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Physicochemical characteristics of Tunya-Sirin and Hom-Lanna Rice Flour

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Abstract

The physicochemical properties of rice flour samples from different cultivars (Tunya-Sirin; TS, Hom-Lanna; HL, RD-6 and KDML-105 were evaluated with the aim of establishing their specific food uses. Results revealed that the 4 rice varieties had similar in shapes and sizes of the starch granules. Crystallinity degree of the rice flour from TS and HL had higher value than RD-6 and KDML-105. Thermal properties and viscosity behavior results revealed that the flour from HL variety had the highest in gelatinization enthalpies and setback. Chemical analysis found that HL rice flour had higher in amylose content, free amino nitrogen, phenolic compound than the other rice flour samples. Results on *in vitro* starch digestibility revealed that the flour from RD-6, KDML-105 and TS rice varieties were significantly higher in starch digestibility and glycemic index than HL rice flour.

Keywords: Amylose content, thermal properties, pasting behavior, glycemic index

1. Introduction

Rice (*Oryza sativa* L.) is an important convenience food in Asian country. Rice is being used as main dish, snack, beverage, and gluten-free bakery products (Kadan et al., 2001). These novel foods usually require rice having known physical properties, protein contents and its functional properties. These properties include hypoallergenicity, digestibility, bland flavor, cooking quality, and a wide range of amylose/amylopectin ratios. Rice varies in size, shape, aroma and stickiness. Rice is also available in a number of colors, including white, red and deep purple. In recent year, the National Science and Technology Development Agency and Agricultural Technology Research Institute in Thailand have been engaged in a number of rice improvement programs to enhance both yield and quality. Tunya-Sirin rice is new white glutinous rice that was developed by backcross breed. In addition, Hom-Lanna rice is deep purple rice gets its dark color from its outer coating of black bran, which was available in Northern part of Thailand. However, the physicochemical properties and nutritive value of these new rice varieties are not well established. Thus this work covers these aspects in terms of appearance, granule morphology, pasting behaviors, thermal properties, crystallinity degree, amylose content, proximate analysis, free alpha amino nitrogen, total phenolic compound, *in vitro* starch digestibility and glycemic index by comparative to the quality of available Thai rice cultivars (RD-6 and KDML-105).

2. Materials and methods

2.1 Rice flour preparation

Four varieties of Thai rice (*Oryza sativa*, L.) used in this study were Tunya-Sirin (TS), Hom-Lanna (HL), RD-6 and KDML-105) obtained from Agricultural Technology Research Institute, Lampang, Thailand. Paddy rice grain was dehusked using a rubber roller. Broken kernels were separated from the whole dehusked grain obtained. The dehusked grains were ground using Cyclotec milling (CyclotecTM 1093, Foss, Sweden) and sieved through a

100 micrometer sieve. The rice flour samples were then packed in plastic bags and stored at 4°C until further determinations. Analyze grade of chemicals used were purchased from Sigma Chemical Company, St. Louis, USA.

2.2 Physical property analysis

Physical properties studied were the grain size and shape with five replicates of ten kernels per sample using a micrometer screw gauge (Mitoyo Co.), alkali spreading value (1.7% KOH concentration) and L^*, a^*, b^* color parameters (Minolta CR310, Minolta Co. Ltd., Japan). Microscopic images of the 4 rice flour samples were examined using SEM with magnifications of 6,000X. Rapid Visco Analyzer (RVA model 4, Newport Scientific, Warriewood, NSW, Australia) was using to determine the pasting behaviors of the four rice flour samples. Thermal properties of the four rice flour samples were performed by differential scanning calorimeter (DSC, Mettler Toledo DSC 1).The resulting thermograms were analyzed using Mettler Toledo Stare software (ver. 9.20) for the onset temperature (To), peak temperature (Tp),conclusion temperature (Tc) and transition enthalpy. X-ray diffraction patterns of the 4 rice flour samples were measured with copper K_2 radiation (λ=0.154 nm) using a diffractometer (JEOL, JDX-3530, Japan). The diffractometer was operated at 300 mA and 30 kV, 2θ range from 0 to 50.0° with a step size 0.05° and a count time of 2s. The data was analyzed with program MDI Jade 6.5 (Japan). The crystallinity of rice flour samples were calculated as the proportion of crystalline area to total area at angles between 12 to 47°2θ.

