Comparing the sensory characteristics, physical properties, and consumer acceptability of purple rice cultivars

Somsiri Somthawil [1,2] and Sujinda Sriwattana [1,2]

Abstract

Sensory profiles from descriptive analysis, physical properties and consumer acceptance were used to compare qualities among purple rice growing in six different locations of cooked purple rice – Phayao, Chiang Rai, Omkoi, Doi Saket, Baantumkaw and Kantai. Results showed that the high intensity ratings for purple color and black color of Omkoi purple rice corresponded to the high for color and appearance. In contrast, the high intensity ratings for brown color and the low value of L* in Kantai purple rice resulted in a low consumer acceptance score for color. The samples with high glossiness intensity ratings, even though the differences were not significant ($p \geq 0.05$), received high acceptance scores for appearance. When comparing aroma and flavor intensity ratings with acceptance scores, high acceptance scores coincided with high intensity for purple rice odor, rice flavor and purple rice flavor. Omkoi purple rice and Doi Saket purple rice had high sweetness intensity which resulted in high overall flavor and overall acceptance. The high hardness intensity ratings from descriptive analysis of Kantai purple rice and Phayao purple rice were consistent with the high hardness values measured by texture analyzer. Considering the aftertaste of cooked purple rice, the low astringency intensity ratings of Omkoi purple rice resulted in high acceptance scores, whereas the high intensity ratings the bitterness in Chiang Rai purple rice and Kantai purple rice resulted in low acceptance scores for aftertaste. Conclusively, the highest overall acceptance scores of Omkoi purple rice corresponded to the high intensity ratings for purple and black color attributes, purple rice odor, rice flavor, purple rice flavor, sweetness, springiness and stickiness as well as the low intensity rating for astringency.

Keywords: purple rice, sensory profiles, physical properties

[1] Product Development Technology Division, Faculty of Agro-Industry, Chiang Mai University, Chiang Mai 50100, Thailand

[2] Sensory Evaluation and Consumer Testing Unit, Chiang Mai University, Chiang Mai 50100, Thailand

* Corresponding author, e-mail: Sujinda Sriwattana, sujinda.s@cmu.ac.th and sujindapdt@gmail.com

1. Introduction

Purple rice is a special cultivar of rice (*Oryza sativa L.*) that contains dark purple color pigments. It is a major crop in Southeast Asia and mainland China (Ryu *et al*., 1998; Pereira-Caro *et al*., 2013). In recent years, purple rice has grown increasingly popular in Asian countries, including Thailand. In Thailand, purple rice is known by many different names, including black sticky rice, Forbidden Rice, Wild Rice, Chinese Black Rice, Khao Kum, Muser purple rice and Kaow Luemphoa (Manojai, 2009). It has a long and noteworthy history as a locally-grown rice in Northern and North-eastern Thailand. At least 42 varieties of purple rice are cultivated in Thailand. Traditionally, purple rice is consumed as cooked whole grain; mixed with white rice before cooking to enhance the flavor, color, and nutritional value; or mixed with other foods, such as ice cream or Thai traditional desserts, as a flavoring or coloring agent.

Previous research has identified the chemical composition and biological activities of purple rice. Some studies have looked at the enriched purple-black pigments, anthocyanins, in purple rice for potential use in nutraceutical or functional food formulations, given their remarkable antioxidant and anti-inflammatory properties (Hu *et al*., 2003; Sompong *et al*., 2011). Other profitable components have been identified in purple rice, including polyphenolics, flavonoids, vitamin E, phytic acid, and c-oryzanol (Pengkumsri *et al*., 2015; Ming-wei *et al*., 2006; Suzuki *et al*., 2004). Few studies have researched other properties such as physical, textural, or sensory purple rice, or compared these properties with white rice. Several studies have investigated physical properties (Gayin *et al*., 2009; González *et al*., 2004; Lyon *et al*., 2000), sensory profile and sensory acceptability (Kwak *et al*., 2013) of white rice. Some of these studies indicated that measuring the texture attributes of cooked rice by sensory and instrumental methods is important because of the increased popularity of rice and rice products by globally diverse cultures which will help to match rice with specific characteristics to populations that demand those attributes. (Lyon *et al*., 2000). Due to the growing popularity of purple rice and the limited research on its physical and sensory properties the purpose of this research were to study the sensory profile, physical properties, and sensory acceptability of cooked purple rice and to identify and quantify the differences among purple rice growing in different locations.

