The Physicochemical Characteristics of Palado Seed Flour *(Aglaia* sp.) and Its Potential Use as a New Alternative Flour in Indonesia

Syamsul Rahman[1*], Salengke Salengke[2], Abu Bakar Tawali[3], Meta Mahendradatta[4]

[1]Agribusiness Study Program, Faculty of Agricultural, Universitas Islam Makassar,
Jl. Perintis Kemerdekaan Km 9 No.29, Makassar, Sulawesi Selatan 90245, Indonesia
[2]Departement of Engineering Agricultural, Faculty of Agriculture, Universitas Hasanuddin, Indonesia
[3,4]Departement of Food Science and Technology, Faculty of Agriculture, Universitas Hasanuddin, Indonesia.
Jl. Perintis Kemerdekaan Km 10, Makassar, Sulawesi Selatan, 90245, Indonesia
[*]Corresponding author: Syamsul Rahman, Email: syamrah68@gmail.com

Submitted: January 17, 2021; Revised: August 11, 2021; September 7, 2021; Accepted: September 11, 2021

ABSTRACT

Flour is one of the main energy sources for humans and an important ingredient in food processing, for use as fillers, thickeners, gel, film forming and adhesives. Therefore, this study aimed to analyze the physicochemical characteristics of palado seed flour *(Aglaia* sp.) including proximate analysis and chemical properties comprising energy, carbohydrates, water, and protein, content, as well as dietary fiber, starch, amylose and amylopectin. Furthermore, the physical properties including yield, particle size, degree of whiteness, paste clarity, gel strength, swellability and water absorption, as well as the potential use of palado flour (*Aglaia* sp) in food processing were analyzed. The study was conducted with a method comprising two stages, namely pre-treatment including processing palado fruit into seeds, drying, and extracting flour, as well as proximate analysis of the physicochemical characteristics. The results showed energy content of 396.14 kcal/100 g, carbohydrates 69.78%, water content 7.53%, protein 9.59%, fat 8.74%, dietary fiber 4.02. %, ash 4.36%, starch 41.31%, amylose 5.68% and amylopectin content 35.63%. Meanwhile, the physical characteristics include the yield of 84.21% with a particle size of 60 mesh, degree of whiteness 29.27%, paste clarity 29.7%, gel strength 109.96 gf, swelling power 0.4%, and water absorption 133.72 %. Based on the results, palado flour has high potential to be developed as the main or alternative ingredient in bread and noodle processing, such as durian and jackfruit seed flour.

Keywords: *Aglaia sp* seed flour; characteristics; physicochemical; new alternative flour

INTRODUCTION

Only 3.000 out of 800.000 known plants are edible species, but at present, only 150 species are regularly consumed, from which 12 are sources of staple food worldwide, such as wheat, rice, corn, potato, sweet potato, cassava, banana, coconut, soybean, common bean, sugar cane and beet (Somowiyarjo, 2015). The Kementerian Negara Riset dan Teknologi Republik Indonesia, (2006) has identified various forest-based plants which have the potential to be used as food sources. One of the edible plant organs is palado seeds (*Aglaia* sp.) which are endemic to Sulawesi, particularly the Western part. Traditionally, people who live near the forests and watersheds in Karama Regency Mamuju eat the unknown seeds as snacks, it also serves as the staple food during poor harvest times. However, the changes in the eating habits or diet of the communities, development

DOI: http://doi.org/10.22146/agritech.63255
ISSN 0216-0455 (Print), ISSN 2527-3825 (Online)

of food technology, socio-economics and culture, as well as the situation of the global trade contributed greatly to the introduction of new food products which gradually replaced palado seeds (*Aglaia* sp.).

Palado (*Aglaia* sp.) is a of *Meliaceae* and its population is found in West Sulawesi, mainly found in the valleys and mountains of the Mamuju, North Mamuju, Majene, Polman, and Mamasa region. The plant thrives naturally in the lower mainlands to the highlands. According to (Praptiwi et al., 2006)A. silvestria (M. Roemer *Malanesia* regions have diverse types of *Aglaia* namely Borneo (50 species) and Sumatra (38 species). As reported by (Praptiwi et al., 2006)A. silvestria (M. Roemer some species are used to make wood as a building material, and fruits for consumption, while *A. odorata* flowers are used for fragrances in beverages and cosmetics.

Based on the observation, most of the potential threats to the survival of palado plants (*Aglaia* sp.) in Mamuju come from human activities (Rahman, 2013). Activities such as forest burning, illegal logging, land clearing, and land conservation, in the surrounding communities, can disturb the natural habitats of these wild plants. Additionally, the latest threat is the exploitation of the wood by the community to be sold as building materials. The use of palado fruits as a food alternative is rare in the communities around the forest. Lempang & Asdar (2006) reported that timber is categorized into the third class of strong wood, culminating in its use as a material for light loads' construction such as rafters, battens, walls, trim, and celling. Palado wood can also be used as a material for molding, finir, pallet as well as pulp and paper. It is a wild plant and can live up to hundreds of years with the tree height reaching between 30-50 m. This plant produces fruits once a year after reaching the age of 10, while the flowering season starts in September and the harvest time is from February to March. On average, palado plants that are already 10 years old can produce wet palado fruits as much as 250-500 kg. In other words, forest-based fruits, which have been used for food by local people for generations, still had limited uses due to the need for boiling, frying, or roasting. In terms of nutrient composition, a hundred grams of dried palado seeds contains 8.94% crude protein, 14.75% crude fat, 3.74% crude fiber, 64.04% carbohydrate, 4.87% water and 3.66% ash (Rahman, 2013).

