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Comparative Physical Characterization of Water Ratio Changes of Hang Rice during Cooking

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Abstract. Hang rice is promoted as high nutritious food since it has higher nutritional value than Jasmine white rice. However, cooked Hang rice prepared by the same rice to water ratio as in the case of Jasmine white rice was found to be broken and hence affected appearance and texture acceptance to consumers. The purpose of this research was to study physical characterization of Hang rice undergoing cooking. Hang rice was cooked using different Hang rice to water ratios (2:1, 1:1, 1:2 and 1:3 w/w) at cooking time of 0-50 min. It was found that increased water ratio and cooking time resulted in cooked Hang rice with increased color change and elongation of the product. However, increased water ratio and cooking time resulted in cooked Hang rice with significantly decreased hardness ($P \leq 0.05$). Results could be advantage to the optimization of Hang rice cooking and Hang rice products.

Keywords: Cooking, Hang rice, Physical property, Water ratio.

1. Introduction

Hang rice is one of high nutritional values rice products, produced in the East North of Thailand. It is promoted as high nutritious food since it is rich of carbohydrate, vitamin and minerals. Hang rice is achieved from harvesting grain from varieties of rice such as Khao Dawk Mali (KDML) 105 or Jasmine rice (*Oryza sativa* L.) and glutinous rice (*Oryza sativa var. glutinosa*) in immature but fully formed stage (dough stage). Then it is streamed, dried and partially polished. In Hang rice manufacturing, starch molecules are heated during streaming and absorb more water, swell and gelatinize. After that, the rice is dried and induced pre-gelatinized starch. It is most probable that morphological, physical and structural properties of Hang rice would be different from those of Jasmine rice and glutinous rice.

Hang rice is consumed by cooking or streaming. However, an ample amount of water to obtain desirable texture of cooked Hang rice would be different from other rice. Cooked Hang rice prepared by the same ratio of rice to water as in the case of Jasmine white rice was found to be over cooked. In addition, its morphology was found to be broken and hence affected appearance and texture acceptance to consumers. Varieties of rice affect rice quality such as cooking, eating and nutrition qualities of rice [1]. Moreover, cooking time and cooking conditions affect physical, morphological and structural changes of the cooked rice [2-4]. To study physical characterization of Hang rice prepared by using different ratios of Hang rice to water could be advantage to consumers and applied to other products development from Hang rice. The purpose of this research was to study physical characterization viz. color change, elongation and texture of Hang rice, prepared from different Hang rice to water ratios, undergoing cooking time.

2. Methodology

2.1. Raw Materials and Sample Preparation

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Hang rice (produced from Jasmine rice, *Oryza sativa* L.) was obtained from Ban Na Bor Village, Sakon Nakhon Province, Thailand. Moisture content of the rice was controlled to 4-6% (wb) prior to vacuum packed in laminate low density polyethylene bag and kept at 4°C until use (not over than 3 months).

Hang rice was equilibrated at room temperature for 30 min prior to cook. Sample was weighted and added with distilled water with Hang rice to water ratios of 2:1, 1:1, 1:2 and 1:3 (w/w). Different Hang rice to water ratios were mixed in a stainless beaker prior to heat in a boiling water bath (100°C) at boiling time of 0, 5, 10, 15, 20, 30, 40 and 50 min, respectively. After different boiling time achieved, cooked Hang rice was rinsed and kept in plastic box before cooling with cold water at 0-2°C for 5 min. Cooked Hang rice was then measured color changes, elongation and textural properties.

2.2. Properties Determination

- **Color**

Color test was conducted before and during different cooking time. Five samples in each cooking time were taken to color measurement using colorimeter (Minolta CR300, Japan). Color measurements (L^*, a^* and b^*) were taken in triplicate. Color changes, ΔE, was expressed below [5]:

$$\Delta E = \sqrt{\left(L^* - L\right)^2 + \left(a^* - a\right)^2 + \left(b^* - b\right)^2} \quad (1)$$

where the L, a, b, represent lightness, redness-greenness and yellowness-blueness of raw Hang rice before cooking and L^*, a^*, b^*, represent target color of Hang rice at different cooking time. Larger ΔE denotes greater color change from reference material.

