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Characteristics of Flattened Rice Flour Used with Daifuku

Yotsinee Huadong & Tita Foophow*

Department of Nutrition and Culinary Arts for Health Capability and Anti-aging Wellness, School of Culinary Arts, Suan Dusit University, Dusit, Bangkok, 10300 Thailand

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Abstract

Flattened rice, an immature sticky rice product, contains high nutritional values and bioactive compounds. Based on its health values, this rice has been used as a functional ingredient in food. The objective of this study was to characterize the properties of sticky rice flour with substitution of flattened rice flour at 0-100% on Daifuku. Flattened rice flour was green-yellow in color and had very low amylose content (3.34%). The starch granule of flattened rice flour revealed an apparent pigment of phenolic compound and/or chlorophyll. According to pasting properties, peak viscosity, trough viscosity and breakdown of flattened rice flour were less than that of sticky rice flour. The FTIR spectra patterns of flattened rice flour showed it consisted of sticky rice polysaccharide structure as the main proportion. Daifuku with flattened rice flour at 75% had the highest sensory scores in all attributes especially in overall acceptance and texture. For nutritional analysis based on the calculated data, Daifuku with flattened rice flour had higher contents of calcium, iron and vitamin B1 than the control Daifuku. Therefore, the favorable properties of flattened rice flour and Daifuku are useful for further nutritional food product development.

Introduction

Rice (*Oryza sativa* L.) is the staple food for Asian populations and it is cultivated mainly in China, India, Indonesia, Bangladesh, Vietnam and Thailand. Based on amylose content, rice is classified as non-glutinous and glutinous rice (Itthivadhanapong & Sangnark, 2016). Glutinous rice, also called sticky rice, waxy rice, or sweet rice, is commonly grown in the Northeastern region of Thailand. One of sticky rice products is flattened rice (known as Khao Mao in Thailand), which is made from young sticky rice at the dough stage (13 to 19 days after anthesis) (Ekasit & Jiraporn, 2013). The flattened rice is consumed in many Asian countries such as Thailand, Lao, Cambodia, Myanmar, India, Bhutan and Tibet. Many varieties of sticky rice cultivars can be used to produce flattened rice such as Saifon, Lueang Boonma, Sawang, RD6, RD10 and Hang Yee 71 (Salitlertthanasin, 2017). The flattened rice production starts with immature sticky rice grains appearing light green in color (after the milk stage for 1-2 weeks) that are soaked in water for 3-4 hr, roasted and pounded to separate the rice husk. Rice grains are pounded several times and winnowed to obtain soft flattened rice (Nachaisin et al., 2016). Thai

* Corresponding Author
e-mail: tita_foo@dusit.ac.th

traditional desserts made from flattened rice (Khao Mao) such as sweet Khao Mao with coconut flesh (Khao Mao Khlook), fried Khao Mao and grated coconut banana rolls (Khao Mao Thaawt) and roasted Khao Mao served with shrimp relish (Khao Mao Mee). For nutrition information, 100 g of cooked flattened rice contains 364 kcal, 79.9 g carbohydrate, 6.8 g protein and 1.9 g fat which also contains varieties of vitamins and minerals including calcium, phosphorus, iron, vitamin B1 and B2 (Institute of Nutrition, 2013). Furthermore, it has been reported that flattened rice contains bioactive compounds including γ-oryzanols and GABA (Ekasit & Jiraporn, 2013). Considering its nutritional value, the application of flattened rice in food products is an alternative way to obtain a functional food product. The flattened rice can be used from whole grains or milled flour. Previous studies have reported that flattened rice grains can be used as the main ingredient in Thai rice cereal (Khao Mao) bars (Salitlertthanasin, 2017) and breakfast cereal products (Voraputhaporn, 2009). However, no prior report has used flattened rice flour in food products. Normally, sticky rice flour is widely used as an ingredient in snacks and desserts for example mochi, sweet soup balls, dumplings and gluten-free products because of its properties in softness and stickiness (Qin et al., 2016; Ji et al., 2007). Therefore, the application of flattened rice flour to replace sticky rice flour could provide a new appearance and good nutritional value in food products. In this study, the properties of flattened rice flour when substituted for sticky flour at 0-100% are characterized and tested with Daifuku (Japanese rice cake with red bean paste filling) with partial substitution of sticky rice flour with flattened rice flour. Characteristics of Daifuku with flattened rice flour are reported based on physical properties, sensory evaluation and nutritional values.

