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Microwave heat treatment of glutinous rice emping

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Abstract

This study aimed to determine the new cooking method of emping by using a microwave oven at different temperatures (230°C, 240°C, 250°C) and time taken (3.30 mins, 4.00 mins, 4.30 mins, 5.00 mins, 5.30 mins). Next, we will analyse the physicochemical and frictional properties of glutinous paddy (Siding) at 90 days of maturity as it is transformed into emping. The suitable cooking parameter was at a temperature of 250°C and a time of 4.30 mins. The change in length from glutinous paddy to emping was increased from 10.61 mm to 11.01 mm. For width, the change from glutinous paddy to emping was found to be 2.51 mm to 3.14 mm. However, the thickness of glutinous paddy to emping was changed from 1.93 mm to 1.12 mm. The bulk density and true density of emping are lower than glutinous paddy. Lastly, for porosity and angle of repose, the value of emping was higher compared with glutinous paddy.

1. Introduction

Glutinous rice, also known as *Oryza sativa* var. *glutinosa*, is cultivated rice with a long-standing cultural heritage in Asia. Glutinous rice has its characteristics; it is known as waxy rice, opaque, sticky rice, and the grain cultivar is small compared with white rice (Zainal and Shamsudin, 2021). There are several types of glutinous rice in Malaysia, such as Susu, Siding, and Gantung Alu. It is also one of the most important cereal grains and is used as a staple food nowadays in many parts of the world.

Emping is processed from glutinous rice (siding) that is later ripened than normal paddy to make a better emping. The glutinous paddy is a special food made from glutinous rice that has been pounded to become pieces. Glutinous paddy is a slower-ripening variety and is planted late during the closing season. Then, after a few months, the glutinous paddy, which is still green at the stalk, will be harvested for making ringgi (Figure 1). Meanwhile, the yellow glutinous paddy will be harvested for making emping (Figure 2).

Figure 1. Ringgi.

Figure 2. Emping.

Both ringgi and emping have their characteristics in terms of shape, flavour, paddy maturity, colour, and shelf life. In terms of paddy maturity, around 80-85 days are for ringgi, while 90-100 days are for emping. However, the taste for ringgi is sweeter, softer, and green in colour compared with emping. The shelf life of ringgi is shorter, only one to two weeks, compared to emping, which can be extended to one year. Emping has a rough texture and uneven edges which is affected by the pressure exerted during the flattening process.

To make emping, the first step is to cut the half-ripe paddy stalk. The paddy stalks are cut and then tied in a bundle. The bundle of glutinous paddy consists of paddy

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that is green or yellow. Then, the selected paddy is separated from the paddy stalks by hand. The separated grains will be put into a wok and fried without any oil for a certain time until a popping and cracking sound is produced.

Then, the cooked glutinous paddy was immediately flattened by using a long wooden pestle and mortar, or what we called lesung hindik. Traditionally, two or three people are needed during the flattened process to pound and smash the lesung hindik until the glutinous paddy turns a flat shape and the husks are removed. After the flattening process, the glutinous paddy was put into nyiru buluh to remove and separate the husk from the rice flakes during the sieving process. The glutinous paddy is heavier than the husk, so the husk will be separated easily. After separating the husk from the paddy, the emping is ready to eat and looks like oatmeal flakes.

Farmers are more comfortable producing emping using traditional cooking methods since it is a traditional food. However, the traditional cooking method has some limitations and disadvantages, such as the fact that it requires more labour and energy and takes a longer time to cook. Since there is a lack of strategic promotion, emping is getting less attention from people. Furthermore, younger generations nowadays are not interested in involving themselves, participating in, and commercialising this traditional product.

The main objective of this study was to determine the new cooking method of emping by using a microwave oven at different parameters. Next, to determine the physicochemical and frictional properties of emping at the best cooking parameter by using a microwave oven. Last but not least, a microwave oven was used to implement a new cooking method.

2. Materials and methods

2.1 Material

Glutinous paddy (Siding) was collected from Berkat Padi Sdn. Bhd. Sungai Besar, Selangor. The maturity of paddy during harvest was 90 days.

2.2 New cooking method

To implement a new cooking method by using the microwave oven, the glutinous paddy was cooked at the highest temperature. The cooking parameters for different temperatures and times are shown in Table 1.

Table 1. Parameter to determine the best temperature and time.

