ผลของกลูโคสและฟรักโทสต่อสมบัติด้านความหนืดของข้าวเหนียวพันธุ์ กข 6

Effect of Glucose and Fructose on Pasting Properties of RD6 Glutinous Rice

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Abstract

Glucose and fructose (0, 33, 67 and 100% by dry weight of flour) were added to RD6 glutinous rice flour and the pasting properties were investigated by Rapid Visco Analyzer. Results showed that glucose and fructose delayed gelatinization. An increase in gelatinization temperature and time was occurred with sugar added samples, especially for glucose added solution. Increasing in concentration of glucose and fructose caused an increase in peak, trough and final viscosity and fructose gave higher viscosity at same concentration. Moreover, no sugar added and 100% fructose solutions gave high disintegration rate, while 33-67% glucose and fructose solutions gave lower rates. However, retrogradation rates of all samples were not different significantly ($P>0.05$). Correlation analysis showed that glucose and fructose concentrations positively correlated with gelatinization time, peak viscosity, trough, final viscosity and setback with Pearson correlation coefficients equal to 0.454, 0.685, 0.844, 0.880, and 0.566, respectively ($P\leq0.05$).

Keywords: RD6 glutinous rice, pasting properties, glucose, fructose

บทคัดย่อ

เติม กลูโคส และฟรักโทส (0, 33, 67 และ 100% โดยน้ำหนักแห้งของแป้งฟลาวร์) ลงในแป้งฟลาวร์ข้าวเหนียวพันธุ์ กข 6 และนำมาวิเคราะห์สมบัติด้านความหนืดด้วยเครื่อง Rapid Visco Analyzer พบว่า กลูโคสและฟรักโทสทำให้การเกิด gelatinization ช้าลง โดยพบว่ามีการเพิ่มขึ้นของ gelatinization temperature และ time ในตัวอย่างที่เติมน้ำตาล โดยเฉพาะตัวอย่างที่เติมกลูโคส การเพิ่มความเข้มข้นของกลูโคสและฟรักโทสทำให้เกิดการเพิ่มของค่า peak, trough และ final viscosity และฟรักโทสให้ค่าความหนืดที่มากกว่ากลูโคส นอกจากนี้ตัวอย่างที่ไม่เติมน้ำตาลและตัวอย่างที่เติมฟรักโทส 100% มีค่า disintegration rate สูง ในขณะที่ตัวอย่างที่มีกลูโคสและฟรักโทส 33-67% ให้ค่าต่ำกว่า อย่างไรก็ตามค่า retrogradation rate ของทุกตัวอย่างไม่แตกต่างกันอย่างมีนัยสำคัญ ($P>0.05$) จากการทำ Correlation analysis แสดงให้เห็นว่าความเข้มข้นของกลูโคสและฟรักโทสมีความสัมพันธ์กับค่า gelatinization time, peak viscosity, trough, final viscosity และ setback โดยมีค่า Pearson correlation coefficients เท่ากับ 0.454, 0.685, 0.844, 0.880 และ 0.566 ตามลำดับ ($P\leq0.05$)

คำสำคัญ: ข้าวเหนียวพันธุ์ กข 6 สมบัติด้านความหนืด กลูโคส ฟรักโทส

Introduction

RD6 cultivar of glutinous rice, widely grown in Northern and Northeastern Thailand, is a kind of rice which is classified as very low amylose content. Glutinous or sticky rice is not only consumed as main dish, but also modified in different forms to make various kinds of food products such as dessert, snack and topping (Wiset et al., 2011). Generally, the ingredients, such as emulsifiers, fats and oils, sugars, salts, protein, fibers, vitamins and minerals are frequently added into starch formulations in order to change the final product's physical,

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sensory, and nutritional properties (Ortiz et al., 2010), and the physicochemical properties of starch-based food often change by addition of these ingredients during food processing and storage (Chen et al., 2014).

The effect of sugars on cereal flours has been investigated by many researchers. Chen et al. (2014) found that an increase in pasting temperature, peak viscosity, final viscosity, breakdown value, and gel hardness were obtained in flaxseed polysaccharide potato starch complexes with sugar added. Sun et al. (2014) observed that increasing concentration of syrup caused an increase in peak, trough and final viscosity of corn starch and resulted in a lower retrogradation rate. Peak viscosity and the disintegration rate of starch increased in the following order: fructose syrup > maltose syrup > glucose syrup. However, in different starches, the changes of pasting properties are contradictory. Perry and Donald (2002) found that the peak viscosity and breakdown viscosity of cassava starch decreased with increase in the sugar concentration, but peak viscosity and breakdown point of wheat and potato starches increased as the concentration of sucrose, glucose, and glycerol increased (Gunaratne et al., 2007). Therefore, to obtain more understanding on pasting characteristics of Thai glutinous rice, the purpose of this study was to investigate the influence of glucose and fructose on pasting properties of RD6 glutinous rice flour.

