Instant Rice Process Development: Effect of Rice Cooking Methods on the Quality of Jasmine Instant Rice Dried by Industrial Microwave Oven

Patsakul Phukasmas1, Sirichai Songsermpong*1

Address(es): Dr. Sirichai Songsermpong,
1Department of Food Science and Technology, Faculty of Agro-Industry, Kasetsart university, Bangkok 10900, Thailand.

*Corresponding author: sirichai.so@ku.ac.th

ARTICLE INFO
Received 14. 10. 2018
Revised 20. 6. 2019
Accepted 20. 6. 2019
Published 1. 10. 2019

Regular article

OPEN ACCESS

INTRODUCTION

Rice is considered as a major agricultural product of Thailand, and it is the main Thai staple food. In 2017, Thailand exports the highest amount to the world rice market (USDA, 2017). In the present day, the lifestyle has changed, Thai people have a hustle life, more convince and less attention for food preparation. Drying of instant rice plays a pivotal role in the quality of the product. Most researches used hot air drying and faced the problem of long dehydration time and slow rehydration rate (Tein et al., 1998; Zhao et al., 2007; Sripinyowanich and Noomhorm, 2011). Therefore, the quality of instant rice doesn't meet the needs of consumers. However, commercial instant rice is still faced with many problems such as long rehydration time, poor quality and physical appearance including rice agglomeration. There are many researches which solve the instant rice production but still cannot rehydrate within 3 minutes with good quality (Narkrugsa and Thunyawanith, 2002; Rewthong et al., 2014). For Boiling in a pressure cooker (BPC) and boiling in a stainless steel pot (BL), the rice was immersed in water for 10 minutes and drain prior to drying process. BL and SM could be controlled cooking temperature of each method condition respectively. BPC and SPC in pressure cooker had the temperature lower than 14% (w.b.). The results showed that the hardness, stickiness and whiteness of rehydrated rice cooking by different methods had no significant difference with freshly cooked rice. BPC method is the recommended method for instant rice processing since it could provide more porous structures after drying, which relate to fast rehydration for 3 minutes in boiling water and better quality. Furthermore, after rehydration process, the grain appearance was pretty good and did not stick together. Therefore, this knowledge can be applied for the instant rice production at the industrial level.

Keywords: Cooking methods, Industrial microwave oven, Instant rice, Quality

MATERIAL AND METHODS

Preparation of instant rice

Jasmine rice (Khao Dok Mali 105) was obtained from the Office of Agricultural Cooperatives, Roiet, with the moisture content of 12.73 ± 0.07% dry basis (d.b.). The rice sample was kept in storage room at 0°C until use.

Cooking methods for instant rice

Jasmine rice was brought to room temperature and cooked by a pressure cooker (Satien Stainless Steel Public Co., Ltd., Thailand) and cooked by stainless steel pot (Satien Stainless Steel Public Co., Ltd., Thailand) for conventional methods, using 500 grams of rice per condition. (McCabe, 1976; Narkrugsa and Thunyawanith, 2002; Prasert and Suwannaporn, 2009). Four cooking method were investigated; Boiling in a pressure cooker (BPC), Steaming in a pressure cooker (SPC), Boiling water method (BL) and Steaming method (SM). The industrial microwave oven (6,400 watt, 2,450 MHz) was used to dry the cooked rice in each treatment to the moisture content lower than 14% (w.b.). The results showed that the hardness, stickiness and whiteness of rehydrated rice cooking by different methods had no significant difference with freshly cooked rice. BPC method is the recommended method for instant rice processing since it could provide more porous structures after drying, which relate to fast rehydration for 3 minutes in boiling water and better quality. Furthermore, after rehydration process, the grain appearance was pretty good and did not stick together. Therefore, this knowledge can be applied for the instant rice production at the industrial level.

Keywords: Cooking methods, Industrial microwave oven, Instant rice, Quality

FREE ACCESS
hour. After that, soaked rice was put into cheesecloth and 150 ml of water was sprayed. Prior to cook with pressure and conventional steam rice cooker for SPC and SM respectively, at 105°C for 30 minutes until completely cooked (fully gelatinized). After that, cooked rice was soaked in cold water (0°C) for 1 minutes and drain out. To separate rice grain from the water, after rice cooking, the sample from four conditions was submerged into liquid nitrogen (-196 ± 0.24°C) to prevent agglomeration of rice before drying and dried by microwave drying immediately. The processing experiment plan is shown as flowchart (Fig 1).