2.3 Chemical composition and starch digestibility

The rice flour samples were analyzed for moisture content, protein, fat and ash content by the AACC (2000) procedure. The apparent amylose content, free α-amino nitrogen phenolic compound in the 4 rice flour samples were determined by the method of Juliano (1985), Bollag *et al.*, (1996) and Iqbal (2005), respectively. Resistant starch (RS) content in the 4 rice flour samples was determined using a Megazyme Resistant Starch kit. The glucose oxidase/peroxidase reaction was used to measure glucose released from the digested starch and resistant starch. Resistant starch and digested starch were calculated as glucose × 0.9. *In vitro* starch hydrolysis and glycemic index (GI) were determined according to Goñi *et al.*, (1997). Using the hydrolysis curve (0-180 min), the hydrolysis index (HI) was calculated as the percentage of total glucose released from the samples, to that released from white bread. The glycemic index of the samples was estimated according to the equation: GI = (39.71 + 0.549)× HI.

2.4 Statistical Analysis

Completely Randomized Design was used to evaluate the means of physicochemical analysis of the native and heat-moisture treated rice flour samples. The data obtained for the physicochemical properties were subjected to analysis of variance (ANOVA), followed by Duncan's Multiple Range Test procedure for difference between treatment by using computer program.

3. Results and Discussion

3.1 Appearance and morphology

The grain size and shape, alkali spreading value and color value of Tunya-Sirin (TS), Hom-Lanna (HL), RD-6 and KDML-105 are presented in Table 1. The four rice samples was similarity in grain size and shape, but significant differently ($p \leq 0.05$) in alkali spreading value of whole rice grain. RD-6 rice grain was higher in alkali spreading value (7) than the TS, KDML-105 and HL rice grain. In addition, color value of KDML-105 was extremely whiter than TS and RD-6 rice four, while HL rice flour was deep purple (55.12 *L**, 1.55 *a**, 4.14*b**). SME images of the four rice flour samples are shown in Figure 1. They were all small in sizes within the range of 3-10 μm which were individual granules and compound granules. Lindeboom et al., (2004) reported that the size of starch granules varied between non-waxy, waxy, and cultivar to cultivar. Non-waxy cultivars reportedly showed greater variation than the waxy cultivars. In addition, the compound granules were the presence of residual protein as indicated by Cardoso *et al*., (2006).

3.2 X-ray diffraction

X-ray diffraction patterns of the four rice flour samples are displayed an A-type diffraction pattern with strong peaks at 15.28°, 17.23°, 18.78° and 22.53 ° (2θ) (Figure 2). Relative crystallinity of flour from TS rice variety was slightly greater than HL, RD-6 and KDML-105 varieties, which were 26.28%, 26.16%, 26.11% and 25.07%, respectively. This suggested that amylopectin is the main contributor to crystalline order within the granule.

3.3 Pasting behavior

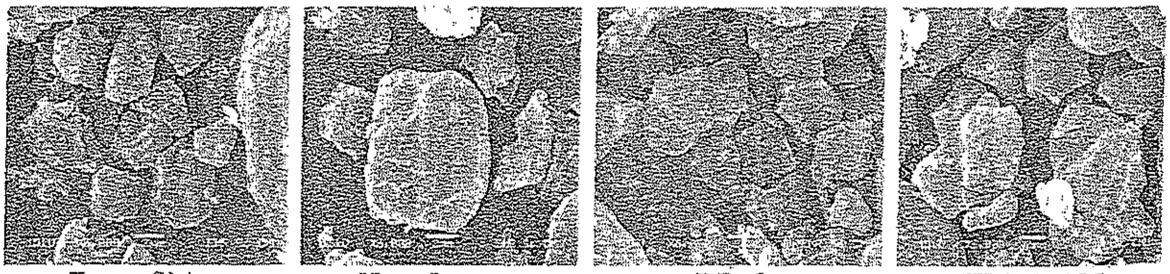
Pasting properties of the 4 flour samples revealed significant different ($p \leq 0.05$) between the 4 varieties of Thai rice are summarized in Table 2. Pasting temperatures of the four rice flour ranged from 65.98 to 90.95°C, the highest was KDML-105 and the lowest was TS rice flour. Peak viscosity, hold strength and breakdown were the highest in KDML-105 then follow by TS, RD-6 and HL, respectively. In addition, HL rice flour had the highest of final viscosity and setback, while TS was the lowest.

