fraction is dominated by globulin at 72.1% and albumin at 22.3% (Doss et al., 2011) b. According to Makeri et al. (2017) the albumin protein fraction has an isoelectric point at pH 4.0 and globulin at pH 3.5. The low solubility value at pH 4 was caused by slight electrostatic repulsion which supports precipitation (Fennema, 2017). The levels of amino acids contained in jack beans also affect the solubility of the protein.

Water Absorption Capacity (WAC)

Water absorption capacity is the ability of a material to absorb and retain water in the matrix for a certain time (Khattab & Arntfield, 2009). Starch, protein and water contained in food affect water absorption capacity (WAC). WAC of the 24 h soaking treatment was higher than those of 12 h and 6 h (Figure 3).

Figure 2. Soluble protein of jack bean flour with soaking time of 6h (—), 12h (—), and 24 h(—) combined with boiling time 5 min (■), 10 min (●) and 15 min (▲)



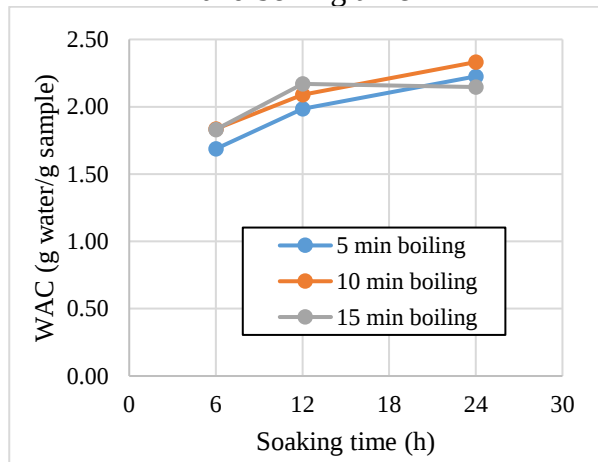
WAC in Figure 3 showed that the longer the soaking time, the more WAC increased. This is caused by leaching of water-soluble components, giving a space for water to be trapped in the matrix. Yulianti et al. (2022) also explained that soaking will stretch the bean matrix so that the bean enlarges. The

stretching of the matrix causes a large space available after the drying process for water to enter the bean matrix.

Boiling also affected the water absorption capacity of the sample. Boiling caused protein denaturation. Aguilera et al. (2009) stated that denaturation causes the

protein structure which was originally quaternary and tertiary to open and reveal peptide bonds and polar side groups therefore it can absorb more water. Heat treatment also caused the starch-protein complex structure to open and it can absorb and trapped water.

Figure 3. Water absorption capacity of jack bean flour with combination of soaking time and boiling time

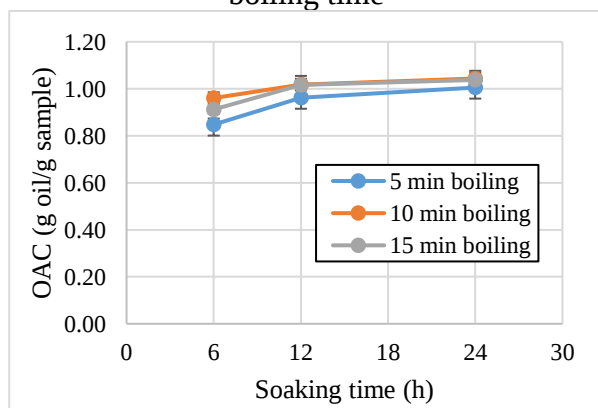


The higher the soaking and boiling time, the higher the WAC obtained, but Figure 3 showed a decrease in WAC in the 15 min boiling treatment to 24 h soaking. This was caused by soaking for 24 h which activated the amylase enzyme which has the potential to hydrolyze starch granules and the ability to absorb water decreased. Boiling for 15 min also supported hydrolysis which reduced the WAC of jack bean flour.

Oil Absorption Capacity (OAC)

Hydrophobic groups in proteins and the ability of starch to form starch-lipid complexes with oil influenced the absorption capacity of oil. The results of the oil absorption capacity of jack bean flour are shown in Figure 4.