Materials and methods

Raw materials: Milled RD6 glutinous rice from Chiang Rai was purchased. Glutinous rice flour was prepared by grinding and sieving through a 120-mesh sieve. Chemical composition analysis was done, RD6 glutinous rice flour has 6.79±0.09% of protein, 0.36±0.01% of fat, 4.91±0.02% of amylose, 0.45±0.03% of ash and 8.86±1.15% of moisture content. Glutinous rice flour was mixed with glucose and fructose at concentration of 0, 33, 67 and 100% by dry weight of flour and then used to determine pasting properties.

Pasting properties: Pasting properties of glutinous rice flour was determined using a Rapid Visco Analyzer, RVA (Newport Scientific, model Super 3). A plot of the pasting viscosity (cP) versus time was used to determine pasting temperature, peak time, peak viscosity, trough, final viscosity, breakdown and setback. The disintegration and retrogradation rates were calculated from the ratio of breakdown value to peak viscosity and the ratio of setback to peak viscosity, respectively (Sun et al., 2014).

Statistical analysis: Analysis of variance (ANOVA) was done and significant calculated mean values were compared using Duncan's multiple range test at P= 0.05 level of significance. The correlation analyses were done to correlate amount of sugar added with pasting parameters from RVA measurements.

Results and Discussion

Pasting results of RD6 glutinous rice flour with different concentrations of glucose and fructose were presented (Table 1). As shown, pasting temperature and peak time of glutinous rice flour with sugar added increased significantly. Glucose and fructose delayed gelatinization and glucose gave higher pasting temperature. Similar results were reported by Sharma et al. (2009) and Sun et al. (2014). Chen et al. (2014) described that this result might be attributed to the hydration of the sugar, which leads to less free water for the hydration of starch and inhibition of starch swelling.

Increasing in concentration of glucose and fructose caused an increase in peak, trough and final viscosity and fructose gave higher viscosity at same concentration. These changes in viscosity might be interpreted as a crosslinking between the sugar molecules and the starch chain (Sudhakar et al., 1995) that enhanced peak viscosity and final viscosity. By contrast, for breakdown and setback, the pattern was reversed. When sugar was added to glutinous rice flour, lowering of breakdown was occurred. However, increasing in concentration (from 33 to 100%) gave higher breakdown values. For setback, at low concentration of glucose and fructose (33 and 67%), the values were not different significantly with pure

glutinous rice flour (P>0.05). In addition, the disintegration and retrogradation rates (Figure 1) were calculated and Sun et al. (2014) explained that disintegration rate showed the disintegration speed of starch paste, while retrogradation rate was defined to indicate how quickly a short-term retrogradation (Sun et al., 2014). In this experiment, for 33-67% glucose and fructose solutions, disintegration rate decreased 5.5-8.6%, in comparison with pure glutinous rice flour. No sugar added and 100% fructose solutions gave higher disintegration rates. The retrogradation rates of all samples were not different significantly (P> 0.5). By contrast, Sun et al. (2014) found that disintegration rate of corn starch mixed with syrup increased. When the concentration of syrup was low, the retrogradation rate of starch showed little change. In addition, increasing syrup concentration resulted in a lower retrogradation rate than the pure corn starch. Correlation analysis (Table 2) showed that amount of sugar (glucose and fructose) positively correlated with peak time, peak viscosity, trough, final viscosity and setback with Pearson correlation coefficients equal to 0.454, 0.685, 0.844, 0.880, and 0.566, respectively ($P \leq 0.5$). Disintegration rate positively correlated with both breakdown and setback, whereas retrogradation rate positively correlated with only setback value.

Summary

The competition between sugar and starch, through association with available water molecules, led to a significant increase in pasting temperature. The peak viscosity, trough and final viscosity of RD6 glutinous rice flour in different concentration of glucose and fructose increased and peak viscosity increased in the following order: fructose > glucose. Disintegration rate decreased at 33-67% glucose and fructose, while the retrogradation rate showed no change for both glucose and fructose.

