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Physical properties and cooking qualities of local and commercial brown rice varieties in Thailand

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Abstract Commercial brown rice has a lot of varieties with different grain shapes and colors. The physical properties of rice grain are observed by eyes whereas the cooking qualities was tested by the consumers, milling machine adjustments and plant breeding improvemens. This research was reported 10 local and commercial brown rice varieties as Phraya Leumkaeng, Kaipa, Ngoa Lertin, Buekee, Khao Dawk Mali 105, Tubtimchumphae, Hommalideang, Sungyod, and Riceberry. The result showed that three local brown rice varieties of Kaipa, Ngoa Lertin, and Buekee showed short grains, medium shape, high sphericity, low grain expansion percentage or grain elongation percentage and water absorption percentage in comparison to other six commercial brown rice varieties of Khao Dawk Mali 105, Tubtimchumphae, Hommalideang, Sungyod, and Riceberry which were longer grains. The longest grain with slender shape was Khao Dawk Mali 105, and the second longest was Tubtimchumphae that showed the highest grain expansion and water absorption percentages. Phraya Leumkaeng sticky rice was the highest of grain width and thickness that resulted to over 100-grain weight and more grain elongation percentage after cooking. Organic and inorganic Khao Dawk Mali 105 rice showed different grain lengths. Organic Khao Dawk Mali 105 grains showed longer length than inorganic grains; although the shape, sphericity and cooking qualities like grain elongation percentage, grain expansion percentage and water absorption percentage.

Keywords: Physical properties, Cooking qualities, Local brown rice, Commercial brown rice

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Introduction

The physical qualities of rice are indicators which measured by visual observation such as shape, color, and broken grains. Usually, consumers choose the full grains more than broken grains. Different physical characteristics of grain shape affect broken grains in the same hulling machine without adjustment of milling roller (Wanitchang *et al*., 2013). Apart from consumers' interest in physical quality of rice, cooking quality of rice was evaluated in terms of elongation ratio, water uptake of cooked rice and volume expansion to identify cooking index. Cooking index increased with increased in water uptake, elongation and volume expansion of cooked rice. This contributes to fluffy characteristic (Mohapatra and Bal, 2007). Furthermore, cooking quality involves a number of related factors such as chemical composition of rice, paddy drying, and storage duration (Wiset, 2012).

At present, there are a lot of commercial rice varieties in the market but they differs in terms of appearance, cooking quality and nutritional value. Many local rice varieties have not been certified by the Rice Department, Ministry of Agriculture and Cooperatives, Thailand. These include Kaipa with slender grain similar to Khao Dawk Mali 105 (Royal Project Foundation, n.d.a.); Khao Ngoa Lertin with short and bold grain and soft texture when cooked (Royal Project Foundation, n.d.b.); and Khao Buekee with striped and yellowish grain. Most of the commercial rice varieties certified by the Rice Department are those with plantation and high yield stability, e.g. Khao Phraya Leumkaeng as sticky rice with soft texture when cooked and the ratio of water for cooking is 1:1.5-2 (Rice Product Development Division, n.d.a); Khao Tubtimchumphae with soft texture when cooked and low amylose content of 9-12% (Chum Phae Rice Research Center, 2017); Khao Hommalideang a long and slender grain with low glycemic index and friable texture (Rice Product Development Division, n.d.b.); Khao Sungyod with low amylose (15±2 %), soft texture when cooked, red dehusked grain of length x width x thickness = 6.7 x 1.8 x 1.6 mm (Rice Research and Development Division, 2016); and Khao Riceberry with long and slender grain, soft texture when cooked, 15.6% amylose, glycemic index of 62, and low gelatinization temperature of < 70 ^{o}C (Rice Department, 2017). Popular and exported rice as Khao Dawk Mali 105 contains 12-17% amylose, with soft texture when cooked, grain length x width x thickness = 7.5 x 2.1 x 1.8 mm. (Rice Seed Center Khon Kaen, 2019).

Today, many rice varieties mentioned above are niche market rice such as colored rice with high nutritional value for consumers with literacy about rice varieties (Rice Seed Center Phrae, n.d.). Organic rice, another kind of niche

market rice, is grown in non-chemical plantation system that uses microbial pesticide.

In the current study, the rice varieties were selected from those available in the market and have diversity in various aspects. These included 10 brown rice varieties: 1 sticky and 9 non-sticky. They were categorized into 3 groups as to color: 1) straw-color dehusked as certified rice varieties (Phraya Leumkaeng, Khao Dawk Mali 105) and uncertified or local rice varieties (Kaipa, Ngoa Lertin, and Buekee); 2) red-color dehusked rice as certified rice varieties (Tubtimchumphae, Hommalideang, Sungyod); and 3) purple-color dehusked rice as certified rice variety (Riceberry). Khao Dawk Mali 105 was examined in comparison with 2 plantation systems, i.e. organic and inorganic systems.

