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Physico-Chemical Properties of Gembili (*Dioscorea esculenta* L.) Flour from White-fleshed and Purplish-White-fleshed Tubers

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Abstract

Flour quality in the form of physicochemical and sensory properties is an essential parameter that will influence the design, process, and results of the processing of gembili flour derivative products. This study aims to evaluate flour's physical and chemical properties from white-fleshed gembili tubers (Yawal Porei) and purplish-white-fleshed gembili tubers (Thai) and determine consumer preferences for the flour produced. The physical properties of gembili flour were analyzed, including yield, whiteness, and fineness modulus (FM). Meanwhile, the chemical composition of the flour analyzed includes moisture content, carbohydrates, protein, ash content and crude fibre. 35 untrained panellists were used in organoleptic tests to assess consumer preferences. The results show that the two gembili tubers produce flour with different physical and chemical properties. White-fleshed gembili flour has several advantages in terms of physical and chemical properties, namely yield (15.62% ± 0.41), whiteness (79.55 ± 0.98), carbohydrates (82.86% ± 0.21) and crude fibre (5.28% ± 0.61) which has the potential as a rice analogue, noodles, cake, fillers, and cookies. Meanwhile, purplish-white-fleshed gembili flour has a high protein content (5.40% ± 0.16) and ash content (6.75% ± 0.05), which has the potential as a bakery product. The FM of the two types of gembili flour was not much different and has a moisture content that meets the Indonesian National Standard, below 14.5%. The sensory assessment showed that the panellists preferred white-fleshed gembili flour to purplish-white-fleshed gembili flour. The sensory assessment showed that the panellists preferred white-fleshed gembili flour to purplish-white-fleshed gembili flour.

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1. Introduction

Gembili (*Dioscorea esculenta* L.) is one of Papua's local food crops. Gembili is used as a staple food and the primary source of carbohydrates that the Papuan people consume by boiling or burning for a long time (Prabowo et al., 2014). This plant has the advantage of being able to grow under forest stands and is distributed from highlands and valleys, including the Central Mountains and Baliem Valley (Jayawijaya), to lowland areas in the Merauke Regency area, South Papua Province (Susila et al., 2023). Gembili is widely cultivated by Papuan farmers, for example, by the Kanum tribe, which lives in Yanggandur Village in Wasur National Park in Merauke. In the Kanum tribe, gembili is

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known as *Kumbili*, which has a higher cultural value than money. Without gembili, the Kanum tribe's marriage rituals cannot be carried out because gembili is used as a complement and "*mas kawin*" for the marriage ceremony (Ondikeleuw and Malik, 2020; Sabda et al., 2019).

According to Susila et al. (2023), there are 30 cultivars of gembili in Papua, and 17 of them are cultivated by the Kanum tribe in Merauke (Paay, 2004 *In* Rauf and Lestari, 2009). Gembili is planted from November to September and can be harvested gradually at the age of 9 months after planting and can be harvested when the leaves of the gembili plant have dried up (Ondikeleuw and Malik, 2020). Data from the Central Bureau of Statistics of Merauke Regency in 2022 recorded that gembili production reached 1,833.64 tons, with Sota District as the largest production site (BPS, 2023).

The gembili plant stores its food reserves in tubers that contain high carbohydrates (31.3%), which have great potential as an alternative food source for food diversification (Sabda et al., 2019). As a source of local food ingredients, gembili can be utilized and further developed into various derivative products such as cake products (Imzalfida, 2016; Masrikhiyah, 2020), cookies (Ervitasari and Larasaty, 2021; Prameswari and Estiasih, 2013), sausage and nugget additives (Herlina et al., 2015; Pratiwi et al., 2016) and so on. However, gembili can be processed into derivative products by first processing gembili into an intermediate product, namely gembili flour (Pratiwi et al., 2016; Richana and Sunarti, 2004).

Processing gembili flour has the potential to be an alternative to reduce and even substitute the use of wheat flour, which can reduce the amount of wheat imports. Gembili is rich in carbohydrates and has a high yield, so it has the prospect of being utilized as tuber flour through the flouring process (Pratiwi et al., 2016; Sabda et al., 2019). Gembili flouring is processed by grinding to reduce the size of food, which is intended to preserve and increase the economic value of gembili (Prabowo et al., 2014; Simatupang et al., 2021).

Flour characteristics, such as the whiteness, fineness modulus, yield and chemical composition of flour, such as moisture content, carbohydrates, ash, protein, and crude fibre, as well as sensory properties, become flour quality parameters that can affect the process and result in further processing (derivative products) of gembili flour. This study is expected to be used as a reference in making gembili flour-based products to obtain a description of the characteristics and information on the physicochemical and sensory properties of flour from two types of gembili tubers for flour processing.