- **Elongation**

Length of Hang rice before and after cooking was measured using vernia caliper. Elongation was expressed below:

$$Elongation = \frac{length\ of\ cooked\ rice}{length\ of\ raw\ rice} \quad (2)$$

- **Texture**

Textural property of cooked Hang rice sample was determined using a texture analyzer (TA-XT2i, Stable Micro System, Surrey, England). A back extrusion test of sample was set according to Leelayuthsoontorn and Thipayarat [2]. Cooked rice sample in the cylindrical test cell was compressed by a spherical plate plunger of 35 mm diameter during measurement. Pre-test speed and test speed were set at 1.0 mm/s and post-test speed were set at 10mm/s. Compression distance was 10% strain. A force-time curve was obtained from the test and hardness (the maximum compressive force during extrusion (N)) was recorded.

2.3. Statistical analysis

All analysis was done in triplicate. An analysis of variance (ANOVA) was used to analyze the data and significant different between Hang rice to water ratios and cooking time were compared at a significance level of 95%.

3. Results and Discussion

3.1. Color change

Fig. 1 shows color changes of Hang rice with different Hang rice to water ratio undergoing cooking. Increased water ratio and cooking time resulted in cooked Hang rice with increased color change. Hang rice is produced from partially polishing and this leads color of Hang rice is yellow-gold. Kerdpiboon et al. [6] found that increase of water resulted in porridge with decreased lightness, redness and yellowness of Hang rice porridge. These induce greater color change from reference material.

3.2. Elongation

Fig. 2 represents elongation of Hang rice with different Hang rice to water ratio undergoing cooking. Elongation of cooked Hang rice is between 1-2.03 depending on ratios of Hang rice to water and cooking time. It was found that increased water ratio and cooking time resulted in cooked Hang rice with increased

elongation of the cooked rice (Fig. 2). Besides, elongation of Hang rice trends to increase with increase of cooking time. During cooking, the rice granules absorbed water and swell to great extent compared to the original size. This causes ruptures and hence amylase leaching and these affect morphology of the rice [2,7]. Charoendee and Kerdpiboon [8] found that increase of water ratio and cooking time displayed more morphological changes to the cooked Hang rice.

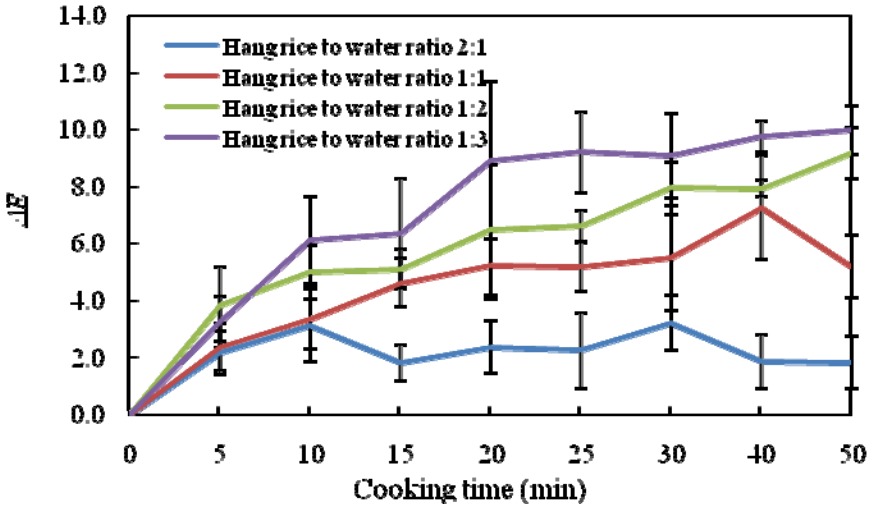

Fig. 1: Colour change of Hang rice during cooking with different Hang rice to water ratio.

