Chemical Properties of Three Selected Thai Rice and Texture Profiling of Cooked KumDoiSaket Rice

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Abstract

This research aimed to investigate the physicochemical characteristics of Thai rices (Hom-Mali105, Hom-Nin and KumDoiSaket) and focused on texture profiling. Thereafter, the effects of selected cooked rice as being influenced by the different water to rice ratios (1:1, 1:1.5, 1:2 and 1:2.5) were evaluated. The chemical compositions of Thai rice samples were significantly different. Moreover, KumDoiSaket rice was the highest contents of fat and protein. In addition, KumDoiSaket rice showed the highest contents of antioxidant activities (DPPH, ABTH radical scavenging activity, FRAP value), total phenolic compounds and total anthocyanin indicated that the strongest activities of KumDoiSaket rice selected for further studying. The rice: water ratio of KumDoiSaket rice was assessed by measuring color, texture profile analysis (TPA), scanning electron micrographic (SEM) and sensory evaluation as descriptive analysis and sensory acceptance. The rice: water ratio had an effect on cooking characteristics of all various ratios. When increasing the rice: water ratio, L* value significantly decreased while a* and b* values significantly increased. The textural profile analysis (TPA) showed that the rice: water ratio of 1.2 and 1:2.5 significantly lower on the hardness, cohesiveness, chewiness, gumminess and resilience. Using scanning electron microscopy, the microstructure revealed surface and crossed section was difference among the cooked rice of different rice to water ratio. Twelve trained panelists received three months of training in terminology development, reference selection, intensity scaling (a 150 millimeter line scale) and warm-up sample before conducting generic descriptive analysis. The sensory descriptive results identified eight attributes of texture profiles of cooked KumDoiSaket rice; adhesiveness to lips, hardness, adhesiveness, cohesiveness, chewiness, gumminess, roughness of mass and tooth pack. The results showed that the intensity ratings were significantly different for the all attributes of cooked KumDoiSaket rice at various rice-water ratios. The sensory acceptance test of cooked KumDoiSaket rice was neither like nor dislike, like slightly, with an average score of 5.2–6.2 on the 9-point hedonic scale. This study could help the consumer and food industry for the selection of the suitable ratio of rice to water 1:1.5 and 1:2 in rice cooking provided the highest score of overall liking on consumer preference.

Keywords: Thai Rice, Antioxidants, Sensory descriptive, Texture profile, Physicochemical

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1. Introduction

Rice (*Oryza sativa* L.), is the major staple food world-wide, it is over half of the world's population. The major compositions of rice are carbohydrates, lipids and protein. Jasmine brown rice is favorite varieties in Thailand because of its aroma and soft texture. The Jasmine brown rice is the popular health product because it's full of nutrients and bioactive components, which can prevent a variety of diseases. In addition, pigment rice or colored rice also has the high antioxidant contents such as anthocyanin and phenolic compound (Reddy *et al*., 2016 and Chatthonpisut *et al*., 2015). The pigment rice has received much attention due to beneficial health effect on heart disease. The phenolic compounds have been found as the major active compounds for the antioxidant. For the pigment rice, the main bioactive compound of phenolic content has been reported as an anthocyanin (Zhang *et al*., 2006). Anthocyanins in pigmented rice have been identified. They are cyanidin-3-glucoside and peonidin-3-glucoside (Hu *et al*., 2003); malvidin, pelargonidin-3, 5-diglucoside, cyanidin-3-glucoside and cyanidin-3, 5-diglucoside (Zhang *et al*., 2006); cyanidin-3-glucoside, pelargonidin-3-glucoside (Yawadio *et al*., 2007).

"Texture is defined as the sensory manifestation of the structure of food and the manner in which that structure reacts to applied force" (Szczesniak., 1968). The texture is also a considerable attribute of food acceptance by consumers. Hardness is the most important parameter which affects the decision to consume cooked rice in Asian markets (Meullenet *et al*., 1998). Sensory profiling analysis is the only method that specifies the attributes of a sample and a rating intensity on a suitable scale. The texture has been determined as a multidimensional characteristic that only humans can perceive, define, and measure (Szczesniak., 1987). For the instance, the descriptive analysis is a useful tool for characterizing texture properties of cooked rice. The evaluation of texture properties involving the use of instruments that are specifically designed for the evaluation of the physical characteristics of food is a common practice in the food industry. The two approaches, sensorial and instrumental, are often explored simultaneously; the purpose of evaluated correlations between the two methods (Szczesniak., 1968) is to potentially derive an instrumental method capable of predicting the sensory characteristics of a food on a routine basis.