The problems in processing palado fruit into wet seeds include rapid browning with high-fat and water content. Therefore, the processing of semi-finished products must be conducted to preserve the harvest. Due to the limited application and the short shelf life of wet palado seeds, flouring is necessary to facilitate its uses as a food ingredient. According to Pangastuti et al., (2013) flour processing is an alternative process. Semi-finished products are recommended because they are more durable when stored, easily mixed with other flour, can be enriched or fortified with nutrients, malleable, and more quickly cooked to match the demands of the very practical modern life. The emergence of more diverse products can also encourage the development of flour-based industries, thereby increasing the resale value of the commodities (Rahmawati et al., 2012). Based on the information above, this study aimed to investigate and assess the potential of palado seeds as a food source alternative by processing into flour and examine its physicochemical properties. The results are expected to encourage the use of palado seeds to provide food and flour for industries as well as to rehabilitate land and conserve soil.

MATERIALS AND METHODS

Material

The raw material used was palado fruits from forests around Karama river basin, Sampaga district, Mamuju regency, West Sulawesi, Indonesia, with optimal maturity when falling from the tree. The chemicals used for the analysis were distilled water, HNO_3, diethyl ether, K_2SO_4, HgO, H_2SO_4, HCl, I_2, KI (Kimia Farma, Scotland) and other chemistry analysis materials obtained from the Laboratory of Research Testing and Postharvest Development, Bogor, Laboratory of Department of Industrial Technology of Agriculture, and the Laboratory of the Department of Food Science and Technology, Faculty of Agricultural Technology, Agricultural Institute of Bogor.

Instruments

The instrument used to analyze the physicochemical properties of palado flour are Blender (Phillips HR2057, Dutch), FFA 23 A model disc mil, automatic Siever, cabinet dryer (H.ORTH.GmbH D-6700, ITHU type, West Germany), color reader, furnaces, ovens (Memmer U-30), an analytical balance (Explorer), Stable Micro Systems (TAXT-2 Texture Analyzer), desiccator, Soxhlet device Kjeldahl, water bath (Memmert P Selecta Precisterm, Iran), centrifuge (Hettich Zentrifugen-EBA 20), viscometer, and digital scales (Adventurer Pro). Furthermore, the texture analyzers employed were colorimeter, oven, filter cloth, cup, petri dish, Erlenmeyer, beakers, mohr pipettes, thermometer, spectrophotometer (UV-Vis Shimadzu UV Mini 1240, Indonesia), 60 mesh sieve, cylinder, Griffin shake flask, and other equipment in the laboratory.

This study was divided into three stages, the first is a preliminary treatment which includes processing palado fruit into seeds, drying, and extracting flour, while the second is the main study comprising proximate analysis of the physicochemical characteristics.

Making Palado Seed Flour

Selected palado fruits were peeled manually, with boards as cooking pads and small round pieces of wood to press the base using both hands to push the seeds. This was done until enough seeds were obtained, which were then dried for 4-four days to reach a moisture content of 4.87% with an average temperature of 35ºC. The flouring process adopted the method from (Khomsatin et al., 2012) in manufacturing cornmeal. It began by soaking the dried seeds in 2 kg of water for 12 hours, with a temperature of 37 ºC. Subsequently, the water was drained and the seeds were milled with a disc mill, the obtained flour was placed inside a heated cabinet with a dryer for 15 -18 hours until it dried at a temperature of 50 – 60 ºC. The flour was sifted using a 60 mesh sieve, or with a particle size of 0.250 mm, while the yield was calculated using Equation 1, an approach used by (Akanbi et al., 2009).

$$Flour\ yield\,(\%) = \frac{Weight\ of\ flour\,(g)}{Weight\ of\ edible\ portion\,(g)} \quad (1)$$

Proximate Analysis and Chemical Properties of The Flour

The proximate analysis of palado seed flour was carried by adopting a standard method reported by (Cheng & Bhat, 2015)physicochemical and sensory qualities of substituting jering seed flour into wheat chapatis (unleavened Indian flat bread which included the determination of moisture content, protein, fat, and crude fiber through three replications. The moisture content is determined by hot air oven method (AOAC, 1995; Carolina & Ilmi, 2016). The crude protein content was determined by Kjeldahl method SNI 01-2891-1992 (Carolina & Ilmi, 2016), and crude fat content was determined by Soxhlet Extraction (AOAC, 1995; Carolina & Ilmi, 2016), crude fibesr are determined by (AOAC, 1995; Carolina & Ilmi, 2016), dry ash (AOAC, 1995; Carolin & Ilmi, 2016) for ash content and difference method (AOAC, 1995; Alozie & Chinma, 2015) for carbohydrate content. The energy is calculated by multiplying the total weight (g) by crude proteins, carbohydrates, fats, and total fiber foods by factors of 4, 4, 9 and 2 (AOAC, 1995). To analyze the flour chemical properties, the total starch content was determined by using starch hydrolysis with acid and reduced sugar which was assessed by the Anthrone method (AOAC, 1995). The amylose content was determined by the method described by (AOAC, 1995; Ng et al., 2014)pH and amylose content of ripe Cavendish banana flour (RBF, with the analysis carried out in three repetitions.

Analysis of The Physical Properties' Characteristics of The Flour

The palado flour physical properties included the analysis of whiteness, paste clarity, swelling power, gel strength, and water absorption using the following treatments which were conducted three times for each characteristic.

Determination of the Flour Color

The color of palado flour was determined using a method previously described by (Cheng & Bhat, 2015) physicochemical and sensory qualities of substituting jering seed flour into wheat chapatis (unleavened Indian flat bread through the use of a colorimeter (Minolta Spectrophotometer CM-3500d, Japan) calibrated by the standard white and black plate. The sample color was written in terms of L^* (lightness), a^* (green, $-a$ to red, $+a$) and b^* (blue, $-b$ to yellow, $+b$).