Materials and methods

1. Raw materials

The young sticky rice was obtained from local sticky rice varieties in Nang Rong District, Buri Ram Province, Thailand. Sticky rice flour (Golden Coins brand, Thai Flour Industry Co., Ltd.), red bean paste (Been brand, Zensprout Co., Ltd.) and sugar (Mitr Phol Sugar Co., Ltd.) were purchased from a local market.

2. Preparation of flattened rice flour

Flattened rice was made from young sticky rice (immature grains). The paddy was harvested on the 18th day after anthesis and was green in color. The young grains were roasted on medium heat. After cooling down, the grains were pounded with a mortar, sieved and winnowed using a threshing basket in order to separate the flattened grains from the rice husk. The grains were dried to be flattened rice. To obtain flattened rice flour, flattened rice was milled using the dry milling method, sieved at 100 mesh, packed in sealed plastic bags and kept at 4ºC until used.

3. Properties of flattened rice flour as a substitute for sticky rice flour

Flattened rice flour was used as a substitute for sticky rice flour at 0%, 25%, 50%, 75% and 100% (w/w), respectively. Each flour sample was blended and sieved at 60-mesh. Color values of the flours were determined by a Handy colorimeter (NR-3000, Japan) in CIE color scale as L (lightness-darkness), a (redness-greenness) and b (yellowness-blueness). Amylose content of the flours was determined accordingly to the method of ISO6647-2 (2007). Furthermore, morphological analysis of starch granules in flours was determined by using light field microscopy.

The pasting properties of the flours were determined accordingly to the method of AACC (2000) using a Rapid Visco Analyzer (RVA-4, Newport Scientific, Australia) controlled by Thermocline v.2.3 software. The sample mixture, containing 3 g of flour (12% moisture basis) and 25 mL distilled water, was transferred into an aluminum cup. The temperature profile was composed of heating the sample at 50ºC for 1 min and then raised to 95ºC within 3 min 48sec. After that, it was kept at 95ºC for 2 min 30sec., cooled to 50ºC within 3 min 48sec and kept at 50ºC for 2 min.

Fourier transform infrared spectroscopy (FTIR) of the flours was analyzed by attenuated total reflection-Fourier transform infrared spectrometer (ATR-FTIR) (IRTracer-100, Shimadzu, Japan). ATR-FTIR data were carried out between wavenumbers of 4000–500 cm^{-1} with 40 replicate collections.

4. Preparations of Daifuku

A control formulation for Daifuku (Boonchai, 2020), calculated as % weight of sticky rice flour, consisted of 100% sticky rice flour, 100% red bean paste, 22.5% sugar and 125% water. Four formulations of Daifuku were prepared by flour mixes of flattened rice flour substituted for sticky rice flour at 0, 25, 50 and 75% (w/w), respectively. Other ingredients for all formulations were fixed in weight. For Daifuku preparations, flour, sugar and water were mixed and stirred in a bowl until obtained batter. The bowl with the batter was covered with plastic wrap on the top and heated by the microwave (R-250, Shape, Japan) at a moderate power level (800 watts) for 3 min. Next, the bowl was removed from the microwave and the dough was mixed with a wet spatula and then returned to microwave for another 3 min. If the dough was not smooth, it was returned to microwave for one more min. The cooked dough was sticky and translucent. The temperature of dough after microwave was 90°C. After that, the mochi dough was placed on a cutting board floured with tapioca flour, cut the dough (20 g) and flattened into a rectangle. Then, the red bean paste (20 g) was placed at the center of the mochi dough and wrapped with the dough. The end of the mochi dough was pinched together and made into a ball shape. Daifuku was sprinkled with tapioca flour and kept in a plastic box with a lid.