**Microwave drying treatment**

Microwave drying was done by using industrial microwave oven (continuous microwave oven) developed by PrimAsia Technology (Thailand). Schematic diagram was shown in figure 2. This machine consisted of eight magnetrons (6,400 watt), the frequency of 2,450 MHz. The cavity of microwave was made of stainless steel with outer dimension at 800 mm x 4,000 mm x 1,700 mm (Width x Length x Depth). The frozen rice was transferred to the teflon conveyor belt, which set the speed at 40 Hertz (0.7 m/min) to transfer sample (120 grams per min) into microwave cavity for drying process. Drying was continued until the final moisture content was lower than 14% wet basis (TACFS, 2017).

**Determination of qualities of instant rice**

**Moisture content determination during microwave drying**

The moisture content of instant rice was determined in triplicate following AOAC (2000) method. The moisture content of sample was determined by hot air oven. 10 grams of sample from each condition was dried at 105°C for 24 hour, and weight difference was measured and calculated in percent wet basis. The moisture content of sample was calculated from following equation.

\[
W_m = \frac{W - W_d}{W} \times 100
\]

Where \(W_m\) is moisture content of rice on wet basis, \(W\) is the weight of rice (in grams), \(W_d\) is the dry matter weight of rice (in grams).

**Rehydration ratio and rehydration time**

The instant rice was filled with boiling water (100°C) to rehydrate by using rice to water ratio as 1: 1.25 (w/w) in polypropylene (PP) plastic cup. The rehydration time was recorded when the rehydrated instant rice is soft and more than 90% of grains of 100 grams were absent of hard core inside (Sripinyowanich and Noomhorm, 2012). Three replications were carried out. The Rehydration ratio was calculated according to Prasert and Suwannaporn (2009). The water rehydration ratio was calculated from equation below.

\[
\text{Rehydration ratio (RR)} = \frac{\text{weight of rice rehydrated (g)}}{\text{weight of rice before rehydration (g)}}
\]

**Microstructure evaluation**

The structure of the instant rice after drying was investigated by using a scanning electron microscope (Hitachi TM3030 plus, Hitachi, Krefeld, Germany) with 500x magnification for the surface and cross section. The morphological changes of the appearance and pore size were characterized using an acceleration voltage of 15 kV electron intensity.

**Texture characteristics**

The hardness of rehydrated instant rice was measured by using a Texture analyzer (TA-XT plus, Stable Micro System, England) with 35 mm spherical plate. 15 grams of cooked instant rice was pressed and compression distance was 50% strain of the height and pre-test speed, test speed and post-test speed of the plunger were set at 1.0, 1.0 and 10 mm/s, respectively (Leelayuthsoontorn and Thipayarat, 2006). 10 replications were performed. The maximum forces were averaged and reported as hardness. The maximum negative forces were reported as stickiness.

**Whiteness index (WI) measurement**

Instant rice of 100 grams was sampled and the color was measured by using a HunterLab MiniScan XE plus colorimeter (Hunter Associates Laboratory Inc, USA). The color parameters were measured in CIELAB color system. \(L^*\) is a measure of the lightness, \(a^*\) describes as redness-greenness and \(b^*\) describes as yellowness-blueness. Therafter, the whiteness index of instant rice was calculated by using the following equation (Leelayuthsoontorn and Thipayarat, 2006).

\[
\text{WI} = 100 \times [(100-L^2) + a^{2} + b^{2}]^{0.5}
\]

**Volume expansion**

The volume expansion of the product was measured by measuring the volume of the 100 g instant rice by using graduated cylinder. Then measure the volume of the instant rice again after rehydration as shown in the equation (Prasert and Suwannaporn, 2009).

\[
\text{Volume expansion} = \frac{\text{volume of rehydrated rice (ml)} - \text{volume of rice before rehydration (ml)}}{\text{volume of rice before rehydration (ml)}} \times 100
\]

**Statistical analysis**

Analysis of variance (ANOVA) was performed by using a statistical SPSS software (Version 17; SPSS Inc.; Chicago, IL, USA). Comparison between means were examined using Duncan multiple range test (DMRT) at \(p \leq 0.05\) significance level. The results from three replications were presented as means values with standard deviations.