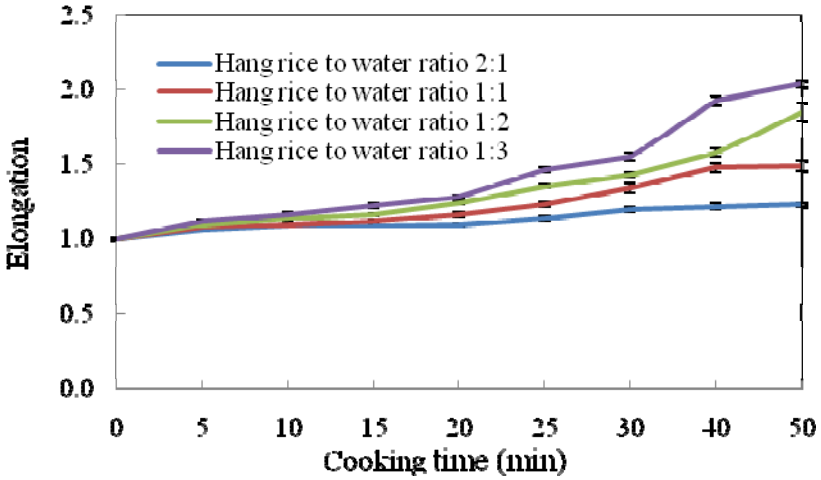

Fig. 2: Elongation of Hang rice during cooking with different Hang rice to water ratio.

3.3. Hardness

Table 1 represents elongation of Hang rice with different Hang rice to water ratio undergoing cooking. Hardness of the product is between 10.44-169.56 N depending on Hang rice to water ratios and cooking time. At the same ratio of Hang rice to water, hardness of Hang rice decreased significantly as the cooking time increased ($P \leq 0.05$). During cooking, water is absorbed into the rice grains and hydrogen bonds between the starch molecules are replaced by bonds between the starch and water molecules [9-10]. The starch molecules expand and cause starch leaching. The amount of starch leaching is a function of temperature and the fine structures of amylose and amylopectin, related to the texture of cooked rice [11]. The leaching of starch causes the reduction of hardness of cooked Hang rice.

At the same cooking time, increase of water ratio results in decrease hardness of the product. This is because starch molecules had more water to absorb and decrease compression force of the product. Results could be supported as in the same trend as elongation of cooked Hang rice.

4. Conclusions

Increase of water ratio and cooking time results in cooked Hang rice with increased color change and elongation of the rice. Increased water ratio and cooking time resulted in cooked Hang rice with significantly decrease hardness (P≤0.05). Results could be advantage to the optimization of Hang rice cooking and Hang rice products.

Table 1: Hardness of cooked Hang rice with different Hang rice to water ratio and cooking time

Cooking time (min)	Hang rice to water ratio			
	2:1	1:1	1:2	1:3
5	169.56 ± 18.85^{Cb}	103.26 ± 24.69^{ABd}	121.25 ± 29.74^{Bd}	58.19 ± 44.50^{Ab}
10	147.99 ± 23.93^{Bab}	76.58 ± 14.78^{Ac}	79.79 ± 22.32^{Ac}	54.10 ± 20.56^{Ab}
15	136.01 ± 29.88^{Bab}	35.76 ± 7.07^{Ab}	50.49 ± 13.27^{Ab}	39.48 ± 11.10^{Aab}
20	135.97 ± 36.10^{Bab}	29.29 ± 7.12^{ABa}	23.10 ± 2.01^{Aa}	32.62 ± 10.40^{Aab}
25	108.34 ± 12.04^{Ca}	28.05 ± 6.19^{Bab}	13.59 ± 2.74^{Aa}	13.70 ± 5.05^{Aa}
30	119.10 ± 22.38^{Ba}	$15.363.48^{Aa}$	13.12 ± 3.06^{Aa}	17.68 ± 4.05^{Aa}
40	137.88 ± 34.56^{Bab}	16.21 ± 4.81^{Aa}	11.84 ± 1.43^{Aa}	11.32 ± 1.64^{Aa}
50	106.46 ± 11.59^{Ba}	16.03 ± 2.50^{Aa}	11.38 ± 2.37^{Aa}	10.44 ± 2.64^{Aa}

^{a,b,c,d} Means with different letters in the same column are significantly different ($P\leq0.05$)
^{A,B,C} Means with different letters in the same row are significantly different ($P\leq0.05$)

5. Acknowledgements

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