5. Physical properties of Daifuku without red bean paste

Color values of Daifuku surfaces (without red bean paste) were determined using CIE color scale. For texture analysis, five replications of each Daifuku were measured by a texture analyzer (TA-XT2i, Stable Micro System, UK). The sample (20 g with 1.5 diameters) was compressed using a double-cycle program with a 100 mm aluminum probe. The probe was declined at a speed of 1 mm/sec to 75% sample height. After 10 sec, the compression was repeated to complete the measurement (Modified from Wongbasg & Jangchud, 2011). Hardness and springiness were obtained from the texture profile analysis.

6. Sensory evaluation of Daifuku

The untrained panelists of 40 people were assigned for sensory evaluation of the Daifuku prepared from flour mixes with red bean paste. The 9-point hedonic scale of preference test (1 = dislike extremely and 9 = like extremely) was used for six attributes regarding appearance, color, flavor, taste, texture and overall acceptance. All samples were placed on white dishes and presented with random 3-digit code numbers. Drinking water was served to participants for mouth rinsing between samples.

7. Nutritional values of Daifuku

Nutritional values including energy, carbohydrate, protein and fat of Daifuku were acquired using the nutritional analysis program (Thai NutriSurvey version 2.0). The obtained data sets were reported as per 40 g of Daifuku.

8. Statistical analysis

All experiments were conducted in triplicates and data from three samples were analyzed statistically using ANOVA and significant differences were done using Duncan's multiple range test ($p \leq 0.05$). A completely randomized design was applied for preparations and property determinations of the flours and Daifuku, while a randomized complete block design was applied for the sensory evaluation. All analysis was conducted using SPSS software Version 22 (SPSS Inc.; Chicago, IL, USA).

Results and discussion

1. Properties of Flattened rice flour substituted for sticky rice flour

Due to the application of flattened rice flour in place of commercial sticky rice flour, therefore the properties of flattened rice flour were determined and compared with commercial flour at 0-100% substitution. The appearance and color of the flour mixes are shown in Fig. 1 and Table 1. The flour mixes containing high percentages of flattened rice flour displayed lower L and a values but higher b values, indicated by darker and more green and yellow than others. Flattened rice flour harvested at the dough stage (15-20 days after anthesis), is considered as immature grains. The paddy of this stage is green or green-yellow in color because of the chlorophyll and carotenoid pigment. After that, the grains were roasted in medium heat, the roasting time and temperature had an effect on the dark color of the grains due to Maillard reactions (Ekasit & Jiraporn, 2013). In regards to the flour preparation, flattened rice flour was milled using the dry milling method, in which the flour contains the pigments from the pericarp and seed coat. Therefore, the color of flour with an increase in flattened rice flour levels became green-yellow.

Table 1 Physicochemical properties of flattened rice (FR) flour substituted for sticky rice flour at different levels

FR flour substitution (%)	Amylose content (%)	Color		
		L	*a*	*b*
0	7.89	99.78 ± 0.31^{a}	-1.44 ± 0.27^{a}	5.99 ± 0.23^{e}
25	6.83	97.39 ± 1.57^{a}	-1.18 ± 0.25^{b}	7.73 ± 0.31^{d}
50	5.64	92.50 ± 2.53^{b}	-2.26 ± 0.08^{c}	10.66 ± 0.23^{c}
75	4.96	86.58 ± 1.83^{c}	-2.44 ± 0.09^{c}	13.89 ± 0.41^{b}
100	3.34	73.78 ± 4.46^{d}	-3.17 ± 0.33^{d}	20.39 ± 0.72^{a}

Remark: Means ± S.D. with different superscripts in the same column represent significantly different ($p \leq 0.05$)