Determination of The Paste Clarity of The Flour

The paste clarity was determined by using the method of (Muliani et al., 2013), about 1% of the starch solution was heated in the water bath at 95^{o}C for 30 minutes while stirring, and then cooled to a temperature of 25 °C for 1 hour. A spectrophotometer was used to measure the paste clarity with transmittance percentage (%T) at 650 nm and distilled water was used as a blank.

Determination of The Swelling Power of The Flour

The swelling power was determined by using the method reported by (Pranoto et al., 2014), 0.2 g of palado flour was inserted into the centrifuge tubes and added with 10 ml of distilled water. The samples were equilibrated at 25 °C for 5 minutes and then placed in the water bath at 95 ºC for 30 minutes. Subsequently, they were cooled at 20 °C for one minute, while the starch samples were centrifuged at 3500 rpm for 15 minutes to separate the gel and the supernatant, then the gel was weighed to determine the swelling power by using Equation 2.

$$Swelling\ power = \frac{(gel\ \ weight + container) - (sample\ weight + container)}{sample\ weight} \quad (2)$$

Determination of The Gel Strength

The gel strength was determined using *Stable Micro Systems* (TAXT-2 *Texture Analyzer*). Gelling was conducted using the method described by (Muliani et al., 2013), the gel was made by dissolving 10 g of palado flour using 100 g of distilled water, then it was heated for 30 minutes at 95 °C. When the paste was still hot, it was placed in the plastic cylinders 3.5 cm diameter, 4.0 cm height, covered with aluminum foil and stored for 1 hour at room temperature and 24 hours at 40 °C. The gel was pressed using a cylinder with a diameter of 10 mm at 1.0 mm/s, and a distance of 10 mm, gel strength is the maximum value for emphasis expressed in gel-force/gf.

Measurement of Powdery Water Absorption

The water absorption was determined using the method of Yamazaki (1953) which was modified by (Amoo et al., 2014) most of wich are imported for a fee. Research on the exploitation of alternative starch sources will reduce the burden of imports. Starches from the flour of local varieties of Dioscorea rotundata namely Pona, Labreko, Asobayere and Muchumudu was analyzed to determine its physicochemical and functional properties. Results obtained showed significant differences ($p<0.05$). Dilution of flour suspense is carried out with 2.0 g of dry weight of palado in 40 ml of water, then stirred for 1 hour in a Griffin shake flask and centrifuged at 2200 rpm for 10 minutes. Free water is separated from the wet starch, further dried for 10 minutes, and then weighed**.**

Table 1. The proximate composition and chemical properties in 100 g of palado flour (% dried basis)

Parameter (unit)	Value
Energy (kcal)	396.14±0.031
Carbohydrate (%)	69.78±0.016
Water content (%)	7.53±0.024
Protein (%)	9.59±0.014
Fat (%)	8.74±0.009
Dietary fiber (%)	4.02±0.012
Ash (%)	4.36±0.014
Starch (%)	41.31±0.012
Amylose (%)	5.68±0.014
Amylopectin (%)	35.63±0.008

RESULTS AND DISCUSSION

Proximate Composition and Chemical Characteristics of The Palado Flour

Palado, an indigenous plant commonly found in West Sulawesi, Indonesia has not fully utilized as food source. Due to the high carbohydrate content in palado seeds, it could be a potential material for making flour. This study aimed to investigate and assess the potential of palado seeds as a flour and examine its physicochemical properties. The result showed that approximately 84.21% of flour yield was obtained. The flour has fine fibers and is easily smoothed, thereby passing through even smaller sieves. According to (Amoo et al., 2014) most of wich are imported for a fee. Research on the exploitation of alternative starch sources will reduce the burden of imports. Starches from the flour of local varieties of Dioscorea rotundata namely Pona, Labreko, Asobayere and Muchumudu was analyzed to determine its physicochemical and functional properties. Results obtained showed significant differences ($p<0.05$) starch test results are measured as a persentage obtained afterwards extracting 1 kg of raw materials. Therefore, there is no prospect of developing palado to serve as starch and flour. The results of proximate analysis and chemical characteristics for palado flour which include moisture content, protein, dietary fiber, fat, ash, energy, carbohydrates, starches, and amylose as in Table 1.

The Energy and Carbohydrate Contents of The Flour

Palado flour contains 396.14 kcal of energy and 69.78% carbohydrate, this is greater than wheat by 365 kcal, rice by 364 kcal, and corn flour by 355 kcal, respectively (Direktorat Gizi Departemen Kesehatan RI, 1981). Furthermore, the energy content is almost similar to sweet potato flour, ranging from 392.00 kcal to 399.60 kcal (Mohd Hanim et al., 2014). The high energy content of palado flour is due to its high fat content of 8.74%, since 1 g of fat is equivalent to 9 calories. In contrast, it has a lower carbohydrate content than the 77.3% in wheat flour, 80.0% in rice and 73.7% in corn flour (Nutrition Directorate, the Ministry of Health, Republic of Indonesia, 1996), compared to the carbohydrate content of sweet potato flour ranges from 86.35%-88.40% *(*Mohd Hanim et al., 2014). Carolina & Ilmi, (2016) reported that the carbohydrate content of red and white canna are 97.88% and 96.53%, respectively.

The water content of the flour

The water content analysis shows that palado flour contains 7.53% water, which is higher than the content in sweet potato flour (4.40%-5.15%) as reported by (Mohd Hanim et al., 2014). Additionally, the water content of wheat and *Jering* seeds flour were 11.32% and 7.58%, respectively (Cheng & Bhat, 2015) physicochemical and sensory qualities of substituting jering seed flour into wheat chapatis (unleavened Indian flat bread. The amount of water in the material will affect the durability against damages caused by microorganisms and insects. Flour is dried to reduce the moisture content thereby inhibiting the growth of microbial and enzyme activities which cause damage to the flour/starch. The water content in food affects the durability against microbes, which is expressed as water activity (A_w). It refers to the amount of free water that can be used by microorganisms for growth (Carolina & Ilmi, 2016), according to a previous report, microbes are still capable of growing with 14% - 15% of water content (Richana & Sunarti, 2004).

