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Effects of Composite Rice Flour and Water Content on Qualities of Thai Rice Cake

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ABSTRACT

This study was conducted to determine the effects of composite rice (Jasmine, JR and Yellow-11 varieties) flour ratio and water content on the physical quality and sensory acceptability of Thai rice cake. A 3×3 full factorial design was used: 3 ratios of JR and Yellow-11 rice flours (10:90, 20:80, 30:70) and 3 levels of water content (0.3, 0.5, 0.7 times of dry-mix weight) were investigated. As the amount of JR flour increased, the amylose content of the composite flour decreased, causing springiness of Thai rice cake to decrease due to a loss in expandability of the flour. The optimal composite flour ratio was 20:80 with added water at 0.5 times of the dry-mix weight. This ratio produced the Thai rice cake with acceptable softness and springiness, and overall liking of the product was rated as "like moderately." The water ratio greater or lesser than 0.5 times, respectively, resulted in a sticky or dry product.

Key words: acceptability, composite rice flour, Thai rice cake, textural quality

INTRODUCTION

Thai desserts have long been symbolic of Thai tradition. The three main ingredients for making Thai desserts are flour, sugar and coconut milk. Functional ingredients affect characteristics of end products such as pumpkin custard (Jangchud *et al*., 1999), rice cake (Mohamed and Hamid, 1998) and extruded snack product (Suknark *et al*., 1999). Rice flour is one of the main ingredients used in a number of Thai desserts such as Khanom Tan, Khanom Chan and Khanom Krok. Rice starch granules are polygonal in shape with a very small size of 2-5 mm. (Hoseney, 1994). The size, structure, and shape of starch granules affect flour characteristics such as swelling power, solubility and gelatinization temperature (Leach *et al*., 1959). Starch granules compose of a mixture of two polymers : amylose and amylopectin (Whistler and Bemiller, 1999). Rice is classified by the amylose content as waxy (0-2%), very low (5-10%), low (10-20%), intermediate (20-25%) and high (25-33%) amylose rice (Juliano *et al*., 1981). Rice flours with different physicochemical properties yield products with different textural qualities. Therefore, an appropriate rice variety must be selected as a raw material to produce products, such as desserts and noodles.

Thai rice cake (Khanom Tan) is a traditional Thai dessert made by steaming fermented batter consisting of rice flour, sugar, salt, coconut milk and palmyrah fruit pulp to yield a soft and spongy product (Rojanapaiboon, 1989). Palmyrah fruit pulp contains yeast that ferments the batter to

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obtain a spongy product. Jasmine rice (JR) is a major crop in Thailand. The milling process produces a significant quantity of broken JR currently having low economic value. The broken JR and flour have been underutilized for further food production, particular for Thai dessert, as they yield undesirable texture quality. The composite flour of broken JR and other rice varieties may provide an alternative for better utilization of broken JR.

The objective of this study was to determine physicochemical properties of rice flour and the effects of composite rice flour ratio (JR and Yellow-11) and water content on physical and sensory acceptability of the traditional Thai rice cake (Khanom Tan).

MATERIALS AND METHODS

1. Preparation of raw materials and rice cake

Rice (*Oryza sativa*, JR and Yellow-11 varieties), palmyrah fruit pulp, coconut powder, sugar, baking powder and yeast were purchased from a local supermarket in Thailand. Yellow-11 rice and broken JR were separately prepared into rice flours using a wet milling process. Rice (2 kg) was soaked in water (4 l) for 4 hrs and then milled with additional water at the ratio of 1:3 (soaked rice: water). Flour was separated by centrifugation, then dried at 60°C for 4-6 hrs to attain an approximate moisture content of not greater than 14%, packed in polypropylene bags and stored at 5-10°C until further used.

Steriled palmyrah fruit pulp was prepared according to Boonthrapong *et al.* (2000). Palmyrah fruit pulp was packed in a lacquered can (307×113), exhausted, sterilized at 121°C for 15 min and rapidly cooled with water at room temperature (30°C).

Thai rice cake was prepared by mixing composite rice flour, sugar, salt, coconut milk, sterilized palmyrah fruit pulp, yeast and baking powder. The batter was fermented for 45 min. The fermented batter was portioned into small cups (20g each) and steamed for 15 min to obtain a spongy product. The product was left at room temperature for 15 min, removed from the cups and stored in sealed polypropylene plastic bags for further quality evaluation.

2. Experimental design

A 3X3 full factorial design was used. Three levels of broken JR: Yellow-11 rice flour ratios (10:90, 20:80, 30:70) and three levels of water content (0.3, 0.5, 0.7 times of total dry-mix weight) were investigated. A total of nine Thai rice cake products were made, each was prepared in duplicate (two experimental replications).

