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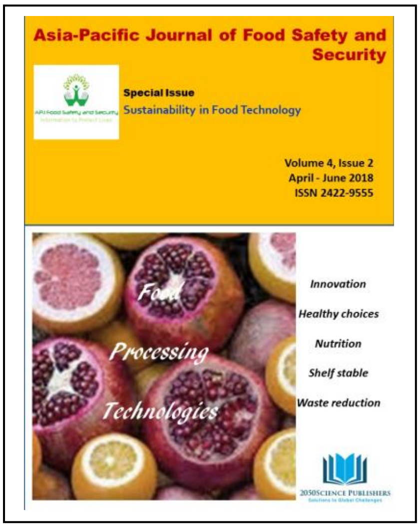
Effect of Microwave Drying Technique on the Properties of Dried Rice Food

Dayang Norulfairuz Abang Zaidel[a]*, Nur Ain Syamilah Ismail[a], Yanti Maslina Mohd Jusoh[a], Ida Idayu Muhamad[a], Zanariah Hashim[a], Zulkifli Khair[b]

[a]School of Chemical and Energy Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia

[b]School of Human Resource Development and Psychology, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, Johor Bahru, Malaysia

***Corresponding author's email address:** dnorulfairuz@utm.my



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Highlights

- Drying methods are critical determinant in the preparation of dried food.
- Rice formulation and drying technology affected the properties of dried rice.
- Microwave drying technology is a modern technique that can be used for drying of food to extend the shelf-life of food product and shorten the processing time.

About Author

Dr. Dayang Norulfairuz Abang Zaidel is a senior lecturer at the School of Chemical and Energy Engineering, Faculty of Engineering, Universiti Teknologi Malaysia in Johor Bahru, Malaysia. She is an active member of Food and Biomaterial Engineering Research Group (FoBERG) and Asia Pacific Institute of Food Professionals. Her research is focusing on the food processing and technology, food rheology, food nutrition, and green technology involving enzymes.

Abstract

Drying methods are critical determinant in the preparation of dried food because each parameter plays important role in achieving the desired quality. The objective of this study was to investigate the effect of drying conditions of combined oven and microwave drying on the properties of rice-based ready-to-eat dried food. Cooked rice sample (with different ratio of white rice and glutinous rice) was dried by oven at 90 °C for 130 min and followed by drying in microwave at various power level (450 and 750 W) and time (1, 3 and 5 min). Moisture content and color of the dried rice sample were determined after drying in microwave. The results showed that the dried rice sample using glutinous rice formulation contained the highest moisture content. Moisture content of dried rice decreased with the increase of drying time in microwave. Color analysis shows that mixed white rice and glutinous rice gave the best result of hue angle and chroma value. From this study, it can be concluded that microwave drying technology is a modern technique that can be used for drying of food to extend the shelf-life of food product and shorten the processing time.

Keywords: Microwave technology; drying; rice; shelf-life; processing time

1. Introduction

Ready-to-eat foods (RTE) is categorized as animal or plant derived food that is cooked, frozen and processed to be consumed directly without cooking or requiring minimal preparation such as reheating or boiling prior to consumption. RTE foods are packaged in air tight sealed solutions and manufactured to last fresh for long time in packed lunches, frozen, home meal replacements and ready meals. Typical RTE foods availably at market are frozen or chilled, retort, canned and dried RTE meals, with broad variety of RTE products type, including meat and poultry products, cereal and vegetable based products. RTE foods are also found an ideal use as functional foods for specific-proposed food products, including space, military, elderly, emergency functional foods, immune-compromised patient foods and domestic consumption as well (Almasyhuri *et al.*, 2012).

Rice is a staple food for most of the Asian region, contributed more than one fifth of the calories. From nutritional standpoints, rice contains high carbohydrate as source of energy, fibre protein, moderate of fat, higher digestibility and universal acceptability and consumption (Idowu *et al.*, 2010). Moreover, rice also contains trace elements such as iron, zinc and others that play a crucial role for biological basis of the altered resistance to infection (Mbatchou and Dawda, 2013). Therefore, rice, recognized as a good source of nutritional values especially high in antioxidant properties, that provide and promote human health (Ahmad *et al.*, 2016), make it potentially chosen as functional food especially during emergency period.

