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# Effect of Cooking Methods on Physicochemical Properties of Brown Rice

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***Abstract*—The present study aimed to compare the chemical compositions and physicochemical properties of Jasmine brown rice (Oryza sativa cultivar Kao Dok Mali 105). Brown rice was cooked by various cooking methods, namely electric cooker, microwave oven, steaming, and conventional method. The results indicated that the conventional cooking method significantly reduced protein and fat content. The lowest degree of gelatinization was observed in rice cooked by steaming method. The water to rice ratio of 2:1 showed significantly higher on the hardness, chewiness, and cohesiveness, but lower on the degree of gelatinization than those of other cooking methods.**

***Keywords-component; brown rice; cooking method, chemical compositions, degree of gelatinization, texture profile***

## I. INTRODUCTION

Brown rice is one of the most popular health products due to it is rich in nutrients and bioactive components [1], which can prevent a variety of diseases. Amongst several varieties of brown rice, Jasmine brown rice is one of the most popular varieties in Thailand and export because of its aroma and soft texture, which generally is consumed as a whole kernel of cooked rice. From the survey of [2] on the methods of cooking in consumer countries, it was found that the cooking was depended on rice types and rice eating culture. The basic methods include oven cooking, steaming, and boiling in water. During cooking, rice was changed in the structure of starch, the physical properties, chemical compositions, and nutritional qualities [3]. The study on the effect of cooking methods on several aspects occurring to rice would benefit the manufactures to produce high quality of cooked rice and would also benefit to consumers to prepare the higher nutritional and eating quality of rice. The aim of this work was to investigate the effects of cooking method and ratio of water to rice on the chemical compositions and physicochemical properties of brown rice

## II. MATERIALS AND METHODS

### A. Materials

Jasmine brown rice samples (*Oryza sativa* cultivar Kao Dok Mali 105) were obtained by dehulling the Jasmine rough rice purchased from the Department of Agricultural Product Technology, Mahasarakham University, Mahasarakham, Thailand.

### B. Cooking methods for brown rice

The brown rice kernel was cooked by various cooking methods, namely electric cooker, microwave oven, steaming and conventional method. The brown rice was washed with water and the water was drained off prior to subjecting to cooking by different methods. For the electric rice cooker method, the brown rice kernel was placed in the cooking pot with the ratio of water to rice of 3:1 (w/w) and cooked until the electric cooker was automatically turned off and simmered for 5 minutes to obtain completely cooked rice. For the microwave oven method, the brown rice was placed in a glass bowl (3 cups) and water was added with the water to rice ratio of 4:1. Rice was heated for 25 minute until all water disappeared and simmered for 5 minutes. In the conventional method (the traditional rice cooking in Thai); the brown rice was cooked with excess water in stainless steel pot. The mixture was boiled until rice kernel began to gelatinize (pasting occurred and cooking water almost disappeared) and then cooking water was drained off as much as possible. The brown rice was simmered until completely cooked and desired edible cooked rice was obtained. For the steaming method; the brown rice kernel was placed in the stainless steel bowl (1 cup) with the ratio of water to rice of 1.25:1 (w/w) and cooked for 30 minute until completely cooked rice and all cooking water was disappeared. The cooking temperature profiles of each method were determined using a programmable temperature data logger [2].

The study on the effect of water to rice ratio was investigated by cooking brown rice in the electric cooker and the ratios of water to rice were varied as 2:1, 3:1, and 4:1 (w/v).

### C. Proximate Analysis

The chemical compositions were determined by the standard methods of AOAC [4]. The moisture content was done by drying in an oven at 105°C until constant weight, ash content was determined using a muffle furnace temperature at 550º C, protein content was evaluated by the Kjeldahl method, using 5.95 as the conversion factor, and crude fat was determined by Soxhlet extraction method.

### D. Textural property of cooked rice

The texture of cooked rice was evaluated by adopting the method of [5] and [6] with some modifications using the Texture profile analysis (TPA) (TA-XT2i Texture Analyzer, Texture Technologies Corp., Scarsdale, NY/Stable Micro Systems, Godalming, Surrey, UK) with a texture expert software program. Cooked rice was determined immediately after cooked and cooled down to approximately 30°C. A standard two-cycle program was used to compress the gels for a distance of 10 mm at a crosshead speed of 2 mm/ min, using a 35 mm cylindrical probe with a flat end. Texture parameters of hardness, cohesiveness, chewiness and springiness were derived from the instrument software.

### *E. Degree of gelatinization*

The degree of gelatinization was measured according to the method reported by [7]. The cooked rice was dried in oven at 58°C and ground through the sieve (80 mesh). The sample (0.2g) was prepared in 125 ml Erlenmeyer flasks; 98 ml of distilled water was added and KOH 10 M 2.0 ml and then mixed for 5 minutes prior to centrifugation at 3000 rpm for 15 min. The supernatant (1.0 ml) was pipetted and added with hydrochloric acid 0.5M 0.4 ml followed by 10 ml of distilled water and 0.1 ml of iodine solution. The mixture was homogenized then measuring the absorbance at 600 nm. The degree of gelatinization of standard starch was prepared as the same manners of sample to obtain the standard curve of rice and applied to calculate degree of gelatinization of sample.

