Evaluation of Physicochemical, Functional and Pasting Properties of Soybean, Mung Bean and Red Kidney Bean Flour as Ingredient in Biscuit

L Ratnawati, D Desnilasari, D N Surahman and R Kumalasari
Development Centre for Appropriate Technology, Indonesian Institute of Sciences, Subang, Indonesia
Email : lia.romeo@gmail.com

Abstract. This present study was aimed to evaluate the physicochemical, functional and pasting properties of soybean, mung bean and red bean flour. The physicochemical (moisture, ash, protein, fat, carbohydrate, energy, starch, total dietary fiber and color), functional properties (swelling power, solubility, water holding capacity, oil holding capacity and bulk density) and pasting properties (peak viscosity, breakdown viscosity, setback viscosity, final viscosity and pasting temperature) of flours were evaluated. Soybean flour had highest values of fat, ash, protein content, solubility, and oil holding capacity while the lowest value for starch, carbohydrate, swelling power and peak, breakdown, final and setback viscosity. Mung bean flour had highest values of swelling power and peak viscosity, while the lowest value for ash content, solubility, water holding capacity, and total dietary fiber. Red bean flour had the highest starch, carbohydrate, water holding capacity, total dietary fiber, breakdown and setback viscosity, while the lowest value for ash, fat and protein content. From the three types of legumes were analyzed in this study, mung bean flour can be the best choice for wheat flour substitution as ingredient biscuit because it has high swelling power and peak viscosity, and low setback, breakdown viscosity and pasting temperature.

Keywords: physicochemical properties, functional properties, pasting properties, soybean flour, mung bean flour, red kidney bean flour

1. Introduction
Legumes are edible seeds and belong to the family Leguminosae and widely cultivated in tropical and subtropical countries such as Indonesia. Legumes seeds are prime importance in human and animal nutrition, due to their high protein content (20-50 %) [1]. Some types of legumes that are widely grown in Indonesia include soybean, mung bean and red bean. Production of soybean, mung bean and red bean in Indonesia includes 538,253 tons in 2017 [2], 271,463 tons in 2015 [3] and 100,316 tons in 2014 [4].

Processing legume into flour is a simple food processing and can be used as a raw material for biscuits. Biscuits are one of the dried food products that are made by baking dough made from flour or its base ingredients, oil or fat with or without the addition of other permitted foods. The minimum protein content of the required biscuits is 5%. One alternative of vegetable ingredients to replace or substitute flour is legume flour because of its relatively high protein content. Before being used as an ingredient in making biscuits, it is important to know the physicochemical, functional and pasting properties of each type of legume flour.
Functional properties are fundamental physicochemical properties that reflect the complex interactions between composition, structure, molecular conformation and physicochemical properties of the components together with the associated environment. Functional characteristics are needed to evaluate and predict how protein, fiber, fat, and carbohydrates play a role in the food system [5]. Several functional properties of food, especially flour may include swelling power, solubility, water or oil absorption capacity and bulk density.

In addition to physicochemical and functional properties, the pasting properties are also important to learn. Testing of pasting properties serves to determine the sensory characteristics of a better product and determine the use in various foods. Pasting property can also be exchanged for anything that might be expected during food processing. Several previous studies related to physicochemical and functional properties of legume flour tests have been conducted by Du et al. [7]. However, previous studies did not discuss the characteristics of soybean flour, and the application of legume flours on the food product. This study aimed to evaluate the physicochemical, functional and pasting properties of soybean, mung bean, and red kidney bean flour as an ingredient in a biscuit.

2. Materials and Methods

2.1. Raw materials

The soybean (Glycine max), mung bean (Vigna radiata L.) and red kidney bean (Phaseolus vulgaris L.) were obtained from a local market in Subang and Lembang, West Java.

2.2. Flour preparation

Soybean, mung bean and red kidney bean were washed and soaked using water at 60-70°C for 3 h. After that, the legumes were dehulled and dried at 50°C, 12 h. Then, the samples were reduced particle size using disk mill and sieved using a 40 mesh sieve. Samples were kept into sealed plastic and stored until further use at 4°C.