3. Amylose determination

The apparent amylose content (%) was determined according to the method of Juliano (1971). Three replications were performed for each flour sample.

4. Pasting properties

Yellow-11 and JR flours were separately analyzed in triplicate for pasting characteristics using a Rapid Visco Analyzer (4D, Newport Scientific Pty. Ltd., Australia). A suspension of 10% flour in de-ionized water (dry basis, w/v) was heated from 50 to 95°C at an increasing rate of 12°C /min with constant stirring at 160 rpm. The sample was held at 95°C for 2.5 min (break down), then cooled to 50°C at a rate of 13°C/min (setback), and held for 2 min. The total cycle was 13 min. Pasting temperature was recorded as the temperature at which an increase in viscosity was first observed. The values reported included pasting temperature (°C), peak viscosity (RVU), final viscosity (RVU), trough (lowest viscosity, RVU), break down (different between peak viscosity and trough, RVU), set back from peak (the difference between final viscosity and peak viscosity, RVU) and set back from trough (the difference between final viscosity and trough, RVU).

5. Texture profile analysis (TPA)

The texture profile characteristics of Thai rice cakes were analyzed using the Lloyd Texture Analyzer (TA 500, Intro Enterprise Co., Ltd, England). The texture analyzer was equipped with a 50 kg load cell and a 50 mm diameter compression cell. The test speed was set at 50 mm/min and the distance to compress sample was 60% strain. The hardness (N) and springiness (mm) of the samples were recorded and an average of 10 measures was reported. Puffiness of the Thai rice cakes was measured in mm as the length from the top to the bottom of Thai rice cake.

6. Color determinations

Colorimetric measurements of Thai rice cakes were determined in triplicate at the center of the product surface using a spectrophotometer (CM 3500d, Minota Camera Co., Ltd, Tokyo, Japan). The CIE color values were recorded as L* = lightness (0 = black, 100 = white), a* (-a* = greenness, +a* = redness) and b* (-b* = blueness, +b* = yellowness).

7. Sensory acceptability

For consumer acceptance, two pieces of each of the 9 Thai rice cake samples were evaluated by 30 untrained panelists. Panelists were asked to evaluate 2 sets of samples. The first set composed of five samples, then took a 10-min break, and the second set of four samples were evaluated. They individually evaluated the samples in partitioned booths under fluorescent light at room temperature. A 9–point hedonic scale (1 = dislike extremely; 5 = neither like nor dislike; 9 = like extremely) was used to evaluate acceptability of the product attributes (yellow color, springiness, puffiness, sweetness and overall acceptance).

8. Statistical analysis

The physical and sensory data were analyzed by analysis of variance (ANOVA). Duncan's multiple range test (DMRT) was performed for post-hoc multiple comparison. Statistical significant difference was established at $p<0.05$.

RESULTS AND DISSCUSSION

1. Properties of rice flour

The pasting temperature of broken JR and Yellow-11 rice flours was 62.0 and 71.8°C, respectively (Table 1, Figure 1). This indicates that swelling power and solubility of JR flour are likely greater than those of Yellow-11 rice flour. The amylose content of rice starch also affects swelling power. The amylose content of Yellow-11 rice flour (33.34%) was greater than JR flour (20.92%). Rani and Bhattacharya (1995) reported that high amylose rice starch granules were strong

Table 1 Pasting properties of Yellow-11 rice flour and Jasmine rice flour obtained from the RVA viscoamylograph[1/].

Attributes	Jasmine rice flour	Yellow-11 rice flour
Pasting temperature (°C)	62.0±12.8	71.8±12.7
Peak viscosity (RVU)	287.5±1.7	267.5±0.3
Trough (RVU)	186.1±3.1	98.9±0.1
Breakdown (RVU)	101.3±3.2	68.5±2.6
Final viscosity (RVU)	309.4±6.8	374.1±1.7
Setback (RVU)	123.3±3.7	175.2±1.2

[1/] Mean values ± standard deviation of 3 replications.