This research aimed to investigate the physicochemical content and antioxidant of three rices, which were selected being based on antioxidant content, and studied on the texture profiling on the effect of water to rice ratio.

2. Materials and Methods

2.1 Chemical composition of rice flours

2.1.1 Materials

Three rice varieties named Hom-Mali105 (brown rice), Hom-nin (black rice) and KumDoiSaket (purple rice) were obtained from dehulling the rough rice from Lanna Rice Research Center, Chiang Mai University. The rice grains were stored in aluminum foil bags at 4ºC until used in the experiment. Preparation of rice flour by grinding, and then the rice flour was analyzed for moisture content, crude protein, crude fat, crude fiber, ash, total antioxidant activity, total phenolic compounds and total anthocyanin content.

2.2.2 Chemical composition of rice flours

The moisture, lipid, fiber, ash and carbohydrate contents were the analysis of rice flours by AOAC standard methods (AOAC, 2000). Protein content was an analysis by Kjeldahl (1883) methods, estimated from total nitrogen using a conversion factor of 5.956.

2.2.3 Antioxidant activity of rice flours

The rice flours (10 g) were extracted with 50 mL of 80% methanol for 4 h at room temperature and then centrifuged at 6000 rpm at 4°C for 15 min and supernatant was separated from the residue and stored at -4ºC until used for analysis.

DPPH radical scavenging assay of rice flours was determined using the method by Brand-Williams *et al*. (1995) with some modifications. Each sample of methanol extract (0.1 mL) was mixed with 2.9 mL of 0.06 mM DPPH (1,1-diphenyl-2-picrihigrazil) methanol solution, then incubated for 30 mins in a dark room at room temperature. The measurements were carried out on a spectrophotometer (UV-vis model 1601, Shimadzu, Japan) at a wavelength of 517 nm. The results were expressed as milligrams of Gallic acid equivalent (GAE) per 100 g of dry basis.

ABTS radical scavenging assay of rice flours was determined using the method by Wipavadee *et al*. (2014) with some modifications. The redical cation ABTS•+ was prepared by mixing 7 mM ABTS•+ and 2.45 mM potassium persulfate, which was allowed to stand in the dark at room temperature for 12-16 hrs. Before using, ABTS•+ solution was diluted with 80% methanol until reaching an absorbance of 0.700±0.02 at 734 nm. Twenty microliters of the rice extract was mixed with 1.48 mL of the working solution, and then incubated for 7 min in the dark at room temperature. The measurements were carried out on a spectrophotometer (UV-vis model 1601, Shimadzu, Japan) at a wavelength of 734 nm. The control was prepared using 80% methanol without ABTS•+ solution. The results were expressed as mg a Trolox equivalent per 100 g of dry basis.

The ability to reduce ferric ions of rice flours was determined using the modified method by Vareeporn *et al.* (2011). The FRAP reagent including 300 mM acetate buffers at pH 3.6, 10 mM TPTZ in 40 mM HCl and 20 mM $FeCl_3.6H_2O$ in the ratio of 10:1:1. Freshly prepared and pre-warmed (37°C) of FRAP reagent (0.95 mL) was added in a test tube containing 50 µL of extracted sample and then incubated at 37°C for 30 mins. An increase in absorbance at 593 nm was measured. The results were expressed as milligrams of Trolox equivalent per 100 grams of dry basis.

Total phenolic content of rice flours was determined according to Reddy *et al*. (2016). A sample of methanol extract (200 µL) was mixed with 1 mL of 10% sodium carbonate and 1 mL of Folin-Ciocalteu's reagent diluted to 1:10 with water. The total final volume was made up to 5 mL with distilled water. The reaction mixture was left for 2 h at room temperature. The absorbance was recorded at 765 nm. The results were expressed as milligrams of Gallic acid equivalent (GAE) per 100 g of dry basis.

Total anthocyanin content of rice flours was determined using pH-differential method as being modified by Finocchiaro *et al*. (2010). Briefly, 2.7 mL of buffer solution pH of 1.0 or 4.5 was mixed with 300 µL of extracted sample, and incubated at room temperature for 20 min. After that, the absorbance was measured at 510 and 700 nm. The results were expressed as milligrams of cyaniding chloride equivalent (CCE) per 100 grams of dry basis. The absorbance of positive control and sample solution (A) was calculated in equation1.

$$A = (A_{510} – A_{700}) \text{ in pH } 1.0 - (A_{510} – A_{700}) \text{ in pH } 4.5$$

2.2 Effect of water to rice ratio on physical properties and sensory evaluation of cooked KumDoiSaket rice

2.2.1 Rice cooking

Rice grains were washed with water and the water was drained off prior to subjecting to cooking by an automatic rice cooker. The ratios of rice to water varied of 1:1, 1:1.5, 1:2 and 1:2.5 (W/W) and cooked until the electric cooker was automatically turned off and simmered for 5 min to obtain completely cooked rice.