Fat content of the flour

Based on the results, the fat content is 8.74%, generally, palado flour has higher fat than the 1.57% in wheat (Cheng & Bhat, 2015)physicochemical and sensory qualities of substituting jering seed flour into wheat chapatis (unleavened Indian flat bread, 1.00% in rice, and 1.00% in tapioca flour (Imanningsih, 2012). Furthermore, (Waterschoot et al., 2014) stated that the fat content of corn starch ranges from 0.6%- 0.8%, 0.8%-1.2% in wheat, and 0.6%-1.4% in rice starch. A previous study found that during the extraction process, the fat content is still bound to starch, therefore, because it does not disappear along with the pulp, it can increase the weight of starch (Richana & Sunarti, 2004). However, an extremely high fat content is considered an excessive nutritional factor, and is also less profitable in the process of starch storage because it causes rancidity (Pangastuti et al., 2013). Fat content can disrupt the starch gelatinization process because it potentially forms complexes with amylose, thereby inhibiting the release of amylose from the starch granules (Richana & Sunarti, 2004). Most of the fat is absorbed by the surface of the granules which forms the hydrophobic layer of fat. The fat layer will inhibit the binding of water by the starch granules culminating in the reduction of thickness and viscosity by the amount of water reduced.

The protein content of palado flour

The protein content is 9.59%, this is langer than sweet potato flour ranging from 3.50% to 3.85% (Cheng & Bhat, 2015)physicochemical and sensory qualities of substituting jering seed flour into wheat chapatis (unleavened Indian flat bread. This amount is lower than the wheat (13.38%) and the in Jering seed flour (15.20%) (Cheng & Bhat, 2015) physicochemical and sensory qualities of substituting jering seed flour into wheat chapatis (unleavened Indian flat bread. Flour or starch with lower protein levels tends to have high viscosity, thereby increasing the quality of the flour (Richana & Sunarti, 2004). Protein and starch form a complex with the surface of the granules and cause the starch viscosity to drop, culminating in lower gel strength. In contrast, the protein content is expected to be high due to the use of starch, hence, when it is used, no further substitute material will be required.

The ash content of the flour

The analysis results show that the ash content is 4.36%, this is higher than that of sweet potato, which ranges between 2.75 to 3.20% (Alozie & Chinma, 2015) as well as wheat and Jering seed flour of 0.84% and 1.34% respectively (Cheng & Bhat, 2015) physicochemical and sensory qualities of substituting jering seed flour into wheat chapatis (unleavened Indian flat bread. The quantitative value of the ash content contained in starch is sourced from minerals in seeds as well as from the soil and air contamination during processing. In addition, food processing can also affect the availability of minerals in the body (Andarwulan et al., 2011). The use of water in the washing process and immersion reduces the availability of minerals due to the use of water for extraction. In other words, the extraction process in food reduces the mineral content.

Fiber content of the flour

The analysis shows that the fiber content of the flour is 4.02%, which is higher than in wheat (2.55%) and Jering seeds flour (2.03%), respectively (Cheng & Bhat, 2015)physicochemical and sensory qualities of substituting jering seed flour into wheat chapatis (unleavened Indian flat bread. However, it is still lower than the fiber content of sweet potato flour which ranges between 11.20% to 14.80% (Mohd Hanim et al*., 2014)* due to the presence of cellulose fibers with less lignin and hemicellulose. According to (Richana & Sunarti, 2004), starch generally contains lower fiber than flour because during the extraction process, large fiber is washed away together with dregs. (Herawati & Sri Widowati, 2009) also stated that fiber-containing starch is very low compared to flour because in the extraction process, most fibers contained in the dregs have been separated. Besides, the fiber content of the starch is affected by the harvesting method and source. When the starch content at the source has reached its optimum limit, then the next batch in grain crops will continue to fall slowly and begin to change into fibers (Richana & Sunarti, 2004).

Starch Flour

The starch content of palado flour was 41.31%, which was higher than that of yam (38.80%) (*Dioscorea hispida*) (Santoso et al., 2015) and canna starch (40.18%) (Richana & Sunarti, 2004). Based on the results, palado seed has the potential to be used as composite flour. According to (Akanbi et al., 2011) noodles produced from a mixture of 20% breadfruit and 80% wheat flour show superior proximate, culinary sensory attributes, because both materials are high in crease fiber which has been reported to reduce symptoms of chronic constipation, heart disease associated with high cholesterol, diverticular disease, and risk of colon cancer. Therefore, it can be concluded that the noodles produced from breadfruit along with wheat flour are better than ordinary noodles, and are important functional food (Nasution et al., 2017).

Palado seed is also suitable as an alternative flour in food processing and can compete with breadfruit flour mainly because it is rich in minerals, carbohydrates, and gluten-free. According to (Ravinder et al., 2018) gluten-free flour is beneficial because it helps reduce the symptoms of chronic constipation, the risk of colon cancer, and minimizes symptoms associated with celiac disease. Palado seed flour can also compete with jackfruit, which is mixed with rice and pigeon pea flour, according to (Sharma et al., 2019)particle size (PS higher substitution of jackfruit flour in the mixture causes the particle size and water absorption capacity to increase in the peak viscosity, through the relative crystallinity, oil absorption capacity, and it also decreases the foaming properties.

