ADVANCES IN AGRICULTURAL AND FOOD RESEARCH JOURNAL

Original Research Article

Physical Properties of Brown and White Malaysian Glutinous Rice Kernels (*Oryza sativa* L.)

Puteri Nurain Megat Ahmad Azman[1], Rosnah Shamsudin[1,2*], Norhashila Hashim[3], Hasfalina Che Man[3]

[1]Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, UPM Serdang 43400, Selangor, Malaysia, puteri.nurain@ymail.com

[2]Institute of Plantations Studies, Universiti Putra Malaysia, UPM Serdang 43400, Selangor, Malaysia.

[3]Department of Biological and Agricultural Engineering, Faculty of Engineering, Universiti Putra Malaysia, UPM Serdang 43400, Malaysia, norhashila@upm.edu.my, hasfalina@upm.edu.my

**Corresponding author: Rosnah Shamsudin, [1]Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, UPM Serdang 43400, Selangor, Malaysia; rosnahs@upm.edu.my

Abstract: Glutinous rice, also known as waxy rice, is a variety of short or long rice grains that become sticky when cooked. The physical properties (length, width, thickness, equivalent diameter, aspect ratio, surface area and colour) of brown and white glutinous rice kernels from cultivar *Siding* were determined in this study. The physical properties of the glutinous rice kernels differed significantly (p<0.001). For brown glutinous rice kernels, the length, width, thickness, equivalent diameter, and aspect ratio were 6.95 ± 0.27 mm, 1.83 ± 0.08 mm, 1.42 ± 0.07 mm, 2.64 ± 0.06 mm, and 0.26 ± 0.01, respectively. The white glutinous rice kernel had mean values of 6.24 ± 0.38 mm (length), 1.70 ± 0.09 mm (width), 1.41 ± 0.06 mm (thickness), 2.47 ± 0.08 mm (equivalent diameter), and 0.27 ± 0.02 (aspect ratio). The obtained colour values showed that the glutinous rice kernels were light brown and white. Based on the results, the dimensions (length, width, thickness, equivalent diameter, aspect ratio, surface area) decreased due to the milling process applied to brown glutinous rice kernels, producing white glutinous rice kernels. The physical properties of glutinous rice significantly impact the design of postharvest machinery, handling equipment, grading, and other applications.

Keywords: colour; dimensions; glutinous rice; physical properties; *Siding*

Received: 23rd March 2024

Accepted: 22nd February 2025

Available Online: 3rd March 2025

Published: 30th June 2025

Citation: Azman, P. N. M. A, Shamsudin, R., Hashim, N., *et al.* Physical properties of brown and white Malaysian glutinous rice kernels (*Oryza sativa* L.). *Adv Agri Food Res J* 2025; 6(1): a0000500. https://doi.org/10.36877/aafrj.a0000500.

1. Introduction

Rice is one of the most popular staple foods in the world, especially in Asian countries. There are thousands of rice cultivars worldwide, and glutinous rice (*Oryza sativa* var. glutinosa), often known as sticky rice or waxy rice, is one of the best-known (Mahmood *et al*., 2018). *Siding* cultivar is one of the most preferred cultivars in Malaysia. According to

Zainal and Shamsudin (2021), the *Siding* cultivar seed germinated below their leaves. Mature paddy rice (whole grains with the husk intact) has a brown kernel enclosed by the husk. The husk, also known as the hull, is the most outer part of a paddy grain. The caryopsis also includes endosperm and embryo. The bran part accounts for one-tenth of the weight of the raw grain and has a significant nutritional value due to the presence of proteins, lipids, and fibre (Nawaz, 2018). The pericarp is made up of thin bran layers of proteins. The embryo is the grain's reproductive organ, high in protein and fat. The endosperm, the grain's main component, mainly comprises starch granules with minor amounts of proteins, lipids, and water. Therefore, brown rice is the unpolished rice kernel that includes the bran, embryo, and endosperm layers. Brown rice has recently been identified as a significant functional food due to its high phenolic content and biological activity (Gao *et al*., 2018). Meanwhile, white rice is the polished rice kernel that includes the embryo and endosperm layers without the bran layer. White glutinous rice is readily available in the marketplace and is used to make food.

