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Factors Affecting Water Soluble Polysaccharide Content and Pasting Properties of Thai Glutinous Rice

Vipa Surojanametakul*, PatchareeTungtrakul and Warunee Varanyanond

ABSTRACT

The effect of milling time, flour milling process, and storage time on the content of water soluble polysaccharides (WSP) and the pasting properties of three Thai glutinous rice varieties (RD6, RD10, and Sanpatong) were evaluated. The results showed that WSP content varied by rice variety. Unpolished RD6 rice contained the highest WSP followed by RD10 and Sanpatong, respectively. Glutinous flour prepared from grain with longer milling time had lower ($p<0.05$) WSP content. Dry-milled glutinous rice flour exhibited higher WSP content and higher peak viscosity than wet milled flour. For milled glutinous rice stored in Nylon bags at room temperature, the WSP content tended to decrease during the first 3 months of storage and then stabilize thereafter. Higher Peak viscosity of glutinous rice flour was obtained in either flour with WSP portion or in the flour added with ∝-amylase inhibitor (10mM $CuSO_4$).These finding might be useful for Thai glutinous rice flour production and its widely application use.

Key words: glutinous rice, water soluble polysaccharide, ∝-amylase sensitive substance

INTRODUCTION

Glutinous, or waxy, rice is the second most popular consumed as staple food in Thailand, especially in form of steamed rice, sweet dessert or snack. Although Thailand has many glutinous rice varieties, the specific use for each product type is still based on the usual experience. Scientific report concerned whether the pervious results of glutinous rice properties were correct. Thus the properties which relate to its characteristic should be further studied. Rice starch either from non-glutinous or glutinous varieties consists of two components, a linear glucose polymer, amylose, and a branched polymer, amylopectin, which its ratio is different depeneding on the varieties. For glutinous rice, the major constituent is amylopectin and it possesses unique physical and chemical properties such as low pasting temperature and low final viscosity. This phenomenon was explained as a higher endoginous ∝-amylase activity in glutinous rice flour. Enzymeatic degradation of the starch polymer greatly affected the behavior and functional properties of starch (Frigard *et al*., 2002). The effect of amylase activity on rapid visco analyzer profiles in non-glutinous and glutinous rice varieties was also reported. Inhibition of ∝-amylase using $CuSO_4$ or mercury chloride in amylography analysis of Japanese glutinous rice were reported to increase peak viscosity and

Institue of Food Research and Products Development, Kasetsart University, Bangkok 10900, Thailand.
* Corresponding author, e-mail: ofrm@ku.ac.th

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express variety difference among glutinous rice varieties (Kikuchi, 1998). While the opposite effect was observed in high amylose rice·(Tungtrakul and Yoshihashi, 2002). However, the activities of the enzyme were similar for both non- and glutinous rice varieties on isolated genetic line (Matsukura *et al.*, 2001). Therefore, the differences between the regular and glutinous rice were the presence of water soluble polysaccharide (WSP) portion, especially in glutinous rice, which can easily dissolve in water and had a role on the paste viscosities (Horio *et al.*, 1988, Surojanametakul and Yoshihashi, 2003).

This water soluble polysaccharide consists only of glucose and it is suspected that basic structure is similar to amylopectin, but it has a larger number of shorter chain branches (Yoshihashi *et al.*, 2004). Thus a better understanding about factors that affect the properties of Thai glutinous rice, especially the existing of water soluble polysaccharide content and its role on gelatinization phenomenon would useful for Thai glutinous rice manufacturing.

MATERIALS AND METHODS

Materials

Three Thai glutinous rice varieties (RD 6, RD10 and Sanpatong) cultivated in Surin province as paddy form were obtained from Thailand’s National Rice Research Institute.

Rice Sample Preparation

Effect of milling time

Paddy rice grain were dehulled, the brown rice were then passed through a rice milling machine (Ngen Seng Huat Ltd., Thailand). The samples of milled rice were collected during milling at 0, 30, and 60 seconds. The milled grain were ground into flour and refrigerated until use.

Effect of flour milling process

Milled rice grain (at a milling time of 30 seconds) from each glutinous rice variety was prepared as flour by either a dried-milling or a wet-milling process. For dry milled flour, the rice grain was ground using a Ultracentrifugal Mill (ZM100,Retch,Germany) attached with 0.5 µm screen. For wet-milled flour, the rice grain was soaked in water for 1 hour and drained. Then soaked grain was added with fresh water (2 parts of soaked rice to 1 part of water, by weight) and passed through a stone grinder. The flour slurry was collected and pressed to remove excess water. The moist rice cake was beated and dried in a hot air oven at 45°C until the moisture content was reduced to 10-12%. The flour was then ground again by using a Ultracentrifugal Mill.

