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Physical Characteristics of Local Light-Brown Waxy Sorghum with Varying Levels of Polishing

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ABSTRACT

Sorghum contains a high level of tannins and is known to be anti-nutritional and give rise to an astringent flavour, so polishing is needed. This study aimed to characterize local light-brown waxy sorghum from Lamongan due to varying levels of polishing. An experimental procedure with five replications was used. The results showed that the weight of 1000 grains, seed volume, bulk density, and true density one-time polishing was 20.3109±0.3606 g, 0.016±0.000 ml, 0.755±0.015 g/ml, and 1.70±0.02 g/ml, respectively, whereas the two-time polishing was 12.6072±0.6172 g, 0.010±0.000 ml, 0.843±0,011 g/ml, and 1.67±0,02 g/ml, respectively. The sorghum seed size after one-time polishing was length 4.64±0,23 mm, width 2.98±0,17 mm, height 2.38±0,08 mm, and sphericity 69.04%, whereas after two-time polishing it was 2.90±0.12 mm, 2.89±0.09 mm, 1.84±0.11 mm, and 85.82%, respectively. More polishing resulted in a decrease in 1000 seed weight, hardness, volume, porosity, and true density of sorghum. The results also revealed that sorghum was red after one-time polishing and yellow-red after two-time polishing. Tannin content was 8971.59±42.87 mg/L and 915.88±11.64 mg/L, respectively for one-time and two-time polishing. Light-brown waxy sorghum from Lamongan should be polished two-time to be developed into flour and instant sorghum rice.

1. INTRODUCTION

Sorghum (Sorghum bicolor L. Moench) is a cereal commodity that is being developed in Indonesia. Sorghum can be cultivated as green fodder in a closed hydroponic system, which is a hydroponic system with continuous and recycled nutrients (Radi *et al*., 2022). One of the regions that produces sorghum is Lamongan. Lamongan has 200 ha of sorghum grown throughout two sub-districts, around 190 ha in Babat District and 10 ha in Sugio District (Arfah, 2022). A light-brown waxy sorghum is one variety of sorghum that was developed in Lamongan. Amylose content is lower in waxy sorghum than in non-waxy sorghum. Non-waxy sorghum has an amylose percentage of 20–30%, whereas waxy sorghum has an amylose content of less than 10% (Romadhoni *et al*., 2014). The main component of sorghum seeds is starch, ranging from 56-73% with an average of 69.5% (Suarni, 2016). Sorghum also has a protein content of 11%, higher than rice, which is only 6.8%. In addition, sorghum is used to provide good quality gluten-free products due to phytochemicals and low glycemic index (GI) (Gallo *et al*., 2021). Sorghum is also a potential source of dietary fiber to be developed (Suarni, 2016).

However, sorghum contains tannins, around 3.67–10.66% (Anidah, 2022). Tannins are polyphenolic chemicals that can form complexes with proteins, lowering protein quality and digestibility. Tannins have the ability to suppress the function of digestive enzymes, particularly amylase and trypsin. The decrease in the activity of the amylase enzyme will have an impact on the decrease in starch digestibility (Widowati *et al.,* 2010). This causes the absorption of protein and starch in the body to be low. In addition, the presence of tannins also causes a slightly bitter taste, so it can affect the palatability or taste of sorghum products. Sorghum seeds with brown or black seed coats have more tannin than seeds with white or light seed coats (Suarni, 2016). A red genotype with pigmented testa has a moderate tannin content, a brown genotype with pigmented testa has a high tannin content, and a white genotype without pigmented testa has no detectable tannin levels (Dykes & Rooney, 2006). In addition, (Human, 2011) also stated that the nutritional content of brown sorghum is quite high, but the digestibility of protein and starch in sorghum is lower than other cereals. The polishing process, which involves using abrasive methods to remove the sorghum pericarp from the seed core, is one of the attempts to lessen tannins. Another sorghum polishing technique is the immersion process in an alkaline solution (NaOH and Na_2CO_3) (Amrinola, 2015), but this cannot reduce the tannin content all at once, so the process is less effective and inefficient. Based on this, a study was carried out to determine the physical characteristics of light-brown sorghum polished at one and two levels using abrasive methods.