Rice kernel quality differentiation implies market worth and significantly impacts local cuisine recognition or prospective adoption of new cultivars (Nádvorníková *et al*., 2018). Physical properties are one of the most important quality characteristics. Researchers have made valuable efforts to investigate the fundamental physical properties of biomaterials, emphasizing their application in the design of machines and processes (Pathak *et al*., 2019). All engineers, industrial processors, scientists, physicists, plant breeders, researchers, and others who can identify novel applications for biomaterials can benefit from basic information on their physical properties (Pradhan *et al*., 2010). The physical properties of foods, including rice, have critical impacts on optimizing agricultural machinery and practices, developing new varieties with specific properties to improve milling efficiency, and designing conveyor systems and transportation equipment.

In recent times, the physical properties of glutinous rice have been explored across various cultivars, including *Ketan Nangka, Ketan Bilatung, Ketan Bodas, Ketan Pecut, Susu Thai, local Susu* and *local Siding*, as evidenced by the research conducted by Indrasari *et al*. (2019) and Zainal and Shamsudin (2021), respectively. Nevertheless, it's worth noting that there is a scarcity of prior studies that have delved into comparing the physical properties of brown and white glutinous rice. As a result, this study aimed to evaluate the physical properties of brown and white Malaysian glutinous rice kernels, such as mean length, width, thickness, equivalent diameter, aspect ratio, surface area, and colour.

2. Materials and Methods

2.1 Sample Preparation

Local paddy glutinous rice (*Siding* cultivar) was obtained from a Kuala Selangor, Malaysia farm. The paddy glutinous rice has been hulled to produce brown rice kernels, which have then been milled to make white rice kernels. Only head rice samples were

collected and analysed; each measurement was conducted with enough values to provide a significant result. Physical properties of the samples, such as length (mm), width (mm), thickness (mm), equivalent diameter, aspect ratio, surface area (mm^2), and colour, were conducted at room temperature.

2.2 Length, Width, and Thickness

One hundred kernels of brown and white glutinous rice were chosen randomly. Dimensions such as length (L), width (W), and thickness (T) were measured using a Vernier calliper with an accuracy of 0.01 mm, as shown in Figure 1.

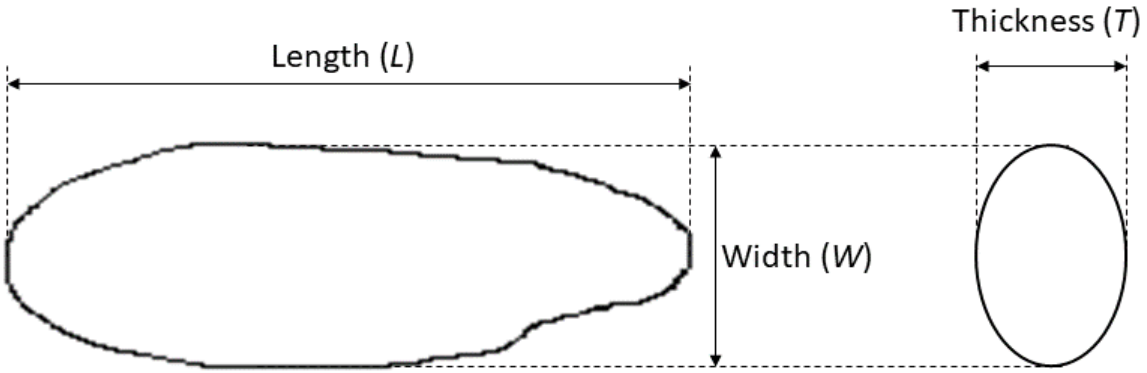

Figure 1. Dimensions of glutinous rice kernel

2.3 Equivalent Diameter

The equivalent diameter in considering a prolate spheroid shape for one hundred glutinous rice kernels was calculated using an equation (1) as below (Mohsenin, 1986; Nádvorníková *et al*., 2018):

$$D_e(\text{mm}) = \left(\frac{L \times (W+T)^2}{4}\right)^{\frac{1}{3}} \quad (1)$$