Effect of storage time

Milled glutinous rice grain was packed in Nylon bags and stored at room temperature for 7 months. Rice samples were randomly pulled out each month and milled as flour.

Properties analysis of rice sample

All rice samples were analyzed for moisture content by AOAC (1990).

Water soluble polysaccharide in flour sample was examined using the method discribed by Surojanametakul and Yoshihashi (2003). Weighed 3 g of rice flour into a rapid Visco Analyzer (RVA) canister and added with 25 ml of distilled water with and without amylase inhibitor (10mM$CuSO_4$). The mixture was subjected to RVA analysis with a constant stirring rate (160 rpm) and temperature (37 °C) for 1 hr. The water soluble fraction was removed by centrifugation and the WSP content (expressed as total saccharide) was examined by the method of Dubois *et al.*(1956).

Pasting properties of all rice flour samples with and without WSP portion were determined using a Rapid Visco Analyzer (RVA-super 3, Newport Scientific, New South Wales, Australia) with temperature program of AACC method No. 61-2.

The color of stored glutinous rice flour was determined using a Color Computer by Data Color International. Chemical properties of glutinous rice were also determined for moisture, protein and ash content by AOAC (1990). Water activity was analyzed by using an Aw instrumental (Novasiana, Switzerland).

RESULTS AND DISCUSSION

Effects of milling time

WSP content (expressed as total saccharide) for rice varieties at different milling times were summarized in Table1. It was found that unpolished glutinous rice had a significantly higher WSP value than did the polished rice samples ($p<0.05$). Among the three samples unpolished RD6 possessed the highest WSP content while Sanpatong had the lowest. In all glutinous rice varieties the WSP content was significantly decreased as milling time increased ($p<0.05$). However, it was noticed that the grain with longer milling time showed higher peak viscosity value. This was the attributed to the affect of starch content in the rice flour samples which play a role during starch gelatinization. Peak viscosity of all glutinous flour in water containing ∝-amylase inhibitor (10mM$CuSO_4$) exhibited higher values than did flour without the ∝-amylase inhibitor. These results were consistent with the results reported by Tungtrakul and Yoshihashi (2002) and Surojanametakul and Yoshihashi (2003).

Effect of rice flour milling process

The results showed that the milling process affected WSP content in rice flour. All wet milled samples had lower ($p<0.05$) WSP content as well as lower peak viscosity value than dry-milled flour (Table 2 and 3). Only a small amount of WSP content was left in wet milled flour. This implied the polysaccharide is easily dissolved in water. The RVA profile of flour with the WSP portion exhibited a higher peak viscosity than did flour without WSP. The peak viscosity of both flour types (wet and dry-milled) was slightly different when WSP portion was removed. Therefore, WSP affected the viscosity of glutinous rice flour, especially the peak viscosity.

Effect of storage time

WSP content of glutinous rice tended to decrease as the duration of storage increased (Figure 2). After a period of 3 months the WSP content stabilized. Since the activity of ∝-amylase enzyme decreases as storage time increases

Table 1 Water soluble polysaccharide (WSP) content of glutinous rice flour at three milling times.

Samples	Time of milling(sec)	Moisture (%)	WSP ± SD (%dry basis) in 10 mM$CuSO_4$
RD 6	0	9.06	14.71 ± 0.70^{a}
	30	10.27	9.33 ± 0.43^{b}
	60	10.12	7.34 ± 0.50^{c}
RD 10	0	10.25	13.90 ± 0.11^{a}
	30	10.49	11.72 ± 0.37^{b}
	60	9.97	10.10 ± 0.38^{c}
Sanpatong	0	11.19	7.08 ± 0.20^{a}
	30	10.98	6.45 ± 0.21^{b}
	60	10.38	5.52 ± 0.05^{c}

The means with different superscript letters within the same column within the same variety are significantly different ($p< 0.05$) by Duncan's Multiple Range Test