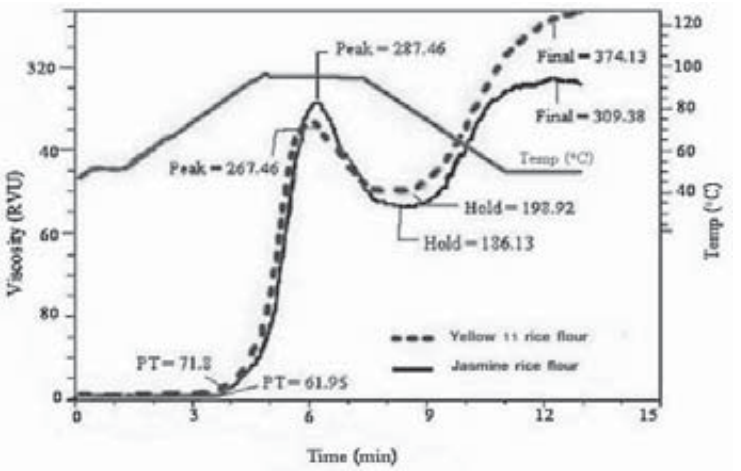

Figure 1 Pasting behavior curve of Yellow-11 rice flour and Jasmine rice flour.

and rigid, and, therefore, resisted swelling and disintegration, while low amylose rice starch granules were weak and fragile, so tended to swell and disintegrate. The peak viscosity of JR and Yellow-11 rice flour was 287.5 and 267.5 RVU, respectively. Flour with a lower peak viscosity has a lower thickening power than flour with a higher peak viscosity; therefore, Yellow-11 rice flour has a lower thickening power than JR rice flour. The final viscosity of JR and Yellow-11 rice flours was 309.5 and 374.1 RVU, respectively. The final viscosity of rice paste is related to the amylose content. Flour with a higher amylose content gives a higher final viscosity. Lai (2001) reported that rice contained 28.8% amylose had a higher final viscosity than the one with 17.9%. The setback from through is also related to the amylose content and reflects retrogradation of starch. The setback values of JR and Yellow-11 rice flours were 123.3 and 175.2 RVU, respectively, indicating that Yellow-11 rice flour had greater retrogradation tendency than JR flour.

2. Physical properties of Thai rice cakes

For color characteristics of Thai rice cakes, the composite rice flour ratio significantly affected ($p<0.05$) a* and b* values but did not affect L* value (Figure 2). Water content significantly affected ($p<0.05$) the L*, a* and b* of the products. At both water content levels of 0.3 and 0.5 times of dry-mix weight, as the amount of JR flour increased, the a* and b* values increased and the products became more reddish and yellowish. For each level of composite rice flour ratio, a* and b* values significantly decreased with increased water content. Sterilized palmyrah fruit pulp contains β-carotene of 17.65 mg/100g (Boonthrapong *et al*., 2000), which gave an orange color in rice cake. Addition of water would dilute this pigment resulting in reduction of red and yellow color of the products.

For texture qualities of Thai rice cakes, the composite rice flour ratio and water content showed significant effects ($p<0.05$) on hardness and springiness (both obtained from TPA) and puffiness (Figure 3, 4, and 5). As the water content increased from 0.3 to 0.5 times of total solid weight, hardness decreased, regardless of the composite flour ratios. Furthermore, the hardness of Thai rice cakes gradually decreased as the JR flour increased. However, when water was added at 0.7 times, hardness significantly increased (Figure 3) and the product became dense and gummy. The lower hardness value indicates a softer texture of the

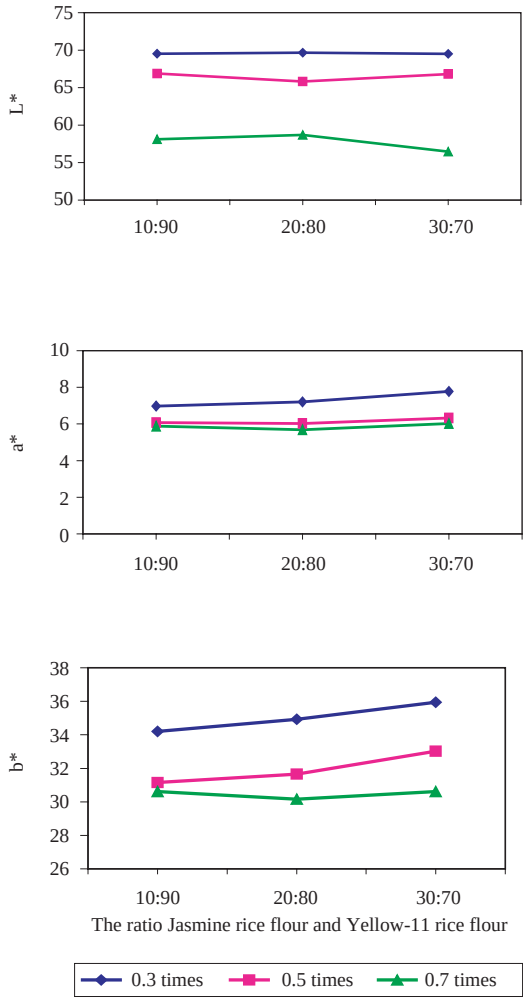

Figure 2 Color L*, a* and b* of Thai rice cakes at different rice flour ratios and water contents.