Moisture content and drying techniques are considered the most important key factor to facilitate rehydration time, sensory attributes and eating qualities of dried RTE rice products. Dehydration or drying process is the final step in RTE rice process and determines, to a large extent, the final quality of the product being manufactures. Conventional drying methods are largely employed for numerous food and non-food products before the emergence of varieties novel food processing such as vacuum or hot air drying, freeze-drying, spray-drying and others. Among the available conventional methods, oven or hot air drying is the oldest method widely used for food preservation because of its uniformity, hygienic characteristic and rapid dried product that can have extended agriculture products shelf life of at least one year (Falade and Solademi, 2010). Nevertheless, the principle of conventional drying is heated by the surrounding air by convection followed by conduction where heat must diffuse in from the surface of the material reported lead to substantial degradation in food quality attributes (Gowen *et al.,* 2008). Although oven drying can reduce moisture content faster at high temperature, but these condition had substantially caused on intense color changes and structure are getting harder affected by the severity of the heating treatment (Luangmalawat and Prachayawarakorn, 2008).

The quality of final food product has gained the importance because consumers become more health conscious which led to the introduction of varieties thermal and non-thermal processing methods (Chandrasekaran *et al.*, 2013; Doymaz, 2015; Stratakos and Koidis, 2015). Example of thermal processing methods are ohmic heating, microwave heating and radio frequency and for non-thermal are high pressure processing, light pressure homogenizations, pulsed electric fields, ultrasound and ionizing irradiation. Additionally, the thermal process methods in combination with conventional process methods are reported as the best alternative to optimize the stability and preserve nutritional and sensory equalities of food products (Gowen *et al.*, 2008). Among the thermal methods, microwave technology has gained immerse importance in industrial food applications and widely used in cooking, drying, pasteurization and preservation of food materials (Lakshmi and Singh, 2007).

This study is aimed to investigate the effect of microwave technique on the properties of dried rice food. Different formulation of rice sample using two types of rice (white rice and glutinous rice) were dried using combination of oven and microwave technique. Microwave parameters (drying time and power level) were varied in this study. The dried rice was analyzed for its moisture content and color measurement.

2. Materials and Methods

2.1 Materials and Chemicals

White rice, glutinous rice, minced chicken (Brand name: Ramly), mixed vegetables (Brand name: Simplot), mixed spices (Brand name: McCormic) and cooking salt were purchased from local supermarket in Skudai, Johor, Malaysia. The chemicals used were chloroform, methanol sodium sulfate, hydrated copper sulphate, potassium hydroxide solution and potassium sodium tartrate and Bovine Serum Albumin (BSA) (lyophilized powder ≥ 96%, 2-8, agarose gel). All the reagents used were purchased from Sigma Aldrich and Fisher Scientific.

2.2 Rice Sample Preparation

White rice (WR) and glutinous rice (GR) were used in the experiment with three different ratios: 100% WR, 50% WR to 50% GR and 100% GR. About 200 g of rice was washed thoroughly by tap water, at least three times in order to remove the dust particles and adhering bran and presoaked in water for 25-30 min at ambient temperature (Ramesh *et al.,* 1996). About 100 g of mixed vegetables containing of an approximate portion of corn, peas and carrot was grinded using two-speed food stainless steel blender before its being cooked together with minced chicken and rice. Minced chicken (30 g) was rinsed with tap water and tossed to remove excess water. Mixed spices (5 g) and salt (1.5 g) were mixed well with the minced chicken and then left for 30 min.

The prepared samples of rice, minced chicken and mixed vegetables were mixed and stirred thoroughly to ensure the properly mixed of ingredients. Ratio of rice to water used as recommended by Idowu *et al.* (2010) was 1:2.5. Mixture of rice, minced chicken and mixed vegetables was cooked in electric cooker (Wing, Malaysia) for 20 min. After the cooking period, the sample was extended warmed for 15 min to increase the degree of gelatinization (Quoc and Jittanit, 2015).