2. Materials and Methods

2.1 Preparation of rice samples

For this study, purple rice growing in different locations; Phayao, Chiang Rai, Omkoi, Doi Saket, Baantumkaw (commercial product) and Kantai (commercial product) were purchased from different provinces in Northern Thailand. The appearance of all rice is illustrated in Figure 1.

Figure 1 The appearance of cooked purple rice growing in different locations

1= Phayao, 2= Chiang Rai, 3= Omkoi, 4= Doi Saket, 5= Baantumkaw and 6= Kantai

All milled purple rice samples were washed before cooking. Water was added in a ratio of rice to water (by weight) of 1:1 following our preliminary study. All samples were cooked in rice cooker-steamers (Panasonic, JFC International, Norcross, GA) for 1 hour following the method of Maisuthisakul and Changchub (2012). For descriptive analysis and consumer acceptance tests, all samples were kept warm in an incubator to control the temperature at 60-70°C.

2.2 Analysis of the physical properties

The physical properties of the cooked purple rice samples were investigated. Color was measured using Minolta Camera; Chroma Meter: CR-310, Japan. Texture Profile analysis (hardness adhesiveness springiness, cohesiveness gumminess and chewiness) was performed using a table-top TA-XT2 texture analyzer (TA-XT Plus, UK) according to Daomukda (2011). 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. Moreover, the moisture content was also conducted follow AOAC 950.46 (AOAC, 2012).

2.3 Descriptive analysis

Participants were recruited among the students from the Product Development Technology Division, Faculty of Agro industry, Chiang Mai University. All participants who had previous experience in sensory evaluation were screened according to ASTM (1981). The screening criteria were comprised of: (1) panelists were able to perceive smell or taste, (2) panelists were able to correctly identify the four basic tastes (sweet, salty, sour and bitter), (3) panelists were able to correctly indicate or describe some common odors (banana, orange, grape, peach, jasmine flower and vanilla), (4) panelists were able to correctly rank the increasing order of taste (sweet, salty, sour, bitterness) solutions at different concentration levels (one reverse pair for the adjacent samples was allowed), and (5) panelists were available to participate.

Twelve panelists were selected and trained in descriptive analysis during approximately 2- hour training sessions/day. Panelists were trained to use 150 mm line scales to, identify and rate the four basic tastes: sweet, sour, bitter and salty.

Then, all panelists were introduced to different rice samples to develop the lexicon. The references were found to train the panelists in the identification and quantification of all attribute intensities. Each reference was presented at different levels of intensity to standardize the use of the 150 mm line scale. The development of the lexicon included familiarizing the panelists with different attributes using the references. The descriptors were selected by panel consensus. After the lexicon was developed, all panelists received training in attribute intensity (Table 1).

After training, twenty grams of each rice sample in plastic cups with three-digit identifiers were presented to the twelve panelists. Panelists evaluated each sample individually, using water and unsalted crackers to cleanse their palettes between samples. After tasting each sample, panelists waited for 5 min before tasting the next samples in a new randomized order.

Table 1 Sensory terms and references of cooked purple rice (n=12)