**RESULTS AND DISCUSSION**

**Drying Characteristics**

The drying curves of the instant rice by microwave drying from different rice cooking methods are shown in figure 3. There are two stages of drying: moisture content is reduced rapidly and slowly when the drying is near completion. The first period is within 10 minutes of drying process; the moisture content is dramatically decreased. However after 10 minutes of drying, the moisture content slowly decreases when the moisture content is close to the completion state. At first, instant rice had a moisture content range of 64.79 to 70.83 (%d.b.). During first period of drying, the moisture content decreases in a linear manner, which is called a constant drying rate. Then the moisture content reduced slowly which called a falling rate (Feng et al., 2012). According to Thai rice standard (TACFS, 2017), instant rice should have a moisture content less than 14% wb. or
16% db. to prevent microbial spoilage. In addition, both SPC and BPC showed more reduction in moisture and faster dehydration rate. Specifically, in SPC and BPC method took 35 minutes and 40 minutes respectively. However, in SM and BL method, which used conventional rice cooker instead of pressure cooker. It took longer time in dehydration, 50 minutes and 60 minutes for SM and BL respectively. Effect of the cooking methods on the drying of the instant rice was significant (p ≤ 0.05). For the reason that, pressure cooker increased the pressure inside the rice grain and created porous structures when coupling with microwave caused the volumetric heating. It can generate heat inside of the product. As consequence, the moisture inside grain became steam and moved rapidly to the surface. This phenomenon will generate big and more porous structures. On the other hand, BL method, the grain had higher moisture content and drying rate was slower than other cooking methods.

Rehydration ratio and rehydration time

The rehydration curves of instant rice are presented in figure 4 and appearance of instant rice are presented in figure 5. It was shown that the rehydration ratio was increased with increase in the rehydration time. BPC method showed the fastest rehydration time (3 minutes) and after rehydration process the grain appearance was similar to freshly cooked rice and it was individually separated. On the other hand, SPC, BL and SM showed slower in rehydration time about 4.5 minutes, 5.5 minutes and 7 minutes respectively. BPC (Fig 5A) can rehydrate faster since the rice grains structure has plenty of pores which increase accessibility of hot water to penetrate inside of rice faster than other rice cooking conditions.

Microstructure evaluation

The instant rice by BPC method showed the more porous structures on the surface than SPC in the pressure cooker condition. This porous structure made the rehydration faster. Instant rice from BPC condition was expressed in figures 6A and 6E. It was apparent that there are plenty of pores at the surface, big cracks in the cross section and more spongy structure. The SM and BL methods sample (Figs 6C and 6D) showed small pores on the surface and small cracks in the cross section (Figs 6G and 6H), comparing with BPC and SPC methods. From the research of Prasert and Suwannaporn (2009) and Sripinyowanich and Noomhorm (2012), they found that using pressure cooker can increase pores in the grain structure. As consequences, it can increase the surface area for contact with water and absorb water quickly. Furthermore, BPC had bigger pore sizes and more porous structure due to more water during cooking in the pressure cooker.
CONCLUSION

In conclusion, the results from this experiment showed that the cooking methods have an influence on the quality of dried instant rice. The cooked rice that dried with industrial microwave oven (6,400 watt, 2,450 MHz) until the final moisture content was lower than (14% w.b.) to prevent microbial degradation. The use of industrial microwave oven represents a great alternative drying method since the heat from drying process was used to evaporate water, which can generate porous structure within the grain resulting in lower volume expansion.

Acknowledgments: This research was financially supported by the Graduate Program Scholarship from The Graduate School, Kasetsart University, Bangkhen campus, Bangkok, Thailand.

REFERENCES


Table 1 Hardness, stickiness, whiteness and volume expansion of instant rice from different cooking methods

<table>
<thead>
<tr>
<th>Cooking methods</th>
<th>Hardness (N)</th>
<th>Stickiness (N)</th>
<th>Volume expansion (%)</th>
<th>Whiteness index (WI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshly cooked rice</td>
<td>33.87 ± 0.75**</td>
<td>18.24 ± 2.18**</td>
<td>66.73 ± 1.35**</td>
<td>76.38 ± 1.32**</td>
</tr>
<tr>
<td>SPC</td>
<td>33.42 ± 0.08**</td>
<td>18.63 ± 1.35**</td>
<td>66.58 ± 1.47**</td>
<td>76.20 ± 0.11**</td>
</tr>
<tr>
<td>BPC</td>
<td>33.96 ± 1.24**</td>
<td>17.98 ± 0.52**</td>
<td>66.45 ± 0.85**</td>
<td>76.31 ± 0.02**</td>
</tr>
<tr>
<td>BL</td>
<td>32.92 ± 1.03**</td>
<td>17.93 ± 0.36**</td>
<td>65.23 ± 0.04**</td>
<td>75.56 ± 3.42**</td>
</tr>
<tr>
<td>SM</td>
<td>32.71 ± 0.04**</td>
<td>17.87 ± 3.64**</td>
<td>65.39 ± 0.92**</td>
<td>75.11 ± 0.78**</td>
</tr>
</tbody>
</table>

Values in a row within the same group followed by the ns letters were not significantly different cooking methods (p > 0.05).

