Nutritional and physical properties of three varieties of Hanjeli (*Coix lacryma-Jobi*) flour for food diversification and application uses

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Abstract. Hanjeli (*Coix lacryma-jobi*) is widely used as a source for new food development with high nutritional content. However, information about the type of Hanjeli variety used as alternative nutritious food is still limited. In this study, we compared the nutritional and physical properties of three varieties of Hanjeli (*Coix lacryma-Jobi*) flour namely Pulut (HAP), Unpad (HHA) and Batu (HBA) for food diversification and application uses. A comparative evaluation of the nutritional property of Hanjeli flours including moisture, ash, protein, fat, carbohydrates, dietary fiber, calcium, energy, and starch contents was carried out. While for physical property, the yields of Hanjeli flours were analyzed. The results showed that the variety of Hanjeli significantly affected to nutritional and physical properties of flours (P<0.05). *Pulut* was the best variety due to its nutritional and physical properties. In this study, cookies made from 100 % of Hanjeli flour from *Pulut* variety contained moisture (3.97%), ash (1.93%), protein (9.17%), fat (23.58%), carbohydrates (61.59%), dietary fiber (7.69%), and energy (494.29 kcal) which met with the quality requirement of Indonesian National Standard for cookies. Hanjeli is promising as a new source of nutrition for diversification and application food uses.

1. Introduction
Hanjeli (*Coix lacryma-jobi L.*) belongs to the Gramineae family, is a cereal plant that originated from East Asia and Malaya. This plant has been widely distributed in Southeast Asia. In Indonesia, it can be found in Sumatera, Java, dan Borneo islands [1] and is usually used as food and feed ingredients.

Due to its nutritional contents, Hanjeli cereal is potentially used as an alternative to staple food and can be further processed for food diversification. Moreover, protein, fat, and vitamin B1 contents in this cereal are higher than other cereals [2]. Dried Hanjeli cereal exhibits moisture, carbohydrates, protein, ash, and fat of 11.04, 71.81, 10.89, 1.38, and 5.18 %, respectively. Although Hanjeli cereal has lower carbohydrate content than maize, rice, sorghum, millet, and barley, the fat content of this cereal is higher than maize (7.9%), rice (2.1 %), sorghum (4.2 %), and barley (2.4 %). This is in agreement with Grubben and Partohardjono (1996) that mention the maximum fat content in Hanjeli cereal is 7.9 % [14]. Additionally, the high content of calcium of Hanjeli cereal makes this crop can be
utilized as an alternative to other staple foods [3]. Traditionally, Hanjeli cereal is processed as porridge or steamed as soup, snack, or sweet beverage [4].

According to LIPI (1986) in Nurmala (2010) [5], there are four varieties of Hanjeli plants in Indonesia, especially on Java island. The first is the Agrotis variety, known as Hanjeli Batu, which means rock. The seeds of this variety become harden after the drying process, so they are suitable for handicraft materials. The second is the Mayuen variety, known as Hanjeli Pulut. Because of the high content of amyllopectin this variety has been cultured in the rice field or back yard and utilized as flour for consumption. The other varieties are Palustris and Aquatica. They are usually grown on wetlands. In Java Island, those varieties were found around the lake area, especially in Rawa Pening Lake, Ambarawa, Central Java.

Due to the limited information about the nutritional properties of Hanjeli varieties, this study was then conducted to evaluate the nutritional and physical properties of Hanjeli flours from several varieties. Based on those properties, the best variety was chosen and it was applied in trial cookies production. Cookies are a type of biscuits made from soft dough and its cut section exhibits solid textured. Moreover, the fat content of these biscuits is relatively high. Based on Indonesian National Standard 01-2973-1992, the protein content in these biscuits is a minimum of 5 %. By trial of cookies production with Hanjeli flour as raw material, it is expected nutritional values of cookies increase and promote Hanjeli flour utilization for food production.

2. Materials and Methods

2.1. Materials and sample preparation
Plant materials used in this research were three varieties of Hanjeli 'Pulut'; 'Unpad', 'Batu' obtained from Sumedang Regency (6°59'33.0"S 108°06'28.9"E), West Java. Hanjeli flour was prepared based on the modified method as follows: weighting, hulling, milling, flouring (60 mesh) and packaging. Hanjeli cookies are a type of utilization of Hanjeli flour. The making of Hanjeli cookies refer to Saputra, et al., (2014) [6]. An amount of 220 g of margarine was added with 175 g of sugar powder and mixed for approximately 1 min. The mixture then was added one egg that mixed with 1 g of salt. An amount of 220 g Hanjeli flour was added and mixed to produce a dough. The dough is then printed on a baking sheet that has been greased with margarine and then baked at a temperature of 150-160 °C for 20 minutes.