Figure 4. Oil absorption capacity of jack bean flour with combination of soaking time and boiling time



The longer soaking caused the hydration of the jack bean and the matrix in the bean will become wider as indicated by the shape of the bean being larger. The expanded matrix provided space for the oil to bind with the starch and protein of the jack bean. According to Wang et al. (2020), starch, especially amylose, can bind with lipids to form an amylose-lipid inclusion complex where the lipids entered the gaps in the amylose matrix. In Figure 4, the OAC of flour at 10 and 15 min were in the same range. This was caused by boiling which caused damage to starch granules and protein coagulation which reduces the ability to absorb oil (Sutedja et al., 2022).

Emulsion Capacity and Stability

Emulsion capacity was a test to determine the volume of emulsion that can be formed from the emulsification of oil and water by a sample. The component that plays a role in the emulsion capacity of jack bean flour is protein. The emulsion capacity of jack bean flour is shown in Figure 5.

Figure 5 Relation between combination of soaking time and boiling time with jack bean flour emulsion capacity

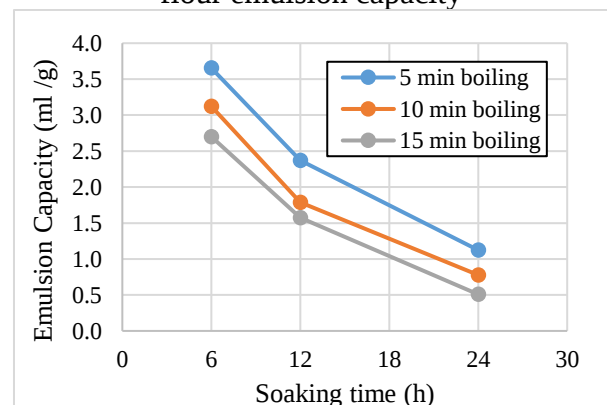


Figure 6. Emulsion stability of jack bean flour with soaking time of 6h (—), 12h (—), and 24 h(—) combined with boiling time 5 min(■), 10 min (●) and 15 min (▲)