2.3 Drying of Rice Sample

The cooked rice sample was dried by air drying at 90°C for 130 min using conventional oven (WGL, China) and followed by drying in domestic microwave (Model R30AOS, Sharp, Japan) at different power levels (450 and 750 W) and intermittent drying time (1, 3 and 5 min) to obtain product with moisture content of less than 12%. The final dried rice samples were stored in air tight container for analysis purpose.

2.4 Analysis of Moisture Content

The moisture content analysis was based on method described by Prasert and Suwannaporn (2009). The moisture content of rice samples of freshly cooked, dried in oven and after microwave drying was measured directly by moisture analyzer (Model MX-50, AND Company, Japan). The moisture analyzer was set up at temperature 178°C for 2 g sample. The measurements were performed in duplicate and recorded in percentage unit.

2.5 Color Analysis

Color analysis for dried rice sample was performed according to method by Pathare *et al.* (2013). The colors of the freshly cooked and dried sample were determined using portable colorimeter, BC-10 (Konica Minolta, USA) based on Hunter system with color values of *L* that measures the whiteness value of color ranges from black at 0 to white at 100, chromaticity coordinate *a* that measures red when positive and green when negative, and chromaticity coordinate *b* that measures yellow when positive and blue when negative. The measurements were performed in duplicate. The values of a* and b* were taken to determine the metric chroma, C* and hue angle, H° by using the equation (1) and (2):

$$C^* = (a*^2 + b*^2)^{1/2} \quad (1)$$

$$H^\circ = \tan^{-1}(b*/a*) \quad (2)$$

3. Results and Discussion

Figure 1 shows the physical changes of rice sample after cooking, drying in oven and drying in microwave. It can be observed that dried rice after microwave drying (Figure 1c) was more puffed and the texture was crunchier compared to the dried rice after oven drying (Figure 1b).

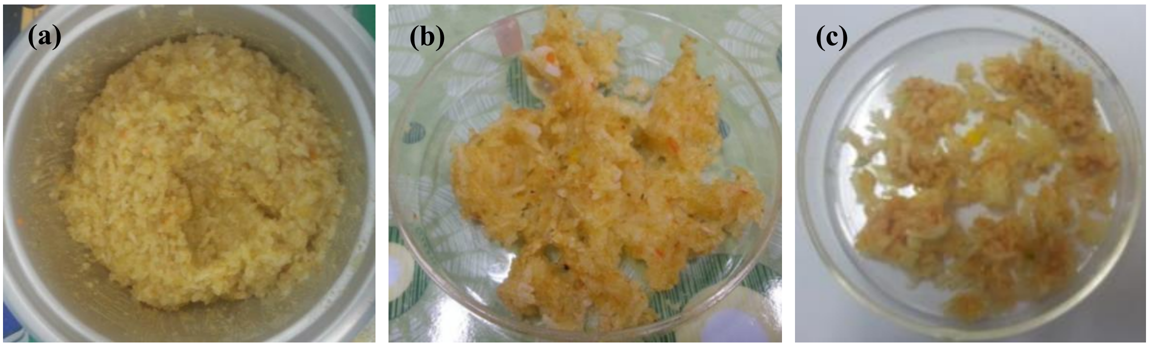

Figure 1. (a) Cooked rice sample, (b) rice sample after oven drying, (c) dried rice sample after microwave drying

Figure 2 shows the moisture content of rice sample after cooking and after drying in oven. The moisture content of cooked rice for all three rice formulation was approximately 75-77% and the value was reduced to 51.6% to 65.5% after oven drying at 90°C for 130 min. The moisture content of 100% GR sample decreased slowly than others from 77.56% to 65.48%. This is because the different properties of white rice and glutinous rice. White rice known as long-grain rice contains high amylose while glutinous rice known as short-grain rice contains high amylopectin and low amount of amylose. At high temperature (e.g. drying at 90˚C), the granules in glutinous rice will burst to release starch molecules that cause rice grains to stick together to form gel and pasty solution, while the granules in white rice tend to remain intact due to high amylose that can delay swelling and rises the gelatinization temperature. Besides that, the study result of Mee-ngern *et al.* (2014) reported that glutinous rice variety had many large micro pores, which were easier to be penetrated by water than white rice varieties. Porosity of material that affected water loss has been reported by Rongkom *et al.* (2013).