Hardness, stickiness, whiteness and volume expansion of instant rice

The hardness of dried instant rice obtained from SM was higher than other cooking methods. In Table 1 shows the hardness and stickiness of dried instant rice after rehydration process. It was found that the hardness of rehydrated instant rice was in the range of 32.71-33.87 N. In contrast, cooking with the pressure cooker (SPC and BPC), boiling (BL) and steaming (SM) did not significantly affect to the hardness and stickiness of rehydrated instant rice. The hardness and stickiness of rehydrated instant rice corresponded to the volume expansion which was not significantly different after rehydration. The whiteness of rehydrated instant rice from different cooking methods have shown no significant difference with the freshly cooked rice. Simultaneously, there was no significant difference in terms of hardness and whiteness of rehydrated instant rice, which means the cooking method did not affect physical properties of rehydrated instant rice. The volume expansion of BPC after rehydration in boiling water for 3 minutes is presented in Table 1. These results revealed that cooking method did not affect the volume expansion of rehydrated instant rice which is similar to the results of Prasert and Suwannaporn (2009). From Table 1, it was found that the volume expansion of instant rice, which dried by industrial microwave oven is lower and this showed the similar result with Jiao et al. (2014), who found the rapid drying method provide lower volume expansion. Since the heat from drying process was used to evaporate water, which can generate porous structure within the grain resulting in lower volume expansion.

Table 1: Hardness, stickiness, whiteness and volume expansion of instant rice from different cooking methods

<table>
<thead>
<tr>
<th>Cooking methods</th>
<th>Hardness (N)</th>
<th>Stickiness (N)</th>
<th>Volume expansion (%)</th>
<th>Whiteness index (WI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshly cooked rice</td>
<td>33.87 ± 0.75**</td>
<td>18.24 ± 2.18**</td>
<td>66.73 ± 1.35**</td>
<td>76.38 ± 1.32**</td>
</tr>
<tr>
<td>SPC</td>
<td>33.42 ± 0.08**</td>
<td>18.63 ± 1.35**</td>
<td>66.58 ± 1.47**</td>
<td>76.20 ± 0.11**</td>
</tr>
<tr>
<td>BPC</td>
<td>33.96 ± 1.24**</td>
<td>17.98 ± 0.52**</td>
<td>66.45 ± 0.85**</td>
<td>76.31 ± 0.02**</td>
</tr>
<tr>
<td>BL</td>
<td>32.92 ± 1.03**</td>
<td>17.93 ± 0.36**</td>
<td>65.23 ± 0.04**</td>
<td>75.56 ± 3.42**</td>
</tr>
<tr>
<td>SM</td>
<td>32.71 ± 0.04**</td>
<td>17.87 ± 3.64**</td>
<td>65.39 ± 0.92**</td>
<td>75.11 ± 0.78**</td>
</tr>
</tbody>
</table>

Values in a row within the same group followed by the ns letters were not significantly different cooking methods (p > 0.05).

Hardness, stickiness, whiteness and volume expansion of instant rice

The hardness of dried instant rice obtained from SM was higher than other cooking methods. In Table 1 shows the hardness and stickiness of dried instant rice after rehydration process. It was found that the hardness of rehydrated instant rice was in the range of 32.71-33.87 N. In contrast, cooking with the pressure cooker (SPC and BPC), boiling (BL) and steaming (SM) did not significantly affect to the hardness and stickiness of rehydrated instant rice. The hardness and stickiness of rehydrated instant rice corresponded to the volume expansion which was not significantly different after rehydration. The whiteness of rehydrated instant rice from different cooking methods have shown no significant difference with the freshly cooked rice. Simultaneously, there was no significant difference in terms of hardness and whiteness of rehydrated instant rice, which means the cooking method did not affect physical properties of rehydrated instant rice. The volume expansion of BPC after rehydration in boiling water for 3 minutes is presented in Table 1. These results revealed that cooking method did not affect the volume expansion of rehydrated instant rice which is similar to the results of Prasert and Suwannaporn (2009). From Table 1, it was found that the volume expansion of instant rice, which dried by industrial microwave oven is lower and this showed the similar result with Jiao et al. (2014), who found the rapid drying method provide lower volume expansion. Since the heat from drying process was used to evaporate water, which can generate porous structure within the grain resulting in lower volume expansion.