2.2.2 Color of cooked rice

The color of rice sample was measured by using Hunter-Lab Colorimeter (Mini-scan EZ, Virginia, USA). The color parameter (L*, a* and b*), the instrument was calibrated with white calibration tile.

2.2.3 Texture Profile Analysis (TPA)

The textural properties of cooked rice were determined by using a texture analyzer (TA-XT Plus, Texture Analyzer, UK). Cooked rice sample (10 g) was immediately placed inside the test cylindrical probe of 50 mm diameter compressing the gels for a distance of 10 mm at a crosshead speed of 2 mm/min. Texture parameters of hardness, cohesiveness, chewiness and springiness were derived from the instrument software.

2.2.4 Scanning electron microscopy (SEM)

The morphological changes of cooked rice grains were observed by using a scanning electron microscopy (JSM-5400, JEOL, Tokyo, Japan) at 10 kV. The cooked rice grains were freeze-dried by liquid nitrogen. After cutting the using scalpel, the crossed section of cooked grains was observed. Samples were attached to an SEM stub using a double-backed cellophane tape. The stub and sample were coated with gold-palladium by an SPI-Module Sputter Coater and then examined and photographed.

2.2.5 Sensory analysis

Twenty panelists trained in descriptive analysis were conducted in an environmentally-controlled sensory laboratory with partitioned booths at Chiang Mai University. During panel orientation (three sessions of 3 h), eight texture attributes were identified by panelists as adequately describing the texture profile of cooked rice. Attribute definitions and techniques are providing in Table 1. Each panelist rated the intensity of each attribute by the first evaluating reference for that particular attribute, and then giving an intensity rating on a 0–15 continuous scale according to Meilgaard *et al*. (1991). Each trained panelist rated the attributes of cooked rice samples. Samples were presented at 60±1°C in preheated glass bowls insulated (Miao *et al*., 2016).

Sensory acceptance test was conducted by using a 9-point Hedonic scale which is 1 = not very like to 9 = very like. The sensory test was estimated for 6 attributes including, appearance, color, aroma, taste, texture and overall liking. Samples were presented at 60±1°C in preheated glass bowls insulated (Miao *et al*., 2016).

Table 1 Attribute definitions and intensity of cooked rice as sensory characteristics

Term	Definition	Technique	Reference(intensity(mm))
Surface:			
Adhesiveness to lips	Degree to which the sample adheres to the lips.	Place the sample between lips, kiss 1 time, and evaluate	Nougat 40, Breadstick 75, Pretzel Rod 100
First chew:			
Hardness	The force used to chew the sample.	Compress or bite through sample with molars or incisors.	Egg white 25, American cheese 45, Hotdog 55, Peanut 95
Chew down:			
Adhesiveness	Contamination intensity of the sample with other surfaces.	Push the tongue out of the palate and use the tongue to pull the sample out of the palate.	American cheese 20, Cream cheese 30, Peanut butter 50
Cohesiveness	Intensity of the adhesion of the sample.	Chew sample with a molar tooth 8 times and evaluates.	Muffin 10, American cheese 50
Chewiness	Frequency of chewed food until ready to swallow.	Chew sample with a molar tooth 8 times per 1 second until ready to swallow.	Rye bread (10) 10, Hotdog (17) 20, Gum drops (25) 30
Gumminess	Intensity of the decomposition of the sample to the state to be swallowed.	Place the sample in the mouth with a tongue to the palate until the sample is broken.	40% Flour paste 10, 50% Flour paste 30, 60% Flour paste 50
Roughness of mass	Amount of roughness perceived in chewed sample.	Chew sample with molar teeth 8 times and evaluate.	Orange peel 30, Cooked oatmeal 65
Residual:			
Tooth pack	The amount of sample attached to the molar tooth after occlusion.	Chew sample up to 8 times, expectorate, feel surface of the crowns of teeth with tongue.	Captain Crunch 50, Heath Bars 100

2.3 Statistical analysis

Statistical analysis was conducted by using SPSS 17.0 (SPSS Inc., IBM Corp., IL, USA) for the analysis of variance (ANOVA) in determining significant differences between the mean values at a confidence level at 95% ($p \leq 0.05$).