The objective was to study information about the diversity in physical properties and cooking qualities of dehusked rice.

Materials and Methods

Determination of physical properties of 10 (local and commercial) rice varieties

The investigation included eight local and one commercial rice varieties contained in vacuum sealed package being sold in the local market from January – March 2018. The other sample was grains of Khao Dawk Mali 105 grown in organic and inorganic plantation systems and hulled at the Department of Agricultural Engineering and Technology, Rajamangala University of Technology Tawan-ok. The 10 rice varieties were categorized by type and color (Table 1). The 100 grains from each variety were randomly selected for 10 times. The grain width, length, thickness and 100-grain weigh were measured. Equation 1 was used to calculate and determine the grain shape as follow: slender with the value >3; medium with the value of 2-3; round and short with the value < 2 (Attaviriyasook, 1991). Sphericity was calculated with Equation 2 (Mohsenin, 1996).

$$\text{Grain shape} = \frac{\text{Length}}{\text{Width}} \quad (1)$$

$$\text{Sphericity} = \frac{(\text{Width} \times \text{Length} \times \text{Thickness})^{1/3}}{\text{Length}} \quad (2)$$

Determination the cooking qualities of 10 local and commercial rice varieties

Random sampling was performed using 10 grains of rice which were stored for 1 month after opening the vacuum sealed package. The grain width, length and weight were measured before soaking the grains in water for 30 minutes, boiled for 10 minutes and then cooled for 3 hours. Cooked grains of the 10 rice varieties were then measured again for their width, length, and weight. The percentage grain elongation, grain expansion and water absorption were calculated using Equation 3-5 (Ge *et al*., 2005).

$$\text{Grain elongation Percentage} = \frac{(\text{Length after cooking} - \text{Length before cooking})}{\text{Length before cooking}} \times 100 \quad (3)$$

$$\text{Grain expansion Percentage} = \frac{(\text{Width after cooking} - \text{Width before cooking})}{\text{Width before cooking}} \times 100 \quad (4)$$

$$\text{water absorption Percentage} = \frac{(\text{Weight after cooking} - \text{Weight before cooking})}{\text{Weight before cooking}} \times 100 \quad (5)$$

Table 1. Type and color of 10 (local and commercial brown) rice varieties

Rice variety	Type	Color
Phraya Leumkaeng	Glutinous	Brown
Kaipa	Rice	Brown
Ngoa Lertin	Rice	Brown
Buekee	Rice	Brown
Khao Dawk Mali 105 (organic)	Rice	Brown
Khao Dawk Mali 105 (inorganic)	Rice	Brown
Tubtimchumphae	Rice	Red
Hommalideang	Rice	Red
Sungyod	Rice	Red
Riceberry	Rice	Purple

Determination the correlation foe physical characteristics of rice and cooking qualities

The data on the physical characteristics and cooking quality of rice were analyzed with SPSS using ANOVA method at the 95% significance level; using Tukey HSD to analyze the Correlations of physical characteristics and cooking quality of rice were determined in terms of grain width, length, thickness, and 100-grain weight to cooking quality i.e. percentage of grain elongation,

percentage of grain expansion, and percentage of water absorption. Statistical analysis was employed by SPSS program, and correlation analysis of data was computed by Pearson Correlation at 95% and 99% level of significance.

Results

Physical characteristics of local and commercial rice varieties

The results revealed that Phraya Leumkaeng had the widest (3.18±0.22 mm.) and thickest (2.14±0.67 mm.) grain that contributed to the highest 100-grain weight (3.35±0.04 g.). Among those uncertified straw-color rice varieties, the northern local rice Kaipa had the shortest grain (5.91±0.47 mm). Ngoa Lertin, and Buekee had the medium shape and the highest sphericity (0.54 and 0.54, respectively). A comparison of organic and inorganic Khao Dawk Mali 105 suggested that organic plantation offered longer grains than inorganic system. However, rice grains from both systems were similar with slender shape and low sphericity (0.41 and 0.41, respectively,). Among the colored grain rice varieties, red color grains showed more distinctive physical property than purple-color grains i.e. Riceberry. Among the red colored grain rice varieties, Tubtimchumphae had the lowest in grain width (1.99±0.10 mm) and thickness (1.63±0.11 mm) which affected the lowest 100-grain weight (1.77±0.08 g. It is also slender in shape (3.36) and had the lowest sphericity (0.42) as seen in Figure.