2.2. Experiment design and statistical analysis
The experimental design used in this study was a complete randomized block design with a single factor. The factor observed was variety plantain, which consisted of 3 levels : X1 = variety 'Pulut', X2 = variety 'Unpad', X3 = variety 'Batu'. Each treatment was repeated 3 times. The response variable (Y) consists of moisture (gravimetry), ash, protein, fat, carbohydrates, dietary fiber, calcium, energy, starch (Luff Schoorl), and yield were analyzed. Data were presented by means ± standard deviation (sd). Data in this study were analyzed statistically using ANOVA at the 5 percent level. Significant differences between mean values were determined using Duncan’s Multiple Range Test (DMRT). Data were analyzed using SPSS Ver.23.0 software, SPSS Inc.

2.3. Analysis
Chemical analysis was carried out for Hanjeli flour including: proximate (moisture, ash, protein, fat, and carbohydrate) and dietary fiber refer to AOAC (2005) [7], calcium content (Iwansyah et al., 2012) [8], energy (Ekafitri et al., 2019) [9], starch content with luff schoorl method. The physical parameter which analysis for Hanjeli flour is yield. The percentage of yield was calculated from the initial weight of raw material and the final weight of the product. Selection of the best variety with effectiveness index method de Garmo [10].

2
3. Results and Discussion

3.1. Nutritional composition of Hanjeli flour

| Samples          | Moisture (%)* | Ash (%)* | Fat (%)* | Protein (%)* | Carbohydrates (%)* | Energy (kcal)* |
|------------------|---------------|----------|----------|--------------|--------------------|---------------|
| “Pulut” Flour    | 13.61±0.12a   | 0.87±0.00bc | 1.41±0.04bc | 12.56±0.39bc | 71.57±0.32c       | 349.15±0.62c  |
| (X1)             |               |          |          |              |                    |               |
| “Unpad” Flour    | 13.06±0.36b   | 0.82±0.17bc | 2.44±0.14d | 13.00±0.12bc | 70.69±0.73b       | 356.67±1.43bc |
| (X2)             |               |          |          |              |                    |               |
| “Batu” Flour     | 11.97±0.19c   | 0.44±0.03c | 1.19±0.17bc | 13.70±0.28a  | 72.70±0.28b       | 356.34±1.47bc |
| (X3)             |               |          |          |              |                    |               |

*the same manuscript in the same column shows that the samples were not significantly different at 5 % significance.

Nutritional parameters of three varieties Hanjeli flour are listed in Table 1. The moisture content of Hanjeli flours from three varieties ranged from 11.97 to 13.61%. Based on Indonesia National Standard especially rice flour (SNI 3549:2009), it is mentioned that the moisture content of flour maximum of 13%. Moisture contents in the food materials affect the self-life of products. The lower moisture content makes the growth of microorganisms slower and extends the self-life of products.

The ash contents of the seeds from three varieties of Hanjeli ranged from 0.44 to 0.87%. Pulut variety showed the maximum ash content (0.87%). The ash contents of Hanjeli seed in this research were lower than the research conducted by Dechkunchorn dan Masubon (2016) dan Chasiricharoenkul et al., (2011) [4,11]. This might be due to the hulling process in flour preparation of this research. The hulling process decreased inorganic mineral contents in the endocarp and brain of Hanjeli seeds and to have impacted on decreasing of ash contents [4,12].

The fat content of Hanjeli flour from three varieties ranged from 1.19 to 2.44%. Hanjeli fat content was 7.9 % higher than other cereals such as corn (4.9 %), rice (2.1 %), sorghum (4.2 %), and barley (2.4 %). However, the fat content of Hanjeli flour from this study was lower Liu et al., (2015) [13] study (5.1-9.4%). Meanwhile, according to Grubben and Partohardjono (1996) (14), the highest fat content of Hanjeli seeds can reach 7.9 %. In this study, the highest fat content was Unpad Hanjeli flour (2.44%) followed by Pulut and Batu varieties. The types of fatty acids that are mostly contained in Hanjeli seeds are oleic, linoleic, palmitic, and stearic fatty acids [15].

The protein content of Hanjeli flours in this study ranged from 12.56-13.70% (Table 1). These values are lower than the protein content in black Hanjeli flour (16.85%) [4]. Hanjeli flour from the Batu variety showed the highest protein content (13.70%). It was higher than the protein content of white Hanjeli flour (13.28%) in Dechkunkhon and Masubon (2016) [11] report. In agreement with Dechkunchorn (2016) and Chasiricharoenkul et al. (2011) [4,11], black Hanjeli seeds possessed a higher protein content compared to white Hanjeli flour [4,11]. The protein content in Hanjeli seeds was generally 14.10% higher than rice (8.80%), corn (10.50%), millet (12.80%), and sorghum (11.40%) [14]. After Hanjeli seeds were processed into flour, the protein content ranged from 12.56-13.70%. The protein content of Hanjeli flour is higher than corn (7.89%) and rice (6.98%) flours [16,17].