3. Results and Discussion

3.1 Chemical composition of rice flours

3.1.1 Chemical composition of rice flour

The chemical composition of flours from pigmented rice including moisture, fat, protein, ash, fiber and carbohydrate contents is represented in Table 2. From the results, the chemical composition of Hom-Mali105 Hom-Nin and KumDoiSaket show any significant differences (P<0.05) among the means. Hom-Mali105 had the highest moisture and carbohydrate content was 13.39% and 86.63%, respectively. The fat and protein contents were the highest in KumDoiSaket and Hom-Nin exhibited the lowest fat, Hom-Mali105 exhibited the lowest protein. According to Gunaratne *et al*. (2011), brown rice limited 1.90–2.40% of fat and 7.30–11.90% of protein. Therefore, comparing to brown rice and aromatic pigmented rice (Reddy *et al*., 2016), the fat and protein contents varied from 0.39 to 2.59% and 9.26 to 13.11%, respectively. The fiber and ash contents of rice flours range from 1.23 to 1.44% and 1.46 to 1.88%, respectively. The fiber and ash contents were the highest in KumDoiSaket and Hom-Nin, Hom-Mali105 exhibited the lowest protein.

Table 2 Variety difference in chemical composition of rice flours

Varieties	Moisture	Fat	Protein	Fiber	Ash	Carbohydrate
Hom-Mali105	13.39±0.09[a]	1.42±0.04[b]	9.26±0.47[c]	1.23±0.02[b]	1.46±0.06[b]	86.63±0.45[a]
Hom-Nin	12.28±0.12[c]	0.39±0.01[c]	11.52±0.23[b]	1.44±0.10[a]	1.87±0.08[a]	84.78±0.40[b]
KumDoiSaket	12.92±0.10[b]	2.59±0.08[a]	13.11±0.34[a]	1.39±0.08[ab]	1.88±0.02[a]	81.03±0.45[c]

Note: - Mean value±error (n=3). Means within the same column with different letters are different significantly at $p<0.05$.

3.1.2 Antioxidant properties

The total antioxidant capacity of flours from Hom-mali105 Hom-Nin and KumDoiSaket rice is represented Figure 1. The total antioxidant capacity, which defines the capacity of diverse food antioxidants in scavenging free radicals, has been proposed to scrutinizing the health effects of antioxidant-rich foods (Sompong *et al*., 2011). The capacity of antioxidant activity was based on the ability of DPPH and ABTS to inhibit the oxidation by donating electrons in free radicals causing lipid peroxidation (Boo *et al*., 2012). The results observed that flour from KumDoiSaket rice variety showed the highest DPPH and ABTS radical scavenging activity (Figure 1A) when comparing to Hom-Nin and Hom-mali105 rice flours; the value of the DPPH radical scavenging activity is 187.64 mg/100g dry basic for KumDoiSaket followed by Hom-Nin (151.28 mg/100 g dry basic) and Hom-Mali105 (72.30 mg/100 g dry basic). ABTS radical scavenging activity is 181.65 mg/100g dry basic for KumDoiSaket followed by Hom-Nin (138.57 mg/100 g dry basic) and Hom-Mali105 (61.26 mg/100 g dry basic), which showed the lowest DPPH and ABTS radical scavenging activity and also differed significantly (p<0.05).

The FRAP of Hom-Mali105, Hom-Nin and KumDoiSaket rice flours are represented in Figure 2B. The FRAP value for KumDoiSaket was the highest (1.66 mg/100 g dry basic) and that of Hom-Mali105 was found to be the lowest (1.00 mg/100 g dry basic). These results agreed with those of Zhang *et al*. (2010) who reported colored rice contains more antioxidant activity than non-colored rice.

The total phenolic content and total anthocyanin of flours from Hom-mali105, Hom-Nin and KumDoiSaket rice are represented in Figure 2. The total phenolic content for KumDoiSaket was the highest (133.88 mg/100g dry basic) and that of Hom-mali105 was found to be the lowest (55.89 mg/100g dry basic). This result was not differed from the report by other researchers (Daiponmak *et al*., 2014 and Pengkumsri *et al*., 2015). The total Anthocyanin for KumDoiSaket was the highest (20.22 mg/100 g dry basic) and that of Hom-Mali105 was found to be the lowest (0.17 mg/100 g dry basic). There was rarely anthocyanin content observed in Hom-Mali105 rice, since anthocyanin pigments are rich in intensely pigmented rice (black/ purple rice). According to Pengkumsri *et al*. (2015), no anthocyanin content observed in non-pigmented rice. In summary, among the groups of pigmented rice varieties, KumDoiSaket rice showed more antioxidant activities; the amount of the phenolic content and anthocyanin content was varied with the change in the color or pigment type of rice varieties. Therefore, we were decided to study the rice to water ratio in the next experiment.

