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Nutritional Characteristics and Potential Applications of Flour Prepared from Indonesian Wild White Yam (*Dioscorea esculenta L.*)

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Abstract

Gembili or wild white yam (Dioscorea esculenta L.) is one of underutilized tubers that can be found during dry season in Indonesia and other Southeast Asian countries. Although it has been consumed as staple food by people for centuries during famine, no further studies have been conducted to explore its potentials in food applications. This work aims to study the preparation, characterization and potential analysis of Gembili flour for use as raw material in novel foods development. Creamy white flour was obtained from white yam tuber from milling and sieving of dried tuber chips. The flour has water content about 12.08%, which is acceptable for storage. No lipid was detected. In addition, the protein, ash, and fiber content of the flour were respectively 3.00%, 1.27%, and 9.04%. The carbohydrate and amylose contents of the flour were 86.69% and 29.92% indicating its suitability for energy source. As expected, the cyanide content is very low of about 1.688 ppm suggesting that it is safe for consumption. Refer to those properties, Gembili flour can be a promising raw material for the preparation of bakery, cookies, noodle and confectioneries.

Keywords: *proximate composition, flour, white yam, food, preparation*

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INTRODUCTION

Daily life exhibits the fact that human and animal cannot be separated from food issues. As can be seen recently, the rapid development of health science has increasingly influenced people's lifestyle and food choices. Accordingly, this condition encourages the food industries to extensively find raw material alternatives and food manufacturing process, specifically for breads and cookies. The steady increase of wheat flour price in the world due to climate change and higher demand also triggers the search of wheat flour alternatives (Retnowati et al., 2018). A lot of efforts have been performed to replace or substitute wheat flour as the main ingredient of breads and cookies, also noodles as the example of favorite dishes in Indonesia.

Most areas in the main islands of Indonesian archipelago are rich in tubers and root plants.

Literature study suggested that those plants show high potential for the production of flour for use in food applications. Cassava, taro and sweet potato are reported to be the most utilized tubers by Indonesian people, while other tubers and roots are not so popular because mostly are being seasonal bulbs (Kumoro et al., 2012). Since they cannot be harvested throughout the year, they are not always available in traditional market every time. One of these tubers is Gembili which is the member of Dioscorea family. It is a seasonal food plant and generally planted in Indonesia in the end of September to October. This tuber can only be harvested after being grown for 7 – 9 months, usually during dry season. The yellowing leaves and withered vines indicate of mature crop, which is usually ready to harvest around May to July (Senanayake et al., 2012). Physically, Gembili tuber has a thin skin with some plumes attached on the surface, while the flesh exhibits a creamy color and is traditionally consumed by people upon steaming, boiling, baking, frying or roasting (Retnowati et al., 2018).

According to Okunlola and Odeku (2011), Dioscorea tubers have a large quantity of starch, which is about 54% to 74%. Therefore, it could be a potential source of basic energy. Gembili flour is safe for consumption by people who are sensitive to gluten as celiac disease and gluten ataxia (Niland et al., 2018). Recent nutrition science development proves that gluten free foods are increasingly popular as a part of healthy diets. Unfortunately, high moisture content has caused yam tubers to become highly perishable and bulky (Coursey and Ferber, 1979). Hence, the conversion of Gembili tuber into flour as the most acceptable forms will not only increase its economic value, but also makes it easy to store for further uses as raw material in the manufacture of cakes, bread, cookies or noodles Processing of yam tuber into flour offers a higher possibility to extend the availability of yam supply during the off-season, thereby reducing the loss during storage and lowering the cost for marketing and transportation (Retnowati et al., 2018). Despite its allergen issue, gluten in wheat flour has an important role in the bread making (Toufeili et al., 1999). Therefore, a number of researches have been conducted to improve the gluten free flour through physical, chemical and biological modification or addition of hydrocolloids in dough flour to obtain closely similar baking properties of wheat flour (Naqash et al., 2017).

Unfortunately, as the member of Dioscorea family yam tubers may contain different antinutrients, which prone to have deleterious effects to both human and animals when they are consumed (Polycarp et al., 2012). Therefore, the safe level antinutrients content in the tuber should be assured before further uses. The most common antinutrients contained in the yam tuber are phytic acid, tannin, and cyanogens. Yang and Lin (2008) reported that the age of harvest, variety, geographical condition or the storage condition after harvest may considerably affect its antinutritional content.

The objectives of this work were to determine the proximate nutrient composition of Gembili flour and to analyze the potential uses of Gembili flour for future development as a raw material for food or other applications.

MATERIALS AND METHODS

Sample of Gembili flour preparation

Gembili tubers were purchased from the local market in Gunungpati sub-district, Semarang City, Central Java province, Indonesia.