2.3. Flour analysis

2.3.1. Physicochemical properties.

Physicochemical analysis of legumes flour was evaluated such as proximate, energy, starch, amylose, amylopectin, protein digestibility, total dietary fiber, phytic acid, and color analysis. Proximate analysis was evaluated following Indonesian National Standard [8] procedures and included the following: moisture content, ash content, crude fat by Soxhlet extraction.

Protein content was analyzed using DuMaster protein analyzer (DuMaster D-480, Buchi, Switzerland). Total carbohydrate was calculated from the difference (100-(% moisture + % ash + % protein + % fat)). Total dietary fiber content of flour was performed using a combination of enzymatic and gravimetric method [9]. TDF was calculated by equation (1):

$$ TDF (%) = \left( \frac{\text{weight residue} - \text{weight protein} - \text{weight ash}}{\text{weight sample}} \right) \times 100 $$

The color of flours was measured using colorimeter (NH310, China). Each sample was measured three replicates. The result determined were L* value indicates the lightness, 0-100 representing dark to light, a* value indicates the degree of redness to greenness and b* value indicates the degree yellowness to blueness.

2.3.2. Functional properties.

Functional properties of legumes flour were analyzed such as swelling power, solubility, water absorption capacity, oil absorption capacity and bulk density. Swelling power and solubility were determined by following the method described by Pranoto et al. [10] with slight modification. A sample (0.2 g) was put in a pre-weighed centrifuge tube, added with 10 mL distilled water and mixed using vortex. The sample was allowed to stand at room temperature (20-25°C) for 5 min and then put in a water bath at 95°C for 30 min. After that, it was cooled at 20-25°C for 10 min. The sample was centrifuged at 3000 rpm for 15 min to separate gel and supernatant. The gel after separating from supernatant was expressed as swelling power. While the supernatant is placed on a
plate that has been known to weigh and then dried in an oven to a constant weight. Swelling power (2) and solubility (3) were calculated by using following equation:

\[ Swelling \text{ power (g/g)} = \frac{W_2 - W_1}{W_0} \quad (2) \]

Where \( W_0 \) = weight of the dry sample (g), \( W_1 \) = weight of the dry sample + centrifuge tube (g), \( W_2 \) = weight of gel + centrifuge tube (g)

\[ Solubility \text{ (%) } = \frac{W_2}{W_1} \times 100\% \quad (3) \]

Where \( W_1 \) = weight of the dry sample (g) and \( W_2 \) = dry weight of supernatant (g)

Water absorption capacity (WAC) and oil absorption capacity (OAC) were determined by following the method described by Brishti et al. [11] with slight modification. The 0.25 g of flour was mixed with 5 mL distilled water or oil in pre-weighed centrifuge tube for 30 secs using a vortex. Then, sample was allowed to stand at room temperature (20-25°C) for 15 min and centrifuged at 3000 rpm for 15 min. After centrifugation, the supernatant was decanted, and the centrifuge tubes + precipitate were re-weighed. The WAC and OAC were expressed as grams of water/oil absorbed per gram of the sample. The WAC and OAC were calculated by using following equation (4):

\[ WAC \text{ or OAC (g/g)} = \frac{W_2}{W_1} \quad (4) \]

Where \( W_1 \) = weight of the dry sample (g) and \( W_2 \) = weight of precipitate + centrifuge tube (g)

Bulk density of flour was determined using the procedure of Butt and Batool [12], 10 g of samples were put into a 100 ml measuring cylinder and tapped to a constant volume and the bulk density (g/cm³) calculated using the formula: Bulk density = weight of flour (g) / flour volume (cm³).

2.3.3. Pasting properties. Pasting properties of flours were analyzed using Rapid Visco Analyzer (RVA-TecMaster, Macquarie Park, Australia). A suspension of 3.5 g (14% wb) of flour in 25 g distilled water was stirred at 50°C (160 rpm) for 1 min, heated from 50 to 95°C for 7.5 min, held at 95°C for 5 min, cooled from 95 to 50°C for 7.5 min and held at 50°C for 2 min. The following data were recorded: peak viscosity, setback viscosity, breakdown viscosity, final viscosity and pasting temperature.