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2. Research Methodology

2.1 Time and Place

This study was conducted from July to December 2023. The research was carried out at the Food and Postharvest Engineering Laboratory (TPP) of the Musamus University Agricultural Engineering Study Program as preliminary research to prepare gembili (*Dioscorea esculenta* L.) flour, test several physical properties, and organoleptic tests of flour. The primary research was conducted at the Chemical Analysis and Food Quality Control Laboratory of the Department of Food Science and Technology, Hasanuddin University, to analyze the chemical properties of gembili flour.

2.2 Tools and Materials

The equipment used in this study included an analytical scale, Memmert brand water bath, mercury thermometer, knife, cutting board, slicer, ruler, plastic container, measuring cup, perforated tray, aluminium tray, Memmert brand electric oven, blender, and one set of Tyler sieves with sizes of 6, 10, 16, 20, 30, 60, 80, 100 mesh, pan, colormeter, stopwatch, cup, plastic clip, desiccator, questionnaire, glass jar, and label paper.

The main material used in this study was Gembili tuber (*Dioscorea esculenta* L.). The white-fleshed and purplish-white-fleshed gembili tubers come from Yanggandur Village, Sota District, Merauke Regency. In the local language, each gembili tuber is named "*Yawal Porei*" and "*Thai*" (Susila et al., 2023). Other materials used in this study were salt (NaCl) and clean water.

(a) (b)

Figure 1. White-fleshed "*Yawal Porei*" (a) and Purplish-White-fleshed "*Thai*" (b) gembili tubers.

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2.3 Gemblli Tuber Flour Making

Flour preparation begins with washing gembili tubers using water to remove dirt and soil attached to the surface of the tubers. The gembili tubers were blanched in hot water at 80°C for 1 min to prevent browning reactions. The gembili tubers were peeled and sliced using a slicer to a thickness of ± 1-2 mm. The sliced tubers were then soaked for 2 hours in 3 liters of water that had been added with 5% salt from the volume of water to maintain the original colour of the tubers, prevent browning reactions, eliminate odor, and tartness in the gembili tubers. After soaking, the sliced tubers were rinsed with running water, drained, and mechanically dried in an electric oven for 10 h at 60°C to produce gembili chips. The next step was the size reduction of the gembili's chip using a blender at medium speed for 2 min, followed by sieving with a 6-, 10-, 16-, 20-, 30-, 60-, 80, 100 mesh tyler sieve driven by a vibrator for 5 minutes. The flour that passed through the minimum 80 mesh sieve was analyzed for physicochemical properties and organoleptic testing. The stages of gembili flour preparation used in this study are shown in Figure 2.

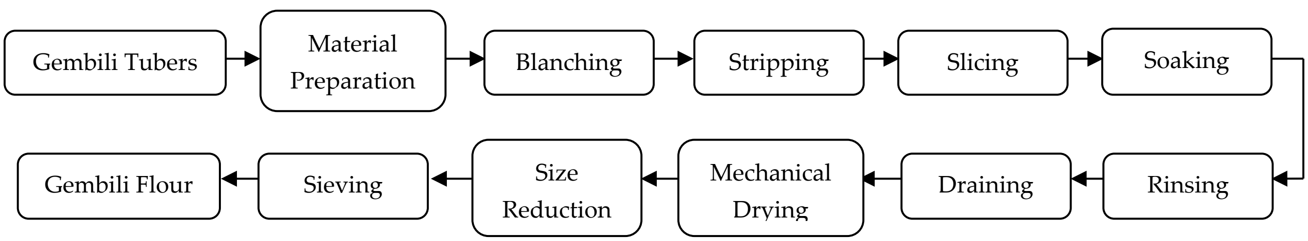

Figure 2. Flow chart of making gembili tuber flour.

2.4 Gembili Tuber Flour Yield Analysis

The yield of gembili tuber flour was analyzed by comparing the weight of flour produced with the weight of fresh gembili tubers before peeling which can be calculated by Equation 1 (Wa Ode et al., 2021).

$$R = \frac{b}{a} \text{x } 100 \quad (1)$$

Description: R = yield (%); a = weight of fresh gembili tubers (g); flour weight (g).