Figure 3 shows that the moisture content of the dried rice sample decreased after drying in microwave. The moisture content values reduced significantly at higher microwave power (750 W) for 1 to 5 min drying time with 92%, 95% and 88% reduction for 100% WR sample, 50%:50% WR:GR sample and 100% GR sample, respectively. While the reduction in moisture content for dried sample after drying using 450 W microwave power were 51%, 92% and 81%, respectively. From the result, the moisture content of 100% GR was the highest than others due to high content of water molecule inside it after drying in oven. For dried food product, the recommended desired moisture content is in the range between 6-12%, a stable moisture value for storage and extending product shelf life (Prasert and Suwannaporn, 2009).

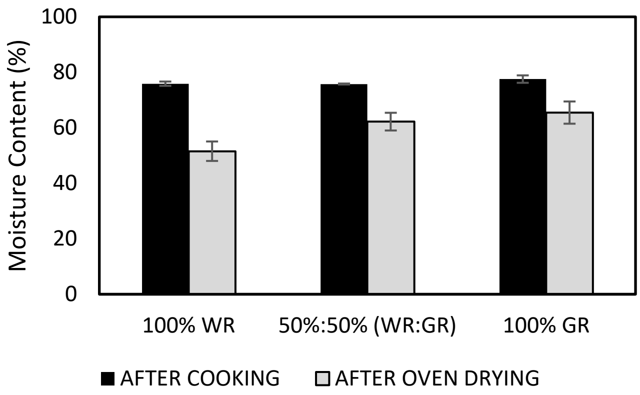

Figure 2. Moisture content (% wt) of dried rice sample for different rice formulation after cooking and oven drying (oven temperature at 90°C for 130 min).

The trend of graph in Figure 3 shows that the moisture content of the dried rice samples decreased rapidly at higher power level. This is due to the high power level (pressure) of microwave on the dried rice samples that cause the water molecules inside temperature to be released rapidly. It can be seen that moisture content of the samples dried at 750 W at 5 min was below 12% which is the suitable percentage of moisture content for preventing the food from contamination to extend shelf life. However, the moisture content cannot be too low because it causes the samples to become too dry and hard.

From the result in Table 1, the different rice formulation affected the color measurement of dried rice samples. The increasing values of hue angle indicate the change of color from pale red (nearly yellow color) toward pure yellow. It can be seen that the highest value of hue angle was from the 100% WR sample that shows the color of 100% WR was better than others (in term yellow color). This indicates that the probability for 100% WR sample to burn was low. At 450 W, the hue angle values of 50:50 WR:GR sample were also in the range of acceptability of food products.