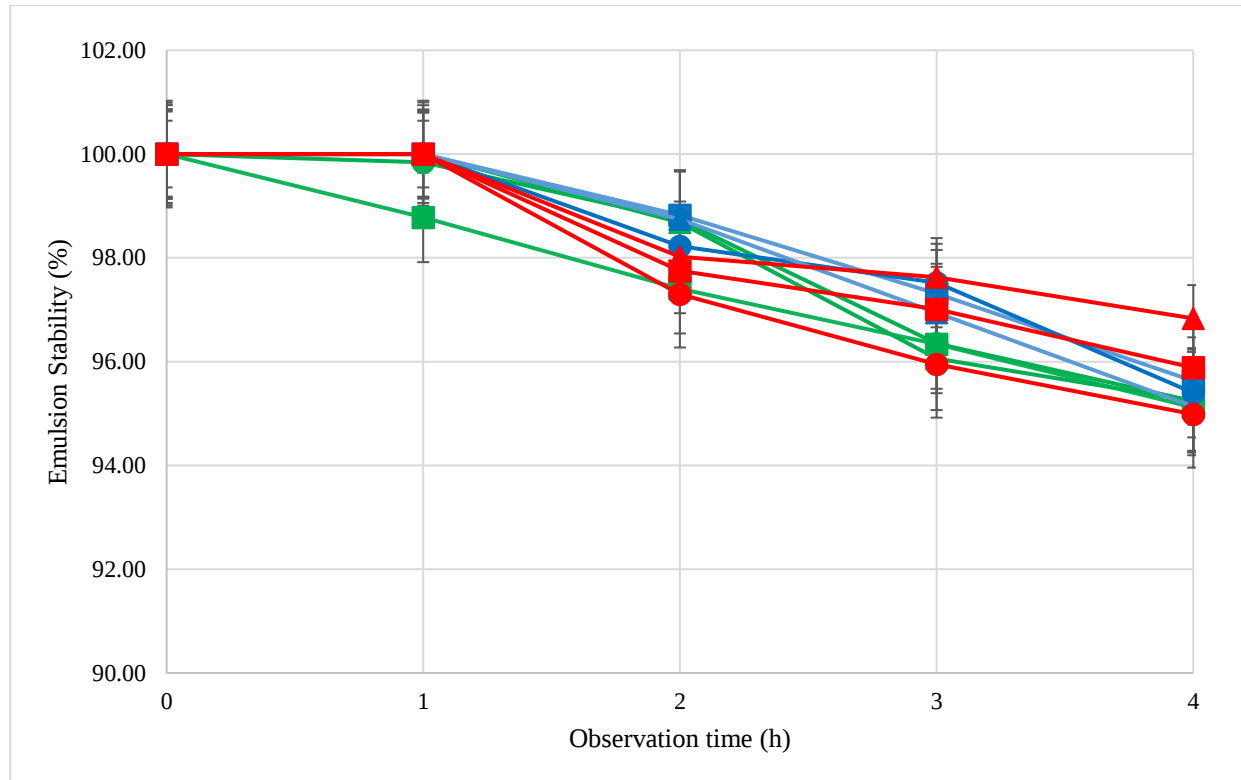


Figure 5 showed that the emulsion capacity decreased with increasing soaking time. This was caused by leaching of protein and other water-soluble components into the soaking medium during the soaking process. The decreased in soluble protein caused fewer hydrophobic and hydrophilic groups available to bind oil and water. It was also supported by protein solubility data in Figure 2, where the soluble protein decreased with increasing soaking time.

The emulsion capacity of all treatments decreased with increasing boiling time. Boiling caused protein denaturation in which the quaternary and tertiary structure of the protein opened. It caused the protein's polar and non-polar groups to be more exposed and can bind with the oil and water fractions. This caused hydrophobic amino acids to bind oil more easily at the interface area (Acevedo et al., 2017). Figure 5 showed that the longer the soaking and the longer the boiling, the emulsion capacity will decrease.

The most stable emulsion was shown by soaking for 12 hours and boiling for 5 minutes (Figure 6). In this treatment, denaturation has not occurred completely. According to Fennema (2017), partial denaturation can increase emulsion stability due to increased

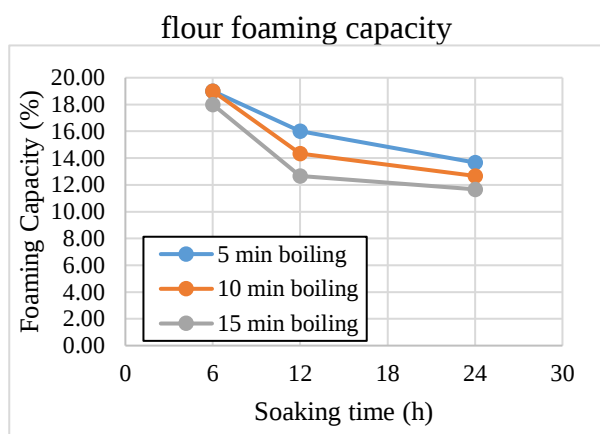
flexibility of protein molecules and hydrophobicity on the protein surface. In open conditions, proteins that have free sulfhydryl groups and disulfide groups underwent slow polymerization through disulfide-sulfhydryl reactions.

Soaking and boiling times both had an influence on the capacity and stability of the emulsion. The emulsion capacity decreased with increasing soaking and boiling time. Emulsion stability also decreased with increasing boiling and soaking time, but the highest stability was obtained from 12 hours of soaking and 5 minutes of boiling.

Foam Capacity and Stability

Figure 7. showed that the foaming capacity of sword bean flour decreased with increasing soaking and boiling time. Protein played a role in foam formation. According to Sutedja et al. (2022) polar groups of protein molecules bonded with water and non-polar groups bonded with air. Protein denaturation will open the quaternary and tertiary structure of the protein so that the non-polar groups are exposed.

Figure 7. Relation between combination of soaking time and boiling time with jack bean



The stability of foam was influenced by the ability of partially denatured proteins to form a viscoelastic interface layer that does not easily collapse (Trianto et al., 2013). The stability of the foam increased with increasing boiling time and the most stable foam was in the 12 h soaking and 15 min boiling treatment because in the first 10 min the foam did not collapse too much and was able to hold the foam volume for 30-60 min. This was caused by starch gelatinization which destroyed the starch granule structure.