2.4. Statistical Analysis

The data reported in all of the tables are the averages of triplicate analysis. Significant differences for multiple comparisons were determined by one-way analysis of variance (ANOVA) followed by Duncan test by SPSS statistical package.

3. Result and Discussion

3.1. Physicochemical properties

The physicochemical properties of soybean, mung bean and red kidney bean flour are shown in Table 1.

The highest of moisture content was observed for red kidney bean flour (7.60 %) and the lowest for soybean flour (4.66 %). Whereas the difference between red kidney bean flour and other samples i.e. soybean and mung bean flour was significant (p<0.05) and between soybean and mung bean flour was not significant. The previous studies were reported that moisture content of mung bean, red kidney bean, and soybean flour are 8.30, 7.16 and 5.4 %, respectively [12; 13; 14].

The ash content of red kidney bean, mung bean, and soybean flour are 2.70, 2.70 and 4.23 %, respectively. There was significant difference (p<0.05) between soybean flour with mung bean and red kidney bean flour, but no significant difference between mung bean and red kidney bean flour. The mung bean flour in this study has ash content (2.70 %) similarly with the study was conducted by
Brishti et al. [11] that is 3.02%. While, the raw and boiled red kidney bean flour have ash content, i.e. 4.4 and 2.2% [6]. The result of this study slightly different from the previous study was reported that the ash content of soybean flour is 3.60% [15]. Ash content can indicate the mineral content in food.

Table 1. Physicochemical properties of soybean, mung bean and red kidney bean flour

| Physicochemical Properties | Types of flours |
|----------------------------|-----------------|
|                            | Soybean flour   | Mung bean flour | Red kidney bean flour |
| Moisture, % wb             | 4.66<sup>a</sup> | 5.63<sup>a</sup> | 7.60<sup>b</sup> |
| Ash, % wb                  | 4.23<sup>b</sup> | 2.70<sup>a</sup> | 2.70<sup>a</sup> |
| Fat, % wb                  | 25.01           | 1.31            | 1.11              |
| Protein, % wb              | 40.94<sup>b</sup> | 24.99<sup>a</sup> | 22.53<sup>a</sup> |
| Carbohydrate, %wb          | 25.32<sup>a</sup> | 65.41<sup>b</sup> | 66.50<sup>b</sup> |
| Energy, Kcal/100 g         | 488.77<sup>a</sup> | 373.01<sup>b</sup> | 365.88<sup>c</sup> |
| Starch, % wb               | 8.66<sup>a</sup> | 55.18<sup>b</sup> | 55.46<sup>b</sup> |
| Amylose, % wb              | 1.79<sup>a</sup> | 23.45<sup>c</sup> | 20.14<sup>b</sup> |
| Amylopectin, % wb          | 6.87<sup>a</sup> | 31.74<sup>b</sup> | 35.33<sup>c</sup> |
| Protein Digestibility, %   | 80.54<sup>c</sup> | 33.63<sup>a</sup> | 39.59<sup>b</sup> |
| Total Dietary Fiber, % wb  | 9.89<sup>b</sup> | 6.57<sup>a</sup> | 23.80<sup>f</sup> |
| Phytic Acid, % db          | 2.92<sup>b</sup> | 1.79<sup>a</sup> | 1.58<sup>a</sup> |
| Color                      |                |                 |                   |
| L (Lightness)              | 79.07<sup>a</sup> | 83.37<sup>ab</sup> | 86.74<sup>b</sup> |
| a (Redness)                | 2.60<sup>b</sup> | 0.86<sup>a</sup> | 1.31<sup>a</sup> |
| b (Yellowness)             | 19.61<sup>c</sup> | 13.51<sup>b</sup> | 6.79<sup>a</sup> |

Different superscript alphabets indicate significant differences among treatments (p<0.05).