Temperature (℃)	Time (min)				
230	3.3	4.0	4.3	5.0	5.3
240	3.3	4.0	4.3	5.0	5.3
250	3.3	4.0	4.3	5.0	5.3

2.3 Physicochemical properties

2.3.1 Dimensions (length, width, and thickness)

Size is defined as the dimensional characteristics of a material. To determine the average size of paddy grain, a sample of 20 was obtained at random. There are three principles of dimensions, such as length (L), width (W), and thickness (T). All these principles were measured by using a digital vernier calliper that had the least accuracy of 0.01 mm. Dg, also known as geometric mean diameter, was determined by a method by the method described by Ehiem *et al*. (2016).

$$Dg = (LWT)1/3 \quad (1)$$

2.3.2 Sphericity, aspect ratio, volume, surface area, L/B ratio

The sphericity is described as the ratio of the surface area of the sphere that has the same volume as that of the paddy grain. Equation (2) can be used to determine the sphericity of the grain. In terms of sphericity, it is described as the ratio of the surface area of the sphere that has the same volume as that of the paddy grain. The following equation used by Sirisomboon *et al*. (2007) can be used to determine the sphericity of the grain. Next, the ratio of width to the length of grains is known as the aspect ratio, Ra. It can be determined by using equation (3).

$$\mu = (LWT)^{(1/3)}/L \quad (2)$$

$$Ra = (Width\ (mm))/(Length\ (mm)) \times 100 \quad (3)$$

$$V = (\pi Dg^2)/6 \quad (4)$$

$$S = \pi Dg^2 \quad (5)$$

$$L/B\ Ratio = (Width\ (mm))/(Length\ (mm)) \quad (6)$$

2.3.3 Bulk density, true density and porosity

The bulk density is known as the ratio of a mass sample of paddy grains (Mg) to its total volume (Vb). It can be determined by filling 150 mL of volume into a measuring cylinder. First, the initial weight of the cylinder was determined by using an electronic balance. After filling, the container was gently levelled at the top, with no additional manual compaction being done. Then, the sample and the cylinder were weighted. Lastly, the bulk weight was recorded.

$$\rho b = Mg/Vb \quad (7)$$

True density is known as the ratio of a mass sample of paddy grains (Mgt) divided by the solid volume occupied by the sample (Vdw). Next, 50 mL of distilled water was poured into the 25 mL beaker. After that, 5 g of the emping sample was added. The toluene

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displacement method can be used to determine the true density of paddy grains. The measurement was replicated five times using the formula below (Shittu *et al*., 2012).

$$\rho t = Mgt/Vbw \tag{8}$$

Meanwhile, the value from bulk density and true density can be used in equation (9) below to determine the porosity value. The total volume of internal pores within the grains to its bulk volume is defined as porosity. Porosity was determined as the ratio of the difference in the true density and bulk density to the true density and exhibited in percentage as an equation according to Mirzabe *et al*. (2013). Where ρb is bulk density in (g/cm^3) and ρt is true density in (g/mL). The result was expressed as a percentage (%).

$$P = (\rho t - \rho b)/\rho t \times 100 \tag{9}$$

2.3.3 Angle of repose

The angle of repose is known as the angle with the horizontal at which material will be able to stand when piling (Tabatabaeefar, 2003). By allowing the sample to fall from 150 mm until the maximum height was reached, the glutinous paddy grains were heaped over a 50 mm circular disc. Ten times height was replicated, and the reading was recorded to get the average reading. The angle of repose can be determined by using the equation (Amber, 2014). The angle of repose can be determined by using equation (10) below.

$$\Theta = \tan^{-1} (2H/D) \tag{10}$$

Where Ɵ = angle of repost, H = height and D = diameter.

3. Results and discussion

3.1 New cooking method

From this study, the emping of different heating temperatures and times were compared only via visual observation. Some characteristics must be observed to determine whether the emping was fully cooked. Firstly, the cooked emping might produce a popping sound during microwave treatment. The emping easily flattened after being pounded by a wooden pestle and mortar. Another study by Shiv Kumar and Prasad (2017) found that increased temperature or time of roasting results in decreased hardness value of flaked rice. It will result in low moisture content and puffing of starch granules in the cooked rice, thus easily flattened. The husk is also easily removed from the paddy. Lastly, the shape of the emping is thinner than the raw paddy.

Figure 3 shows no significant effect on grain expansion at 230°C, with the time taken from 3.3 min until 5.3 min. As a result, the glutinous paddy is not fully cooked as a lower temperature is exerted inside the microwave oven. The husk also cannot be removed and separated from the paddy grains after the flattened process. Therefore, the temperature at 230°C with a ranging time of 3.3 min to 5.3 min was not suitable to cook emping by using a microwave oven.

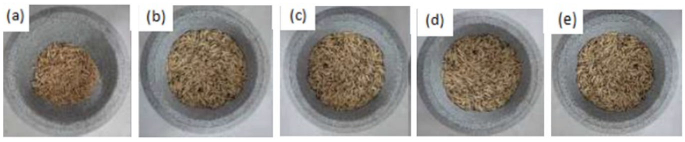

Figure 3. Cooking temperature at 230°C at different time: (a) 3.3 min (b) 4.0 min (c) 4.3 min (d) 5.0 min (e) 5.3 min.