2.4 Aspect Ratio

Aspect ratio is defined as the ratio of its width to its length. The dimensionless aspect ratio (R_a) of 100 glutinous rice kernels was determined using equation 2 (Zainal & Shamsudin, 2021):

$$R_a = \frac{W}{L} \quad (2)$$

2.5 Surface Area

The surface area (*SA*) of one hundred glutinous rice kernels was calculated by substituting the measured length, width and thickness into an equation 3 (Mohsenin, 1986; Nádvorníková *et al*., 2018):

$$SA\ (\text{mm}^2) = \frac{\pi \times B \times L^2}{2 \times L\text{-}B} \tag{3}$$

Where *B* (dimensionless*)* is a function of width and thickness (equation 4),

$$B = (W \times T)^{\frac{1}{2}} \tag{4}$$

Where L = length (mm); W = width (mm); T = thickness (mm) of glutinous rice kernels.

2.6 Colour

The colour properties of glutinous rice kernels were determined using a colour meter (WR-18, FRU, China) to determine the values of L^* (whiteness or darkness), a^* (greenness or redness), and b^* (yellowness or blueness). These dimensionless values were used to calculate the chroma using equations 5 and 6 (Azman *et al*., 2020) below. (c^*) and hue angle (h^*). Each sample was measured five times, and the results were recorded.

$$\text{Chroma, } c^* = \left[\left(a^*\right)^2 + \left(b^*\right)^2 \right]^{\frac{1}{2}} \tag{5}$$

$$\text{Hue angle, } h^* = tan^{-1}\left(\frac{b^*}{a^*}\right) \tag{6}$$

2.7 Statistical Analysis

All the collected data was analysed using Minitab Statistic 16 Edition. On all data, a one-way analysis of variance as a function of glutinous rice kernel form was applied to determine the significant differences between mean values (p<0.05) at a 95% confidence level. Tukey test was used to predict homogenous groups and analyse the physical properties between brown and white glutinous rice kernels. Each study was conducted in five replicates, and the details were reported as the average of five independent data.

3. Results

Tables 1 and 2 indicate the mean values of physical properties of the brown and white glutinous rice kernels measured, such as length, width, thickness, equivalent diameter, aspect ratio, surface area, and colour.

Table 1. Physical properties of each 100 brown and white glutinous rice kernels

Physical properties	Glutinous rice kernels					
	Brown			White		
	Min	Max	Mean	Min	Max	Mean
L (mm)	6.60	7.70	6.95 ±0.27[a]	5.60	7.00	6.24 ±0.38[b]
W (mm)	1.70	2.00	1.83 ±0.08[a]	1.50	1.80	1.70 ±0.09[b]
T (mm)	1.30	1.50	1.42 ±0.07[a]	1.30	1.50	1.41 ±0.06[b]
D_e (mm)	2.54	2.81	2.64 ±0.06[a]	2.27	2.67	2.47 ±0.08[b]
R_a	0.25	0.30	0.26 ±0.01[b]	0.24	0.31	0.27 ±0.02[a]
SA (mm^2)	18.59	22.93	19.89 ±0.92[a]	14.64	20.47	17.35 ±1.28[b]

Data are expressed as mean ±SD; *L*, length; *W*, width; *T*, thickness; D_e, equivalent diameter; R_a, aspect ratio; *SA*, surface area; min, minimum; max, maximum value. Different letters indicate statistically significant differences exist $p<0.001$ for each row. The means of not sharing a letter are significantly different. Tukey test was applied with 95% simultaneous confidence intervals.