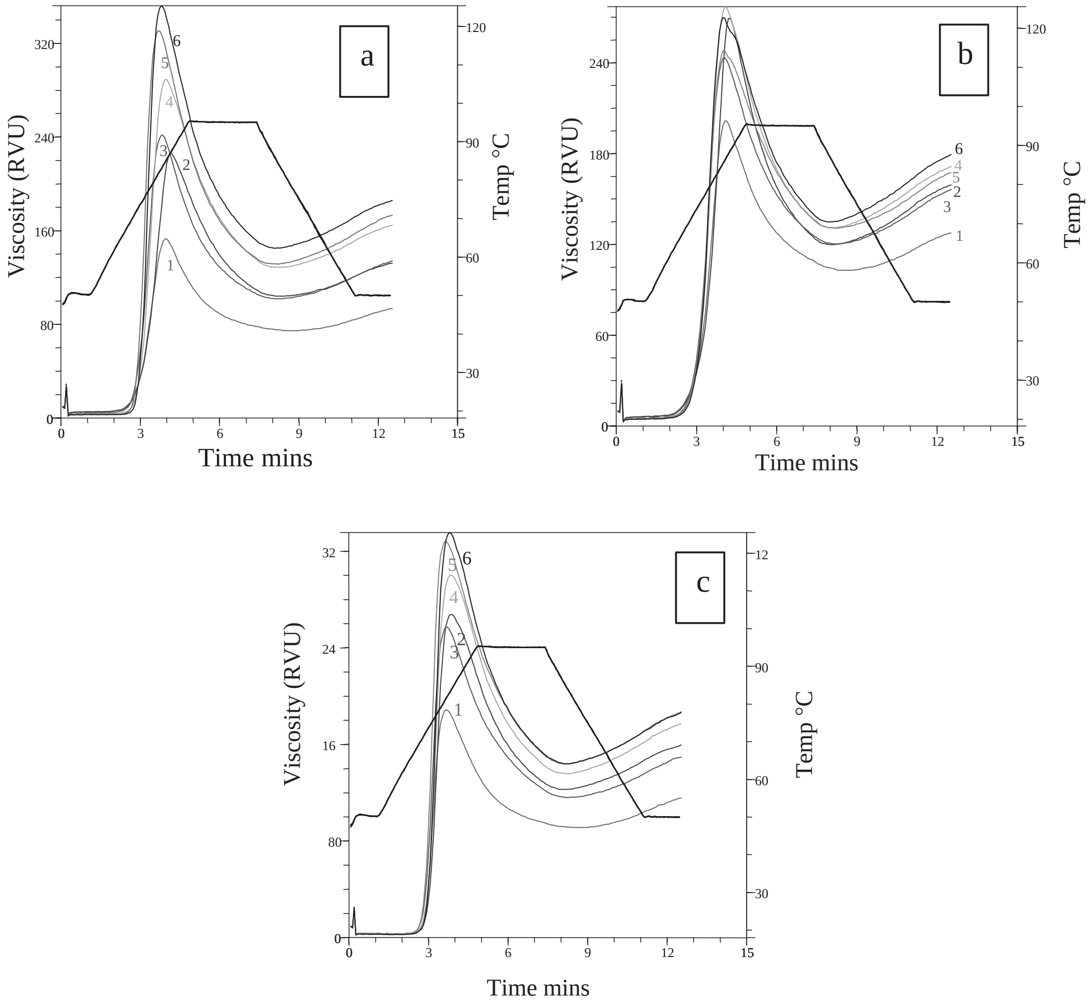

Figure 1 RVA profile of glutinous rice flour in water and 10 mM $CuSO_4$
a= RD6 b= RD10 c= Sanpatong
1: 0 sec of milling (water) 2: 0 sec of milling ($CuSO_4$)
3: 30 sec of milling (water) 4: 30 sec of milling ($CuSO_4$)
5: 60 sec of milling (water) 6: 60 sec of milling ($CuSO_4$)

Table 2 WSP content in wet milled and dry milled glutinous rice flour.

Samples	WSP ± SD of milled rice flour in $CuSO_4$ (% dry basis)		WSP ± SD of milled rice flour in water (% dry basis)	
	Wet milled	Dry milled	Wet milled	Dry milled
RD 6	3.30±0.06 [b]	9.33±0.43 [a]	3.83±0.08 [b]	14.87±0.46 [a]
RD 10	2.03±0.07 [b]	11.72±0.37 [a]	2.65±0.02 [b]	15.28±0.25 [a]
Sanpatong	2.66±0.12 [b]	6.45±0.21 [a]	4.30±0.04 [b]	9.29±0.07 [a]

The means with different superscript letters within the same row are significantly different ($p < 0.05$) by Duncan's Multiple Range Test

Table 3 RVA viscosity values of wet milled and dry milled glutinous rice flour in 10mM $CuSO_4$ with and without water soluble polysaccharide fraction.