Cooking qualities of the local and commercial brown rice varieties

Results showed that Phraya Leumkaeng had the highest grain elongation percentage (8.80±5.90). Among the straw-colored local rice varieties, Kaipa and Buekee had the lowest grain expansion percentages (2.31±1.22 % and 2.93±1.37 %, respectively). Ngoa Lertin had the lowest grain elongation and the lowest water absorption percentages (1.13±0.79 % and 4.44±2.71 %), respectively. Among the colored grain rice, red-color grains showed more distinctive cooking qualities than purple grain rice i.e. Riceberry. The red colored rice Tubtimchumphae showed the highest grain expansion and water absorption percentages (8.23±2.19 and 26.36±2.08, respectively). Hommalideang and Sungyod showed the lowest grain elongation percentages at 1.66±0.61 and 2.17±0.80, respectively (Figure 2).

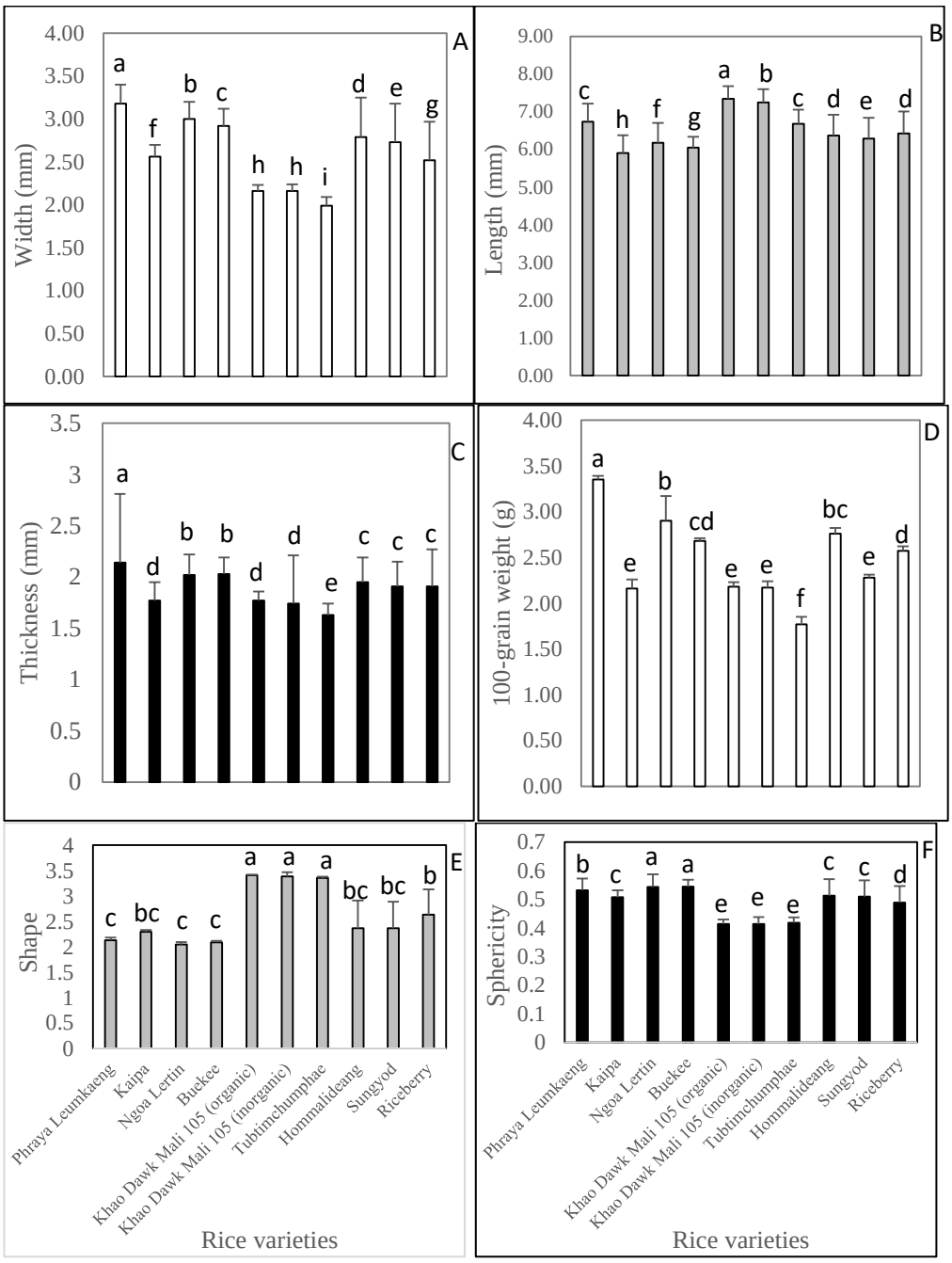

Figure 1. Physical characteristics of the 10 (local and commercial) rice varieties; A = width, B= length, C= thickness, D= 100-grain weight, E= shape and F= sphericity