Hanjeli seeds contain lower carbohydrates than corn, rice, sorghum, millet and barley [14]. The carbohydrate content of Hanjeli flour from three varieties ranged from 70.69 to 72.70 %. The carbohydrate content of the Batu variety Hanjeli flour was 72.70%, the highest compared to other varieties. The carbohydrate content of these results was lower than the carbohydrate content of Hanjeli
flour reported by Handayani (2018) [18] which was 89.52% (18). This difference in nutritional content can be caused by differences in various types, growing areas, and the sample preparation process [12].

The total energy of three varieties of Hanjeli ranged from 349.15 to 356.67 kcal. The total energy of Unpad (356.67 kcal) and Batu (356.34 kcal) varieties was not significantly different (p > 0.05), while the Pulut variety showed the lowest total energy (349.15 kcal). The lower total energy in Pulut variety was caused by the low protein and fat contents compared to the other varieties studied. According to Jomduang and Orathai (2019) [12], total energy on three varieties of Hanjeli in this research was lower than black and white endocarp Hanjeli (366.81 dan 365.67 kcal) [12].

The next discussion is the nutritional content of three varieties of Hanjeli flour from starch, calcium and dietary fiber content that illustrated in Table 2. The starch content of flours from three varieties of Hanjeli ranged from 63.62 - 64.88% (Table 2). The highest starch content of Hanjeli flour was from the Batu variety (64.88%). Compared to the results from Zhang et al., (2020) [19] which has a starch content of 61.22%, Batu variety was higher. Starch is the major component of Hanjeli seed and contributed up to 70% of its content [20]. The difference in starch content of each variety can be caused by genetic variations in each variety. Cereal starch is the main source of carbohydrates, such as rice, black glutinous rice, white glutinous rice, wheat, barley and others. Different sources of cereal starch produce different ratios of amyllose and amylopectin. White rice that is commonly consumed by Indonesians is rice that contains high amyllose compared to amylopectin, thus giving it dry and not sticky properties. One of the cereals such as white glutinous rice contains more amylopectin than amyllose [21], thus giving glutinous property. This glutinous rice is widely used as glutinous rice flour and can be processed into various kinds of foods.

The calcium content of Hanjeli flour from three varieties ranged from 111.79 - 164.40 mg / 100g. The calcium content of the Unpad variety flour was 164.40 mg / 100g, the highest compared to other varieties. The mineral content of calcium in the three varieties of Hanjeli flour was higher than the content in Hanjeli seeds reported by Corke and Huang (2015) and Jomduang and Orathai (2019) [12,20] with calcium content values of 49 mg / 100 g and 12.23-15, 80 mg / 100g. In addition, the calcium content of Hanjeli flour is also higher than the calcium content of Hanjeli flour reported by Chhabra and Rajinder (2015) [22] (12.5 mg / 100 g). This difference in nutritional content can be caused by differences in variety types, growing areas, and the sample preparation process [12].

Dietary fiber is a component of food that cannot be hydrolyzed by human digestive enzymes. The dietary fiber of Hanjeli flour from three varieties ranged from 6.62-7.43%. The highest dietary fiber contents of Hanjeli flour was Pulut variety 7.43% and it was significantly different from the other varieties, Unpad (6.62%) and Batu (6.62%) varieties (p <0.05). The dietary fiber contents of Hanjeli flour in this study were close to a report from Handayani (2018) which is 6.73% and lower than the dietary fiber content of black Hanjeli seeds (9.41%) and white Hanjeli (3.2%) [12]. Jomduang and Orathai (2019) reported that the type of variety, growing area, hulling process affected the nutritional content of Hanjeli flour [12]. This is in agreement with Tensiska et al., (2017) [23] which stated that an intensive hulling process decreases dietary fiber due to most of the fibers concentrated in the endocarp and bran of Hanjeli seeds [23].