Samples	with/without (-) WSP fraction	GT (°C)	Peak vis. (RVU)	Breakdown (RVU)	Setback (RVU)	Final vis. (RVU)
RD6	+	68.85	289.08	160.33	-124.25	164.83
dry milled	-	71.25	190.67	100.25	-76.83	113.83
RD 6	+	69.75	218.33	135.21	-110.33	108.00
wet milled	-	70.49	186.13	105.75	-86.79	99.33
RD10	+	68.05	277.08	146.08	-105.67	171.42
dry milled	-	71.30	186.42	96.50	-76.08	110.33
RD 10	+	70.88	245.58	162.59	-130.21	115.38
wet milled	-	71.30	208.96	130.38	-103.34	105.63
Sanpatong	+	69.55	257.50	164.58	-123.25	179.17
dry milled	-	70.45	187.25	94.67	-64.58	112.67
Sanpatong	+	69.65	220.84	132.34	-99.75	120.83
wet milled	-	70.08	188.67	104.04	-74.75	113.92

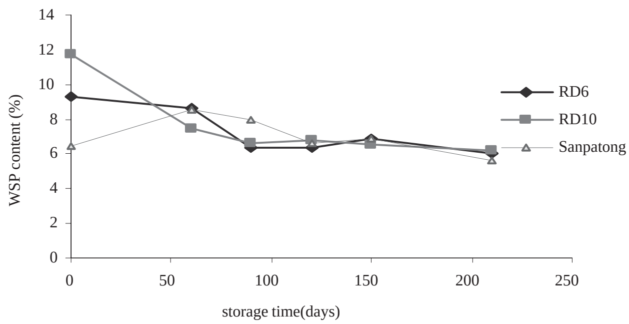

Figure 2 WSP content of glutinous rice varieties stored at room temperatue for 7 months.

(Dhalwal *et al.*,1991). This implied that the WSP is a weaker portion for enzyme ∝-amylase as reported by Surojanametakul and Yoshihashi (2003).

RVA profile showed the peak viscosity value of all glutinous rice varieties tended to increase with prolonged storage time (Figure 3). These results are consistent with the findings of Dhaliwal *et al.*(1991). It was noticed that the peak viscosity value of flour with WSP portion, either in 10 mM$CuSO_4$ or water, was greater than flour without WSP portion. The results obtained concided with Surojanametakul and Yoshihashi (2003) who reported that water soluble fraction had effects on pasting properties. The results indicated that WSP worked as glue to stick swelled or gelatinized starch granule in rice. During storage, rice color changed in lightness, redness and yellowness. Sapatong rice varieties showed a greatest change in a* and b* values among the samples (Table 4). However, the chemical composition such as protein, ash as well as Aw excepted moisture changed only slightly (Table 5).