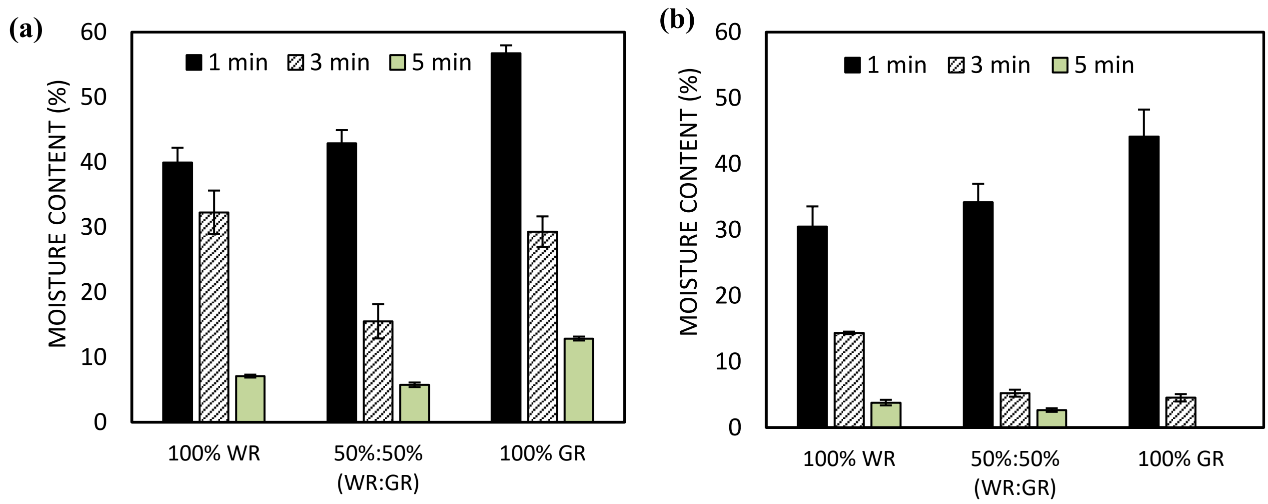

Figure 3. Moisture content (%) of dried rice samples for three different rice formulation and undergoing different microwave drying times at power levels (a) 450 W and (b) 750 W

It can be seen that the increasing power level in microwave caused the color of dried rice sample become dark yellow (pale red color). According to Prasert and Suwannaporn (2009), the longer drying time on dried cooked rice will allow heat exposure on it that will cause more penetration of browning color. The color for all dried rice samples at 750 W was dark yellow (a bit reddish) while for all dried rice samples at 450 W was still in yellow color (but the different saturation of yellow color). From the colorimetric result, the color of dried rice samples that was in the range of acceptability of food products was the 50%:50% WR:GR sample which contains the lowest value of hue angle (75.09) and the lowest of chrome value (37.48) (for power level at 450W).

According to Luangmalawat and Prachayawarakorn (2008), a good quality of dried food color should be in white color range. The discoloration can affect customer's acceptability on the food product. If the food material is treated beyond the optimum processing conditions, the color will be turned to intense browning or darkening color and caused significant color difference than freshly cooked. The formation of browning or darker coloration of food products is due to both enzymatic and non-enzymatic of browning reaction and destruction of pigments in the product compounds (Pathare *et al.,* 2013).

Table 1. Colorimetric result of different rice formulation after drying in microwave at 450W and 750W

Power (W)	Sample	L*	a	b	Chroma, C*	Hue angle, H°
450	WR	67.34 ± 2.57	10.71 ± 1.19	42.13 ± 1.34	44.62 ± 2.18	76.05 ± 0.91
	WR:GR	70.16 ± 1.05	9.56 ± 0.71	35.88 ± 1.64	37.48 ± 1.71	75.09 ± 0.92
	GR	74.19 ± 0.62	9.34 ± 0.73	36.27 ± 1.43	37.67 ± 1.47	75.34 ± 1.06
750	WR	62.74 ± 4.22	14.08 ± 1.75	38.52 ± 1.56	41.38 ± 1.82	70.12 ± 2.16
	WR:GR	66.83 ± 1.75	12.75 ± 0.75	35.88 ± 1.26	38.24 ± 1.40	70.68 ± 1.00
	GR	68.12 ± 3.11	12.77 ± 0.88	35.61 ± 1.07	37.78 ± 1.00	70.18 ± 1.63

WR: 100% WR; WR:GR: 50%WR:50%GR; GR: 100% GR

4. Conclusion

This study shows that varying rice formulation (ratio of white rice and glutinous rice), the microwave power level (at 450W and 750W) and drying time (1, 3, and 5 min) affected the properties of dried rice samples such as moisture content and color of the final product. The moisture content of dried rice samples decreased when the power level and drying time in microwave increased. Moisture content of final dried rice samples was below 12% for drying at 750 W for 5 min. However, the color of dried rice samples at 450 W showed the best result especially the color of mixed white rice and glutinous rice (not too bright yellow and not too dark yellow/pale red). In conclusion, combination of oven and microwave drying technique can be used to reduce the moisture content of dried food product and maintain the color (appearance) of the final product. Microwave is highly potential for use in food industry to shorten processing time.

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