### Table 2. Starch, calcium and dietary fiber content of Hanjeli flour.

| Samples         | Starch (%)* | Calcium (mg/100g)* | Dietary fiber(%)* |
|-----------------|-------------|--------------------|-------------------|
| “Pulut” Flour (X1) | 63.62±0.31  | 111.79±10.01       | 7.43±0.11         |
| “Unpad” Flour (X2) | 63.38±0.24  | 164.40±32.19       | 6.62±0.65         |
| “Batu” Flour (X3) | 64.88±0.65  | 117.73±18.23       | 6.62±0.27         |

*a* the same manuscript in the same column shows that the samples were not significantly different at 5% significance.
3.2. Physical property of Hanjeli flour

Table 3 shows the yield of each Hanjeli variety converted into flours. The yields ranged from 15.64 to 27.48 %. Pulut variety presented the highest yield compared to Batu and Unpad varieties.

Table 3. The yields of Hanjeli flour.

| Samples             | Yields (%) |
|---------------------|------------|
| “Pulut” Flour (X1)  | 27.48±0.63a|
| “Unpad” Flour (X2)  | 17.72±0.52b|
| “Batu” Flour (X3)   | 15.64±0.36c|

*the same manuscript in the same column shows that the samples were not significantly different at 5 % significance.

3.3. Selection of the best treatment

Based on an analysis of yield data, moisture, ash, protein, fat, carbohydrates, dietary fiber, calcium, energy, and starch. Based on the assessment criteria of the analysis data, the best treatment will be obtained. The highest rating was determined from the highest score (Nh). Nh (result value) is obtained from the effectiveness value (Ne) multiplied by the normal weight (BN) of the parameter.

Table 4. Selection of the best variety with effectiveness index method.

| Samples             | Nh yield | Nh moisture content | Nh ash content | Nh protein content | Nh carbohydrate | Nh dietary fiber | Nh calcium | Nh energy | Nh starch | Total Nh | Rank  |
|---------------------|----------|---------------------|----------------|--------------------|-----------------|------------------|------------|-----------|-----------|----------|-------|
| “Pulut” Flour (X1)  | 0.452    | 0.000               | 1.000          | 0.000              | 0.231           | 0.146            | 0.359      | 0.000     | 0.000     | 0.053    | 2.240 | 1     |
| “Unpad” Flour (X2)  | 0.051    | 0.113               | 0.884          | 0.128              | 0.000           | 0.000            | 0.417      | 0.336     | 0.000     | 0.000    | 1.929 | 2     |
| “Batu” Flour (X3)   | 0.000    | 0.310               | 0.000          | 0.349              | 0.236           | 0.338            | 0.000      | 0.034     | 0.321     | 0.338    | 1.926 | 3     |

Table 4 shows that Pulut flour (X1) exhibits the highest Nh value. Thus, the Hanjeli flour from Pulut variety (X1) was selected based on the de Garmo method with the highest score of 2.240. This study recommends Pulut as the best variety due to its physical and nutritional parameters compared to other studied varieties.

3.4. Food application: cookies of Hanjeli flour

The Hanjeli flour from Pulut variety was then applied in the cookies product. The nutritional contents of cookies made from Hanjeli Pulut flour are presented in Table 5. By using 100 % of Hanjeli flour, the nutritional characteristics of cookies in terms of the contents of protein and fat contents were 9.33 and 23.58 %, respectively, which is met with the requirement of Indonesian Standard National 01-2973-1992 (min 5 % and 9.5 % for protein and fat, respectively).
Table 5. Nutrition composition of cookies with 100% Hanjeli “Pulut” flour.

| Constituent       | Amount       | Unit                   |
|-------------------|--------------|------------------------|
| Moisture          | 3.97±0.10    | %                      |
| Ash               | 1.93±0.09    | % dry weight basis     |
| Protein           | 9.33±0.36    | % dry weight basis     |
| Fat               | 23.58±1.95   | % dry weight basis     |
| Carbohydrates     | 61.59±2.52   | % dry weight basis     |
| Dietary fiber     | 7.69±1.41    | % dry weight basis     |

Data are presented as means ± standard deviation (sd) (n=3).

4. Conclusions
Based on the analyses of the nutritional and physical properties of three varieties of Hanjeli seeds, Pulut variety was chosen as the best raw material to be applied in cookies production. Hanjeli flour made from Pulut variety presented 13.61 % of moisture, 0.87 % of ash, 1.41 % of fat, 71.57 % of carbohydrates, 349.15 kcal of energy, 63.62 % of starch, 111.79 mg of calcium per 100 g dry weight, 7.43 % of dietary fiber, and 27.48 % of the maximum yield. Additionally, the proximate analysis of Hanjeli flour-based cookies showed the moisture, ash, protein, fat, carbohydrates, and dietary fibers were 3.97, 1.93 %, 9.33 %, 23.58 %, 61.59, and 7.69 %, respectively. The Hanjeli cookies developed in this research meet the SNI quality requirements for cookie products. This research suggests that Hanjeli is a promising source to be developed for other high nutritional contents of food products.

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