Anggraeni & Yuwono, (2014) reported that based on the analysis results in raw materials of sweet potato *(Ipomoea batatas)* the starch content is 23.55%, 22.78%, and 16.37% in the Red, White, and Ayamurasaki or purple variety respectively. The starch content of foodstuffs can be influenced by plant age and storage after harvesting (Kusnandar, 2019). Meanwhile, the factors that influence the drying process foodstuffs are the initial moisture content of the material, environmental humidity, and heat transfer media intermediaries (Santoso et al., 2015). Furthermore, (Richana & Sunarti, 2004) explained that the starch content of foodstuffs is one of the criteria for making high-quality flour, both as food and non-food ingredients.

Amylose-Amylopectin Content of The Starch

The amylose and amylopectin content is 5.68% and 35.63% respectively, this shows that the ratio in the palado starch is 1:5. According to Waterschoot et al., (2014), the distinction of starch production depends on the difference between the amylose and amylopectin content, structure, granular organization, the presence of lipid, protein and minerals, as well as the size of the starch granules. Kusnandar (2019) reports that the ratio of amylose and amylopectin in starch granules is very important and is often used as a parameter for the selection of starch sources as well as during food processing in providing desired functional properties. This is because the ratio affects the ability of starch pastes when forming gels, as well as in thickening, or forming films. The amylose component is is strongly associated with increased water absorption and perfection of the product gelatinization process, while amylopectin determines the product development ability (Hidayat et al., 2009).

Moreover, both content also influences the starch granule size and molecular weight, this is because the amylose fraction forms an amorphous part of granules and increases the size, but the molecular weight is not significantly high, namely 10^6 unit (Richana & Sunarti, 2004). Amylose and amylopectin content also affect the physicochemical properties of the starch i.e. gelatinization temperature power development (*swelling* power) and solubility. As stated by (Behall & Howe, 1995), consumption of food high in amylose normalizes the insulin response of hyperinsulinemia subjects and shows potential benefits for diabetics. The analysis results on the physical properties of palado flour including whiteness, paste clarity, gel strength, *swelling* power, and water absorption are shown in Table 2.

Table 2. Characteristic of physical properties of palado (*Aglaia sp.*) flour

Parameter	Value
Whiteness (%)	29.27±0.014
Pasta clarity (%T)	29.70±0.012
Gel strength (gf)	109.96±0.017
Swelling power (%)	0.41±0.014
Water absorption (%)	133.72±0.017

Whiteness of The Flour

The whitishness rate of palado flour is 29.27%, this shows higher than coconut yam flour (*Dioscorea alata*) by 20.05%. However, it is lower than suweg (*Amorphophallus campanulatus*) by 39.05% (Richana & Sunarti, 2004). So that the results of this study show that the whitish level of palado flour is lower than the quality standards listed in the Indonesian National Standard

(SNI), which requires that the minimum discharge of starch must be 85%. Browning is the process of a yellow pigment formation which eventually turns into dark brown due to the oxidation of polyphenolic compounds by polyphenols enzyme naturally present in food (Yulianti & Ginting, 2012). This change also takes place during the processing of fruits into seeds and the immersion in the flouring process. The color change occurs especially during drying using sunlight, the longer the drying process, the more susceptible the sample to polyphenols enzyme activity. To inhibit the polyphenols' enzyme activity, sulfite salt or chloride can be added to the water bath during starch processing (Ginting et al., 2015)chemical, and sensorial characteristics of 10 promising clones of purple-fleshed sweet potato and two varieties (Ayamurasaki and Antin 1.

Paste Clarity of The Flour

The analysis of paste clarity is associated with dispersion properties and retrogradation, according to (Haryanti et al., 2014), paste clarity is related to retrogradation, which is the re-establishment of hydrogen bonds of amylose molecules. The formation of stronger hydrogen bonds between the molecules of amylose culminates in syneresis, i.e, water separation from starch gel structure. The greater the retrogradation, the lower the ability of passing light, thereby reducing paste clarity (Haryanti et al., 2014). Based on the analysis, the value of paste clarity of palado flour is 29.7%T, (Hardiyanti et al., 2013), which is lower than that of modified potato starch (33.30%T), but higher than the value for tapioca starch, namely 28.30% T (Haryanti et al., 2014). This is due to the repeated heating process during the processing of palado flour, which affected the clarity of the paste produced.

Gel Strength of The Flour

Gel strength is the amount of load for deforming the gel before the breakdown or damage, according to (Aini et al., 2009), it correlates with the protein level and starch ratio, the higher the protein content, the lower the gel strength. Therefore, the lack of water absorbed by the starch can inhibit the gelatinization process, lowering the peak paste viscosity and strength of the gel produced. Based on the analysis results, the gel strength is 109.96 gel force (gf), which is higher than that of *durian* seed starch (*Durio zibethinus* Murr.) with 6.03 gf (Sumarlin et al., 2021). This is because the amylose content of palado flour is only 4.18%. Flour with low amylose content tends to undergo low retrogradation, culminating in a weak gel structure against pulling (Ginting et al., 2015) chemical, and sensorial characteristics of 10 promising clones of purple-fleshed sweet potato and two varieties (Ayamurasaki and Antin 1. The gel strength is influenced by the differences in matrices of rheological properties of amylose, volume fraction, hardness of starch granules, and also the interaction between the continuous phase and the dispersed phase in the gel (Aini & Hariyadi, 2007).