2.5 Whiteness Analysis

The whiteness was measured by placing a flour sample in a petri dish and then shooting it using a colormeter 3 times. Measurements were taken to obtain lightness (L), redness (a), and yellowness (b) so the whiteness can be calculated using Equation 2 (Mawarni and Widjanarko, 2015).

$$W = 100 - \{(100 - L)^2 + a^2 + b^2\}^{0.5} \quad (2)$$

Description: W = whiteness; L = value indicating brightness; a = value indicating red (+) to green (-); b = value indicating yellow (+) to blue (-) colour.

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http://journal.ipb.ac.id/index.php/jtep
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2.6 Fineness Modulus Analysis

The Fineness Modulus (FM) is an index to determine the fineness of flour using a Tyler sieve with a certain mesh size. According to Musadi et al. (2019), the Fineness Modulus is the sum of the cumulative percent of residual material left on the sieve divided by 100. This study used sieves measuring 6, 10, 16, 20, 30, 60, 80, 100 mesh, and a pan were used to sift gembili flour samples for 5 minutes. The flour left in each sieve was weighed and expressed as retained weight and the percentage was calculated using Equation 3.

$$Xi = \frac{Wi}{W\ total}\ x\ 100 \tag{3}$$

Description: Xi = percentage of weight retained on each sieve (%); Wi = weight retained on each sieve (grams); Wtotal = total weight of retained sample (grams).

After obtaining the percentage of weight retained in each sieve, the cumulative retained percentage can be calculated by summing the percentage of weight retained in each sieve (Equation 4).

$$Cumulative\ retained\ percentage = (X_1 + 0) + (X_2 + X_1) + (X_3 + X_2) + \cdots + (X_n + X_{n-1}) \tag{4}$$

The Fineness Modulus (FM) value of gembili flour can then be calculated using Equation 5 (Witdarko et al., 2015).

$$\text{FM} = \frac{Cumulative\ retained\ percentage}{100} \tag{5}$$

2.7 Chemical Contents Analysis

Chemical contents in gembili flour analyzed include carbohydrate content (by difference), moisture content by gravimetric method, ash content by furnace method, crude fibre content by the condenser and gravimetric methods, and protein content by Kjeldahl analysis method.

2.8 Organoleptic Test

Organoleptic test was conducted on 35 untrained panellists (Pamungkas and Priyanti, 2019; Ratulangi and Rimbing, 2021) The parameters tested were colour, taste, aroma, texture, aftertaste, and general consumer acceptance of gembili flour. The test uses a questionnaire with a hedonic scale that is transformed into a numerical number with a degree of preference. The test scores are (1) very dislike, (2) dislike, (3) somewhat like, (4) like, and (5) very like.

3. Result and Discussion

3.1 Yield, Whiteness and Finness Modulus

Yield is the ratio between the results of a process and the initial raw materials before processing, which shows the high and low results obtained from a process. The higher the yield value, the more

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products are produced. The results of the gembili flour yield analysis from two types of tubers, which are differentiated based on the colour of their flesh, can be seen in Table 1.

Table 1. Yield, whiteness, and fineness modulus from two types of gembili flour

Type of Gembili Flour	Physical Parameters		
	Yield (%)	Whiteness	Fineness Modulus
White-fleshed	15.62 ± 0.41	79.55 ± 0.98	1.10 ± 0.13
Purplish-white-fleshed	12.34 ± 1.43	73.40 ± 1.91	1.11 ± 0.02

White-fleshed gembili produced higher flour yields than purplish-white-fleshed gembili, which is thought to be related to the weight of the tubers and chemical content, such as the carbohydrate content in the flour produced in this study (Table 2). According to Susila et al. (2023), white-fleshed gembili tubers (*Yawal Porei*) and purplish-white-fleshed gembili tubers (*Thai*) can have weights of 0.9 kg and 2 kg, respectively. Which certainly affects the amount of skin wasted during the peeling process. In addition, the carbohydrate content of white-fleshed gembili tubers is thought to be higher than that of white-purplish gembili tubers, which can be seen from the presence of starch sediment during the soaking process of white-fleshed gembili tuber slices, which is thought to affect the yield produced (Rahman et al., 2015; Sabda et al., 2019). The yield results in this study are still lower than the yield in some previous studies, as reported by Jamaludin and Andari, (2023) 14.39% - 29.88% and Simatupang et al. (2021) 14.46% - 23.57%.

(a) (b)

Figure 3. The colour of gembili flour from white-fleshed (a) and purplish-white-fleshed (b) tubers.