Figure 4 shows the result at the temperature of 240°C with the different times taken. There was no significant effect on grain expansion at the times taken of 3.3 min, 4.0 min, and 4.3 min. The lower temperature and shorter time taken during emping cooking will result in the glutinous paddy not being fully cooked. At 5.0 mins and 5.3 mins, only a few paddies can be flattened, but the rest are not fully flattened. The paddy was not fully flattened, and the structure of the paddy was not affected, and the husk was not removed after the flattened process.

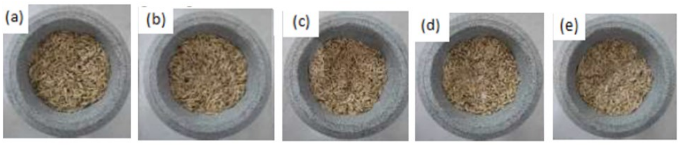

Figure 4. Cooking temperature at 240°C at different time: (a) 3.3 min (b) 4.0 min (c) 4.3 min (d) 5.0 min (e) 5.3 min.

Figure 5 shows the result of the temperature effect during emping cooking at 250°C with the different times taken. There was no significant effect on grain expansion at the times taken of 3.3 mins and 4.0 mins. Even though the glutinous paddy was cooked at a higher temperature, a shorter time taken during emping cooking will result in the grains not being fully cooked. Figure 5(c) shows that the best parameter to cook emping using a microwave oven was at a temperature 250°C and a time of 4.3 mins. The glutinous paddy can maintain its stickiness and is easy to flatten. Liv Wan (2021) stated that glutinous rice is immediately recognisable by its sticky and glue-like texture when cooked. Because of its stickiness, the cooked paddy was easy to flatten. Furthermore, the husks are easily removed and separated from the paddy grains during the flattening process. However, at 5.0 mins of cooking time, the glutinous paddy can also be flattened to become emping, resulting in a much-broken paddy. For 5.3 mins of cooking time, the glutinous paddy has already become pop rice and fully broken during the flattened process. Higher temperatures and longer time

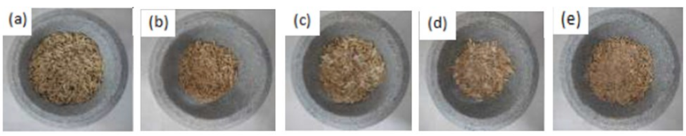

Figure 5. Cooking temperature at 250°C at different time: (a) 3.3 min (b) 4.0 min (c) 4.3 min (d) 5.0 min (e) 5.3 min.

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taken during emping cooking will affect the texture of the grains as it will result in the pop rice.

To compare the traditional cooking method and microwave heat treatment, it was shown that microwave ovens helped to cook emping at higher temperatures and take a shorter time. Thus, it helped the farmers to increase the production of emping. The temperature for the traditional cooking method measured by the infrared thermometer was around 190℃ to 214℃ lower than a microwave oven, which is 250℃. Meanwhile, the traditional cooking method takes 8 to 9 mins longer than the microwave oven, which only requires 4.3 mins to 5.0 mins. Implementing a microwave oven for cooking emping required less labour and energy compared to traditional cooking methods. However, the traditional cooking method needs open space to set up firewood to cook emping, while less space is needed when using a microwave oven. A microwave heat treatment method gives more benefits, thus having upscaling opportunities to be implemented by farmers in the future.

3.2 Size (length, width, and thickness)

Table 2 shows the size comparison between glutinous paddy (Siding) and emping. The length, width, and thickness of glutinous paddy change due to the transformation from raw paddy to emping. The length from glutinous paddy to emping was changed from 10.61 mm to 11.01 mm. In terms of width, the major change from glutinous paddy to emping was found to be 2.51 mm to 3.14 mm. However, the thickness of glutinous paddy to emping was decreased from 1.93 mm to 1.12 mm. During the flattened process, the length of glutinous paddy was increased and expenses their thickness with higher major dimensions and lower dimensions (Dahare *et al*., 2019).

Table 2. Size comparison between glutinous paddy (Siding) and emping.