Chemicals and standard

Analytical grade of chemicals used for browning prevention (potassium metabisulfite) and Gembili flour proximate analysis were the products of Merck-Indonesia and were purchased from an authorized chemical store in Semarang-Indonesia. Analytical grade (petroleum ether) and standard (amylose) with a purity >98 % were the product of Merck (Germany) and were purchased and directly used without further treatment.

Preparation of Gembili flour

The Gembili tubers were carefully washed with clean tap water to ged rid of the adhering dirt and other undesirable materials from the tubers, and to inhibit the microbial growth on the final product. They were peeled and trimmed to remove defective parts, washed, and shreded with an automatic machine to obtain thin slices (±5 mm). Then, the slices were soaked in potassium metabisulfite solution (0.075%) for 1 hour to prevent browning as suggested by Jayakody *et al*. (2007). The tuber slices were rinsed again with flowing water and were further spread in a single layer on drying trays and dried under sunshine for 3 days and were subsequently crushed in a laboratory scale crusher, milled into flour with a hammer mill to obtain flour. The flour was then passed through -180 μm +250 μm sieves. Only the Gembili flour retained on the 250 μm was used in this

Composition analysis

The proximate analysis (moisture (M), ash (A), lipid (L), and protein (P) content (N × 6.25) of Gembili flour was conducted strictly according to AOAC methods (Latimer Jr, 2016). Then, the carbohydrate content was calculated by differences. In addition, the amylose content was determined following the methode developed by Juliano (Juliano, 1971). The total cyanide content in mg HCN equivalents/kg fresh weight (ppm) was determined based on the method previously used by Bradbury *et al.* (1999). All analyses were performed in triplicates. The reported values were the average of them.

RESULTS AND DISCUSSIONS

Nutritional compositions

The proximate composition of Gembili flour is presented in Table 1. The moisture content of food samples is an indicator of shelf life and quality of solid foods. Although the moisture content of the lesser yam flour obtained in this study (12.08%) is slightly higher than those reported in the literature, it is still below the recommended safe level (12–13%) for storage of flour set by Codex Alimentarius Commission through joint food standards program of Food and Agriculture Organization/World Health Organization (FAO/WHO) (Codex Alimentarius Commission, 1995). Foods with moisture content higher than 14% are vulnerable to bacterial attacks and mould growth, which produce undesirable changes (Ihekoronye and Ngoddy, 1985).

However, there was no lipid content detected in the Gembili flour. A similar observation was reported by Saskiawan and Nafi'ah (2014) who found an extremely low-fat content (0.15 %) on Gembili flour planted in Cibinong-West Java, Indonesia. While two researchers (Senanayake *et al.*, 2012; Ukpabi, 2010) reported that fat contents of *D. esculenta* flour were comparable to wheat flour. Interestingly, the absence of lipid in Gembili flour suggests that the flour is a healthier choice of food, as perceived by consumers, especially in relation to cardio-vascular diseases (Tortoe *et al*., 2017).

The protein content of the Gembili four is closely similar to that observed by Saskiawan and Nafi'ah (2014), but far lower than those found by Ukpabi (2010) and Senanayake *et al*. (2012) for D. esculenta farmed in Nigeria and Sri Lanka. The Gembili flour has a lower protein content compared to that of American wheat flour (Ukpabi, 2010). For some food product applications, the protein content of wheat flour is too high and can be diluted with other starches of lower protein content. This is the case with biscuit making. The protein content of the mixture required is around 7.0–8.5 % for sweet biscuits or 8.4–10 % for biscuit sponge (Snow and O'Dea, 1981). Therefore, the Gembili flour has the potential to partially substitute wheat flour to obtain composite flours with acceptable protein contents for certain food applications.

Ash content, which reflects the mineral content in food (Tortoe *et al.*, 2017) even though contamination can indicate a high mineral concentration in a food sample (Baah *et al*, 2009), Although Gembili contains lower ash content than that of D. esculenta grown in Nigeria and Sri Lanka (Senanayake *at al*., 2012; Ukpabi, 2010), it still could serve as a fairly good source of dietary minerals.

Fiber is a type of carbohydrate that the body cannot digest. Though most carbohydrates are broken down into sugar molecules, fiber cannot be broken down into sugar molecules, and instead it passes through the body undigested. Fiber helps the peristaltic movement of food substances during digestion and regulates the body's use of sugars, helping to keep hunger and blood sugar in check. The Gembili four contains 9.04% of fiber, which is much higher than those reported by other researchers (Senanayake *at al*., 2012; Ukpabi, 2010). According to the provisions of Codex Alimentarius (2009), food containing more than 6g/100g dietary fiber can be considered as having a high content of dietary fiber. Thus, Gembili flour is a good source of dietary fibers.