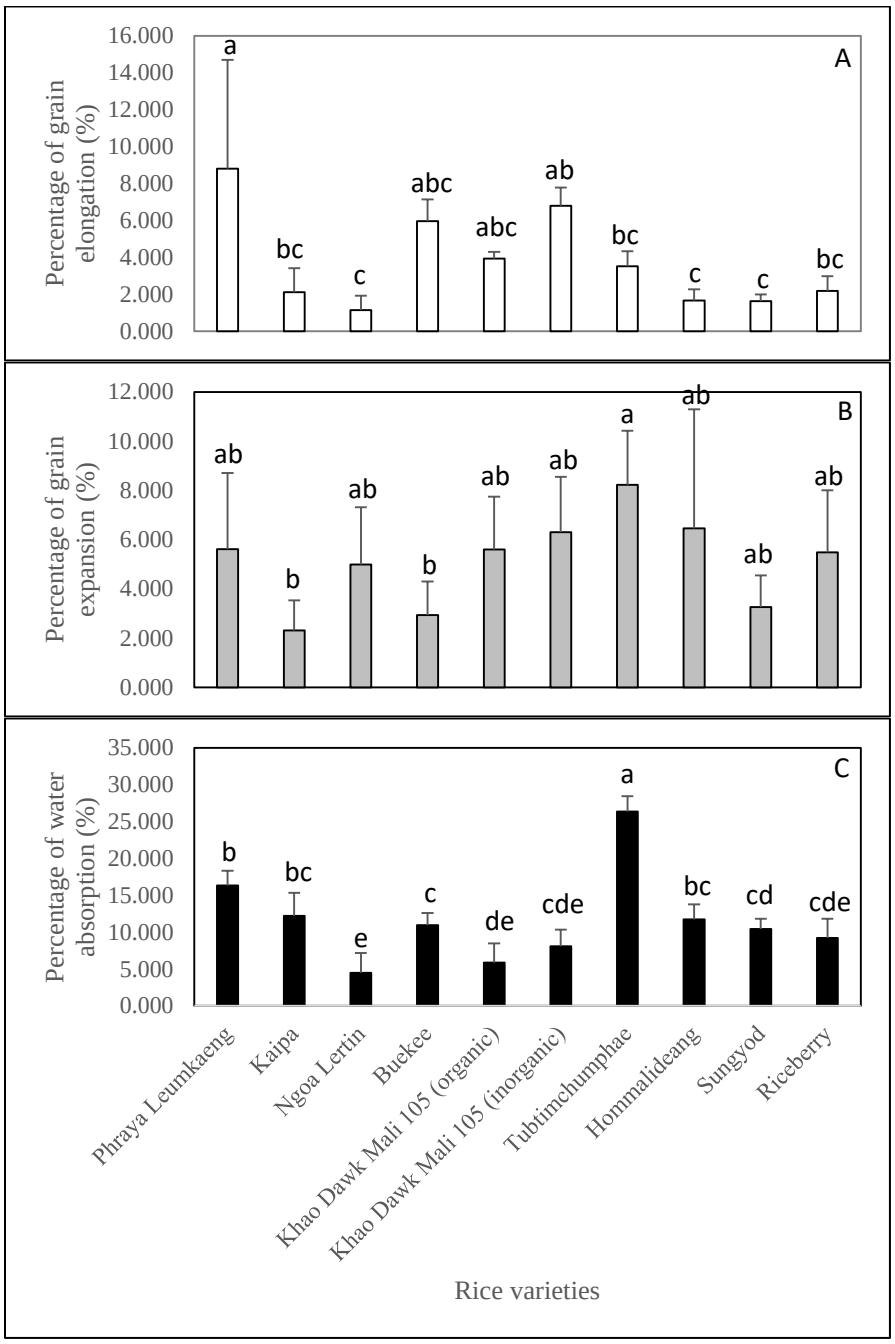

Figure 2. Cooking qualities of the local and commercial rice varieties; A= grain elongation percentage, B= grain expansion percentage and C = water absorption percentage

Table 2. Correlations of physical characteristics and cooking qualities of 10 brown rice varieties