Table 2. Colour values of brown and white glutinous rice kernels

Colour	Glutinous rice kernels					
	Brown			White		
	Min	Max	Mean	Min	Max	Mean
L^*	64.35	65.48	64.99 ±0.48[b]	77.34	79.01	78.26 ±0.60[a]
a^*	8.23	8.71	8.41 ±0.20[a]	3.97	4.31	4.14 ±0.13[b]
b^*	32.18	32.77	32.49 ±0.22[a]	21.03	21.73	21.20 ±0.30[b]
c^*	33.34	33.79	33.56 ±0.18[a]	21.40	22.15	21.60 ±0.31[b]
h^*	1.00	1.00	1.00 ±0.00[b]	1.00	1.00	1.00 ±0.00[a]

Data are expressed as mean ±SD; L^*, whiteness or darkness; a^*, greenness or redness; b^*, yellowness or blueness; c^*, chroma; h^*, hue angle; min, minimum; max, maximum value. Different letters indicate statistically significant differences exit $p<0.001$ for each row. The means of not sharing a letter are significantly different. Tukey test was applied with 95% simultaneous confidence intervals.

3.1 Length, Width, and Thickness

The dimensions of each 100 brown and white glutinous rice kernels were measured, and the results of mean values were shown in Table 1. The length of brown and white glutinous rice kernels varied from 6.60 to 7.70 and 5.60 to 7.00 mm, while their width also varied from 1.70 to 2.00 and 1.50 to 1.80 mm, respectively. The brown and white glutinous rice kernels' thickness varied from 1.30 to 1.50 mm. The mean dimensions of the brown glutinous rice kernel length, width, and thickness were 6.95 ± 0.27 mm, 1.83 ± 0.08 mm, and 1.42 ± 0.07 mm, respectively. Meanwhile, the white glutinous rice kernel had the length, width, and thickness with mean values of 6.24 ± 0.38 mm, 1.70 ± 0.09 mm, and 1.41 ± 0.06 mm, respectively.

The dimensions for length, width, and thickness of brown glutinous rice kernel were slightly higher than white glutinous rice kernel, with differences of 10.22%, 7.10%, and 0.70%, respectively. Significant differences existed between the glutinous rice kernels'

length, width, and thickness (p<0.001). Based on the previous study of Zainal and Shamsudin (2021), the white local *Siding* glutinous rice had the highest values in width (1.98 ± 0.08 mm) and thickness (1.48 ± 0.10 mm) compared to white glutinous rice kernel in this study, with the differences of 14.14% and 4.73%, respectively. However, they had the same length value, which was 6.24 mm. Furthermore, the length and width values obtained for *Ketan Gadok*, *Ketan Nangka*, *Ketan Bilatung*, *Ketan Bodas* and *Ketan Pecut* were 5.87 mm and 2.44 mm, 5.81 mm and 2.64 mm, 6.15 mm and 2.53 mm, 5.95 mm and 2.46 mm, and 5.77 mm and 2.41 mm. These results from the study of Indrasari *et al*. (2019) were the lowest compared to the previous research by Zainal & Shamsudin (2021) and this current study. The dimensions of glutinous rice varied depending on the rice cultivar and the cultivation method in different places. Rice kernel dimensions are physical properties that must be considered when selecting sieve separators and calculating power during rice milling (Shittu *et al*., 2012).

3.2 Equivalent Diameter

Table 1 shows the mean values of each 100 brown and whit glutinous rice kernel's equivalent diameter. Based on the results, the equivalent diameter varied from 2.54 to 2.81 and from 2.27 to 2.67 mm for brown and white glutinous rice kernels, respectively. The brown glutinous rice kernel had an equivalent diameter of 2.64 ± 0.06 mm. Meanwhile, the equivalent diameter of the white glutinous rice kernel measured was 2.47 ± 0.08 mm. Table 1 showed that the brown glutinous rice kernel had the highest value (6.44%) of equivalent diameter compared to the white glutinous rice kernel. Equivalent diameter is crucial to establishing grain properties (Nádvorníková *et al*., 2018). This difference between brown and white glutinous rice kernels was due to the milling process.