Swelling Power of The Flour

The analysis shows that the *swelling* power of palado flour namely 0.41%, is lower than that of acetylated-modified *jackfruit* seed flour (*Arthocarpus heteropyllus* Lamk.) of 7.4% as reported by (Sulistiyaningsih et al., 2019) and *lai* seed starch (*Durio kutejensis*) at 10.79% (Fiqtinovri et al., 2020). The interaction between flour molecules will be reduced when there is an acetyl group incorporated into the flour molecule. In addition, water access to the flour amorphous area rises, thereby increasing the hydration and swelling of the flour granules. The higher the amount of amylopectin in the flour, the wider the amorphous area, and the greater the water absorption. In other words, swelling power in flour is influenced by water absorption, the greater the water absorption, the higher the swelling power (Amalia & Kumoro, 2016). According to (Haryanti et al., 2014), high *swelling* power implies higher starch ability to expand in water. This is caused by the low amylose in starch which is influenced by several factors, such as water absorption, gelatinization temperature, and the amylose content. The presence of lipids in the flour or starch grains can inhibit the hydration of granules and *swelling*, mainly due to the high amount of amylopectin (Suarni et al., 2013)and then the resulting starch was analyzed for its proximate composition, physicochemical and functional properties. The results showed that the characteristics of starch from all varieties, including moisture, ash, starch, and degree whiteness satisfied the SII (Indonesian Industrial Standard. Furthermore, the formation of amylose-lipid complexes inhibits the *swelling* of starch granules, while Jufri et al., (2006)which relatively easy to find in tropic area such as Indonesia. The objective of this research was to observe the ability of durio seed starch as binder in wet granulation of ketoprofen tablet formu- lation. Durio seed starch obtained by extraction and drying methode. Starch as a paste used in wet granulation as a binder. Tablet made by wet granulation with ketoprofen (25% revealed that amylose starch can influence the development process and the viscosity level of starch.

Water Absorption of The Flour

Water absorption or the hydration capacity indicates the percentage of water that can be absorbed by the flour after it is made into dough, which is then centrifuged at 2000 rpm for 5 minutes (Hidayat et al., 2009). The analysis results show that the water absorption of palado flour is 133.72%, which is higher than the value for the enzymatically modified jackfruit seed flour (*Arthocarpus heteropyllus* Lamk.) of 31%, as reported by (Ma'rufah et al., 2016). Flour or starch with high water absorption can be used as raw materials for bread dough. Furthermore, water absorption is affected by the moisture content of the materials and the amylose – amylopectin ratio (Jading et al., 2011). High starch content increases the value of water absorption due to the role of amylose-amylopectin composition. Food with high starch content will absorb water more easily due to the availability of amylopectin molecules which are reactive to water molecules (Herawati & Sri Widowati, 2009).

CONCLUSION

Palado flour (*Aglaia* sp.) has great potential to be developed as it has 396.14 kcal/100 g energy content, 69.78% carbohydrates, 7.53% water content, 9.59% protein, 8.74% fat, 4.02% dietary fiber, 4.36% ash, 41.31% starch, 5.68% amylose, and 35.63% amylopectin content. The physical properties are 84.21% yield with 60 mesh particle size, 29.27% whiteness, 29.7%T clarity paste, 109.96 gf gel strength, 0.41% swelling power, and 133.72% water absorption. This indicates that palado flour has the potential to be used as the main raw material in food processing, for example, as the thickener in sauces which require flour with low amylose content without gel formation. Flour with high amylopectin content will give the paste a thicker and sticky texture.

ACKNOWLEDGEMENT

The author thanked the Ministry of Education, Culture, Research and Technology of the the Republic of Indonesia for the scholarship funds used for research of the Doctoral Dissertation Grant, which is part of the Dissertation of the Postgraduate School of Hasanuddin University. We would like to thank the Bogor Postharvest Research and Development Testing Laboratory, the Laboratory of the Departement of Agricultural Industrial Technology, and the Laboratory of the Departement of Food Science and Technology, Bogor Agricultural University, Indonesia, which allowed the use of facilities to test samples during the implementation of the research.

CONFLICT OF INTEREST

There is no conflict of interest between the authors and any party.

REFERENCES

Aini, N., & Hariyadi, P. (2007). Pasta pati jagung putih waxydan non-waxy yang dimodifikasi secara oksidasi dan asetilasi-oksidasi abstract pasta of modified waxy and non-waxy white corn. *Jurnal Ilmu Pertanian Indonesia*, *12*(2), 108–115.

Aini, N., Hariyadi, P., Muchradi, T. R., & Andarwulan, N. (2009). Chemical and rheological properties correlation of white corn flour influenced by spontaneous fermentation of corn grits. *Forum Pascasarjana*, *32*(1), 33–43.

Akanbi, T. O., Nazamid, S., & Adebowale, A. A. (2009). Functional and pasting properties of a tropical breadfruit (Artocarpus altilis) starch from Ile-Ife, Osun state, Nigeria. *International Food Research Journal*, *16*(2), 151–157.

Akanbi, T. O., Nazamid, S., Adebowale, A. A., Farooq, A., & Olaoye, A. O. (2011). Breadfruit starch-wheat flour noodles: Preparation, proximate compositions and culinary properties. *International Food Research Journal*, *18*(4), 1283–1287.

Alozie, Y. E., & Chinma, C. E. (2015). Proximate composition, physical and sensory properties of cake prepared from wheat and cocoyam flour blends. *Journal of Food Research*, *4*(5), 181–188. https://doi.org/10.5539/jfr.v4n5p181

Amalia, R., & Kumoro, A. C. (2016). Analisis sifat fisikokimia dan uji korelasi regresi antara nilai derajat substitusi dengan swelling power dan solubility pada tepung gadung (Dioscorea hispida Dennst) terasetilasi. *Inovasi Teknik Kimia*, *1*(1), 17–26.