The level of whiteness is the ability to reflect light by an object when exposed to light; the higher level of whiteness value indicates the whiter the flour colour (Wa Ode et al., 2021). Based on the data in Table 1, the whiteness value of white-fleshed gembili flour is higher than purplish-white-fleshed

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http://journal.ipb.ac.id/index.php/jtep
DOI: 10.19028/jtep.012.2.259-271

gembili flour, which indicates that the colour of white-fleshed gembili flour is brighter, as shown in Figure 3. However, the whiteness value in this study does not meet the whiteness standard based on SNI 7922-2011 (mocaf flour), which is at least 87.

According to Ayetigbo et al. (2018), Some factors that affect flour colour are the colour of the tuber origin, the length of the drying process, and the heating temperature. The difference in the value of whiteness in this study is thought to be caused by differences in the colour of the origin of the tuber flesh, namely in the purplish-white-fleshed gembili tubers there is anthocyanin content, which is a natural pigment that causes the tuber flesh to be purple in colour (Husna et al., 2013), anthocyanin concentration is what causes several types of tubers to have different gradations of purple colour so that the more intense the purple colour, the higher the anthocyanin content (Montilla et al., 2011). The whiteness value in this study is higher than the whiteness value of gembili flour by Simatupang et al. (2021) of 59.90% - 74.91% or Richana and Sunarti, (2004) of 20.04% - 60.05%, but it is still lower than another study by Jamaludin and Andari (2023) 84.98% - 89.42%.

Fineness modulus (FM) is a value that represents the average particle size of flour milled, which means that the smaller the FM value, the finer the flour particles (Priastuti et al., 2017). The fineness modulus value in Table 1 shows a value that is similar to and higher than the study by Jamaludin and Andari (2023), which reported FM values of 0.345-0.639. The drying temperature and duration influence the flour's FM value, moisture content, milling machine, and mesh size used during sieving (Saputra et al., 2023; Yani and Akbar, 2018).

3.2 Chemical Contents

The results of the chemical contents from two types of gembili flour in Table 2 show that the moisture content of white-fleshed gembili flour is slightly higher than that of purplish-white-fleshed gembili flour, which is thought to be due to differences like the origin of the material, such as the moisture content of the tubers before drying (Prasetyo and Winardi, 2022). The moisture content met the criteria for flour quality standards when based on SNI 3751:2009 (wheat flour) and SNI 7922-2011 (mocaf flour), namely the maximum moisture content of 13% and 14.5%, respectively, so that gembili tuber flour can have a long shelf life. The moisture content in this study was higher than previous studies by Richana and Sunarti (2004) and Jamaludin and Andari (2023), who reported the moisture content of gembili flour as 6.44% and 1.29% - 5.96%, respectively.

Table 2. The chemical contents from two types of gembili flour

Type of Gembili Flour	Moisture content (%wb)	Carbohydrates (%)	Proteins (%)	Ash (%)	Crude Fibre (%)
White-fleshed	10.30 ± 0.31	82.86 ± 0.21	3.51 ± 0.08	5.46 ± 0.04	5.28 ± 0.61
Purplish-white-fleshed	9.66 ± 0.13	79.34 ± 0.23	5.40 ± 0.16	6.75 ± 0.05	5.03 ± 0.52

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Gembili flour is a product that has high calories because it contains many carbohydrates, similar to other flours derived from tubers, such as cassava flour and mocaf flour (Sabda et al., 2019; Wa Ode et al., 2021). The results in Table 2 showed that the carbohydrate content of white-fleshed gembili flour was higher than that of purplish-white-fleshed gembili flour, which was thought to be due to the carbohydrate content in the tubers as reported by Prasetyo and Winardi (2022) that the carbohydrate content in white sweet potato is higher than that in purple sweet potato, which is 89.65% and 89.41% respectively. The results of carbohydrate content in this study were higher than a previous study by Imzalfida (2016), who reported a carbohydrate content of 66.52%, and there were no standards for carbohydrate content in the Indonesian National Standards.

Flour is expected to have a high protein content, so no substitution is needed in its application (Richana and Sunarti, 2004). The protein content of white-fleshed gembili flour is lower than that of purplish-white-fleshed gembili flour, both of which are still relatively lower than the protein content of wheat flour, which is at least 7% (SNI 3751:2009). This finding is still lower than that reported by Richana and Sunarti (2004), who reported that protein content is 6.11%, which is thought to be caused by the nature of origin. Namely, the protein content in different tubers and during processing can cause protein loss (Wa Ode et al., 2021).