3.3 Aspect Ratio

In Table 1, the aspect ratios of each 100 brown and white glutinous rice kernel ranged from 0.25 to 0.30 and from 0.24 to 0.31, respectively. The aspect ratio of brown glutinous rice kernel was 0.26 ± 0.01. Meanwhile, the white glutinous rice kernel had an aspect ratio of 0.27 ± 0.02. Therefore, the white kernel had the highest (3.70%) aspect ratio value compared to the brown glutinous rice kernel. From the obtained aspect ratio values, the brown and white glutinous rice kernels were confirmed as cylindrical. The flow ability characteristics of the rice can be viewed in terms of its aspect ratio (Pathak *et al*., 2019).

3.4 Surface Area

Surface area values varied from 18.59 to 22.93 mm^2 and 14.64 to 20.47 mm2 for each 100 brown and white glutinous rice kernels. The mean value for the brown glutinous rice kernel's surface area was 19.89 ± 0.92 mm^2. The surface area for white glutinous rice kernel was 17.35 ± 1.28 mm^2. Thus, the result showed that the surface area of brown glutinous rice kernel was higher (12.77%) than white glutinous rice kernel. However, the white local *Siding* glutinous rice in the previous study (Zainal & Shamsudin, 2021) had the highest (10.80%) surface area with a value of 19.45 ± 1.73 mm^2 compared to the white glutinous rice kernel in

this study. The surface area perpendicular to the rice's length, width, and thickness will determine the rice's sizing system, water loss, and heat transfer evaluation during the drying and soaking.

3.5 Colour

Based on Table 2, the colour values of brown and white glutinous rice kernels were obtained. The L^*, a^*, b^*, and c^* values of brown glutinous rice kernels ranged from 64.35 to 65.48, from 8.23 to 8.71, from 32.18 to 32.77, and from 33.34 to 33.79, respectively. For brown glutinous rice kernel, the mean values of L^*, a^*, b^*, c^* and h^* were 64.99 ±0.48, 8.41 ±0.20, 32.49 ±0.22, 33.56 ±0.18, and 1.00 ±0.00, respectively. Meanwhile, the range values of L^*, a^*, b^*, and c^* white glutinous rice kernel values were 77.34−79.01, 3.97−4.31, 21.03−21.73, and 21.40−22.15, respectively. The white glutinous rice kernel had L^*, a^*, b^*, c^*, and h^* with the mean values of 78.26 ± 0.60, 4.14 ± 0.13, 21.20 ± 0.30, 21.60 ± 0.31, and 1.00 ± 0.00, respectively.

The results showed that both glutinous rice kernels' colours significantly differed at $p<0.001$. The hue angle represents the pure spectrum of light, whereas chroma represents light's purity, quality, strength, or saturation. According to the results, the white glutinous rice kernel had the highest whiteness value (16.96%) compared to the brown glutinous rice kernel. The highest value of a^*, therefore, the brown glutinous rice kernel was closest to “reddish” colour compared to the white glutinous rice kernel. Based on the b^*, the brown glutinous rice kernel had the highest value of yellowness (34.75%) compared to the white glutinous rice kernel. By concluding the obtained results of colour values, it was proved that both glutinous rice kernels were light brown and white.

5. Conclusions

This study presents information on the physical properties of local glutinous rice kernels, including brown and white kernels cultivar *Siding*. The results showed the physical properties such as length, width, thickness, equivalent diameter, aspect ratio, surface area and colour among brown and white glutinous rice kernels. According to the obtained results, the dimensions (length, width, thickness, equivalent diameter, aspect ratio, surface area) had decreased to produce the white glutinous rice kernel affected by the milling process of the brown glutinous rice kernel. The dimensions for length, width and thickness of brown glutinous rice kernel were slightly higher than white glutinous rice kernel. Moreover, the brown glutinous rice kernel had the highest value of equivalent diameter compared to the white glutinous rice kernel. From the obtained aspect ratio values, the brown and white glutinous rice kernels were confirmed as cylindrical. The result showed that the surface area of brown glutinous rice kernel was higher than white glutinous rice kernel. The colour values of glutinous rice also revealed that they were light brown and white. These physical properties of glutinous rice kernels were interpreted as essential information for developing

milling machines and optimising postharvest processes (handling, processing, and packaging) while minimising losses and damage.