Parameter	Glutinous paddy (Siding)	Emping
Length (mm)	10.61±0.36	11.01±0.21
Width (mm)	2.51±0.11	3.14±0.42
Thickness (mm)	1.93±0.09	1.12±0.45

3.3 Shape (sphericity, aspect ratio, volume, surface area and L/B ratio)

Table 3 shows that the sphericity of glutinous paddy was 0.94% lower than emping, which was 1.17%. According to Mohsenin (2001), the sphericity value for raw rough rice falls in a range from 0.32% to 1%. The previous research finding from Zainal and Shamsudin (2021) mentioned the mean sphericity for the glutinous paddy was 0.42±0.02%. The width ratio to the length of grains is known as the aspect ratio, Ra. The result for the aspect ratio between glutinous paddy and emping did not present significant differences, where the values were 37.00% and 37.30%, respectively. However, the value for volume, surface area, and L/B ratio for glutinous paddy was found to be 597.50 mm^3, 343.07 $mm^{2,}$ and 2.70 mm^2, respectively, while 501.91 mm^3, 305.42 mm^2 and 2.68 mm^2 were obtained for emping. Thus, these values showed remarkable differences. In this study, glutinous paddy has the highest value of surface area, thus resulting in the highest heat transfer rate. A study by Varnamkhasti *et al*. (2008) mentioned that the surface area of the grain positively correlated with the volume of the grain. The heat transfer surface is important as it will influence the rate or speed of heat transfer or heat exchange within the material. A higher heat transfer rate occurs when the material has a smaller surface contact volume per unit.

Table 3. Comparison between shape of glutinous paddy (Siding) and emping.

Parameter	Glutinous Paddy (Siding)	Emping
Sphericity (%)	0.94±0.21	1.17±0.44
Aspect ratio (%)	37.00±9.11	37.30±9.32
Volume (mm^3)	597.50±11.31	501.91±10.42
Surface area (mm^2)	343.07±6.03	305.42±5.01
L/B Ratio	2.70±0.66	2.68±0.51

3.4 Density, true density, and porosity

The understanding of bulk density is important to identify the product weight in the hopper (Ghasemi *et al*., 2007). From Table 4, the value for bulk density in glutinous paddy was 772.73 kg/m^3 and 226.70 kg/m^3. The glutinous paddy also indicated the highest value for true density, which was 1229.51 kg/m^3 compared with emping 1057.89 kg/m^3 and true density was decreased and significant for intact grain. According to Dahare *et al*. (2019), emping processing will cause the glutinous paddy grain to flatten. Hence, it will decrease the voids existing within the sample particles, resulting in an ordered arrangement of particles and consequently lowering the density. Porosity is defined as the air percentage between the particles compared to the unit volume of the particles. The porosity of emping was higher, which was 78.38% compared to 37.15% in glutinous paddy. The decrease in bulk density and true density of emping was significant for intact grains. The flaking process during emping cooking decreases the voids existing within the sample particles, resulting in an ordered arrangement of particles and consequently

Table 4. Comparison between bulk density, true density and porosity of glutinous paddy (Siding) and emping.

Parameter	Glutinous Paddy (Siding)	Emping
Bulk density (kg/m^3)	772.73±1.28	226.70±0.84
True density (kg/m^3)	1229.51±26.86	1057.89±85.34
Porosity (%)	37.15±2.20	78.38±1.46

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lowering the density (Mohapatra and Bal, 2012).

3.5 Angle of repose

The angle of repose is an important physical parameter in the design of particulate material processing, storage and conveying systems. The angle of repose is low when the materials are smooth, rounded, and high for sticky and fine materials. According to Lau (2001), if the angle of repose has a value less than 25°, the flow properties of the object are excellent, while if the angle of repose is bigger than 25°, the flow is said to be poor. The value for glutinous paddy was lower, which was 38.85° and 43.23° for emping. According to Reddy (2004), the value angle of repose will increase with a decrease in moisture content. Based on the comparisons between emping fractions with glutinous paddy fractions, it can be concluded that the flow ability of the emping is less excellent than the glutinous rice fractions.

4. Conclusion

In conclusion, the suitable cooking parameter of emping in microwave oven heat treatment was successfully determined at a temperature of 250°C, ranging from 4.3 to 5.0 mins. The popping sound was produced during the cooking process, thus indicating the paddy grain was already cooked. Next, this study concludes that the physical, frictional, and chemical properties of glutinous paddy are changed during the transformation to become emping. Glutinous paddy and emping have different physical characteristics, such as the dimension that consists of three axial parameters (length, width, and thickness), aspect ratio, volume, surface area, and L/B ratio. The length and width of emping were increased to 11.01±0.21 mm and 3.14±0.42 mm. However, the thickness of glutinous paddy to emping decreased from 1.93±0.09 mm to 1.12±0.45 mm. The result for the aspect ratio between glutinous paddy and emping did not present significant differences, where the values are 37.00% and 37.30%, respectively. The value for volume, surface area, and L/B ratio for glutinous rice was found to be 597.50 mm^3, 343.07 mm, and 2.70 mm^2, respectively, while 501.91 mm^3, 305.42 mm^2 and 2.68 mm^2 were obtained for emping. Furthermore, the glutinous paddy also indicated a higher value in both bulk and true density, with a lower porosity value. For the angle of repose, the value for glutinous paddy is lower, which is 38.85° and 43.23° for emping. The value angle of repose will increase with a decrease in moisture content.

Conflict of interest

The authors declare no conflict of interest.

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