The fat content of legume flours ranged from 1.11-25.01%. The soybean flour has highest fat content (25.01%) when compared with other samples like mung bean (1.31%) and red kidney bean (1.11%). The fat content of mung bean (1.31%) in the present study similarly with the previous study was conducted by Butt and Batool [12] and Brishti et al. [11], reported that the fat content of mung bean is 1.24 and 1.53%. According to Jahreis et al. [15] and Alamu et al. [14], soya flour had the fat content are 22.8 % and 17.56 %, lower than this study. While, based on previous study conducted by Pangastuti et al. [13], stated that the fat content of red bean flour is 8.13% higher than this study. The results for protein content of legumes flour were evaluated higher amount (40.94 %) in soybean followed by mung bean (24.99 %) and red kidney bean (22.53 %). There was significant difference (p<0.05) between soybean flour with mung bean and red kidney bean flour, but no significant difference between mung bean and red kidney bean flour. Previously, Butt and Batool [12], reported that mung bean flour has 25.90 % protein. While, Audu and Aremu [6] reported that raw and boiled kidney bean flour has protein content, 15.3 and 23.6 %. The protein content of soybean flour in this study (40.94 %) is known to be higher than the previous studies (35.60 and 33.53 %) [15; 14]. The three types of legume flour in this study belong to foods that contain high protein. So that all three can be used as ingredients in a biscuit. Legume flour can be an alternative ingredient for making high protein in order to overcome protein deficiency.

Red kidney bean flour had the highest carbohydrate content (66.50%) than soybean (25.32%) and mung bean flour (65.41 %). The difference between soybean flour and other samples i.e. mung bean and red kidney bean flour were significant (p<0.05). The previous study conducted by Dzudie and Hardy [16] reported that the carbohydrate of mung bean flour is 67.1%. Based on previous study conducted by Pangastuti et al. [13] and Audu-Aremu [6], the carbohydrate content of red bean flour was 58.48% and 49%.
The energy value of legumes flour ranged from 365.88-488.77 kcal/100 g. The highest calorie value is soy flour (488.77 kcal/100 g), and the lowest is red beans (365.88 kcal/100 g). There were significant differences (p<0.05) between all samples of legume flour. According to Adelakun et al. [17] reported that soybean flour had the energy value 446 kcal/100 g. The difference in chemical composition in this study with the previous studies can be influenced by genetic, variety and growth environment (geographical location and growing session) [18].

Red kidney bean flour contained the highest amount of starch (55.46%), and lowest was found in soybean (8.66%). There was significant difference (p<0.05) between the starch content of soybean flour with mung bean and red kidney bean flour. Starch content of soybean flour based on previous study higher than present study, i.e. 14.85 % [14]. Starch in flours consists of amylose and amylopectin. Amylose and amylopectin ratios affect the pasting properties of flour or starch. Amylose content of legumes flour was ranged between 1.79-23.45%. The results showed that there were significant differences (p<0.05) in the amylose content between soybean, mung bean and red kidney bean flour. Amylopectin content was significantly different (p<0.05) among the legume flours and the ranged between 6.87-35.33%.

The protein digestibility of the legume flours significantly differed (p<0.05) from each other and ranged between 33.36-80.54% with soybean flour having the highest protein digestibility (80.54%) and mung bean flour having the lowest.

The values for total dietary fiber of red kidney bean, soybean, and mungbean flour were 23.80, 9.89 and 6.57 %, respectively. The differences between soybean and mung bean flour were not significant (p>0.05). However, there were significant differences between red kidney bean flour and other samples. High levels of dietary fiber in food can be useful in providing bulk to foods to relieve constipation as well as maintaining digestive tract health.

Phytic acid of legume flours was ranged between 1.58 until 2.78% with the highest phytic acid content is soybean flour, and the lowest is red kidney bean flour. Phytic acid content of red bean flour in the study conducted by Pangastuti et al. [13] was 1.75%.

The color value of soybean, mungbean and red kidney bean flour are shown in Table 1. The L* value of legume flours was ranged between 79.07-86.74. The difference between soybean and red kidney bean flour was significant (p<0.05). Among the legume flours studied, mungbean showed a higher L* parameter (83.37), indicating its lighter color than soybean (79.07) and red kidney bean (86.74). The* value of mung bean, red kidney bean, and soybean flour were 0.86, 1.31 and 2.60, respectively. The results showed that there were significant differences (p<0.05) in the* value between soybean and other samples, i.e., mung bean and red kidney bean flour. The* parameter of mungbean was lowest (0.86) than other samples, indicates that the presence of a slight green color in it. Red kidney bean in this study has a* value 1.31 and b* value 6.79. Based on the study was conducted by Pangastuti et al. [13], stated that the L*, a* and b* values of the red kidney bean flour are 87.42, 1.62 and 7.27, respectively. The b* value of legume flours was ranged between 6.79-19.61 and significant differences (p<0.05) value between legume flours.