Author Contributions: P.N.M.A.A. conducted the experiments, collected and analysed the data on the results, and wrote the manuscript. R.S. supervised the research and revised the manuscript. N.H. and H.C.M. supervised the experiments. All authors have read and agreed to the published version of the manuscript.

Funding: This work was funded by the Ministry of Higher Education of Malaysia to provide financial support under the Trans-disciplinary Research Grants Scheme (TRGS) with Project Number TRGS/1/2020/UPM/02/7.

Acknowledgments: The authors thank the Ministry of Higher Education of Malaysia for providing financial support under the Trans-disciplinary Research Grants Scheme (TRGS) with Project Number TRGS/1/2020/UPM/02/7. They also thank the Universiti Putra Malaysia for the technical support needed to conduct this research.

Conflicts of Interest: The authors declare no conflict of interest.

References

Azman, P. N. M. A., Shamsudin, R., Che Man, H., *et al*. (2020). Effect of soaking process on physical properties of mature pepper berries (*Piper nigrum* L.). *Food Research*, *4*(S1), 116–123. https://doi.org/10.26656/fr.2017.4(s1).s04

Gao, Y., Guo, X., Liu, Y., *et al*. (2018). Comparative assessment of phytochemical profile, antioxidant capacity and anti-proliferative activity in different varieties of brown rice (*Oryza sativa* L.). *Lwt*, *96*, 19–25. https://doi.org/10.1016/j.lwt.2018.05.002

Indrasari, S. D., Purwaningsih, Jumali, Ardhiyanti, S. D., *et al*. (2019). Physical, milling quality and physicochemical properties of several local glutinous paddy varieties in West Java, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *309*(1), 012014. https://doi.org/10.1088/1755-1315/309/1/012014

Mahmood, A., Mei, L. Y., Md Noh, M. F., *et al*. (2018). Nutrient composition of five selected glutinous rice-based traditional Malaysian kuih. *Malaysian Applied Biology*, *47*(4), 71–77.

Mohsenin, N. N. (1986). Physical properties of plant and animal materials. Structure, physical characteristics and mechanical properties. *Food / Nahrung*, *31*(7), 702–702. https://doi.org/10.1002/food.19870310724

Nádvorníková, M., Banout, J., Herák, D., *et al*. (2018). Evaluation of physical properties of rice used in traditional Kyrgyz cuisine. *Food Science and Nutrition*, *6*(6), 1778–1787. https://doi.org/10.1002/fsn3.746

Nawaz, M. A. (2018). *Processing and quality of glutinous rice* [PhD Thesis, The University of Queensland, Australia]. UQ eSpace. https://doi.org/10.14264/uql.2018.644

Pathak, S. S., Pradhan, R. C., & Mishra, S. (2019). Physical characterization and mass modeling of dried *Terminalia chebula* fruit. *Journal of Food Process Engineering*, *42*(3), 1–10. https://doi.org/10.1111/jfpe.12992

Pradhan, R. C., Meda, V., Naik, S. N., *et al*. (2010). Physical properties of Canadian grown flaxseed in relation to its processing. *International Journal of Food Properties*, *13*(4), 732–743.

Shittu, T. A., Olaniyi, M. B., Oyekanmi, A. A., *et al*. (2012). Physical and water absorption characteristics of some improved rice varieties. *Food and Bioprocess Technology*, *5*(1), 298–309. https://doi.org/10.1007/s11947-009-0288-6

Zainal, N., & Shamsudin, R. (2021). Physical properties of different cultivar local glutinous rice (*susu* and *siding*) and commercial Thai cultivar (*susu*). *Advances in Agricultural and Food Research Journal*, *2*(1), 1–10. https://doi.org/10.36877/aafrj.a0000178