### *F. Statistical analysis*

Analysis of variance (ANOVA) and Duncan's new multiple range test (DMRT) were used to evaluate the effect of cooking methods on compositions and physicochemical properties of brown rice using SPSS statistical software (version 10.0 SPSS, INC., Chicago, USA)) at 95% confidence level ($p \leq 0.05$).

## III. Results and Discussion

### *A. Chemical compositions*

Brown rice is a healthy fiber and vitamin rich food with a multitude of health benefits. Unlike white rice, brown rice only has the outermost layer of the rice kernel removed and left much of the nutritional value of the rice intact. The proximate chemical compositions of brown rice different cooking method were calculated on dry basis and listed in Table I. The protein and fat contents were ranged from 6.83% to 8.69% and 2.12% to 2.45%, respectively. Rice cooked by the conventional method indicated a lower amount of protein and fat than those of other methods; this may due to the water was drained off during the process. Brown rice cooked by different cooking methods presented similar mean values for ash and crude fiber contents, ranged from 1.27 to 1.42% and 1.73 to 2.11% respectively.

TABLE I. Proximate Composition (%) Of Cooked Brown Rice Samples From Different Cooking Methods

| **Cooking Methods** | **Chemical composition (%)** | | | | |
|---|---|---|---|---|---|
| | ***Protein*** | ***Fat*** | ***Fiber*** | ***Ash*** | ***Moisture*** |
| Microwave | 8.49±1.26$^{a}$ | 2.45±0.09$^{a}$ | 1.93±0.23 | 1.42±0.01 | 8.27±0.43 |
| Conventional | 6.83±0.22$^{b}$ | 2.12±0.18$^{b}$ | 2.06±0.43 | 1.37±0.03 | 8.41±0.15 |
| Steaming | 8.05±0.28$^{a,b}$ | 2.42±0.04$^{a}$ | 2.11±0.29 | 1.34±0.01 | 8.06±0.29 |
| Electric cook | 8.69±0.58$^{a}$ | 2.35±0.19$^{a,b}$ | 1.73±0.33 | 1.27±0.16 | 8.5±0.06 |

a. Means within columns followed by the same letter are not significant different at $p \leq 0.05$

### *B. Texture profiles analysis*

Table II shows the textural characteristics of cooked rice obtained from differential cooking methods. The hardness values of cooked rice were ranged from 9.71 N to 12.56 N. The hardness of cooked rice by the microwave and steaming method were harder than those by conventional and electric rice cooking method. There were not different in cohesiveness, chewiness, and springiness values. These results were similar to those reported [8].

### *C. Degree of gelatinization*

The effect of cooking methods on degree of gelatinization and effect of ratio of rice to water on degree of gelatinization of rice by electric cooker are shown in Fig 1 and 2., respectively. The degree of gelatinization of cooked rice form different cooking method was ranged from 90.96% to 999.89%. The gelatinization of starch is depending on time , amount of water and process [9], which cooked rice with steaming method has degree of gelatinization less than another sample ($p \leq 0.05$).

TABLE II. Texture Profile Of Cooked Brown Rice Samples From Difference Cooking Methods

| **Cooking methods** | **Texture Profile** | | | |
|---|---|---|---|---|
| | ***Hardness*** | ***Cohesive-ness*** | ***Springi-ness*** | ***Chewiness*** |
| Microwave | 12.56±1.31$^{a}$ | 0.24±0.00 | 0.39±0.12 | 1.16±0.21 |
| Conventional | 10.03±1.41$^{b}$ | 0.25±0.01 | 0.56±0.07 | 1.36±0.12 |
| Steaming | 12.37±0.65$^{a}$ | 0.25±0.01 | 0.50±0.17 | 1.61±0.55 |
| Electric cook | 9.71±1.08$^{b}$ | 0.25±0.01 | 0.35±0.18 | 0.85±0.47 |

a. Means within columns followed by the same letter are not significant different at $p \leq 0.05$

### *D. Effect of water to rice ratio on physicochemical properties and degree of gelatinization*

The results are showed in Table III; water to rice ratio affected on hardness, chewiness and cohesiveness of cooked brown rice. The water to rice ratio of 2:1 yielded the hardest in texture which may be due to the cooking water was not enough for the gelatinization of starch to completely take place whereas in the water to rice ratio of 3:1 and 4:1, rice was completely cooked and yielded the desired texture [10] and [11]. However, the eating quality of cooked rice depends on several factors such as time, temperature, and stir in a process, all of which have resulted in the hardness and other cooking aspects of cooked rice [12].