The ash content indicates the mineral content in a particular product; the high or low mineral content influences the value (Sofiati et al., 2020). Data from the analysis of ash content (Table 2) show that white-fleshed gembili flour has a lower ash content than purplish-white-fleshed gembili flour, which is thought to be influenced by the type of tuber and soaking process, which can cause the dissolution of minerals in water (Wa Ode et al., 2021; Witdarko et al., 2022). The high ash content in flour can cause the colour of flour to darken owing to the content of inorganic minerals that are resistant to high temperatures (Wa Ode et al., 2021), as shown in Figure 3. This finding is higher than Richana and Sunarti (2004), who reported an ash content of 2.87% and did not meet the standard of SNI 3751:2009 (wheat flour), SNI 7922-2011 (mocaf flour) or SNI 01-3729-2008 (sago flour), with maximum ash contents of 0.7%, 1.5%, and 0.5%, respectively.

Gembili flour has a high crude fibre content consisting of cellulose, lignin, and hemicellulose, which prevents dysfunction in the digestive tract (Oktavianasari et al., 2023). The results of crude fibre analysis in Table 2 show that white-fleshed gembili flour has a higher crude fibre content than purplish-white-fleshed gembili flour, which is the same as the study by Richana and Sunarti, (2004), who reported crude fibre content of 2.29% - 5.64%. The crude fibre content in this study was higher than the maximum crude fibre contents of sago flour (SNI 01-3729-2008) and mocaf flour (SNI 7922-2011), which were 0.5% and 2.0%, respectively.

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3.3 Sensory Characteristics

The results of the organoleptic tests conducted on gembili tuber flour on the parameters of colour, texture, aroma, taste, aftertaste, and general consumer acceptance (overall) are shown in Table 3.

Table 3. Level of favorability from two types of gembili flour

Type of Gembili Flour	Sensory Characteristics					
	Colour	Aroma	Texture	Taste	Aftertaste	Overall
White-fleshed	3.89±0.80	3.97±0.38	3.57±1.07	3.20±0.99	3.63±0.69	3.60±0.81
Purplish-white-fleshed	3.37±0.84	3.86±0.65	3.57±0.85	2.83±0.92	3.57±0.65	3.29±0.67

The average score of the colour parameter (Table 3) of white-fleshed gembili flour is higher than that of purplish-white-fleshed gembili flour. It indicates that the panellists "Somewhat Like" both types of flour, which is thought to be related to the appearance of the colour of white-fleshed gembili flour which is brighter in colour compared to purplish-white-fleshed gembili flour (Figure 3) so that makes the score higher. According to Lamusu (2018), colour is the first impression that panellists will assess; an attractive colour invites panellists or consumers to taste the product.

The average score of aroma parameters of white-fleshed and purplish-white-fleshed gembili flours in Table 3 shows that panellists "Somewhat Like" the aroma of the flour tested. However, the score for white-fleshed-gembili flour was higher but similar to purplish-white-fleshed gembili flour. This data shows no deviant aroma caused by the two types of gembili flour other than the typical aroma of gembili flour. Generally, consumers prefer the distinctive aroma of products that do not deviate from the normal aroma (Ningsih and Noerhartati, 2019).

The average score for texture parameters (Table 3) on white-fleshed and purplish-white-fleshed gembili flour carried out by touching and tasting panellists is the same. It indicates that panellists "Somewhat Like" the texture of the flour tested; this is because both gembili flours are fine-textured (80 mesh) and have fineness modulus values that are not significantly different (Table 1).

The average score of the taste for white-fleshed gembili flour in Table 3 is higher than the score for purplish-white-fleshed gembili flour. It was more preferred (Somewhat Like) than purplish-white-fleshed gembili flour, which had a lower average score, which means the panellists' "Dislike" of the taste of the flour.

The aftertaste parameter in this study was to determine the presence of bitterness in the gembili flour and to confirm the effect of soaking on the bitter taste that usually arises from gembili tubers. The average score of the aftertaste parameter in Table 3 shows that the score for white-fleshed gembili flour is higher than the score for purplish-white-fleshed gembili flour, related to the taste parameter. Panellists felt "Quite like" and had no lingering bitterness after tasting gembili flour.

4. Conclusion

The type of gembili tuber used to make gembili flour can affect its yield, physical properties, chemical properties and sensory characteristics. Flour from white fleshed gembili tubers has a high yield, whiteness, carbohydrate content and crude fibre, which can be used as a rice analogue, noodles, cake mix, filler and cookies. Meanwhile, gembili flour from purplish-white-fleshed tubers has a higher protein and ash content for bakery products. Sensory assessment showed that gembili flour from tubers with white-fleshed was preferable to gembili flour from tubers with purplish-white-fleshed. The water content of gembili flour in this study meets SNI and has the potential to be developed as a composite flour for food products.

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