Term	Definition	Reference
Appearance		
Purple color *	Purple color of cooked rice grains	Green color chart 5P 5/2 = 0.0, 5/4 = 7.5, 5/6 = 15.0
Black color*	Black color of cooked rice grains	Black color chart N3 = 0.0, N2 = 7.5, N3 = 15.0
Brown color*	Brown color of cooked rice grains	Brown color chart 25 YR 10 R 4/4 = 0.0, 3/4 = 7.5, 2/4 = 15.0
Thinness [a]	Thinness of whole rice grain	Japanese rice (Chang brand) 4.0 Japanese rice (Dok Buang brand) 14.0
Length*	Length of whole rice grain	Japanese rice (Chang brand 4.0 Thai Kitchen Jasmine 10.0
Broken rice[a]	Amount of broken rice grains	parboiled 0.0 Thai Kitchen Jasmine 2.0
Stickiness*	Force required to separate individual grain adhering to each other	Raw purple rice 0.0 Cooked purple rice 14.0
Glossiness[a]	Shininess of cooked rice surface	Thai Kitchen Jasmine 10.0
Aroma		
Cooked rice aroma[a]	Aroma related to cooked rice	Water from cooked rice 0.5% 3.0 Water from cooked rice 1.0% 7.0 Water from cooked rice 2.0% 8.5
Purple rice aroma[b]	Aroma related to purple rice	Water from cooked rice 0.2% 0.5 Water from cooked rice 0.6% 1.0 Water from cooked rice 1.0% 3.0
Flavor		
Cooked rice flavor[a]	Flavor related to cooked rice	Water from cooked rice 0.5% 3.0 Water from cooked rice 1.0% 7.0 Water from cooked rice 2.0% 8.5
Purple rice flavor[b]	Flavor related to purple rice	Water from cooked rice 0.2% 0.5 Water from cooked rice 0.6% 1.0 Water from cooked rice 1.0% 3.0

Table 1 Sensory terms and references of cooked purple rice (n=12) (Cont.)

Term	Definition	Reference
Taste		
Sweet[b]	Basic taste associated with sucrose solution	Sucrose solution 0.08% 5.0
Bitter[b]	Basic taste associated with caffeine solution	Caffeine solution 0.05% 2.0
Texture		
Softness*	Resistance given when chewing	Soft tofu 1.0 Butter cake 3.5
Stickiness[a]	Force required to overcome the traction between the food and the palate	Green bean Raitip brand 5.0 Dok Buang sticky rice 10.0
Hardness[a]	Force needed to compress a food between molar teeth.	Cream cheese 1.0, American cheese 4.5, Hot dog 5.5, Peanut 9.5,
Roughness[a]	The amount of particles in the mouth	Chicken rice porridge Knorr brand 3.0
Tooth Pack[a]	The amount of sample left in or on teeth after chewing.	Butter cake S&P 4.0 Rice craker 9.0
Aftertaste		
Astringent*	Harsh sensation perceived in mouth and tongue after swallowing 1 minute	Grape juice 6.5
Bitter[a]	Bitter sensation perceived at the back of the throat after swallowing 1 minute	Caffeine 0.05% 2.0 Sucrose solution 0.08% 5.0
Residue*	Quantity of particles left in the mouth after swallowing 1 minute	Butter cake S&P 4.0 Rice cracker 9.0

Note : * Lexicons developed by our trained panel

The panelists were trained follow ASTM (1981)

Lexicons published by [a] Kiatthanapaiboon (2008), [b] Limpawatana (2007)

2.4 Consumer acceptability of purple rice

Upon cooking purple rice samples were immediately presented to 100 panelists (21–50 years old), members of Chiang Mai University, Thailand. Evaluations were conducted in partitioned booths at the sensory analysis laboratory with controlled temperature (23–25°C) and adequate lighting. Twenty grams of each rice sample were added to a plastic cup with lid and kept warm in an incubator by controlling the temperature at 60–70°C before testing. The rice samples were presented in random order with three-digit blinding codes to minimize bias. Between each sample, panelists cleansed their mouth and palate with distilled water.

All attributes of the cooked rice samples (color, appearance, overall flavor, overall taste, texture, aftertaste, and overall liking) were evaluated using a 9 point hedonic scale with 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely (Peryam and Pilgrim, 1957).

2.4 Statistical data analysis

The means of all physical, textural and sensory attributes were compared using variance analysis followed by the Tukey test (significant difference when $p<0.05$), using the Minitab version 16 program (Minitab Inc., USA).