Gelling Ability

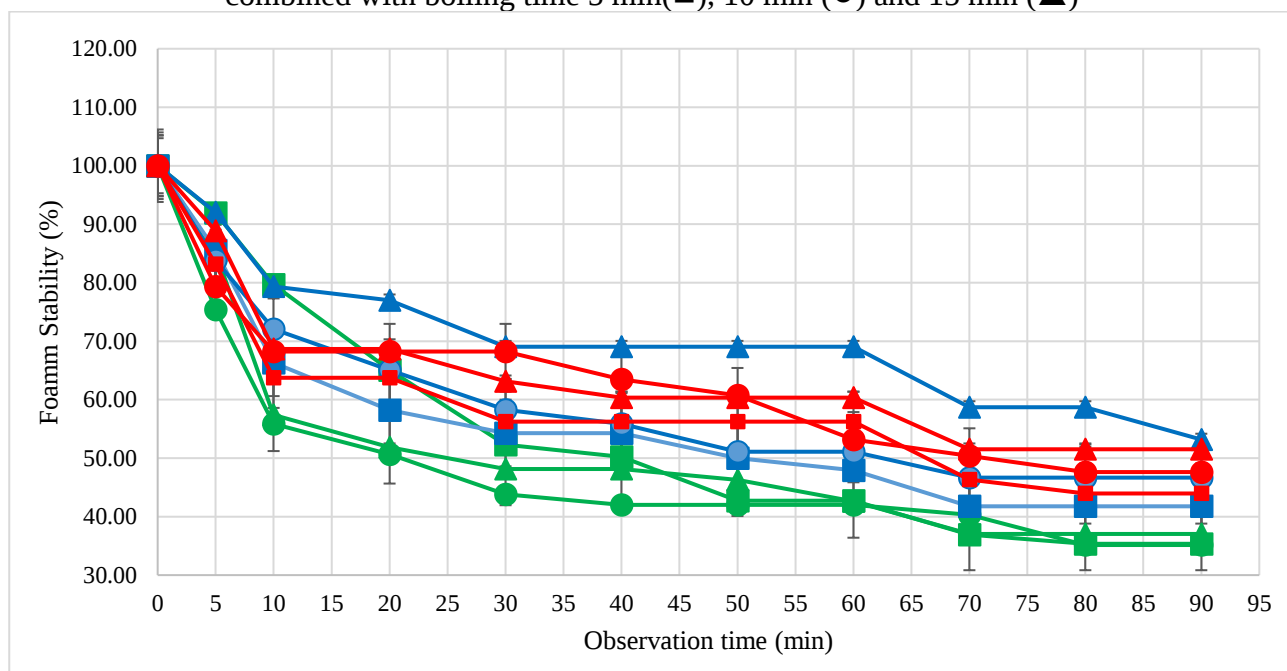
In the research conducted, jack bean flour could not form a gel. It was caused by the low 11S globulin protein fraction in the jack bean. Research by Subagio et al. (2008) found that the 7S/11S globulin ratio in jack beans was

3.57, indicating that the 7S globulin fraction was greater than the 11S globulin fraction. The smaller amount of the 11S globulin fraction indicated that there were fewer sulfhydryl groups needed to form disulfide bonds, resulting in the formation of a weak gel.

CONCLUSION

Soaking and boiling affects the functional properties of jack bean flour. Water content increased as soaking and boiling time increased. Protein solubility decreased as soaking and boiling time increased. Water absorption capacity and oil absorption capacity increased as soaking and boiling time increased. Emulsion and foam capacity decreased as soaking and boiling time increased, but emulsion stability increased and foam stability was getting stabler as soaking and boiling time increased. Gel was not formed in all soaking and boiling time treatment. The combination of soaking time and boiling time needs to be determined by adjusting the functional properties required for these beans. The potential functional characteristic of this jack beans is its emulsification properties. The combination of 24 h of soaking time and 15 min of boiling time provided good emulsion stability after 4 h of storage. This shows the potential functional properties for further utilization of the jack beans.

Figure 4.8. Foam stability of jack bean flour with soaking time of 6h (—), 12h(—), and 24 h(—) combined with boiling time 5 min(■), 10 min (●) and 15 min (▲)



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