Table 1 Grain size and shape, alkali spreading value and color value of the 4 varieties of Thai rice

Rice Varieties	Grain size and shape		Alkali spreading value (1.7%)	Color value (Rice flour)		
	Size (mm)	L/W ratio		*L**	*a**	*b**
Tunya-Sirin	$>7.0^{ns*}$	5.31^{ns}	6.00^{b**}	79.52^{b}	-2.25^{b}	6.19^{a}
Hom-Lanna	>7.00	5.03	5.00^{c}	55.12^{d}	1.55^{a}	4.14^{b}
RD -6	6.6 -7.0	4.22	7.00^{a}	75.83^{c}	-2.65^{c}	5.95^{ab}
KDML-105	6.6-7.0	5.15	6.00^{b}	92.96^{a}	0.36^{b}	6.60^{a}

*ns not significantly different at $p>0.05$

** Means followed by different letters in a column are significantly different at $p \leq 0.05$



Tunya-Sirin Hom-Lanna RD-6 KDML 105

Figure 1 SEM image (magnification×6,000) of starch granules from the 4 varieties of Thai rice

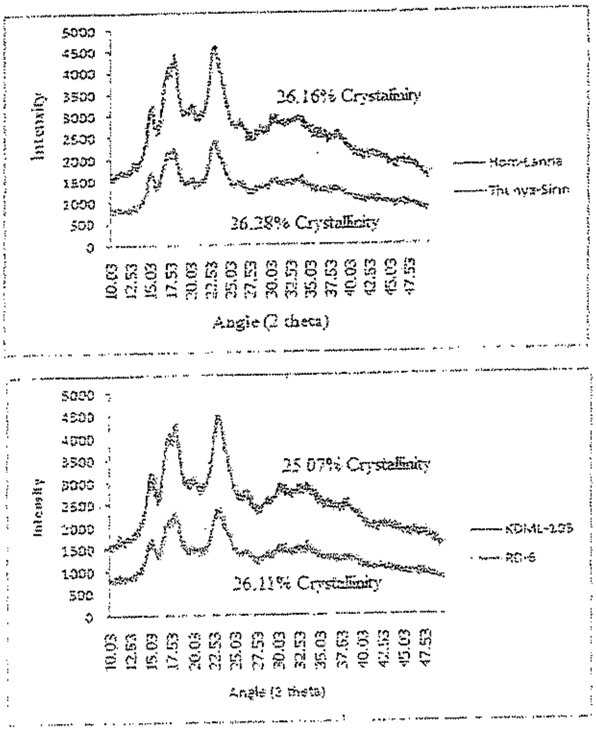


Figure 2 X-ray diffraction patterns and relative crystallinity (%) of flour samples from 4 varieties of Thai rice

Table 2 Pasting behaviors of rice flour from the 4 varieties of Thai rice

Local rice varieties	Peak Time (min)	Pasting Temp. (°C)	Peak viscosity (RVU)	Hold strength (RVU)	Break down (RVU)	Final Viscosity (RVU)	Setback (RVU)
Tunya-Sirin	3.75^{b*}	65.98^{d}	263.19^{b}	144.97^{b}	118.22^{b}	-941.33^{d}	-78.44^{d}
Hom-Lanna	5.73^{a}	80.35^{b}	160.58^{d}	115.36^{c}	45.22^{d}	1,168.70^{a}	97.39^{a}
RD-6	4.02^{c}	72.57^{c}	189.14^{c}	96.33^{d}	92.80^{c}	121.72^{c}	-67.42^{c}
KDML-105	5.82^{a}	90.95^{a}	370.80^{a}	220.06^{a}	150.75^{a}	324.28^{b}	-46.53^{b}

*Means followed by different letters in a column are significantly different at $p \leq 0.05$.

3.4 Amylose content and thermal properties

Table 3 shows the amylose content and gelatinization properties of the different rice varieties. The amylose content and endothermic enthalpy of the four rice flour samples were significantly different ($p \leq 0.05$). The flour from HL rice variety containing higher amylose content (14.71%) than the flour from KDML-105, TS and RD-6 rice varieties which were 11.39%, 5.62 and 5.48%, respectively. The gelatinization parameters of flour from different rice varieties were significantly different ($p \leq 0.05$). Flours containing high amylose content (HL) had higher gelatinization parameters. This may be due to the grain pigment and rigid amorphous regions of the starch granule by the interaction among amylose chains. The stability of amorphous region may be increased, resulting in higher energy for gelatinization and gelatinization temperature.

3.5 Chemical composition

Chemical compositions of flour from 4 varieties of Thai rice (TS, HL, RD-6 and KDML-105) are shown in Table 4. The content of moisture, fat and ash of the 4 rice flour samples were not significant difference ($p>0.05$). While, protein content, carbohydrate content, free alpha amino nitrogen contents and phenolic compound were significant difference $p\leq 0.05$ between the 4 varieties of Thai rice within the range of 11.02-12.24%, 0.05-0.40%, 76.03-77.95%, 1.20-9.37 mg/100 g and 0.12-2.37mg/g sample.