3. Results and Discussion

3.1 Physical properties of purple rice

The physical properties of the six purple cooked rice samples are shown in Table 2, all samples were significantly different ($p<0.05$) in water activity (a_w), moisture, and color. The water activity of the six cooked purple rice sample were quite high in (0.989–1.000). The moisture content of all samples was 52.22–61.02 %. Wanitchan *et al.* (2013) reported similar moisture content in Hom Pathum Thani rice 63.50–73.17%.

Table 2 Physical properties of cooked purple rice growing in different locations

Physical properties	Rice growing in different locations					
	Phayao	Chiang Rai	Omkoi	Doi Saket	Baantamkaw	Kantai
a_w	0.989 ± 0.002 ^{c}	0.997 ± 0.000 ^{a}	1.000 ± 0.001^{a}	0.994 ± 0.004 ^{b}	0.996 ± 0.006 ^{ab}	0.997± 0.000 ^{a}
Moisture(%)	52.22 ± 1.41 ^{c}	57.34 ± 1.36 ^{ab}	59.33 ± 2.28 ^{ab}	61.02 ± 1.38 ^{a}	55.73 ± 3.41 ^{b}	58.34 ± 0.25 ^{ab}
L*	19.17 ± 0.98 ^{a}	18.56 ± 1.29 ^{ab}	16.30 ± 2.00 ^{c}	17.29 ± 1.47 ^{bc}	16.75 ± 1.65 ^{bc}	15.91 ± 1.19 ^{c}
a*	6.17 ± 1.44 ^{bc}	4.52 ± 1.00 ^{c}	6.66 ± 1.94 ^{ab}	8.13 ± 1.33 ^{a}	6.60 ± 1.31 ^{ab}	5.60 ± 1.61 ^{bc}
b*	-2.86 ± 0.68 ^{c}	-1.72 ± 0.31 ^{b}	-1.09 ± 0.84 ^{b}	-0.04 ± 0.71 ^{a}	-1.08 ± 0.75 ^{b}	-1.09 ± 0.81 ^{b}

Note: Means within the same row not followed by the same letters are significantly different (P<0.05)

The coating on the grain surface of all rice sample was purple-black. The L* value (15.91–19.17) of purple rice was quite low. All color parameters differed significantly ($p<0.05$) among the different growing locations and brands in our study. 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 did affect the a* value. Some cooking method could made broken pericarp of rice surface and the leaking of flour in black sticky rice. This might affect the whiteness and a* value.

Table3 Texture analysis of six cooked purple rice samples

Physical properties	Rice growing in different locations					
	Phayao	Chiang Rai	Omkoi	Doi Saket	Baantamkaw	Kantai
Hardness(N)^{ns}	9.20 ± 6.83	9.80 ± 4.13	9.14 ± 4.24	4.28 ± 9.21	10.84 ± 4.99	12.40 ± 5.71
Adhesiveness (g.sec)	129.74±447.76-^{a}	444.90±979.97-^{bc}	285.97±647.92-^{abc}	205.23±627.19-^{ab}	139.38±1015.17-^{c}	270.17±588.28-^{a}
Springiness^{ns}	0.07 ± 0.34	0.06 ± 0.35	0.09 ± 0.37	0.08 ± 0.37	0.03 ± 0.35	0.08 ± 0.34
Cohesiveness^{ns}	0.04 ± 0.40	0.05 ± 0.44	0.05 ± 0.45	0.05 ± 0.44	0.03 ± 0.43	0.05 ± 0.44
Gumminess^{ns}	3.52 ± 2.61	5.12 ± 2.17	4.54 ± 2.10	4.41 ± 2.04	4.71 ± 2.20	4.50 ± 2.09
Chewiness^{ns}	1.04 ± 0.78	2.22 ± 0.95	2.03 ± 0.93	2.16 ± 0.99	1.87 ± 0.86	1.11 ± 0.52

Note: Means within the same row not followed by the same letters are significantly different (P<0.05)
ns not significantly different

The results of texture analysis are shown in Table 3. Only the adhesiveness differed significantly different (p<0.05) among the purple rice growing in different locations. The hardness of the samples in this study (4.13–6.83 N) was similar to that found in white rice in an earlier study (Horrungsiwat and Therdthai, 2013). The method of cooking the rice as well as the rice to water ratio used have been shown to effect on different texture properties, including hardness, adhesiveness, and cohesiveness (Sumret, 2012).