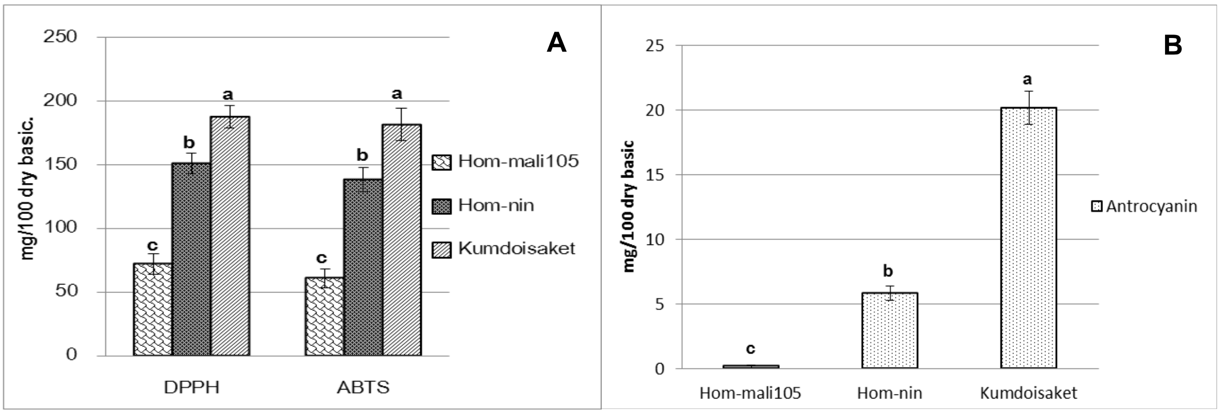

Figure 1 DPPH and ABTS radical scavenging activity (A) and FRAP value of rice flours. Different letters indicate a significant difference within each measured parameter ($p \leq 0.05$).

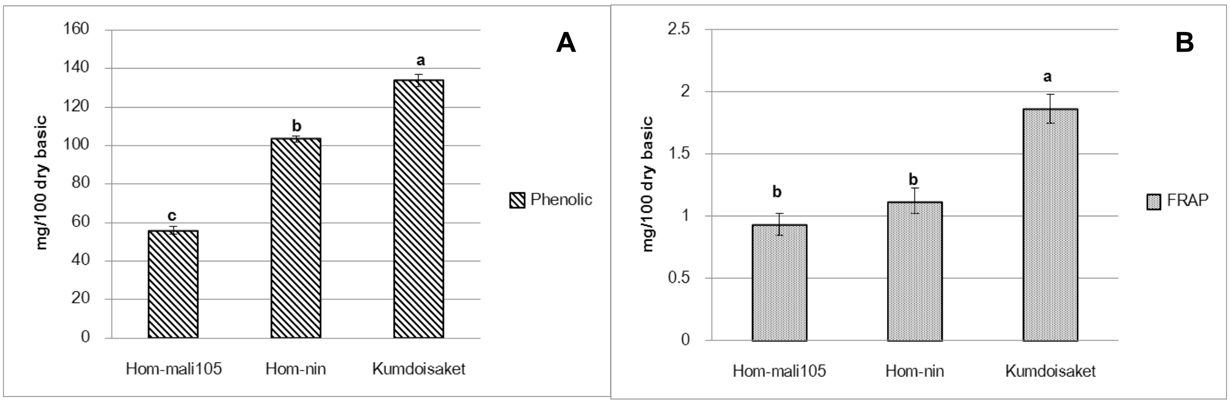

Figure 2 Total phenolic content (A) and total anthocyanin (B) of rice flours. Different letters indicate a significant difference within each measured parameter ($p \leq 0.05$).

3.2 Effect of water to rice ratio on physical properties and sensory evaluation of cooked KumDoiSaket rice

3.2.1 Color and textural parameters of cooked KumDoiSaket rice

The color parameters like L*, a* and b* are revealed in Table 3. L*, a* and b* values for cooked rice from KumDoiSaket rice at different rice to water ratios showed the significant difference ($p<0.05$). The color of cooked rice from KumDoiSaket rice was expressed in CIELAB, L* defines lightness, a* denotes the red/green value and b* the yellow/blue value. The color value values including L* of cooked KumDoiSaket rice limited 22.91–28.79. a*(+) in cooked KumDoiSaket rice limited 3.14–6.05 and b*(+) in cooked KumDoiSaket rice limited 1.28–2.19. Different results from Sumret *et al.*, (2012) showed that cooking black sticky rice with an electric cooker at rice to water ratios of 1:1, 1:2, and 1:3 did not affect the L* and b* values but it did affect the a* value.