Correlations		Grain Width	Grain Length	Grain Thickness	Grain Weight	Elongation percentage	Expansion percentage	Absorption percentage
Grain Width	Pearson Correlation	1	--	++	++		-	
	Sig. (2-tailed)		0.000	0.000	0.000	0.240	0.017	0.229
Grain Length	Pearson Correlation	--	1	--		+		
	Sig. (2-tailed)	0.000		0.000	0.498	0.022	0.103	0.731
Grain Thickness	Pearson Correlation	++	--	1	++	++	--	
	Sig. (2-tailed)	0.000	0.000		0.000	0.003	0.003	0.363
Grain Weight	Pearson Correlation	++		++	1			
	Sig. (2-tailed)	0.000	0.498	0.000		0.057	0.490	0.158
Elongation percentage	Pearson Correlation		+	++		1		
	Sig. (2-tailed)	0.240	0.022	0.003	0.057		0.269	0.314
Expansion percentage	Pearson Correlation	-		--			1	
	Sig. (2-tailed)	0.017	0.103	0.003	0.490	0.269		0.052
Absorption percentage	Pearson Correlation							1
	Sig. (2-tailed)	0.229	0.731	0.363	0.158	0.314	0.052	

--, Inverse correlation, and ++, direct correlation are significant at the 0.01 level (2-tailed).

-, Inverse correlation, and +, direct correlation are significant at the 0.05 level (2-tailed).

Correlations the physical characteristics and cooking quality of brown rice varieties

Results showed that the grain width had directly correlation with grain thickness and 100-grain weight but significant inversed correlation with grain length and grain expansion percentage. Grain length showed directly correlation with grain elongation percentage but significant reversed correlation with grain width and thickness. Grain thickness showed directly correlation with 100-grain weight and grain elongation but significant inversed correlation with grain expansion percentage (Table 2)

Discussion

The physical characteristics of grains may be varied due to plantation system and geographical location. In this study, Khao Dawk Mali 105 grown in different areas and with different plantation systems had different grain lengths but with similar shape, sphericity and cooking qualities. In-nok *et al*. (2016) reported that different plantation systems in the same area for Khao Dawk Mali 105 (organic and inorganic) showed differences in 100-paddy grain weight, 100-dehusked grain weight, amylose content, protein content, starch content, total phenolic content and nitrogen content in milled rice. However, their cooking qualities were not significantly different.

Phraya Leumkaeng had the highest grain elongation percentage which due to its nature as sticky rice with high amylopectin. The results differed from those of Yadev *et al*. (2007) suggesting that high amylose rice produced high ratio grain elongation. However, as Phraya Leumkaeng had wide and thick grains so it might affect the percentage in grain elongation. Tubtimchumphae showed the highest water absorption and the highest grain expansion percentages. These results were in consistent with the findings by Yadev *et al*. (2007) that high water uptake of cooked rice contributed to high grain elongation.

The factors affecting 100-grain weight were high grain width and thickness while the factors affecting grain elongation percentage were grain length and thickness. Moreover, the factors affecting grain expansion percentage were lower grain width and thickness. However, none of the grain physical factors significantly affected the percentage in grain water absorption. The chemical components of rice such as the amount of amylose, paddy drying, and storage duration also affected cooking quality (Wiset, 2012). Increased paddy drying temperatures from 100^{o}C to 150^{o}C had resulted to lower percentage of full grains, increase in cooking duration, increased elongation percentage and increased hardness of Khao Dawk Mali 105 cooked rice

(Waedalor *et al.*, 2010). The increasing storage duration of Khao Dawk Mali 105 from 0 to 6 months was increased water intake of cooked rice and increased volume expansion of cooked rice. However, within one month storage, it was no differences in these characteristics (Soponronnarit *et al*., 2008).

Phraya Leumkaeng sticky rice gave the highest grain width, thickness, 100-grain weight and grain elongation percentage. Among the local rice varieties, Kaipa showed the lowest grain length and grain expansion percentage. Ngoa Lertin and Buekee revealed the medium grain shape and highest sphericity while Khao Dawk Mali 105 showed the highest grain length and the most slender. The red-colored rice, Tubtimchumphae was the lowest grain width, length and 100-grain weight but the highest grain expansion and water absorption.

Hommalideang and Sungyod showed the lowest grain elongation. The purple color rice Riceberry had the moderate level of physical characteristics and cooking qualities compared to the other 9 local and commercial rice varieties.

This study found that grain thickness was directly correlated with grain width, 100-grain weight and grain elongation percentage but in reversed correlation with grain length and grain expansion percentage. Thus, different rice varieties showed various physical characteristics that relatively affected its cooking qualities.

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