product. The amount of water should be optimized to obtain desirable texture of the product. The less amount of water (at 0.3 times) provided a product with less softness because it was not enough for the majority of starch granules to completely gelatinize. However, using an excessive amount of water (0.7 times) yielded a product with greater hardness. The increased water content decreased the viscosity of the batter, thus, reducing its gas retention ability (Mohamed and Hamid, 1998). When adding water to the batter in an excessive amount (0.7 times), product was dense resulting in a higher hardness value. When water was added at 0.3 times, increasing the amount of JR flour did not have a significant effect on hardness (7.4-7.8 N). At 0.5 times of water addition, the hardness significantly increased ($p<0.05$) as the amount of JR flour increased. At 0.7 times of water addition, the hardness of products decreased at a 20% JR flour level but then increased at 30% JR flour level. The product (20% JR, 0.7 times water) had much less bubbles resulting in a significant increase in hardness. This was due to the stickiness property of JR flour that reduced the ability of gas retention of the cooked product which was flat (not spongy) and gummy. Our observation was supported by the study of Nishita and Bean (1979) who reported that rice bread showed a flat and gummy loaf when 100% waxy rice flour was used. When the amount of water content increased from 0.3 to 0.5 and 0.7 times, the springiness significantly ($p<0.05$) decreased (Figure 4). Increasing JR flour from 10% to 30% decreased springiness of the products containing water at 0.7 times. The maximum viscosity of JR flour from RVA (Table 1) was higher than that of Yellow-11 rice flour. The higher viscosity of the batter reduced springiness of the Thai rice cake products.

Puffiness of Thai rice cakes significantly decreased ($p<0.05$) with increased water addition from 0.3 to 0.7 times; however, there was no significant difference ($p<0.05$) between products with water at 0.3 times (Figure 5). At each water content, the amount of JR flour did not significantly ($p<0.05$) affect the puffiness. The puffiness of products at 0.3 - 0.5 times of water addition was 32.1-34.5 mm, while the puffiness value was 20.8-21.3 mm at 0.7 times of water addition (Figure 5).

3. Consumer acceptance

The mean values of the hedonic ratings for sensory attributes of Thai rice cake samples are shown in Table 2. The amount of JR flour and water significantly affected ($p<0.05$) sensory

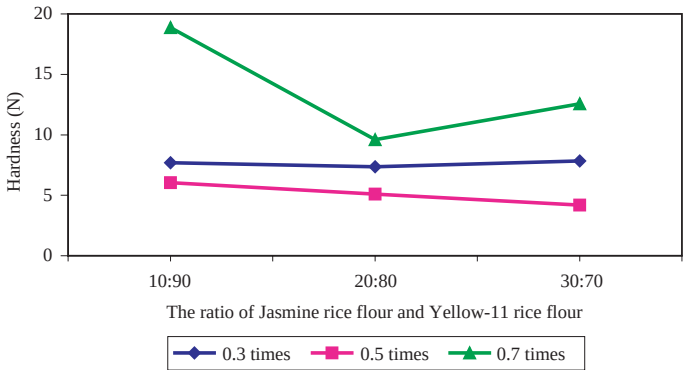

Figure 3 Hardness of Thai rice cakes at different rice flour ratios and water contents.

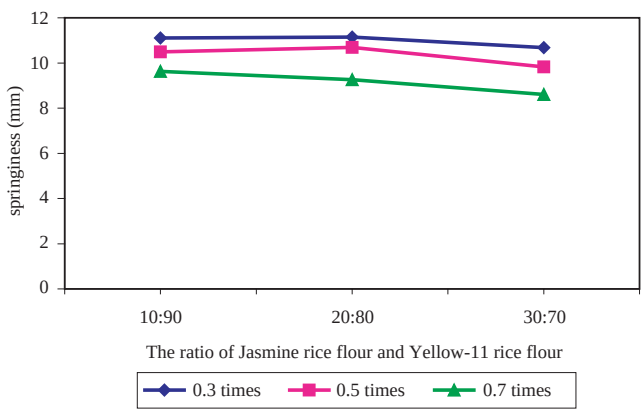

Figure 4 Springiness of Thai rice cakes at different rice flour ratios and water contents.

