

# Cooked Rice Drying by Microwave Assisted Hot Air

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**Abstract.** *This research aimed to study the process of instant rice, cooked rice was dried under different microwave power levels. Quality of products was investigated. Milled rice was pretreated by exposing to microwave at power of 800 W for 30 sec and without exposure before cooking with rice cooker. Cooked rice was dried at drying temperature of 60 °C combined with microwave power at different levels of 0, 400, 600 and 900 W at constant air velocity of 0.23 m/s. Each run used for 500 g. Sample with initial moisture content of 68-72% wet basis was dried down to about 8-11% (aw less than 0.5). Result found that the drying time was affected by pretreatment method and microwave power. The drying time of cooked rice with pretreatment was 386, 170, 140, and 116 min at microwave power of 0, 400, 600 and 900 W, respectively, which was shorter than without pretreatment. Hardness and stickiness of rice with pretreatment were higher than rice without pretreatment. The L\*(lightness) and b\*(yellow value) of dried cooked rice with and without pretreatment had similar trend that it was decreased when the microwave power increased. However, rehydration ratio of cooked rice with pretreatment was higher than without pretreatment.*

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## 1. Introduction

Instant rice is an interesting food for convenience life especially for new generation. This due to it takes a short time for rehydration before eating. To produce instant rice, milled rice must be cooked and dried. These processes affect to the quality of product and starch digestibility [1,2]. When the rice is cooked, water penetrates into the starch granules through the cell wall, causing the transformation of rice starch [3]. When the cooked rice is

dehydrated, properties of rehydrated rice is change due to heat from drying process [1,2].

To improve the quality of a food product, pretreatment is required prior to drying in order to minimize quality variation of product [1]. The use of microwave energy for drying has been shown to have low energy consumption [4]. This because moisture evaporates in the interior and migrates to the surface leading to fast drying, whereas hot-air removes moisture from the surface [5].

In this study, pretreated rice before cooking is investigated for better quality of instant rice. This was compared with milled rice. They were produced under different microwave powers to compare the quality of product.

## 2. Material and Method

### 2.1 Rice preparation

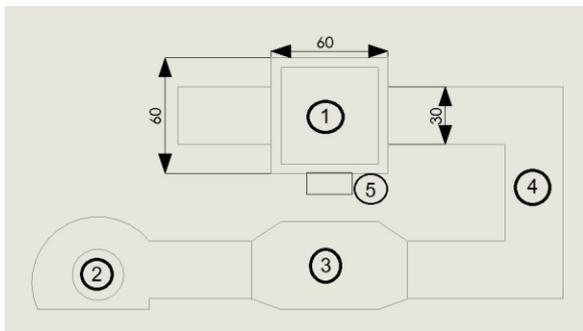
Milled rice cv. Khao Dawk Mali 105 was purchased from supermarket. Milled rice (200 g) was placed in microwave oven at 800 W for 30 sec as pretreated rice. Then, it was cooked using rice cooker with the water to rice ratio of 2:1. Cooked rice was left in the rice cooker for 2 hr until the temperature down to ambient condition prior to drying. Sample was taken to determine the initial moisture content using oven method at 105 °C for 24 hr.

### 2.2 Drying conditions

A laboratory scale microwave assisted hot air is shown in Fig. 1. The schematic is shown in Fig. 2. Cooked rice (500 g) was placed on tray in drying chamber for each run. Then, it was dried by a laboratory scale microwave assisted hot air at drying temperature of 60 °C with microwave powers of 0, 400, 600 and 900 watts. It was dried until Water activity ( $a_w$ ) was less than 0.5 prior to quality determination.