### 3.2. Functional properties

The functional properties of three types of bean flour were evaluated. There is such as swelling power, solubility, water absorption capacity, oil absorption capacity, foam stability, and foam capacity. The result of analysis is shown in Table 2.

The swelling power of the samples ranged between 4.82-10.52 g/g. The results showed that there were significant differences (p<0.05) in the swelling power between soybean and mung bean flour as well as between soybean and red kidney bean flour. The results of this study indicate that the highest swelling power is mung bean flour (10.52 g/g) with the highest amylose content of 23.45%. While the lowest swelling power is soybean flour (4.82 g/g) with amylose content of only 1.79%. This shows that there is a positive correlation between swelling power and amylose content. Singh [19] states that the ability to swell power is influenced by amylose content. The higher the amylose content of a material indicates that there are more hydrophilic groups so that more water is bound and swelling.
power increases. In addition to amylose content, swelling power is also influenced by the size of starch granules. High swelling power can indicate that an ingredient can be applied to improve the characteristics of baked products.

### Table 2. Functional properties of soybean, mung bean and red bean flour

| Functional properties          | Soybean flour | Mung bean flour | Red bean flour |
|-------------------------------|--------------|----------------|---------------|
| Swelling Power, g/g           | 4.82<sup>a</sup> | 10.52<sup>b</sup> | 10.09<sup>b</sup> |
| Solubility, %                 | 34.49<sup>b</sup> | 18.80<sup>a</sup> | 24.21<sup>a</sup> |
| Water Absorption Capacity, g/g | 4.07<sup>a</sup>   | 3.18<sup>b</sup>   | 4.39<sup>a</sup>   |
| Oil Absorption Capacity, g/g  | 3.60<sup>b</sup>   | 3.03<sup>a</sup>   | 3.40<sup>ab</sup>  |
| Bulk Density, g/cm<sup>3</sup>| 0.51<sup>a</sup>   | 1.08<sup>b</sup>   | 0.53<sup>a</sup>   |

Different superscript alphabets indicate significant differences among treatments (p<0.05)

Solubility of the samples are within the range 18.80-34.49%, with the highest solubility value is soybean flour (34.49%), and the lowest solubility value is mung bean flour (18.80%). The results showed that there were significant differences (p<0.05) in the solubility between soybean with mung bean and red kidney bean flour. The solubility which related to the presence of soluble molecules [18]. The solubility value of red kidney bean flour in the previous study was 29.97% [13].

Water absorption capacity (WAC) or oil absorption capacity (OAC) is defined as the absorbed amount of water or fat per gram of flour. One of the factors affecting WAC and OAC values is protein content of foodstuffs [12]. Protein has both hydrophilic and hydrophobic properties to interact with water and oil in foods. WAC indicates the hydrophilic capacity of the protein while the OAC can indicate the hydrophobic capacity of the protein. WAC and OAC were used to indicate protein ability in the food material to prevent fluid loss from a product during food storage or processing [20].

The WAC for soybean, mung bean, and red bean are 4.07, 3.18 and 4.39 g/g, respectively. The WAC was significantly different (p<0.05) between mung bean flour and other samples, i.e., soybean and red kidney bean flour. WAC value of red bean flour is the highest of the others although the protein content is not as high as soybeans. In addition to being influenced by protein content, WAC is also influenced by carbohydrate content [21]. This also includes the level of dietary fiber in ingredients because dietary fiber has the ability to absorb water. The intrinsic factors that affect water-binding properties of food flours with relatively high protein content relate to amino acid composition, protein conformation and surface polarity [22]. The high-water absorption capacity of flour makes it desirable for use in bakery products [23].

The OAC of samples were ranged from 3.03-3.60 g/g. The OAC of the soybean and mung bean flour was significantly different (p<0.05). The ability of flour to absorb and retain water or oil can improve texture and mouthfeel, flavor enhancer and reduce moisture and fat loss of food products like comminuted meats, extenders or analogs and baked dough [24; 25].