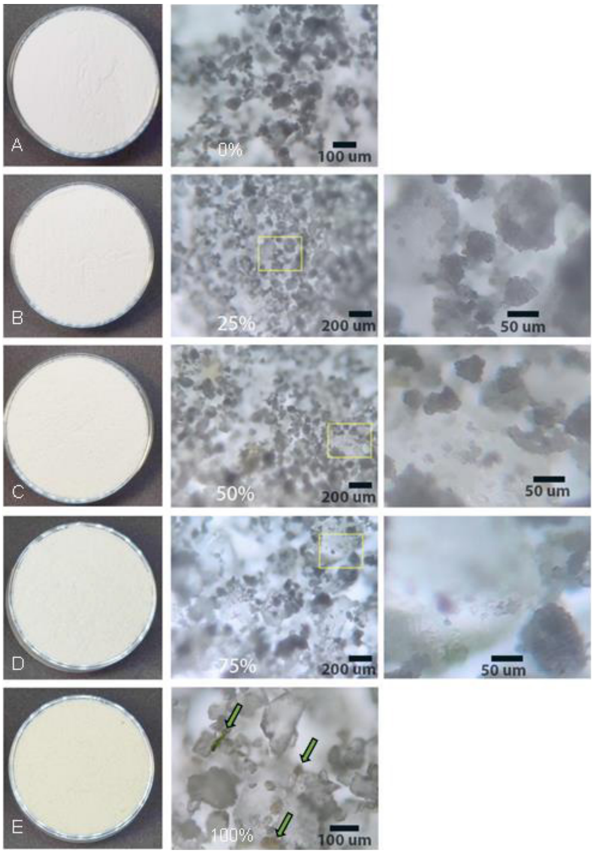

Fig. 1 The flour mix appearance and photomicrographs of starch granules of flattened rice flour substituted for sticky rice flour at 0 (A), 25 (B), 50 (C), 75 (D) and 100% (E) (w/w)

The amylose content of flour mixes are shown in Table 1. Flattened rice flour at 100% had the lowest amylose content (3.34%), whereas sticky rice flour had the highest (7.89%). According to previous studies, Thai sticky rice varieties, RD6 and short grain rice, had amylose content of approximately 2.04-2.61% and 2.03-3.14%, respectively (Keeratipibul et al., 2008). The amylose content of flattened rice flour was lower than that of sticky rice flour probably because of the milling method. The commercial sticky rice flour was milled using the wet milling method, while the flattened rice flour was milled using the dry milling method. The dry-milled flour had lower purity of starch than the wet-milled flour (Foophow et al., 2020), resulting in the lowest amylose content in flattened rice flour. Sticky rice containing high amylose content had a hard and less sticky texture, compared with rice containing low amylose content (Keeratipibul et al., 2008). However, flattened rice flour and sticky rice flour are classified as very low amylose rice (2-9%) (Sompong et al., 2011).

For morphological analysis, the starch granules in flours were determined using light-field microscopy as shown in Fig. 1. The starch granule of flattened rice flour at 100% had a smooth irregular and low sphericity sub-rounded surface structure (Fig. 1E) due to the thermal and mechanical pressure treatment in roasting and flaking at the moisture process of immature rice grain and endosperm morphology (Kumar et al., 2018; Kumar & Prasad, 2017). The starch granule morphology of flattened rice flour was similar to that of flattened rice (data not shown), which had a granular size ranging around 20-100 µm. The arrows in Fig. 1E represent the pigment of phenolic compound (Miraji et al., 2020, 2021; Ogawa et al., 2003; Ratseewo et al., 2019; Tamura et al., 2014) and/or chlorophyll from cell wall matrix as the characteristic color of native flattened rice. The starch granule morphology of sticky rice flour as shown in Fig. 1A represents a well-uniform micro-scale structure with particle size around 1–100 µm, corresponding to characteristics of rice starch granules in prior reports (Govindaraju et al., 2020; Rani & Bhattacharya, 1995). The starch granules of flattened rice flour at 25, 50 and 75% (Fig. 1B-1D) showed that the well-uniform particles dispersed in all mixture samples, which the enlargement photo of the rectangles inset represents at the flattened rice starch and sticky rice starch particles interface.