Fig. 1: Microwave assisted hot air dryer used in this experiment



(1) Microwave oven (3) Heater 20 kW  
(2) Blower 1 hp (4) Air duct  
(5) Control motor Gear box

Fig. 2: Schematic of microwave assisted hot air dryer

## 2.3 Rice Determination

### 2.3.1 Water activity ( $a_w$ )

Sample was placed in a chamber. Water activity was measured using an AquaLab water activity meter (Aqua-Link 3.0, Pullman, WA) which was calibrated with distilled water to obtain  $a_w$  in the range of  $1.000 \pm 0.003$ .

### 2.3.2 Color measurement

The color of dried rice was measured by a Hunter Lab Colorimeter (type Color Flex, USA). The Hunter  $L^*$ ,  $a^*$ ,  $b^*$  scale gave measurement of colors in units of approximate visual uniformity throughout the solid. The  $L^*$  value measures lightness and varies from 100 for a perfect white and 0 for black,  $a^*$  and  $b^*$  when positive measure redness and yellowness, respectively.

### 2.3.3 Rehydration

Rehydration was determined according to the modification method of Le and Jittanit [6]. Dried cooked rice (10 g) was immersed into water (100 ml), heated in microwave oven at 800 W for 5 min and then drained excess water for 5 min. The sample weights before and

after rehydration were used to determine the rehydration by applying equation as following:

$$\text{Rehydration (\%)} = (B-A)/A \times 100 \quad (1)$$

; where B is weight of rehydrated rice and A is weight of dried rice.

### 2.3.4 Textural properties

The measurement of the textural properties of cooked instant rice from 2.3.2 was carried out using Texture Analyzer (model TA.XT.Plus) with the probe type rice extrusion rig as shown in Fig. 3. Hardness and stickiness were reported in this study.



Fig. 3 : Rice extrusion rig probe

## 2.4 Statistical analysis

All measurements were conducted in three replicates and the average of the value was presented as the mean and the standard deviation. The mean comparison from different conditions was analyzed by Duncan's New Multiple Range Test (DMRT) at 5% significance level using SPSS program.

## 3. Results and Discussion

Moisture content of rice with and without pretreatment after cooking was shown in Table 1. After drying, moisture content, drying time and  $a_w$  of dried cooked rice were determined as expressed in Table 1. Initial moisture content of cooked rice is varied due to the surrounding environment during cooking.

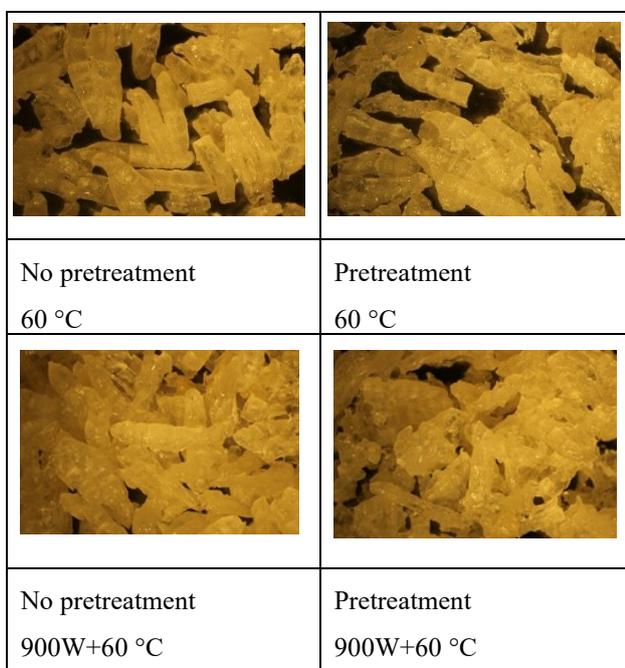
You can see that the drying time of pretreated rice was shorter than normal rice. This might be the loosen hydrogen bond caused by microwave before cooking accelerating the moisture removal during drying in particular at higher microwave power. This due to the microwave accelerated heat inside the product resulted in the fast moisture movement to the surface.