3.6 In vitro Starch digestibility

In vitro starch digestibility studies showed differences in resistant starch, digested starch, total starch and glycemic response in the flour from 4 varieties of Thai rice (Table 5). The flour from HL rice variety had more resistant starch content (5.69%) than the other varieties. The rate of starch hydrolysis was the highest in RD-6 rice flour (81.42%) and the lowest was HL rice flour (45.23%). The estimate glycemic index (GI) values of the RD-6 and TS rice flour was relatively higher (84.41 and 78.59) than that of KDML-105 and HL rice flour (72.31 and 64.54). A systematic review found that GI of the rice ranged from 64 ±9 to 93 ±11, where glucose equal to 100. The high amylose rice gave a lower GI ($p\leq 0.01$) than did the normal-amylose and waxy-rice varieties which was 64 ±7 for white rice and 55 ± 5 for brown rice (Foster-Powell *et al.*, 2002).

Table 3 Amylose content and thermal properties of flour from 4 varieties of Thai rice

Rice varieties	Amylose content (%)	Endothermic enthalpy				
		To (°C)	Tp (°C)	Tc (°C)	Tc-To	ΔH (J/g)
Tunya-Sirin	5.62^{c*}	62.70^{c}	69.17^{c}	76.27^{c}	9.80^{c}	1.05^{ab}
Hom-Lanna	14.7^{a}	65.11^{b}	71.20^{b}	78.26^{b}	13.18^{a}	1.16^{a}
RD-6	5.48^{c}	60.78^{d}	66.35^{d}	73.3^{d}	12.52^{b}	1.04^{b}
KDML 105	11.39^{b}	74.67^{a}	78.87^{a}	84.55^{a}	9.87^{c}	0.15^{c}

*Means followed by different letters in a column are significantly different at $p\leq 0.05$

Table 4 Chemical composition (%) of flour from 4 varieties of Thai rice

Rice varieties	Chemical composition (%)						FAN (mg/100g)	Phenolic compound (mg /g sample)
	Moisture	Protein	Fat	Fiber	Ash	CHO		
Tunya-Sirin	10.84^{ns}	11.02^{b}	0.05^{ns}	0.42^{ns}	0.14^{ns}	77.53^{b}	2.55^{b}	0.42^{b}
Hom-Lanna	10.74	12.24^{a}	0.12	0.69	0.17	76.03^{c}	9.37^{a}	2.37^{a}
RD-6	11.04	9.52^{c}	0.38	0.38	0.14	77.95^{a}	1.20^{c}	0.22^{b}
KDML 105	11.79	9.58^{c}	0.40	0.47	0.15	77.62^{a}	2.07^{bc}	0.12^{b}

* Not significantly different ($p>0.05$)
** Means followed by different letters in a column are significantly different at $p\leq 0.05$.

Table 5 *In vitro* Starch digestibility (%) and glycemic index of flour from 4 varieties of Thai rice

Rice varieties	*In vitro* Starch digestibility (%)			Starch Hydrolysis index (%)	Glycemic Index
	Resistant starch	Digested starch	Total starch		
Tunya-Sirin	3.06 ± 1.01^{c}	69.12 ± 2.14^{b}	72.18 ± 1.10^{c}	70.82 ± 0.54^{b}	78.59 ± 0.3^{b}
Hom-Lanna	5.69 ± 0.06^{a}	67.17 ± 1.11^{c}	72.86 ± 1.05^{bc}	45.23 ± 0.25^{d}	64.54 ± 0.26^{d}
RD-6	2.20 ± 0.21^{d}	73.56 ± 0.66^{a}	75.76 ± 0.45^{a}	81.42 ± 0.97^{a}	84.41 ± 0.49^{a}
KDML-105	3.89 ± 0.06^{b}	69.81 ± 2.45^{b}	73.69 ± 1.48^{b}	59.39 ± 0.26^{c}	72.31 ± 0.66^{c}

* Means followed by different letters in a column are significantly different at $p\leq 0.05$.

4. Conclusion

The TS and HL rice varieties studied exhibited different in physicochemical characteristics especially pasting behavior, thermal properties, amylose content, phenolic compound, free alpha amino nitrogen content and *in vitro* starch digestibility. TS and HL rice varieties recorded lower in estimated glycemic index than the RD-6 and KDML-105 that used as control. They might be useful for healthy food products. Apart from engaging the interest of large scale industrialist, the result of this study may also motivate government to support farmers to increase their output, thereby creating wealth and employment in the country.

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