The textural parameters of cooked KumDoiSaket rice by textural profile analysis (TPA) showed that they are presented in Table 4. Rice to water ratio affected hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness and resilience of cooked KumDoiSaket rice. The rice to water ratio of 1:1 and 1:1.5 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 rice to water ratio of 1:2 and 1:2.5, rice was completely cooked and yielded the desired texture. However, the eating quality of cooked rice depends on several factors such as time, temperature, and stirring in process, all of which have resulted in the hardness and other cooking aspects of cooked rice (Whistler and Bemiller, 1999).

Table 3 Color value of cooked KumDoiSaket rice

color	Ratio Rice: water			
	1:1	**1:1.5**	**1:2**	**1:2.5**
L*	28.74±1.17[a]	28.79±0.84[a]	26.29±1.05[b]	23.28±0.80[c]
a*	3.14±0.63[d]	3.91±0.50[c]	5.34±0.66[b]	6.05±0.95[a]
b*	1.28±0.18[c]	1.83±0.45[b]	2.19±0.37[a]	2.11±0.32[ab]

Note: Means ± standard deviations (n=3). Means within the same row with different letters are different significantly at $p<0.05$.

Table 4 Textural parameters of cooked KumDoiSaket rice by textural profile analysis (TPA)

Textural parameters	Ratio Rice: water			
	1:1	**1:1.5**	**1:2**	**1:2.5**
Hardness (N)	275.72±37.14[a]	264.42±22.20[a]	193.88±13.93[b]	203.82±4.93[b]
Adhesiveness (g.sec)	-12.49±1.81[a]	-16.32±1.91[a]	-20.33±2.42[b]	-22.02±1.30[b]
Springiness	0.41±0.07[a]	0.42±0.07[a]	0.35±0.08[ab]	0.30±0.01[b]
Cohesiveness	0.62±0.02[a]	0.57±0.02[b]	0.46±0.03[c]	0.47±0.02[c]
Gumminess	169.97±23.68[a]	148.64±9.96[a]	88.77±10.39[b]	95.84±5.26[b]
Chewiness	69.83±18.36[a]	62.11±10.82[a]	27.04±9.18[b]	33.43±2.04[b]
Resilience	0.44±0.03[a]	0.40±0.02[a]	0.27±0.06[b]	0.30±0.01[b]

Note: Means ± standard deviations (n=3). Means within the same row with different letters are different significantly at $p<0.05$.

3.2.2 Microstructure of cooked KumDoiSaket rice

The scanning electron micrographic images of cooked KumDoiSaket rice are presented in Figure 3. The surface of cooked rice at rice to water ratio of 1:1 appears to demonstrate the most event and compact structure. The other rice to water showed the surface that is rough. The crossed section of cooked rice was observed that there was a difference among the cooked rice of different rice to water ratio. The appearance of hollows can be explained by the fact, which the microenvironment of the grain periphery is different from that of the grain center. The peripheral cells are smaller in diameter, and contain more protein than those in the center of the grain. Additionally, during cooking a buildup of pressure occurs in the center of the grain that does not happen at the periphery. The periphery therefore remains intact during cooking, whereas the grain center contains both intact and voided areas (Ogawa *et al*., 2003).