2. MATERIAL AND METHODS

2.1. Material

The main ingredient used in the study was local light-brown waxy sorghum that had been polished once and twice, and was obtained from the Sorghum Processed Production House located in Babat District, Lamongan Regency, East Java, Indonesia. The supporting materials used include: aquadest, I2, HCl (25%, 0.01N), NaOH (25%, 30%, 1N), H_2SO_4 (P), 2% H_3BO_4, Na_2CO_3, hexane, methanol p.a, ethanol (80% and 95%), toluene, acetone, selenium, 1N acetic acid, anthrone powder, pure amylose, DPPH, phosphate buffer, alpha amylase enzyme, 1% pepsin enzyme, Folin Ciocalteu reagent, pH paper, filter paper, bromine cresol green indicator (BCG) + methyl red, phenolphthalein indicator and other supporting materials used for sample preparation and analysis. The tools used in this research are: analytical balance Matrix ESJ 210-4B, penetrometer, digital caliper, digital caliper with 0.001mm accuracy, syringe with tube, measuring cup, Erlenmeyer, porcelain cup, oven, furnace, desiccator, destruction tool, electric heater (heater), distillation apparatus, blender, 65 mesh sieve, Kjehdahl flask, condenser, 100 ml volumetric flask, distillate flask, fat flask, soxhlet extraction apparatus, vacuum pump, 10 ml and 25 ml volumetric pipettes, burette, filter paper , fat-free cotton wool, stainless steel fluff, dropper, and other glassware.

2.2. Methods

The exploratory research method was used in this study. The purpose of this research is to map the effect of polishing levels on the physical characteristics of light-brown waxy sorghum from Lamongan. The study employed two samples, namely sorghum polished once and twice, with each parameter being repeated five times for each observation. An abrasive-type sorghum polishing machine is used to polish light-brown waxy sorghum from Lamongan. The data obtained were then analyzed descriptively. Descriptive analysis is the use of statistics to analyze data by describing the data that has been collected. The data obtained from the research results is displayed in tabular form.

2.3. Parameters

The weight of 1000 Grains (WTG) was measured by the Pramono *et al*., (2019) method. The sorghum grain hardness test was measured using a Kiya Hardness Meter (Fujihara Seissakusho, Japan), with the Kamsiati (2018) method. Seed Hardness is determined by placing a sample of sorghum seeds on a measuring instrument, using the Kamsiati (2018) method. Seed volume was measured using a measuring cup, using the Pramono *et al.,* (2019) method. The dimensions of each seed, namely length, width, and height, were measured in three directions by using a digital vernier caliper with 0.001 mm accuracy, using the Song & Litchfield, (1991) method. Bulk density (ρb) was measured by pouring sorghum seeds at a constant speed from a height of 150 mm into a cylindrical container (500 mL volume) until the container was full (Hemmat *et al.,* (2010). Bulk density was determined from the volume of the container and the mass of seeds. True density (ρp) was defined as the ratio between seed weight and actual seed volume, determined using the toluene transfer method. Seed color was measured using a Minolta brand colorimeter (Bender *et al*., 2019).

3. RESULTS AND DISCUSSION

The aim of the research was to determine the effect of the levels of polishing of light brown local waxy sorghum seeds on the physical characteristics of the seeds, which included weight of 1000 grains, seed hardness, seed volume, bulk density, true density, grain porosity, seed size, and seed colour. The results of the research that has been carried out are in Table 1.

3.1. Weight of 1000 Grains

The results showed that more polishing frequency influenced the actual weight of a thousand grains and the weight of a thousand grains of local light-brown waxy sorghum from Lamongan. The actual weight of a thousand grains and the weight of a thousand grains with one-time polishing are 20.31±0.36 g and 19.30 g, respectively, whereas with two-time polishing they are 12.61±0,62 g and 14.44 g, respectively (Table 1). The numbu variety is known to have a weight of 26.52 g/1000 grains and a skin thickness proportion of 0.8% (Yunitasari & Timotiwu, 2017). Rahman *et al*. (2022) discovered that sorghum varieties ranged in weight from 22.66 g to 36 g per 1000 seeds. The weight of 1000 seeds of the Pahat variety was approximately 22.66 g, 31.00 g of the Bioguma variety, and 36.00 g of the Numbu variety. The difference in the weight of a thousand grains and the weight of a thousand grains was also due to differences in genetics, morphology, and different responses of each sorghum variety. This can be used as a reference for choosing varieties that can produce better yields for planting. The weight of a thousand grains of local light-brown waxy sorghum from Lamongan is lower compared to bioguma sorghum. Polishing also affects the weight of a thousand seeds of sorghum produced; the more polishing is done, the weight of a thousand grains gets lower because of the large number of pericarp layers of seeds that are lost during polishing. To generate polished grains, polishing is an abrasive technique that gradually eliminates the testa, pericarp, aleurone, subaleurone, and germ layers. Because testa removal is improved with increasing polishing frequency, grains appear cleaner. Abrasive polishing causes erosion of bran layers from the grain surface of sorghum, so it influences the actual weight of a thousand grains and the weight of a thousand grains (A'yunin *et al*., 2022).