Bulk density is the physical properties of materials in dry mixes and is an important parameter in determining product packaging requirements [26]. In this present study, bulk densities for soybean, mung bean, and red bean are 0.51, 1.08 and 0.53 g/cm<sup>3</sup>, respectively. The results showed that there were significant differences (p<0.05) in the bulk density between mung bean with soybean and red kidney bean flour. Mung bean flour had the highest bulk density than other flours. It indicates that mung bean flour heavier than soybean and red bean flour. The advantage of flour that has high bulk density is that it does not take up too much space when distributing and decreases packaging costs. It can reduce the need for space per unit weight and packaging costs when compared to soybeans and red bean flour. The high flour density indicates that they can function as a good thickener in food products as well as their suitability for use in processed foods. While soybean flour had the lowest bulk density than other samples. The lower bulk densities of soybean flour indication that it is lighter than others.
On the other hand, low bulk density would be an advantage in the formulation of complementary foods [23]. The result of this study similar with previous study was conducted by Pangastuti et al. [13], reported that the bulk density of red kidney bean flour is 0.41 g/cm³.

3.3. Pasting properties

The pasting properties of soybean, mung bean and red bean flour are shown in Table 3. Pasting properties were evaluated such as peak viscosity, breakdown viscosity, final viscosity, setback viscosity and pasting temperature.

| Pasting Properties          | Soybean flour | Mung bean flour | Red kidney bean flour |
|-----------------------------|---------------|-----------------|----------------------|
| Peak Viscosity, cP          | 19.17         | 909.00          | 827.67               |
| Breakdown Viscosity, cP     | 5.33          | 40.00           | 85.00                |
| Final Viscosity, cP         | 32.83         | 1387.67         | 1606.33              |
| Setback Viscosity, cP       | 19.17         | 518.67          | 863.67               |
| Pasting Temperature, °C     | ND            | 77.85           | 81.73                |

Different superscript alphabets indicate significant differences among treatments (p<0.05)

The peak viscosity of mung bean (909 cP) and red bean flour (827.67 cP) was higher than soybean flour (19.17 cP). The results showed that there were significant differences (p<0.05) in the peak viscosity between soybean with mung bean and red kidney bean flour. The peak viscosity of soybean flour is the lowest due to lower starch and amylose content and higher protein content of mung bean and red kidney bean. Protein content in legume flours can inhibit starch granule swelling and reduce viscosity [27]. In addition to proteins that affect starch viscosity, the fat content in flour also affects viscosity. Soybean flour has the highest fat content, so the peak viscosity is low. High-fat content will inhibit the interaction of starch molecules, limiting the swelling of starch molecules so that it affects the viscosity of starch [7].

The breakdown viscosity of the red kidney bean flour significantly differed (p<0.05) from soybean and mung bean flour. The breakdown viscosity of legume flours ranged between 5.33 to 85 cP. The higher the breakdown viscosity, the lower of starch ability to heating and shear stress during cooking [25].

The red kidney bean flour showed higher final viscosity, setback viscosity and pasting temperature, 1606.33 cP, 863.67 cP, and 81.73 °C, respectively. While, the soybean flour was lowest final viscosity and setback viscosity, 32.83 cP and 19.17 cP, respectively. The final viscosity also called cold past viscosity is used to define a particular quality of starch and also indicates the stability of cooked starch paste in actual use. The increased final viscosity for samples could be attributed to aggregation of the amylose molecules on cooling [18].

Setback viscosity is the viscosity that occurs due to a decrease in temperature so that the starch molecules retrograde or reconnect. Setback viscosity correlates with the texture of various products. High setback viscosity causes the product to experience syneresis during freezing/thawing cycles. Setback viscosity of red kidney bean flour shows the highest (863.67 cP) from the other samples.