Furthermore, water to rice ratio affected on degree of gelatinization as shown in Fig 2. The mean values of the degree of gelatinization of cooked rice were ranged from 84.05% to 99.32%. The degree of gelatinization of cooked rice tended to decrease with decreasing the ratio of water to rice. The water to rice ratio of 2:1 resulted in the lowest decrease in the degree of gelatinization ($p \leq 0.05$). Starch gelatinization is a process that break down the intermolecular bonds of starch molecules in the presence of water and heat, allowing the hydrogen bonding sites (the hydroxyl hydrogen and oxygen) to engage more water. Penetration of water increases randomness in the general structure and decreases the number and size of crystalline regions. Crystalline regions do not allow water entry. Heat causes such regions to be diffused, so that the chains begin to separate into an amorphous form [13]. Therefore gelatinization requires adequate of water. The information on degree of gelatinization could be inferred to the susceptibility of the starch to amylase and therefore the extent rate of starch digestibility and glycemic index.

TABLE III. TEXTURE PROFILE OF RICE COOKED BY DIFFERENCE RATIO OF RICE TO WATER USING ELECTRIC COOK

| Ratio of water to rice | Texture Profile | | | |
|---|---|---|---|---|
| | *Hardness* | *Cohesiveness* | *Springiness* | *Chewiness* |
| 2:1 | 14.90±0.54[a] | 0.26±0.02[a] | 0.54±0.07 | 2.11±0.39[a] |
| 3:1 | 9.71±1.08[b] | 0.25±0.01[a,b] | 0.35±0.18 | 0.85±0.47[b] |
| 4:1 | 6.85±0.86[c] | 0.22±0.01[b] | 0.41±0.09 | 0.64±0.23[b] |

a. Means within columns followed by the same letter are not significant different at $p \leq 0.05$

## IV. CONCLUSIONS

There are many methods to cooked rice depending on individual local eating culture. Our results showed that the cooking methods significantly affected chemical compositions and physicochemical properties and eating quality. The ratio of water to rice also affected the eating quality of brown rice. Therefore, rice cookers should consider this main point to get the benefit to consumers.

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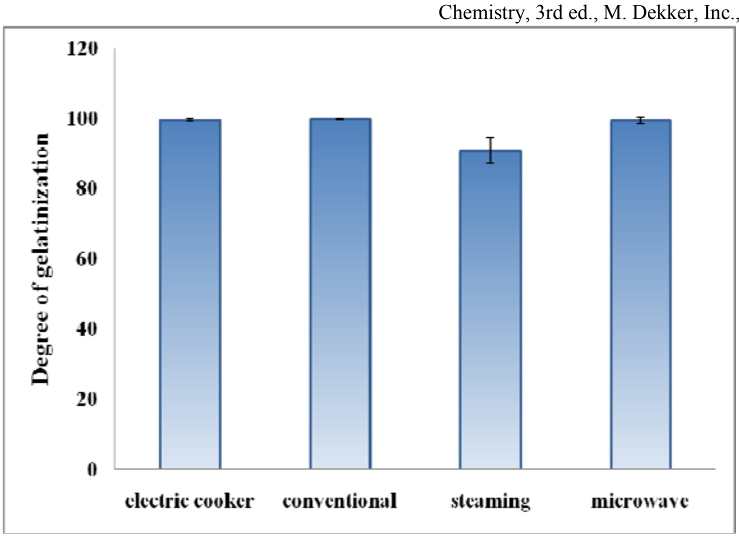


Figure 1. Effect of cooking methods on the degree of gelatinization of cooked brown rice

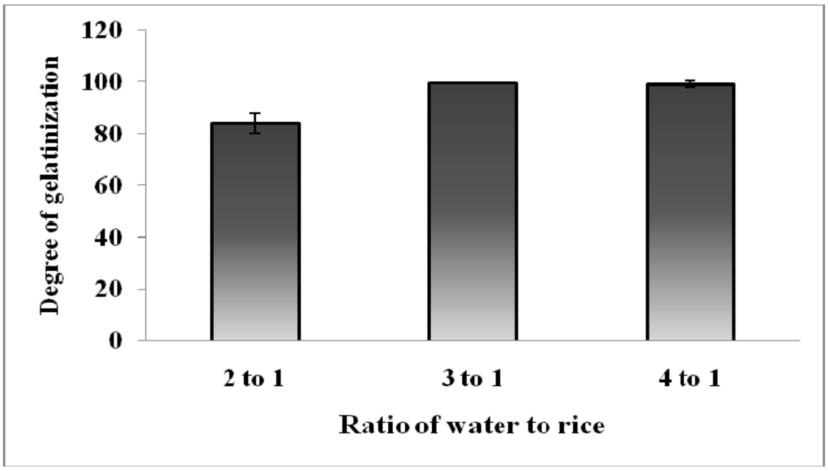

Figure 2. Effect of water to rice ratio on the degree of gelatinization of cooked brown rice