Table 1. Physical characteristics local light-brown waxy sorghum from Lamongan

Parameters	One-time polishing	Two-time polishing
Weight of 1000 grains:		
AWTG (actual weight of thousand grains) (g)	20.31±0.36	12.61±0.62
WTG (weight of thousand grains) (g)	19.30	14.44
Seed hardness (kg)	3.5±0.4	3.2±0.2
The dimensions of seed		
• Seed volume (mL)	0.016±0.000	0.010±0.000
• Length (mm)	4.64±0.23	2.90±0.12
• Width (mm)	2.98±0.17	2.89±0.09
• Height (mm)	2.38±0.08	1.84±0.11
• Sphericity (%)	85,82	69,04
Bulk density (g/mL)	0.75±0.01	0.84±0.01
True density (g/mL)	1.70±0.02	1.67±0.02
Seed porosity (%)	55.64±1.08	49.40±1.00
Seed Color	Red	Red
Lightness (L^*)	30.72±0.19	51.56±0.57
Redness (a^*)	16.10±0.19	13.06±0.05
Yellowness (b^*)	5.94±0.29	8.66±0.21
°Hue	20.24°	33.54°
Chroma	17.16	15.67

3.2. Seed Hardness and Volume

Hardness is a property that shows resistance to breaking due to a given compressive force. Hardness is the maximum ability of a material to withstand the load it received. Hardness measurement can be done by applying a compressive force to the sample until the sample is broken or crushed. The hardness value is determined by the maximum force achieved until the sample is broken or crushed (Hernawan & Meylani, 2016). The results of the seed hardness test are shown in Table 1. Table 1 shows that an increase in the polishing frequency causes a decrease in the hardness of sorghum seeds. The results of the one-time polished local light-brown waxy sorghum hardness test were 3.5±0.4 kg; whereas the two-time polished sorghum were 3.2±0.2 kg. According to Pramono *et al*. (2019), the average seed hardness of 34 types of sorghum from various varieties originating from Lampung is 7.64 kg/cm^2. Sukarminah (2015) research found that the hardness of white sorghum seeds of local varieties of Bandung that were retained on 6 mesh and 7 mesh sieves was 7.73 ± 0.67 kg and 6.49 ± 0.73 kg, respectively. The value of the hardness of a commodity is influenced by several things, such as moisture content and the degree of hardness. The more moisture content is contained in the commodity, the harder the commodity will be. Conversely, the less moisture content contained in the commodity, the more fragile the commodity will be so that the hardness value will be smaller (Hernawan & Meylani, 2016). The physical properties of seed, such as seed shape and seed hardness, also affect the level of insect attack on sorghum seeds. Seeds with a hairy and hard skin surface experience less beetle attack compared to those with a smooth skin surface (Yasin, 2009).

3.3. The Dimensions of Seed

The results of the research are shown in Table 1. The value of the volume of one-time polished local light-brown waxy sorghum was 0.021±0.002ml, whereas two-time polished was 0.012±0.002ml. The average length, width, and height of one-time polishing sorghum were 4,64±0,23 mm; 2,98±0,17 mm; and 2,38±0,08 mm, respectively. The average length, width, and height of two-time polishing sorghum were 2,90±0,12 mm; 2,89±0,09 mm; and 1,84±0,11 mm. According to length, the seeds are classified as very long (>7.5 mm), long (6.61-7.50 mm), medium (5.51-5.60 mm) and short (<5.50mm). It shows that light-brown sorghum from Lamongan is short-seed. According to Booudries *et al*.(2009), the length and width of sorghum seeds were 1.17 and 1.27 and the density (g/L) was 692.8 ± 0.6 for whites and 736.5 ± 0.2 for pigmented sorghum. The dimensions of sorghum are related to the volume of sorghum, which determines the bulk density of sorghum. The larger the volume of sorghum, the smaller the bulk density of sorghum.

The results also showed the value of the sphericity of local light-brown waxy sorghum (Table 1). Seed sphere sphericity is the isoperimetric property of the seed with respect to a sphere. Sphericity is a comparison of a food form with a ball shape where the relative ratio of a ball where the diameter of the ball is the same as the longest volume of the food material (Nurhadi *et al*., 2022). The sphericity value for light brown waxy rice sorghum with one-time polished was 69.04%, and two-time polished was 85.82%. Asoegwu *et al*. (2006) stated that the sphericity value would increase with decreasing seed size. The more polishing, the smaller the seed size, so the sphericity value will increase. Sphericity was used to determine the similarity of seeds to balls. The sphericity of dark brown waxy rice sorghum had twice the higher roundness value (Li *et al*., 2107). This indicated that the shape was close to spherical. Sphericity values were found in the range of 53.3-58.7% for wheat varieties, 44.4-45.8% for the barley variety, 73.5-78.0% for the lentil variety, and 86.3-89.8% for the chickpea variety (Gürsoy & Güzel, 2010).