Pasting temperature is the temperature required by starch granules to begin to swell. Pasting temperature for soybean, mung bean, and red bean is not detected (ND), 77.85 and 81.73 °C, respectively. Pasting temperature of soybean not detected (ND) when analyzed using RVA. It may be related to its lower starch content, and the amylose content in soybean starch is only 1.79 %. When analyzed using RVA, soy flour does not undergo a gelatinization process which is characterized by the mixture remaining dilute. While the red kidney bean has higher pasting temperature (81.73°C), it may be related to its higher starch content (55.46%) and amylose content (20.14%). From the results of a study by Hamid et al. [27], stated that higher amylose content in red cowpea than black pea which
caused lower pasting temperature of red cowpea. The pasting temperature values of red kidney bean and mung bean flour were 77.9 and 73.2 °C, respectively. The pasting temperature value in this study is higher than the previous study. This is likely due to differences in varieties, flour processing methods, equipment and also analysis methods. Low pasting temperature indicates that minimum temperature is needed to cook an ingredient so that it will reduce the energy cost to prepare a product.  

From the results of pasting properties analysis of legume flour, it is known that starch legume is a type C starch, namely starch which has a peak viscosity value that is not so well detected. Starch type C showed limited granular inflating and was relatively constant during cooking. Type C starch is suitable to be applied as raw material for making cookies, biscuits, cakes and other bakery products. Pasting profile of flour or starch influenced by kind of starch, granule size, concentration, amylose/amylopectin ratio, other endogenous materials (particularly lipids and phosphors), added ingredients (salts, sugar, pH modifier etc.) and physical history after pasting (time, temperature and shear stress/shear rate) [28].

4. Conclusion
Soybean flour had highest values of fat, ash, protein content, solubility, and oil holding capacity while the lowest value for starch, carbohydrate, swelling power and peak, breakdown, final and setback viscosity. Mung bean flour had highest values of swelling power and peak viscosity, while the lowest value for ash content, solubility, water holding capacity, and total dietary fiber. Red kidney bean flour had the highest starch, carbohydrate, water holding capacity, total dietary fiber, breakdown and setback viscosity, while the lowest value for ash, fat and protein content. From the three types of legumes were analyzed in this study, mung bean flour can be the best choice for wheat flour substitution as ingredient biscuit because it has high swelling power and peak viscosity, and low setback, breakdown viscosity and pasting temperature.

5. Acknowledgment
The authors are grateful for funding through INSINAS 2018 from Ministry of Research, Technology, and Higher Education and Development Centre for Appropriate Technology for providing the experimental facilities.

6. References
[1] Singh N, Sandhu K S and Kaur M 2004 Characterization of starches from Indian Chickpea (Cicer arietinum L.) Cultivars Journal of Food Engineering 63 4 441-449
[2] Yuniartha L, Kartini D 2018 Produksi kedelai nasional per Februari capai 148.918 ton. https://industri.kontan.co.id/news/produksi-kedelai-nasional-per-februari-capai-148918-ton [27 Agustus 2018]
[3] Indonesian Statistics Agency 2015 https://www.bps.go.id/site/resultTab
[4] Badan Pusat Statistik and Direktorat Jenderal Hortikultura 2015 Produksi, luas panen, dan produktivitas sayuran di Indonesia, Jakarta
[5] Siddiq M, Nasir M, Ravi R, Dolan K D and Butt M S 2009 Effect of defatted maize germ addition on the functional and textural properties of wheat flour Int. J. Food Prop. 12 860-870
[6] Audu S S and Aremu M O 2011 Effect of processing on chemical composition of red kidney bean (Phaseolus vulgaris L.) flour Pakistan Journal of Nutrition 10 11 1069-1075
[7] Du S, Jiang H, Yu X and Jane J 2013 Physicochemical and functional properties of whole legume flour LWT-Food Science and Technology xxx 1-6
[8] Badan Standarisasi Nasional (BSN) 1992 SNI 01-2891-1992 Cara uji makanan dan minuman. BSN, Jakarta
[9] AOAC 1995 Official Methods of Analysis, Association of Official Analysis Chemistry. (Washington D.C : Benyamin Franklin Station)
[10] Pranoto Y, Rahmayuni, Haryadi and Rakshit S K 2014 Physicochemical properties of heat moisture treated sweet potato starches of selected indonesian varieties. Indonesian Food
Research Journal 21 5 2031-2038