Amoo, A. R. N., Dufie, W.-M. F., & Ibok, O. (2014). Physicochemical and pasting properties of starch extracted from four Yam varieties. *Journal of Food and Nutrition Sciences*, *2*(6), 262–269. https://doi.org/10.11648/j.jfns.20140206.14

Andarwulan, N., Kusnandar, F., & Herawati, D. (2011). *Analisis Pangan*. Dian Rakyat.

Anggraeni, Y. P., & Yuwono, S. S. (2014). Effect of natural fermentation in chips of sweet potato (Ipomoea batatas) against physical properties of wheat sweet potato. *Jurnal Pangan Dan Agroindustri*, *2*(2), 59–69.

Behall, K. M., & J.C. Howe. (1995). Effect of long-term consumption of amylose vs amylopectin starch on metabolic variables in human subjects. *American Journal of Clinical Nutrition*, *61*(2), 334–340. https://doi.org/ https://doi.org/10.1093/ajcn/61.2.334

Carolina, Y. F., & Ilmi, F. . (2016). Production of Indonesian Canna edulis type IV resistent starch through acetylation modification. *International Food Research Journal*, *23*(2), 492–497.

Cheng, Y. F., & Bhat, R. (2015). Physicochemical and sensory quality evaluation of chapati (Indian flat bread) produced by utilizing underutilized jering (Pithecellobium jiringa Jack.) legume and wheat composite flours. *International Food Research Journal*, *22*(6), 2244–2252.

Fiqtinovri, S. M., Benita, A. M., Marseno, D. W., & Pranoto, Y. (2020). Sifat fisik, amilograf, dan morfologi pati biji Lai (Durio kutejensis) asetilasi menggunakan asetat anhidrat. *AgriTECH*, *40*(1), 74–83. https://doi.org/10.22146/agritech.33809

Ginting, E., Yulifianti, R., Jusuf, M., & Mejaya, M. J. (2015). Identifikasi sifat fisik, kimia, dan sensoris klon-klon harapan ubijalar kaya Antosianin. *Jurnal Penelitian Pertanian Tanaman Pangan*, *34*(1), 69–78. https://doi.org/10.21082/jpptp.v34n1.2015.p69-78

Hardiyanti, R., Rusmarilin, H., & Karo-Karo, T. (2013). Karakteristik mutu mie instan dari tepung komposit pati kentang (quality characteristics of instant Noodles made from Flour composites of modified potato starch , mocaf flour and wheat flour with the addition of Phospate salt). *Jurnal Rekayasa Pangan Dan Pertanian*, *1*(3), 25–40.

Haryanti, P., Setyawati, R., & Wicaksono, R. (2014). Pengaruh suhu dan lama pemanasan suspensi pati serta konsentrasi Butanol terhadap karakteristik fisikokimia pati tinggi Amilosa dari tapioka. *Jurnal Agritech*, *34*(03), 308–315. https://doi.org/10.22146/agritech.9459

Herawati, H., & Sri Widowati. (2009). Karakteristik beras mutiara dari ubi jalar (Ipomea batatas). *Buletin Teknologi Pascapanen Pertanian*, *5*, 37–44.

Hidayat, B., Kalsum, N., & Surfiana. (2009). Characterization of modified cassava flour processed trough partial pregelatinisation method. *Journal of Industrial Technology and Agricultural Products*, *14*(2), 148–159. file:///C:/Users/acer/Downloads/DATA TENANT PDG PASAR SGS 2021/junal nurbani.pdf

Imanningsih, N. (2012). Profil gelatinisasi beberapa formulasi tepung-tepungan untuk pendugaan sifat pemasakan (Gelatinisation profile of several flour formulations for estimating cooking behaviour). *Penel Gizi Makanan*, *35*(1), 13–22.

Indonesia, D. G. D. K. R. (1981). *Daftar komposisi ahan makanan*. Bharata Karya Aksara.

Jading, A., Tethool, E., Payung, P., & Gultom, S. (2011). Karakteristik fisikokimia pati sagu hasil pengeringan secara fluidisasi menggunakan alat pengering Cross Flow Fluidized Bed bertenaga surya dan biomassa. *Reaktor*, *13*(3), 155–164. https://doi.org/10.14710/reaktor.13.3.155-164

Jufri, M., Dewi, R., Ridwan, A., & Firli. (2006). Studi kemampuan pati biji durian tablet ketoprofen secara granulasi basah. *Majalah Ilmu Kefarmasian*, *3*(2), 78–86.

Kementerian Negara Riset dan Teknologi Republik Indonesia. (2006). Indonesia 2005-2025 Buku Putih. *Buku Putih Penelitian, Pengembangan Dan Penerapan Ilmu Pengetahuan Dan Teknologi Bidang Teknologi Informasi Dan Komunikasi Tahun 2005-2025 Republik Indonesia*, 124. http://lipi.go.id/publikasi/buku-putih-2005-2025-penelitian-pengembangan-dan-penerapan-ilmu-pengetahuan-dan-teknologi-bidang-teknologi-informasi-dan-komunikasi/11298

Khomsatin, S., Sugiyono, & Bambang, H. (2012). Kajian pengaruh pengukusan bertekanan (Steam pressure treatment) terhadap sifat fisikokimia tepung jagung [Study of The Effects of Steam Pressure Treatment on The Physicochemical Properties of Corn Flour]. *Jurnal Teknologi Dan Industri Pangan*, *23*(1), 86–93.

Kusnandar Feri. (2019). *Kimia Pangan Komponen Makro*. Bumi Aksara.

Lempang, M., & Asdar, M. (2006). Struktur anatomi, sifat fisik dan mekanik kayu palado (Aglaia sp.). *Jurnal Penelitian Hasil Hutan*, *24*(2), 171–181. https://doi.org/10.20886/jphh.2006.24.2.171-181

Ma'rufah, A., Ratnani, R. D., & Riwayati, I. (2016). Pengaruh modifikasi secara enzimatis menggunakan enzim α-Amilase dari kecambah kacang hijau terhadap karakteristik tepung biji nangka (Artocarpus heterophyllus Lamk. *Jurnal Inovasi Teknik Kimia*, *1*(2), 65–70.