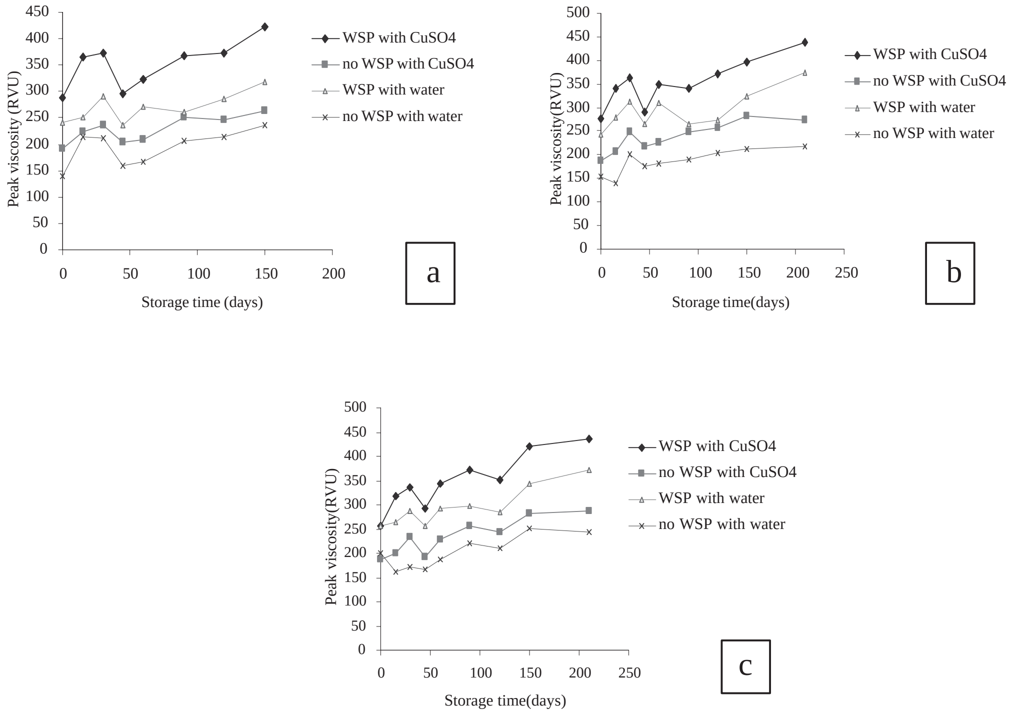

Figure 3 Peak viscosity values of storage of different glutinous rice varieties a= RD6 , b= RD10 and c= Sanpatong

Table 4 Color values of glutinous rice varieties storage at room temperature for 7 months.

Storage time	RD6			RD10			Sanpatong		
(days)	L*	a*	b*	L*	a*	b*	L*	a*	b*
0	83.97	0.22	15.10	86.70	-0.15	11.69	86.02	0.02	12.95
30	84.89	0.23	14.95	85.79	0.13	12.75	86.31	-0.02	13.03
45	85.00	0.22	14.65	85.44	0.12	12.73	86.61	-0.06	12.96
60	84.84	0.21	15.37	85.24	0.20	12.64	85.98	0.11	13.40
90	84.48	0.33	15.84	85.12	0.34	13.27	86.38	0.03	12.99
120	84.92	0.26	15.67	85.87	0.11	13.21	86.36	0.12	13.73
150	85.41	0.30	15.68	85.85	0.15	13.32	86.41	0.14	13.86
210	84.60	0.57	16.64	85.65	0.34	13.36	84.76	0.76	14.66

L* =: Lightness , a*:= redness , b*:= yellowness

CONCLUSIONS

The WSP content of Thai glutinous rice flour was dependent on rice variety. Factors such as grain milling time, rice flour milling process, including the storage time of milled grain also affected the WSP content. Among these factors, rice flour milling process showed the greatest influence upon WSP content as compared to other factors. Higher peak viscosity of glutinous rice flour was obtained in either flour with WSP portion or in the flour added with ∝-amylase inhibitor. Removal of WSP portion from rice flour showed a sharp decrease in its peak viscosity. Besides the

Table 5 Change in moisture content, protein , ash and Aw of various glutinous rice varities storage at room temperatur for 7 months.

Variety	Storage time(days)	Moisture(%)	Protein (%)	Ash (%)	Aw
RD6	0	8.54	9.32	0.54	0.47
	15	10.57	9.04	0.51	0.49
	30	10.72	9.03	0.50	0.49
	60	10.31	9.29	0.55	0.42
	90	9.31	8.64	0.52	0.48
	120	11.69	9.59	0.48	0.53
	180	10.66	9.27	0.53	0.52
	210	11.33	9.40	0.50	0.54
RD10	0	9.38	7.66	0.44	0.52
	15	11.54	7.48	0.59	0.53
	30	11.66	7.60	0.46	0.53
	60	10.99	7.61	0.52	0.46
	90	9.38	7.17	0.55	0.52
	120	10.45	7.62	0.50	0.47
	180	11.62	7.50	0.47	0.54
	210	11.31	7.71	0.44	0.52
Sanpatong	0	8.81	7.69	0.48	0.51
	15	11.19	7.68	0.51	0.50
	30	10.24	7.88	0.48	0.51
	60	11.17	7.80	0.47	0.48
	90	9.49	7.34	0.50	0.51
	120	11.34	7.99	0.47	0.51
	180	11.23	7.77	0.43	0.53
	210	11.61	7.89	0.43	0.51

Average are based on duplicated determination.

amylose and amylopectin, this water soluble polysaccharide also plays a significant role in flour pasting properties. Therefore the process involed in rice flour preparation should be considered for the specific use.

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