[11] Brishti F H, M Zarei S K S, Muhammad M R, Ismail-Futry and Shukri R 2017 Evaluation of the functional properties of mung bean protein isolate for development of textured vegetable protein Int. Food Research Journal 24 4 1595-1605

[12] Butt M S and Batool R 2010 Nutritional and functional properties of some promising legumes protein isolates Pakistan Journal of Nutrition 9 373–379

[13] Pangastuti H A, Affandi D R and Ishartani D 2013 Karakterisasi sifat fisik dan kimia tepung kacang merah (Phaseolus vulgaris L.) dengan beberapa perlakuan pendahuluan Jurnal Teknosains Pangan 2 1 20-29

[14] Alamu E O, Therese G, Mdziniso P and Bussie M 2017 Assessment of nutritional characteristics of products developed using soybean (Glycine max (L.) Merr.) pipeline and improved varieties Cogent Food & Agriculture 3 1-12

[15] Jahreis G, Brese M, Leiterer M, Schafer U, Bohm V and Jena 2015 Legume flours: nutritionally important sources of protein and dietary fiber Ernahrungs Umschau 63 02 36–42

[16] Dzudie T and Hardy J 1996 Physicochemical and functional properties of flours prepared from common beans and green mung beans J. Agric. Food Chem 44 3029-3032

[17] Adelakun O E, Duodu K G, Buys E and Olanipekun B F 2013 Potential Use of Soybean Flour (Glycine max) in Food Fortification in Soybean-Bio-Active Compounds (London : InTech)

[18] Kaur A, Singh N, Ezekiel R and Guraya H 2007 Physicochemical, thermal and pasting properties of starches separated from different potato cultivars grown at different location. Food Chemistry 101 643–651

[19] Singh S, Singh N, Isono N and Noda T 2010 Relationship of granule size distribution and amylopectin structure with pasting, thermal and retrogradation properties in wheat starches J. Agric. Food Chem. 58 1180–1188

[20] Kiosseoglou V and Paraskevopoulou A 2011 Functional and physicochemical properties of pulse proteins. In: Tiwari, K.B., Gowen, A. and McKenna, B., Eds., Pulse Food: Processing, Quality and Nutraceutical Applications (London : Elsevier Inc.) 57-90

[21] Adejuyitan J A, Otonola E T, Akande E A, Bolarinwa I F and Oladokun F M 2009 Some physicochemical properties of flour obtained from fermentation of tigernut (Cyperus esculentus) sourced from a market in Ogbomoso, Nigeria. Afr. J. Food Sci. 3 (2) 51-55

[22] Fekria A M, Isam A M A, Suha O A and Elfadil E B 2012 Nutritional and functional characterization of defatted seed cake flour of two Sudanese groundnut (Arachis hypogaea) cultivars Int. Food Research Journal 19 629-637

[23] Appiah F, Asibuo J Y and Kumah P 2011 Physicochemical and functional properties of bean flours of three cowpea (Vigna unguiculata L. Walp) varieties in Ghana African Journal of Food Science 5 100–104

[24] Kisambira A, Muyonga J H, Byaruhanga Y B, Tukamuhawba P, Tumwegamire S and Grueneberg W J 2015 Composition and functional Properties of yam bean (Pachyrhizus spp.) seed flour. Food and Nutrition Sciences 6 736-746

[25] Adebowale A, Adeyemi I A and Oshodi A A 2005 Functional and physicochemical properties of flours of six mucuna species African Journal of Biotechnology 4 1461–1468

[26] Mohamed T K, Zhu K, Issoufou A, Fatmata T and Zhou H 2009 Functionality, in vitro digestibility and physicochemical properties of two varieties of defatted foxtail millet protein concentrates International Journal of Molecular Sciences 10 5224-5238

[27] Hamid S, Muzaffar S, Wani I A and Masoodi F A 2015 Physicochemical and functional properties of two cowpea cultivars grown in temperate Indian climate Cogent Food & Agriculture 1 1-11

[28] Shimelis E, Meaza M and Rakishit S 2006 Physicochemical properties, pasting behaviour and functional characteristics of flours and starches from improved bean (Phaseolus vulgaris L) varieties grown in East Africa Agricultural Engineering International 3 1–18, FP 05015