Mohd Hanim, A. ., Chin, N. ., & Yusof, Y. . (2014). Physico-chemical and flowability characteristics of a new variety of Malaysian sweet potato, VitAto Flour. In *International Food Research Journal* (Vol. 21, Issue 5).

Muliani, R. R., Dedi, F., Feri, K., & Titi Candra Sunarti. (2013). Functional Properties of Hydroxypropylated and Crosslinked Arrowroot Starch. *Jurnal Teknologi Dan Industri Pangan*, *24*(1), 60–67. https://doi.org/10.6066/jtip.2013.24.1.60

Nasution, E., Sudaryati, E., & Asfriyati. (2017). Pemanfaatan beras merah dan jagung dalam pembuatan mie sebagai bahan pangan fungsional. *Abdi Talenta*, *2*(2), 200–205. http://jurnal.usu.ac.id/abdimas

Ng, K. F., Abbas, F. M. A., Tan, T. C., & Azhar, M. E. (2014). Physicochemical, pasting and gel textural properties of wheat-ripe Cavendish banana composite flours. *International Food Research Journal*, *21*(2), 655–662.

Pangastuti, H. A., Affandi, D. R., & Ishartani, D. (2013). Physical and chemical properties characterization of red kidney bean (Phaseolus vulgaris L.) flour by some processing treatment. *Jurnal Teknosains Pangan*, *2*(1), 20–29. www.ilmupangan.fp.uns.ac.id

Pranoto, Y., Rahmayuni, Haryadi, & Rakshit, S. K. (2014). Physicochemical properties of heat moisture treated sweet potato starches of selected Indonesian varieties. *International Food Research Journal*, *21*(5), 2031–2038.

Praptiwi, P., Harapani, M., & Astuti, I. (2006). Peroxide values of Aglaia argentea Blume, A. silvestria (M. Roemer) Merr., dan A. tomentosa Teijsm. & Binn. *Biodiversitas Journal of Biological Diversity*, *7*(3). https://doi.org/10.13057/biodiv/d070309

Rahman, S. (2013). Proximate analysis of palado seed (Aglaia sp.) as an alternative food source locally based. *Seminar Proceedings of a National Association of Food Technologists Indonesia*, 279–288.

Rahmawati, W., Kusumastuti, Y. A., & Aryanti, N. (2012). Karakterisasi Pati Talas (Colocasia Esculenta (L.) Schott) (Colocasia Esculenta (L.) Schott) Sebagai Alternatif Sumber Pati Industri Di Indonesia. *Jurnal Teknologi Kimia Dan Industri*, *1*(1), 347–351. http://ejournal-s1.undip.ac.id/index.php/jtki

Ravinder, A., Waghray, K., Subbarao, & Evangeline, S. . (2018). Studies on production of gluten free products from Breadfruit flour. *Journal of Food, Nutrition and Population Health*, *2*(1), 1–5. https://doi.org/10.21767/2577-0586.100038

Richana, N., & Sunarti, T. C. (2004). Karakterisasi sifat fisikokimia tepung umbi dan tepung pati dari umbi ganyong, suweg, ubikelapa dan gembili. *J.Pascapanen*, *1*(1), 29–37.

Santoso, B., Pratama, F., Hamzah, B., & Pambayun, R. (2015). Karakteristik fisik dan kimia pati ganyong dan gadung termodifikasi metode ikatan silang. *Agritech*, *35*(3), 273–279.

Sharma, H. K., Kaushal, P., & Singh, A. P. (2019). Rheological measurements of composite flour containing Jackfruit (Artocarpus heterophyllus Lam.) flesh flour and its identification by pattern recognition methods. *Journal of Food Measurement and Characterization*, *13*(1), 404–420. https://doi.org/10.1007/s11694-018-9955-5

Somowiyarjo, S. (2015). Dukungan perlindungan tanaman dalam membangun kedaulatan pangan (Revisi 5 September 2011). *Faperta.Ugm.Ac.Id*, *September 2011*, 1–58. http://faperta.ugm.ac.id/download/bahan_kuliah/susamto/dpt/kedaulatan_pangan.docx

Suarni, Firmansyah, I., & Aqil, M. (2013). Keragaman mutu pati beberapa varietas jagung. *Penelitian Pertanian Tanaman Pangan*, *32*(1), 50–56.

Sulistiyaningsih, M., Kurniasari, L., & Maharani, F. (2019). Modifikasi tepung biji nangka (Arthocarphus heterophyllus lamk) dengan metode asetilasi. *Jurnal Inovasi Teknik Kimia*, *4*(1), 26–32. https://doi.org/10.31942/inteka.v4i1.2683

Sumarlin, Efendi, R., & Rahmayuni. (2021). *Karakterisasi pati biji durian (Durio zibethinus Murr.,) dengan heat moisture treatment (HMT)*. https://repository.unri.ac.id/bitstream/handle/123456789/1662/jurnal sumarlin.pdf?sequence=1&isAllowed=y

Waterschoot, J., Gomand, S. V., Fierens, E., & Delcour, J. A. (2014). Production, structure, physicochemical and functional properties of maize, cassava, wheat, potato and rice starches. *Starch/Staerke*, *66*, 1–16. https://doi.org/10.1002/star.201300238

Yulianti, R., & Ginting, E. (2012). Perbedaan karakteristik fisik edible film dari umbi-umbian yang dibuat dengan penambahan Palsticizer. *Penelitian Pertanian Tanaman Pangan*, *31*(2), 131–136.