The pasting properties of flattened rice flour substituted for sticky rice flour at different levels are shown in Table 2. The peak viscosity, trough viscosity and breakdown decreased with the increase of flattened rice flour content, which was similar to black glutinous rice flour substitution (Itthivadhanapong & Sangnark, 2016). Flattened rice flour at 100% had the lowest peak viscosity and breakdown, resulting from the increase in the degree of starch damage during the flattened rice process. Therefore, flattened rice flour absorbed water and swelled higher than sticky rice flour, which had an effect on the increase of viscosity at low temperatures. In contrast, peak time and set back tended to increase with increasing flattened rice substitution. The pasting temperature slightly decreased and showed a significant difference only at 100% flattened rice flour. In addition, no statistically significant difference between flattened rice flour at 0% and 100% ($p > 0.05$) was found in the final viscosity. The pasting properties of flattened rice flour at 100% corresponded to the result of Ekasit & Jiraporn (2013) for peak viscosity (1440.66-1638.33 cp), trough viscosity (1316.00-1382.66 cp) and breakdown

Table 2 Pasting properties of flattened rice (FR) flour substituted for sticky rice flour at different levels

FR flour substitution (%)	Peak viscosity (cP)	Trough viscosity (cP)	Breakdown (cP)	Final viscosity (cP)	Set back (cP)	Peak time (min)	Pasting temp (°C)
0	2811.00 ± 10.15^{a}	1462.67 ± 10.97^{a}	1348.33 ± 17.62^{a}	1824.67 ± 5.86^{a}	362.00 ± 9.86^{b}	3.74 ± 0.03^{c}	70.20 ± 0.44a
25	2686.67 ± 28.88^{b}	1404.33 ± 33.20^{b}	1282.33 ± 29.94^{b}	1794.33 ± 4.93^{bc}	390.00 ± 31.43^{b}	3.65 ± 0.07^{c}	70.50 ± 0.78a
50	2410.00 ± 23.07^{c}	1365.00 ± 3.61^{c}	1045.00 ± 24.88^{c}	1795.33 ± 21.03^{bc}	430.33 ± 24.58^{a}	3.67 ± 0.04^{c}	69.70 ± 0.00a
75	1905.33 ± 46.05^{d}	1410.33 ± 26.16^{b}	495.00 ± 23.64^{d}	1784.00 ± 24.25^{c}	373.67 ± 10.50^{b}	4.03 ± 0.08^{b}	70.95 ± 0.44a
100	1537.33 ± 24.11^{e}	1352.00 ± 10.82^{c}	185.33 ± 34.50^{e}	1814.33 ± 2.52^{ab}	462.33 ± 9.50^{a}	6.43 ± 0.27^{a}	67.30 ± 2.16b

Remark: Means ± S.D. with different superscripts in the same column represent significantly different ($p \leq 0.05$)

(124.66-255.66 cp). However, these results differed from a previous report (Ekasit & Jiraporn, 2013), which showed less final viscosity (1509.33-1671.66 cp), set back (193.33-289.00 cp), peak time (5.13-5.73 min) and pasting temperature (51.61-55.13 °C).