3.2 Sensory profile of purple rice

After developing the sensory profile (Table 1), trained panelists evaluated the intensities of each attribute for the six cooked purple rice samples. The mean intensity and mean separation of the six cooked purple rice samples are presented in Figure 2. Among six attributes, broken rice, glossiness, cooked rice aroma, and sweet taste were not significantly different (p≥0.05), while the other two attributes differed. Few studies have reported on the sensory profile of purple rice, with most focusing on white rice instead (Kiatthanapaiboon, 2008; Limpawattana, 2007; Yau and Huang, 1996).

Limpawattana (2007) studied the sensory properties of 36 samples of commercial rice from Thailand, China, the United States and Pakistan. The result of Limpawattana showed that eight panelists developed 24 sensory terms of which 18 differed significantly among most rice samples. Some attributes were found in each rice variety.

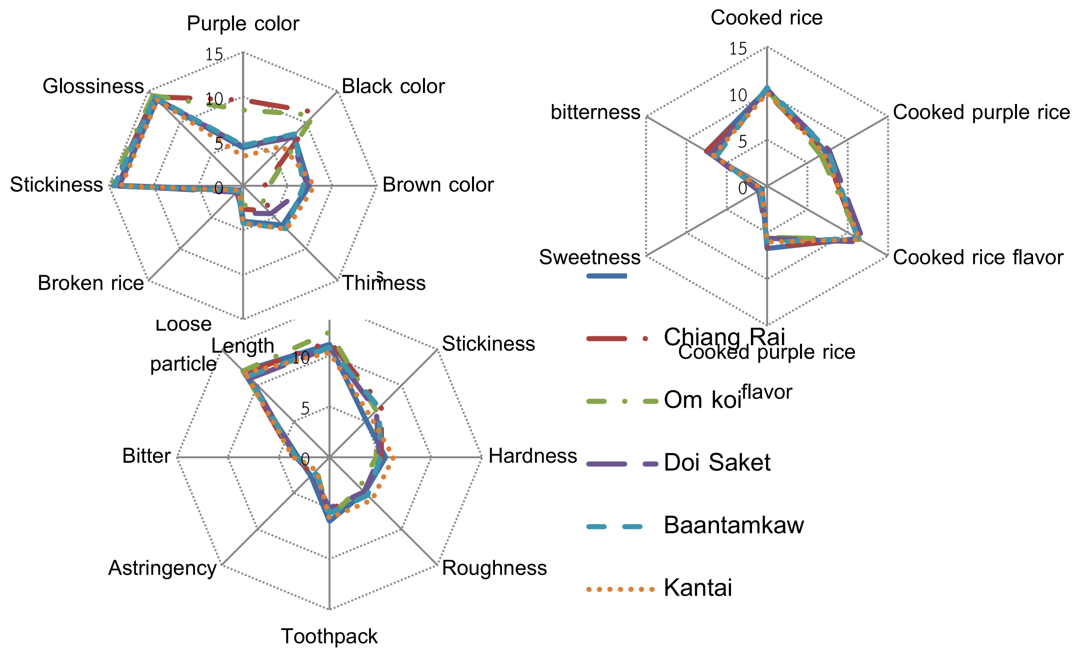

Figure 2 Mean sensory descriptive intensities for sensory characteristics of six cooked purple rice samples

3.3 Consumer acceptance of purple rice

The average consumer acceptance scores for cooked purple rice are shown in Figure 3. The sensory acceptance of all rice samples were neither like nor dislike to like moderately, with an average rating of 5.6–7.0 on the 9-point hedonic scale. Omkoi rice received high intensity for color intensity in descriptive tests; it also had the highest on color attribute. Kantai rice appeared quite thin, long in length, and less glossy; the lowest scores in appearance among five rice samples. Chiang Rai purple rice received lower scores on overall flavor and taste than those of the others samples. This result might be due to a bitter taste of Chiang Rai purple rice.