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Table 1 Pasting properties of RD6 glutinous rice flour from RVA measurement at different concentration of sugar added (glucose and fructose).

% sugar by dry weight of flour	pasting temperature (°C)	peak time (min)	peak viscosity (cP)	trough (cP)	final viscosity (cP)	breakdown (cP)	setback (cP)
0%	71.78±0.75$_{a}$	4.09±0.04$_{a}$	3288.67±24.21$_{a}$	2060.00±27.52$_{a}$	2712.33±17.90$_{a}$	1228.76±16.50$_{c}$	652.33±32.35$_{a}$
glucose added							
33%	75.15±0.06$_{c}$	4.62±0.06$_{bc}$	3256.25±93.04$_{a}$	2239.50±43.97$_{b}$	2844.75±44.05$_{b}$	1016.75±74.16$_{ab}$	605.25±33.63$_{a}$
67%	75.54±0.37$_{c}$	4.72±0.10$_{c}$	3484.75±58.86$_{b}$	2374.25±43.85$_{cd}$	3022.00±20.93$_{d}$	1110.50±87.92$_{b}$	647.75±62.86$_{a}$
100%	75.94±0.05$_{c}$	4.63±0.04$_{c}$	3688.25±53.82$_{c}$	2441.50±48.74$_{d}$	3119.25±25.73$_{e}$	1246.75±49.30$_{c}$	677.75±34.80$_{ab}$
fructose added							
33%	73.89±0.02$_{b}$	4.70±0.05$_{c}$	3247.50±3.54$_{a}$	2315.00±28.28$_{c}$	2959.50±16.26$_{c}$	932.50±24.75$_{a}$	644.50±44.55$_{a}$
67%	74.25±0.07$_{b}$	4.70±0.05$_{c}$	3519.00±98.99$_{b}$	2424.50±21.92$_{d}$	3106.00±33.94$_{e}$	1094.50±77.07$_{b}$	681.50±12.02$_{ab}$
100%	74.32±1.10$_{b}$	4.50±0.05$_{b}$	3991.50±16.26$_{d}$	2596.50±28.99$_{e}$	3342.00±0.00$_{f}$	1395.00±12.73$_{d}$	745.50±28.99$_{b}$

Each value in the table is the average of three replicates (mean ± standard deviation).
$^{a,b,c,...}$Values with different letter in same column were different significantly. ($p \leq 0.05$).

Table 2 Pearson correlation coefficients between amount of sugar and pasting parameters.

	amount of sugar	pasting temperature	peak time	peak viscosity	trough	final viscosity	breakdown	setback	disintegration rate	retrogradation rate
amount of sugar	1	.240	.454*	.685**	.844**	.880**	.237	.566**	-.252	-.046
pasting temperature		1	.821**	.329	.620**	.494*	-.121	-.124	-.476*	-.550**
peak time			1	.125	.626**	.481*	-.474*	-.188	-.838**	-.403
peak viscosity				1	.828**	.899**	.789**	.680**	.322	-.258
Trough					1	.966**	.309	.397	-.263	-.436*
final viscosity						1	.467*	.622**	-.085	-.222
Breakdown							1	.719**	.836**	.041
Setback								1	.493*	.532*
disintegration rate									1	.284
retrogradation rate										1

*, ** Correlation is significant at the 0.05 and 0.01 level, respectively.

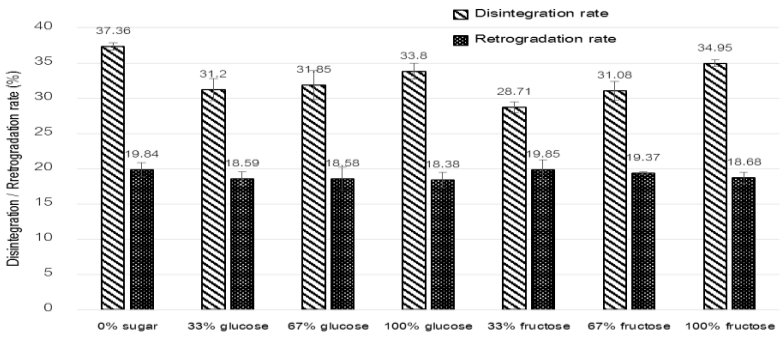

Figure 1 Disintegration and retrogradation rates of glutinous rice flour with different sugar concentrations.