FTIR spectra of flour mixes are shown in Fig. 2A. Main spectral patterns corresponding to characteristics of sticky rice starch (Basnet et al., 2016; Soe et al., 2020; Wang et al., 2019) indicated that all flour mixes consisted of sticky rice polysaccharide as the main proportion. The green rectangle highlights the vibration mode region of C-H stretching and the polysaccharide fingerprint is presented in Fig. 2A inset, the enlargement is in Fig. 2B and 2C, respectively. Broad band at wavenumbers around 3200-3500 cm^{-1} was presented in all samples due to O-H stretching in carbohydrates as the main composition and may be contributed from the NH amide stretching mode of rice proteins (Rahmani & Mani-Varnosfaderani, 2022). The O-H band may also be contributed from the O-H group of small phenolic and chlorophyll components in immature rice by nature, agreeing with the small pigment present in the optical micrograph result. The stretching vibration mode of the C-H group region was identified as some of the main characteristics of rice polysaccharides. Moreover, the C-H stretching region in Fig. 2B revealed predominantly two peaks at 2923.1 and 2853.6 cm^{-1} of the 100 samples, while the sticky rice (flattened rice flour at 0%) indicated weak three peaks of C-H stretching mode at 2929.1, 2885.8 and 2849.7 cm^{-1}, respectively. The gradual gradient decrease of intensity in the C-H stretching region from 100 to 0 sample confirmed that the higher intensity of $C-H_2$ asymmetric and symmetric stretching contributes to higher chlorophyll content of the flattened rice characteristic than the conventional raw sticky rice. The polysaccharide fingerprint region in Fig. 2C represented similarly the main peak shape of glycosidic C-O-C linkage of pyranose with C-OH bending mode at wavenumber around 994-1077 cm^{-1} in all samples. In addition, the 100-sample showed broader and gradually sharper in sticky rice flour (flattened rice flour at 0%), probably due to the contribution of phenolic C-O-C stretching and chlorophyll C-O vibration mode (Chang et al., 2013; Dadwal et al., 2021). However, the crystallinity degree of amylose is also involved in this region because of the milling and heat treatment process (Man et al., 2014, 2012; Soe et al., 2020). Amide I contributed with in-plane NH bending peak due to rice protein associated with polysaccharide COO stretching located at wavenumber around 1744 cm^{-1}. The peak at 1643 cm^{-1} was also attributed to the COO stretch group of polysaccharides and OH group bending mode. Moreover, the couple peaks at around 1744 with 1643 cm^{-1} in flattened rice flour at 100% suggesting the strong intensity of high phenolic C=O stretching mode proportion in flattened rice flour. This result suggested strong peaks at 2923, 2853 and 1730 cm^{-1} were due to characteristics of flatted rice flour and proportions of flattened rice flour to sticky rice flour ratio. In addition, no evidence of new absorption band energy of the flour mixes in FIIR analysis was observed, which could be assumed that no bonding between flattened rice flour and sticky rice flour occurred by a simple physical mixing process.

The flatted rice flour was applied to use as an ingredient in Daifuku based on the properties in soft and sticky texture in products and easily increased viscosity at low temperatures. Daifuku is a Japanese rice cake with red bean paste filling, which is a popular dessert. It is usually shaped into a ball and composed of a chewy and soft outer layer. Therefore, the application of flattened rice flour could provide the new appearance and good nutritional value in food products.

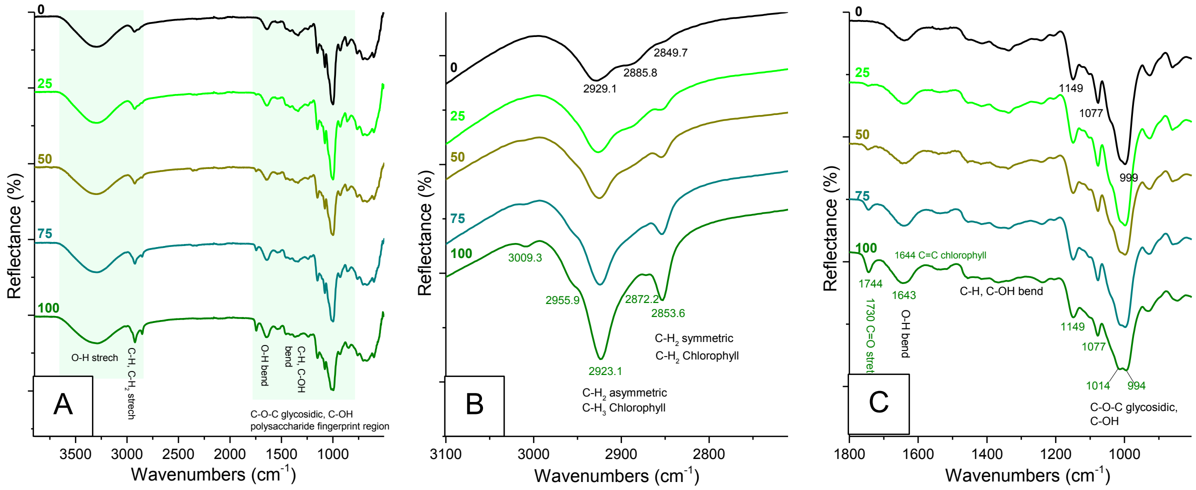

Fig. 2 ATR-FTIR spectra of flattened rice flour substituted for sticky rice flour at 0, 25, 50, 75 and 100% (w/w) with full spectra (A), the region of C-H asymmetric/ symmetric stretching between wavenumbers of 2700-3100 cm-1 (B) and polysaccharide fingerprint region between wavenumbers of 800- 1800 cm^{-1} (C)