In descriptive analysis, Kantai purple rice was high intensity in hardness and stickiness, low in softness in roughness; these led to low consumer acceptance scores of its texture. Kantai purple rice also received low acceptance scores for its aftertaste attribute.

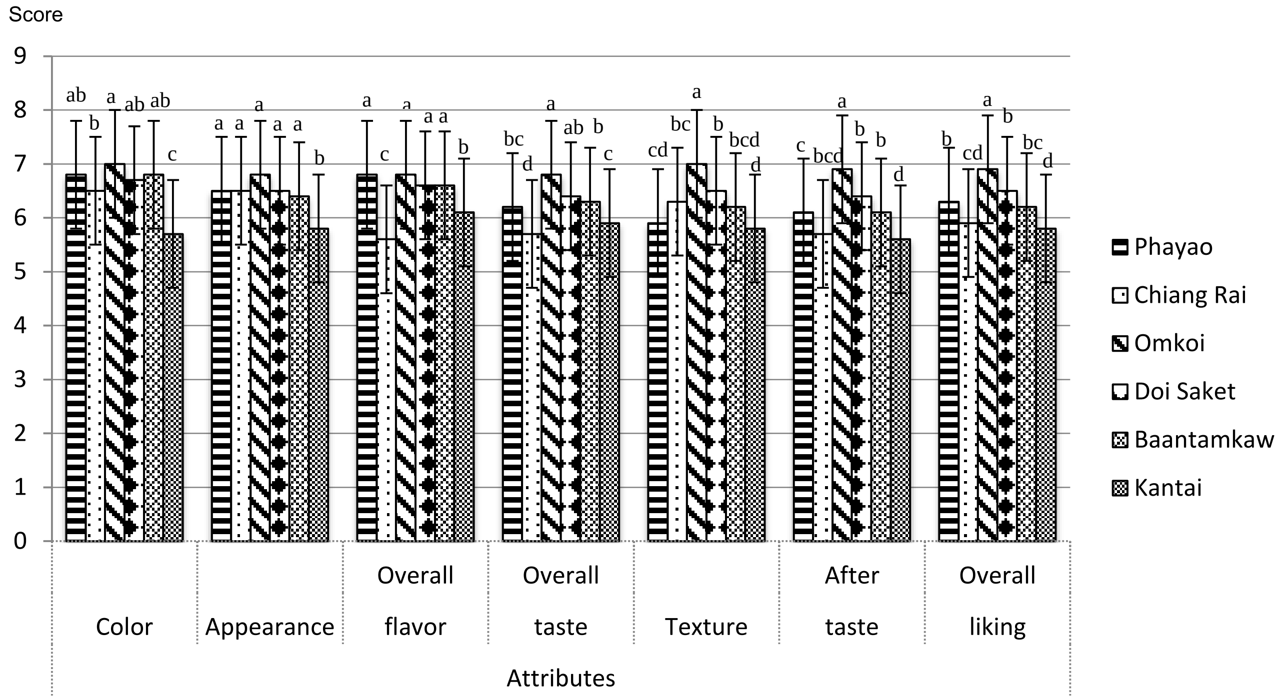

Figure 3 Mean sensory acceptance scores for all attributes of six cooked purple rice samples. The mean attribute scores for color, appearance, overall flavor, overall taste, texture, aftertaste, and overall liking differed significantly ($p<0.05$) among the samples.

4. Conclusion

This research illustrated the basic physical properties and sensory profiles of six Thai northern purple rice samples. Variations were noted among the rice samples based on physical and sensory analysis. Twenty-two sensory terms were indicated and validated for the six cooked rice samples, including, purple color, black color, brown color, thinness, length, cracked rice, stickiness, glossiness, cooked rice, cooked purple rice, cooked rice flavor, cooked purple rice flavor, sweetness, bitter, springiness, stickiness, hardness, roughness, toothpack, astringent, bitter and loose particle. For consumer acceptance test, six purple rice samples were generally acceptable to general consumers who participated in this study (in range of neither like nor dislike to like moderately in all attributes). The results of this study can be used for further studies that relate sensory qualities, some qualities control and consumer acceptance of other purple rice.

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