Pretreatment	Drying conditions	Initial moisture content (%)	Final moisture content (%)	Drying time (min)	a <sub>w</sub>
-	60 °C	72.13 ± 0.42 <sup>a</sup>	8.54 ± 1.24 <sup>d</sup>	400	0.50 ± 0.03 <sup>ab</sup>
	400 W +60 °C	71.38 ± 0.49 <sup>a</sup>	10.38 ± 0.60 <sup>a</sup>	193	0.49 ± 0.05 <sup>ab</sup>
	600 W +60 °C	69.09 ± 2.05 <sup>bc</sup>	8.16 ± 0.28 <sup>d</sup>	153	0.51 ± 0.07 <sup>ab</sup>
	900 W +60 °C	68.35 ± 0.34 <sup>c</sup>	10.14 ± 0.61 <sup>ab</sup>	143	0.53 ± 0.09 <sup>a</sup>
Pretreatment	60 °C	71.27 ± 0.31 <sup>a</sup>	8.69 ± 0.37 <sup>cd</sup>	386	0.43 ± 0.10 <sup>b</sup>
	400 W+60 °C	70.74 ± 0.79 <sup>ab</sup>	9.98 ± 0.23 <sup>abc</sup>	170	0.47 ± 0.35 <sup>ab</sup>
	600 W+60 °C	68.95 ± 2.07 <sup>bc</sup>	9.00 ± 0.60 <sup>bcd</sup>	140	0.45 ± 0.01 <sup>ab</sup>
	900 W+60 °C	70.92 ± 0.68 <sup>ab</sup>	9.11 ± 0.95 <sup>abcd</sup>	116	0.44 ± 0.03 <sup>ab</sup>

**Note:** Means with the different letter within a column are significantly different ( $p \leq 0.05$ ) by DMRT

**Table 1** Moisture content, drying time and a<sub>w</sub> of sample from different conditions

Instant rice of selected conditions is demonstrated in Fig. 4. To compare the appearance by visual assessment, samples show the fissuring occurred during the process in particular drying.



**Fig. 4 :** Samples of dehydrated rice from selected condition taken by stereo microscope at magnification of 0.67

Instant rice was measured appearance color using colorimeter. Result is shown in Table 2. Pretreatment and normal rice had the similar trend that L\* and b\* were slightly decreased when the microwave power increased but not significantly different. Generally, the high temperature leads to a dark product, however, this study shows that the lower microwave power has a longer drying time. This might cause the dark product.

After drying, instant rice was determined in term of rehydration as shown in Table 3. Rehydration of pretreated rice was higher than rice without pretreatment. This might be during pretreatment with microwave cause the vapor inside the kernel resulting in porous structure. When it was rehydrated, it could absorb more water. Regarding to the Fig. 4, the fissuring is obviously shown in the rice kernel. This is the benefit for fast cooking.

Textural properties of cooked rice were measured. Hardness and stickiness were expressed in Table 4. Cooked rice without pretreatment with rice cooker shows the highest hardness and stickiness. This might be instant rice had twice rehydration. During cooking water absorbed by the starch granules causes the hydrogen bonds between the starch molecules to be replaced by hydrogen bonds between the starch and water molecules. After the kernel was occurred to swell and the starch granule affected to structural and physiochemical transformation. From this study, pretreatment could reduce the hardness and stickiness. This due to the vapor pressure inside the kernel led to a pumping effect resulting in porous and loosens the starch bond.