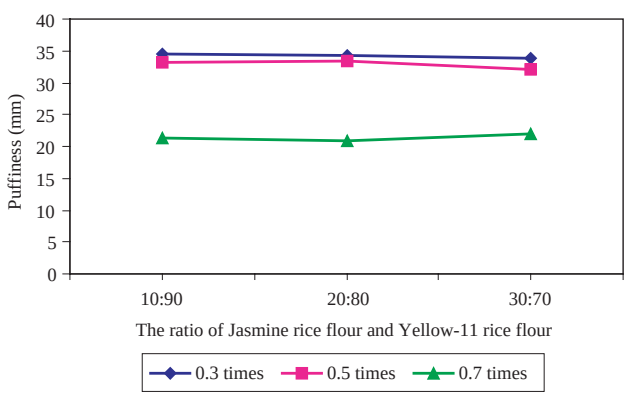

Figure 5 Puffiness of Thai rice cakes at different rice flour ratios and water contents.

Table 2 Consumer acceptability of Thai rice cakes.

Attributes	Ratio of Jasmine rice flour and yellow-11 rice flour	Water content (times of total weight)		
		0.3	0.5	0.7
Yellowness	10:90	6.9(1.3)b	7.5(0.8)a	6.6(1.2)c
	20:80	6.8(1.2)b	7.3(0.9)a	6.6(1.3)c
	30:70	7.0(1.0)b	7.3(0.9)a	6.5(1.3)c
Softness	10:90	4.3(1.6)c	7.0(1.0)a	5.2(1.7)b
	20:80	4.8(1.2)bc	7.6(0.7)a	4.7(1.6)bc
	30:70	5.2(1.4)b	7.2(0.9)a	4.4(1.6)c
Puffiness	10:90	5.5(5.5)b	7.1(0.9)a	3.9(1.9)c
	20:80	5.7(1.6)b	7.4(1.3)a	2.7(1.3)d
	30:70	5.9(1.0)b	7.0(1.0)a	2.9(1.3)d
Sweetness	10:90	6.4(1.1)c	7.3(1.0)a	7.0(0.8)b
	20:80	6.3(1.1)c	7.4(0.7)a	6.4(1.1)c
	30:70	6.3(1.3)c	6.9(1.0)b	6.6(1.1)bc
Overall liking	10:90	4.6(1.3)d	7.3(1.1)a	4.7(1.4)d
	20:80	5.0(1.2)cd	7.5(0.8)a	3.9(1.2)e
	30:70	5.5(1.5)c	6.8(1.0)b	3.8(1.4)e

[a-e] Means within the same attribute with different letters are significantly different ($p<0.05$).
Values were based on a 9-point hedonic scale (1=dislike extremely; 9=like extremely).

acceptability of yellowness, softness, puffiness, sweetness and overall liking. At each JR flour level, the hedonic scores for yellowness, softness, puffiness, sweetness and overall liking of the products at 0.5 times water addition were higher than those at 0.3 and 0.7 times addition. When an excessive water (0.7 times) was added, softness scores significantly decreased as the JR flour increased. The high amount of water and JR flour imparted a stickiness texture of the products that was not acceptable for the consumers. When the low (0.3 times) compared to the high (0.7 times) water content, the products were less softness compared to much stickier/dense texture, both samples were not acceptable. Puffiness of the products at 20% and 30% JR flour and water of 0.7 times was unacceptable with the hedonic score range of 2.7-2.9. The springiness and puffiness of the products at 0.5 times of water addition were significantly higher ($p< 0.05$) than those at 0.7 times water addition as shown in Figure 4 and 5. This result was supported by the finding on the rice cake products by Mohamed and Hamid (1998), who reported that further increase in amylopectin content increased stickiness, decreased firmness volume, and decreased acceptability of the rice cakes. The overall liking of the products with 20% and 30% JR flour and water of 0.7 times was 3.8-3.9; the products were sticky with less softness and low puffiness. Yellowness, softness, puffiness, sweetness and overall liking of the products at 10% and 20% JR flour and water of 0.5 times were more acceptable with higher hedonic scores (like moderately) when compared with other treatments.

CONCLUSION

As the amount of JR flour increased, the amylose content of the composite flour decreased and, thus springiness and puffiness of Thai rice

cake decreased due to a loss in expandability of the batter after steaming. The optimal JR and Yellow-11 rice flour ratios were 10:80 and 20:80 with added water at 0.5 times of the total dry-mix weight. The higher or lower water ratio than 0.5 times, respectively, resulted in a stickier or harder product. Softness, puffiness, sweetness and overall liking of the products were rated as "like moderately" when 10-20% JR and water at 0.5 times were used.

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