3.4. Bulk density, True Density, and Seed Porosity

Bulk density is the ratio of weight per seed volume, including the cavities between the seeds, the cavities between the seeds and the receptacle, and the internal cavities in the seeds. The lower the volume, the higher the bulk density. The void space, which is the quantity of empty voids between the material particles, is represented by bulk density. The higher the density of an object, the less void space it possesses. A higher bulk density will result in less packaging material being used (Kumalasari *et al*., 2015). The results of the research showed that the bulk density of light-brown waxy sorghum from Lamongan changed with different levels of polishing. The more polished, the greater the bulk density value. One-time polishing resulted in an average bulk density of 0.75±0.01 g/ml, while after two-time polishing it was 0.84±0.01 g/ml. This is because the skin, testa, and embryo removed during polishing are lighter than the endosperm. The results of this study are in line with the research of Murtini *et al*. (2016), who stated that after polishing, the brown sorghum seeds from Garut had a bulk density value of 0.866±0.02 g/ml. After two polishings, the bulk density value of light-brown waxy sorghum from Lamongan is nearly identical to that of brown sorghum from Garut.

The bulk density value can be used to predict the volume of processing equipment or transportation facilities and convert unit prices. Altuntaş & Yildiz (2007) statesd that the highest bulk density value is found in large samples. According to Boudries *et al*. (2009), the density of sorghum seeds was 692.8±0.6 g/l for whites and 736.5±0.2 g/l for pigmented sorghum. According to Mukkun *et al*. (2021), the density value of kamba in red local sorghum is 0.60 mg/L, local black sorghum is 0.58 mg/L, local brown sorghum is 0.62 mg/L, and local sorghum white at 0.83 mg/L.

True density is the ratio between the weight of the material and the volume of the material. The true density value is obtained by using the liquid displacement method. The calculation of true density is done by dividing the mass of the material in the air by the difference between the mass of the material in the air and the mass of the material in the water. The true density can be determined using the toluene displacement method. Toluene is used because absorption by seeds occurs at a lower rate (Muhlis *et al*., 2017). True density or particle density is a property used in the separation process from lighter materials. The true density value is influenced by the size and mass of a material. The results revealed that as levels of polishing increased, the true density value decreased. True density values of 1.70 g/mL and 1.67 g/mL were obtained after one-time and two-time polishing, respectively.

The porosity of a commodity is related to the transportation process and workspace analysis, which is useful in consideration in calculating the structural load of a tool or machine (Altuntaş & Yildiz, 2007). Therefore, it is important to know these physical characteristics to optimize the design of equipment for handling these commodities. According to Kumlasari *et al*. (2015), seed porosity also plays an important role in the instantiation properties of a product. Cracks or pores formed in the product will facilitate the transfer of water and heat during cooking, resulting in a softer rice-like product. The larger axis of the product will facilitate and speed up the rehydration time. The results showed that sorghum by polishing once and twice resulted in seed porosity values of 55.64±1.08% and 49.40±1.00%, respectively. The seed porosity decreases with the increasing frequency of polishing. With increasing seed size, the porosity value rises. In this study, the higher the levels of polishing, the smaller the grain size, resulting in a decrease in the porosity value of sorghum.

3.5. Seed Color

The results of the seed color test showed that the higher the polishing frequency of sorghum, the higher the degree of whiteness of the sorghum (Figure 1). Seed color is influenced by the color and thickness of the skin (pericarp), the presence of the testa, and the texture and color of the endosperm. The color of sorghum seeds can be used as an indicator of tannin content (Puspawati, 2009; Fathurrohman, 2012). However, the degree of whiteness is influenced by the variety of sorghums (seed color) and polishing quality (Suarni *et al*., 2013). Varieties with red or brown seeds usually have a higher tannin content than varieties with white seeds. The polishing treatment produces sorghum seeds that do not have a seed coat containing a testa layer. Sorghum has a testa, i.e., a dark (brown) grain coat, that contains antinutritional compounds, such as tannins. Because tannins are removed during polishing, polished sorghum seeds have a whiter color (Budiyanto *et al*., 2021).


a


b

Figure 1. Seed Color of Sorghum (a: One-time polishing; b: Two-tim polishing)

4. CONCLUSION

The descriptive analysis of the research data revealed that the levels of polishing had an effect on the physical characteristics of the light-brown waxy sorghum from Lamongan. More polishing resulted in a decrease in the actual weight of a thousand grains, and in the weight of a thousand grains, seed hardness, volume, porosity, and true density of the local light-brown waxy sorghum from Lamongan. The results also revealed that the higher the polishing frequency, the higher the degree of whiteness of the sorghum, so the sorghum was red after polishing. The results also showed that the higher the polishing frequency, the lower the tannin content in light-brown waxy sorghum.

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