2. Physical properties of Daifuku

Daifuku dough prepared with 100% flattened rice flour proved unable to make a ball shape. The dough at 100% was so wet and sticky, probably due to the pasting properties in the lowest peak viscosity, breakdown and pasting temperature. Therefore, the dough at 100% flattened rice flour had higher water absorption and swelling than others, which had an effect on the increase of viscosity at low temperatures. Thus, four formulations of Daifuku with the substitution of flattened rice flour at 0, 25, 50 and 75% (w/w) were used for physical property determinations. The physical properties of Daifuku are shown in Table 3. The color values of Daifuku containing high percentages of flattened rice flour displayed lower a values but higher b values. The result corresponded to the result of flour mixes in Table 1. Therefore, Daifuku had a darker green color with an increase in flattened rice flour levels.

According to the texture analysis, the increase of flattened rice flour substitution did not significantly influence the hardness of Daifuku ($p > 0.05$). Normally, the high amylose content in flour affects to the harder texture of the product (Lu et al., 2013). Therefore, the product with high amylose content was firm and fluffy, while product with low amylose was soft and sticky. However, flattened rice flour substituted for sticky rice flour at 0-75% had an amylose content of 7.89-4.96% (Table 1), which all flour mixes were classified in the same group as very low amylose rice (2-9%). Therefore, the amylose content of flour mixes had no significant effect on the hardness of Daifuku. These results corresponded with a previous study about the mixed flours between non-glutinous and glutinous rice with amylose content at 1.6-6.4%, in which the hardness of rice crackers (arare) from the mixed flour showed non-significant differences (Keeratipibul et al., 2008). Regarding springiness, the substitution of flattened rice flour at 0% and 25% showed no significant difference ($p > 0.05$), but significantly increased the springiness of Daifuku at 50% and 75% ($p \leq 0.05$). Springiness is related to the elasticity of food. The texture of food with high springiness requires more energy for chewing in the mouth. Therefore, the substitution of flattened rice flour for sticky rice flour significantly increased elastic texture, probably due to the low amylose content in flattened rice flour. The previous report also found that the springiness of cooked noodles increased with a low amylose content of mixed flours (Heo et al., 2012).

3. Sensory evaluation of Daifuku

Sensory evaluation of Daifuku in terms of appearance, color, flavor, taste, texture and overall acceptance are shown in Table 3. Daifuku with the substitution of flattened rice flour at 75% had the highest sensory scores in all attributes, especially in texture and overall acceptance, probably because of the consumer acceptability of the high springiness of Daifuku texture. Daifuku with flattened rice flour had a higher sensory score in appearance, color, flavor and taste compared to Daifuku at 100% sticky rice (control). The results showed that flattened rice flour significantly affected the

Table 3 Physical properties and sensory evaluation scores of Daifuku with different contents of flattened rice (FR) flour