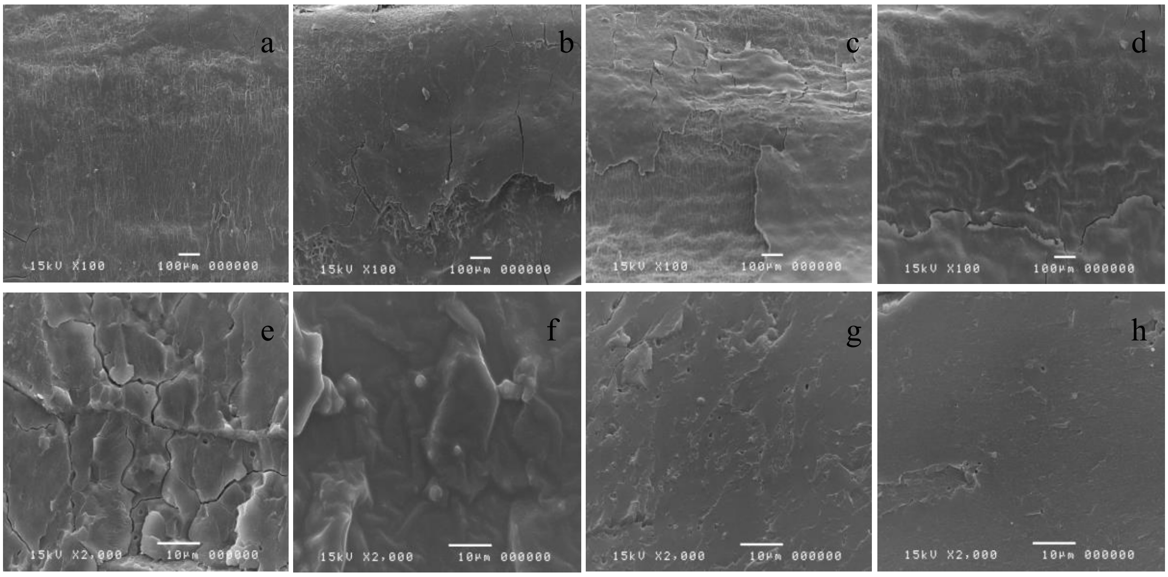

Figure 3 Scanning electron micrographs of the surface (a–d) and the crossed section (e–h) of cooked KumDoiSaket rice: Rice to Water ratio of 1:1 (a, e), Rice to Water ratio of 1:1.5 (b, f), Rice to Water ratio of 1:2 (c, g), Rice to Water ratio of 1:2.5 (d, h)

3.2.3 Sensory descriptive analysis of cooked KumDoiSaket rice

Twelve trained panelists evaluated the intensity of each attribute for the four cooked KumDoiSaket rice samples. The mean intensity and mean separation of the four cooked KumDoiSaket rice samples are presented in Table 5 and Figure 4. Each panelist rated the attribute intensity of each reference. The mean intensity rating was calculated and used as the attribute intensity rating for that particular reference. References were used to remind panelists of particular sensory descriptors and helped to differentiate between the descriptors (Phillipa *et al*., 2009).

Generic description analysis results differed significantly for eight attributes ($p<0.05$) Adhesiveness to lips, hardness, attribute, adhesiveness, cohesiveness, chewiness, gumminess, roughness of mass and tooth pack, which showed the water effect of the texture of cooked KumDoiSaket rice. The result is consistent with the measured value with the textural profile analysis (TPA). A few studies have reported on the sensory profile of purple rice with the most focusing on white rice instead (Kiatthanapaiboon, 2008; Limpawattana, 2007).

Kiatthanapaiboon (2008) studied about the instrumental and sensory texture characteristics of 6 Thai cooked rice varieties. The results of Kiatthanapaiboon (2008) showed that cooked rice samples exhibited significant differences.

Table 5 Intensity rating of cooked rice at different rice-water ratios

Attribute	**Ratio Rice: water**			
	1:1	**1:1.5**	**1:2**	**1:2.5**
Surface				
Adhesiveness to lips	114.50±8.14[c]	117.00±10.19[c]	125.75±8.88[b]	133.00±6.62[a]
First chew				
Hardness	63.58±2.87[a]	54.92±2.81[b]	44.58±2.64[c]	34.08±2.23[d]
Chew down				
Adhesiveness	19.50±1.98[d]	22.25±2.05[c]	26.67±2.15[b]	32.92±2.50[a]
Cohesiveness	31.92±3.70[c]	33.17±3.13[c]	39.33±2.39[b]	42.83±4.53[a]
Chewiness	26.75±1.54[a]	25.25±2.42[b]	19.42±1.56[c]	13.75±1.60[d]
Gumminess	43.58±3.99[a]	38.50±2.78[b]	34.75±2.05[c]	30.67±3.47[d]
Roughness of mass	55.67±4.91[a]	53.75±3.72[ab]	51.58±2.75[b]	51.00±3.36[b]
Residual				
Tooth pack	45.50±5.89[a]	43.33±2.31[ab]	42.08±3.75[b]	40.33±2.71[b]

Note: Mean value ± standard error (n=12). Means within the same row with different letters are different significantly at $p<0.05$.