Pretreatment	Drying conditions	Color values		
		L* <sup>ns</sup>	a* <sup>ns</sup>	b* <sup>ns</sup>
-	60 °C	63.01 ± 2.13	-1.10 ± 0.33	14.00 ± 1.85
	400 W +60 °C	64.70 ± 0.91	-1.01 ± 0.09	14.21 ± 0.67
	600 W +60 °C	63.75 ± 0.31	-1.07 ± 0.09	13.67 ± 1.88
	900 W +60 °C	62.14 ± 0.60	-1.03 ± 0.22	12.82 ± 1.29
Pretreatment	60 °C	64.55 ± 0.29	-0.89 ± 0.39	14.60 ± 1.70
	400 W+60 °C	64.96 ± 0.97	-1.13 ± 0.11	13.21 ± 1.43
	600 W+60 °C	63.82 ± 2.55	-1.14 ± 0.21	13.34 ± 2.04
	900 W+60 °C	63.09 ± 1.13	-1.19 ± 0.03	12.28 ± 0.19

Note: ns= non significance difference

Table 2 Color values of instant rice obtained from different conditions

Pretreatment	Drying conditions	Rehydration (%)
-	60 °C	61.83 ± 0.64 <sup>c</sup>
	400 W +60 °C	63.98 ± 0.94 <sup>bc</sup>
	600 W +60 °C	66.58 ± 2.14 <sup>ab</sup>
	900 W +60 °C	63.98 ± 1.90 <sup>bc</sup>
Pretreatment	60 °C	65.45 ± 1.74 <sup>b</sup>
	400 W+60 °C	65.18 ± 2.11 <sup>b</sup>
	600 W+60 °C	68.91 ± 1.45 <sup>a</sup>
	900 W+60 °C	66.09 ± 0.59 <sup>ab</sup>

Note: Means with the different letter within a column are significantly different ( $p \leq 0.05$ ) by DMRT

Table 3 Rehydration of instant rice obtained from different conditions

Pretreatment	Drying conditions	Hardness (g)	Stickiness (g)
-	-	6324.41 ± 598.22 <sup>a</sup>	-347.61 ± 53.04 <sup>d</sup>
Pretreatment	-	3201.34 ± 1339.75 <sup>bcde</sup>	-245.70 ± 61.10 <sup>bcd</sup>
-	60 °C	3577.33 ± 191.47 <sup>bc</sup>	-235.15 ± 28.11 <sup>bc</sup>
	400 W +60 °C	2710.80 ± 407.82 <sup>bcdef</sup>	-293.14 ± 7.54 <sup>cd</sup>
	600 W +60 °C	3310.53 ± 847.41 <sup>bcd</sup>	-156.73 ± 103.38 <sup>ab</sup>
	900 W +60 °C	3619.51 ± 298.18 <sup>b</sup>	-187.39 ± 58.53 <sup>abc</sup>
Pretreatment	60 °C	2036.34 ± 463.05 <sup>f</sup>	-121.22 ± 19.32 <sup>a</sup>
	400 W+60 °C	2162.31 ± 301.65 <sup>ef</sup>	-154.01 ± 40.49 <sup>ab</sup>
	600 W+60 °C	2362.79 ± 240.20 <sup>def</sup>	-177.21 ± 103.98 <sup>ab</sup>
	900 W+60 °C	2463.50 ± 36.04 <sup>cdef</sup>	-202.07 ± 11.67 <sup>abc</sup>

Note: Means with the different letter within a column are significantly different ( $p \leq 0.05$ ) by DMRT

Table 4 Textural properties of instant rice obtained from different conditions

## 4. Conclusions

Instant rice was produced from pretreated rice by exposing to microwave power of 800 W before cooking compared with milled rice. These were dried under different microwave powers of 0, 400, 600 and 900 W until  $a_w$  was lower than 0.5 Instant rice was determined the properties. From the results, it could be drawn the conclusions as the followings:

- Pretreatment method and microwave power had an effect on drying time.
- Drying time of pretreated rice was 386, 170, 140, and 116 min at microwave powers of 0, 400, 600 and 900 W, respectively, which was shorter than without pretreatment.
- The  $L^*$ (lightness) and  $b^*$ (yellow value) of dried cooked rice with and without pretreatment had similar trend that it was decreased when the microwave power increased but not significantly different.

Rehydration of pretreated rice was higher than rice without pretreatment.

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## Biographies



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