FR flour substitution (%)	Color		Texture		Sensory evaluation					
	a	*b*	Hardness^{ns} (N)	Springiness	Appearance	Color	Flavor	Taste	Texture	Overall acceptance
0	-0.86±0.85^{a}	4.42±0.30^{c}	26.88±1.56	0.0097±0.001^{b}	7.45±1.28^{b}	7.12±1.22b	6.57±1.37^{b}	6.97±1.70^{b}	6.75±1.69^{c}	6.20±2.00^{c}
25	-2,19±0.21^{b}	11.61±1.40^{b}	29.62±2.17	0.0103±0.001^{ab}	7.70±0.95^{ab}	7.72±1.28^{a}	7.40±1.63^{a}	7.62±1.28^{a}	7.35±1.40^{bc}	7.20±1.26^{b}
50	-3.14±0.28^{c}	14.85±0.96^{a}	29.93±2.78	0.0117±0.002^{a}	7.90±0.86^{ab}	7.82±1.22^{a}	7.47±1.39^{a}	7.95±1.04^{a}	7.67±1.09^{ab}	7.67±0.91^{ab}
75	-3.30±0.16^{c}	16.17±0.38^{a}	30.02±3.02	0.0120±0.000^{a}	8.15±1.13^{a}	8.07±1.12^{a}	7.90±1.51^{a}	8.12±1.23^{a}	8.20±1.40^{a}	8.30±1.34^{a}

Remark: Means ± S.D. with different superscripts in the same column represent significantly different ($p \leq 0.05$)
Means ± S.D. with ns in the same column represent not significantly different ($p > 0.05$)

consumer acceptability of the appearance, flavor and taste of Daifuku. The control Daifuku had the lowest sensory scores in all attributes, probably due to the heating condition by the microwave. In this study, the process for Daifuku preparation was fixed controlled variables, which affected the Daifuku characteristics. From the result of sensory evaluation, flattened rice flour can be used as raw material for a partial substitute of 75% of sticky rice flour in Daifuku.

4. Nutritional values of Daifuku

Nutritional values of the control Daifuku and that with the substitution of flattened rice flour at 75% were calculated using the nutritional analysis program (Thai NutriSurvey version 2.0) and the results were shown in Table 4. Daifuku with flattened rice flour (40 g) had 35.6 g carbohydrate, 3.5 g protein, 0.4 g fat, 15.85 mg calcium, 1.26 mg iron 0.093 mg vitamin B1, 0.187 mg vitamin B2 and 158 kcal of energy. From the results, Daifuku with flattened rice flour had a little bit higher content of fat than the control (0.3 g fat). For vitamins and minerals, Daifuku with flattened rice flour had higher contents of calcium, iron and vitamin B1 than Daifuku with sticky rice flour. However, the carbohydrate, protein, energy and vitamin B2 contents of Daifuku with flattened rice flour were similar to the control. A previous report also showed that the protein content of flattened rice was similar to that of sticky rice (Ekasit & Jiraporn, 2013). From prior results of nutritional dough stage rice, it contained higher contents of fat, dietary fiber, calcium, iron, phosphorus, potassium, vitamin B1, vitamin B2 and niacin than sticky rice (Institute of Nutrition, 2013). Furthermore, flattened rice is a rich source of bioactive compounds such as γ-oryzanols and GABA (Ekasit & Jiraporn, 2013). In the future, the nutritional values and bioactive compound of Daifuku with flattened rice flour should be studied with the experimental data to confirm the chemical composition and nutrition quality in product.

Table 4 Nutritional values of Daifuku

Nutritional value	Sticky rice flour Daifuku (control) (40 g)	75% Flattened rice flour Daifuku (40 g)
Carbohydrate (g)	35.8	35.6
Protein (g)	3.4	3.5
Fat (g)	0.3	0.4
Calcium (mg)	5.62	15.85
Iron (mg)	0.98	1.26
Vitamin B1 (mg)	0.084	0.093
Vitamin B2 (mg)	0.186	0.187
Energy (kcal)	158	158

Remark: Nutritional values were calculated using the nutritional analysis program (Thai NutriSurvey version 2.0)

Conclusion

The dry-milled flattened rice flour presented as green-yellow in color and had very low amylose content. The substitution of flattened rice flour for sticky rice flour increased phenolic compound and/or chlorophyll and easily increased viscosity at low temperatures. In Daifuku, flattened rice flour can be substituted with up to 75% sticky rice flour, with the highest scores in all sensory attributes and high nutritional values especially vitamins and minerals. This study shows that flattened rice flour could be applied as a nutritional ingredient for developing healthy and functional food products. However, further studies are suggested to determine the functional properties of flours and chemical properties and bioactive compounds of products in order to apply the flattened rice flour to various food products.

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