The carbohydrate content in Gembili flour is only slightly lower than 90%, but higher than those reported in the literature. This affirms the fact that Gembili flour is a valuable source of dietary carbohydrates, which provides caloric energy (Coursey and Ferber, 1979). This finding is in good agreement with Osunde (2008) who explained that the chemical composition of yam is characterized by high moisture and dry matter mainly of carbohydrates.

Table 1. Chemical composition of *Dioscorea esculenta* Flour grown in different regions

Composition	This work	Cibinong[a]	Nigeria[b]	Sri Lanka[c]	Wheat flour[b]
Moisture (%)	12.08 ± 0.23	8.39	9.40 ± 0.16	10.39 ± 0.15	13.94 ± 0.02
Lipid (%)	0.00 ± 0.00	0.15	1.00 ± 0.00	1.50 ± 0.20	1.50 ± 0.01
Protein (%)	3.00 ± 0.33	3.92	6.51 ± 0.02	9.02 ± 0.65	9.90 ± 0 03
Ash (%)	1.27 ± 0.23	0.72	2.05 ± 0.07	2.10 ± 0.20	1.15 ± 0.13
Fiber (%)	9.04 ± 0.34	NA	1.05 ± 0.12	2.33 ± 0.15	2.20 ± 0.12
Carbohydrate (%)	86.69 ± 0.22	86.84	79.54 ± 2.17	74.66 ± 0.66	71.31 ± 2.14
Amylose (%)	29.92 ± 5.09	NA	NA	19.98 ± 0.28	26.30
HCN (ppm)	1.69 ± 0.86	NA	NA	NA	NA

[a] Saskiawan and Nafi'ah (2014); [b]Ukpabi (2010); and [c]Senanayake *et al.* (2012)

Gembili flour contains high amylose content (29.92 ± 5.09 %). However, this value is slightly lower than the amylose content of D. alata var Krimbang flour obtained from Tulung Agung, East Java-Indonesia (33.1 ± 1.20 %) reported by Aprianita *et al.* (2014a). The proximate composition of tuber flour largely depends on the specific tissues, geographic location, variety, age, environmental conditions and the preparation technique (Garcia and Dale, 1999). Shimelis *et al*. (2006) explained that high amylose content tends to restrict flour swelling and the hot paste viscosity stabilizes. In addition, high amylose contents are desired in starches and flours that are to be used for the manufacture of extrudates (Chevanan *et al*., 2010). Having high amount of amylose, Gembili flour and starch could partially replace wheat flour in snack food formulations to obtain products with a crunchy texture. Amylose within flour or starch could strengthen the dough, which in turn improves the forming and cutting properties of dough to produce snack foods with a crunchy texture (Huang *et al*., 2006).

However, the flour also contains small amount of cyanogens in the form of total hydrocyanic acid. This low antinutrient content suggests that no extensive pretreatment is required to make the flour becomes edible. The safe limit for cyanogens in food material was set by the WHO at 10 ppm for cassava flour (Codex Alimentarius Commission, 1991), and the acceptable limit in Indonesia is 40 ppm (Djazuli and Bradbury, 1999).

Color appearance

Visually, the Gembili flour is light brown in color. However, it is still darker than the commercial wheat flour. Lightness of flours was affected by browning reactions, which occur during its processing (Van Hal, 2000), and this may have extensively affected Gembili flour and reduced its lightness. As a member of Dioscorea family, Gembili tuber contains mucilage, which makes the flour immediately colored right after the tubers are cut. Krishnan *et al.* (2010) proposed that oxidation of phenols by polyphenol oxidases and peroxidases contained in the mucilage of the tuber generate brown color and generally known as enzymatic browning. Apart from the inherent color pigments present in yams, yellowness in yam flours has also been linked to total phenol content and the activity of polyphenoloxidase (Akissoe *et al.*, 2003).

If the color of a food product is one of the important criteria, then the use of native Gembili flour for its manufacture should be less considered. This is because usually white flours are more preferred in various applications (as in white bread making). Theoretically, the substitution of wheat flours with Gembili flour reduces the whiteness but increases the redness and yellowness of the flour composites (Aprianita *et al*., 2014b). Modification of flour either by physical, chemical, biological or their combination may be one way to improve the appearance of Gembili flour (Kumoro and Hidayat, 2018).

CONCLUSIONS

A comprehensive characterization of physicochemical, thermal and functional properties of Ubi Gembili (*Dioscorea esculenta* L.) flour has been successfully carried out. The moisture content of Gembili flour is below the recommended safe level (12.08%) for storage of flour set by Codex Alimentarius Commission. Gembili flour exhibits high carbohydrate and amylose content indicating its good potential as a source of energy. The flour is also rich in protein and fiber, which is an indication of good food. It contains low ash and a safe level of cyanide. However, it has no lipid content. The Gembili flour granules are creamy white in color. If this flour will be used alone or as substitute to wheat flour in bread making, addition of polar lipid can be arranged as needs to improve the loaf volume of bread.

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