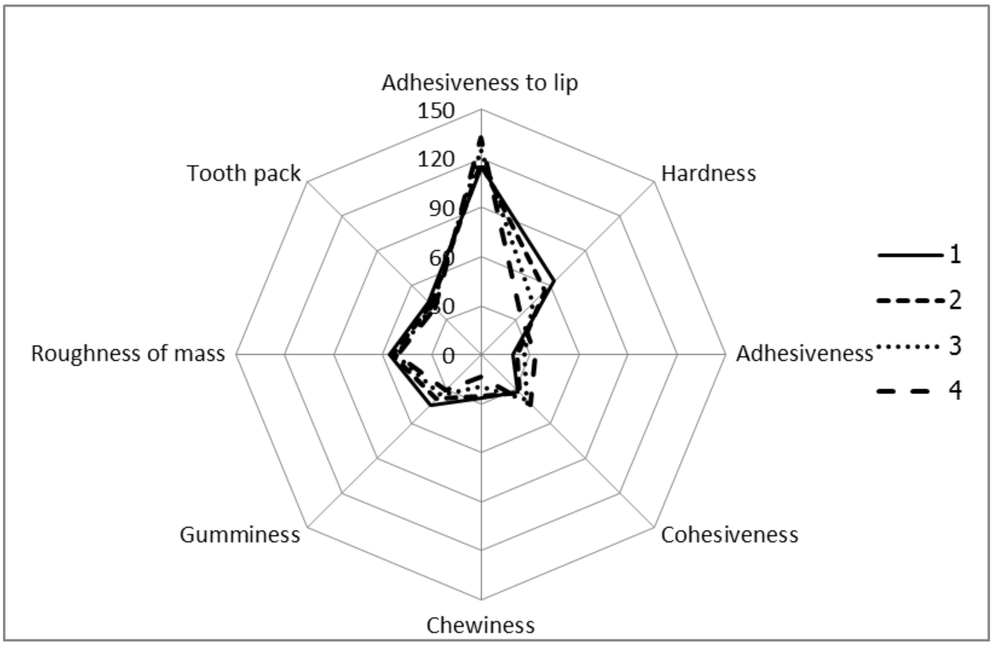

Figure 4 Spider line descriptive analysis of cooked rice. Rice to Water ratio on 1:1 (—— 1), 1:1.5 (- - - 2), 1:2 (······3), 1:2.5 (— — 4).

3.2.4 Sensory acceptance test of cooked KumDoiSaket rice

The average consumer acceptance scores for cooked purple rice are shown in Table 6. The sensory acceptance of all cooked rice samples were neither like nor dislike to like slightly, with an average score of 5.2–6.2 on the 9-point hedonic scale. The result was found that the consumer found no significant differences (p>0.05) of color, aroma and flavor attribute of cooked KumDoiSaket rice at different rice to water ratios. Cooked KumDoiSaket rice at rice to water ratio of 1:1.5, 1:2 and 1:2.5 received high score for texture and overall liking of different rice to water of 1:1. The appearance attribute was shown significant differences (p<0.05) on rice to water ratio of 1:2.5 form rice to water ratio of 1:1.5 and rice to water ratio of 1:2 but not-significant difference (p>0.05) from rice to water ratio of 1:1.5. The ratio of rice to water at 1:1.5 and 1:2 in rice cooking provided the highest overall liking score from consumers.

Table 6 Preference score of cooked rice at different rice-water ratios using 9-point Hedonic scale

Attribute	**Ratio Rice: water**			
	1:1	**1:1.5**	**1:2**	**1:2.5**
Appearance	5.5±1.0[ab]	5.9±1.2[a]	5.8±1.1[a]	5.4±1.1[b]
Color [Ns]	5.3±1.2	5.4±0.9	5.3±1.3	5.5±1.2
Aroma [Ns]	5.7±1.4	6.1±1.4	6.0±1.4	5.8±1.5
Flavor [Ns]	5.9±1.1	6.0±1.1	6.1±1.0	6.0±1.1
Texture	5.2±0.9[b]	5.9±1.3[a]	6.2±1.4[a]	5.8±1.3[a]
Over liking	5.5±1.0[b]	6.0±1.1[a]	6.2±1.0[a]	6.1±0.9[a]

Note: Means ± standard deviations (n=50). Means within the same row with different letters are different significantly at $p<0.05$. [Ns] Means are not different significantly at $p<0.05$.

4. Conclusion

The Thai rice (Hom-Mali105, Hom-Nin and KumDoiSaket) affected the Chemical composition, total antioxidant activity, total phenolic compounds and total anthocyanin. There are different texture profiles of cooked rice depending on rice to water ratio. Our results showed that the rice to water ratio significantly affected the color, textural parameters, microstructure and sensory descriptive of cooked KumDoiSaket rice. The ratio of water to rice also affected the eating quality of cooked KumDoiSaket rice. Therefore, rice cookers should consider this main point to get the benefit to consumers.

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