ผลของกรดอะซิติกต่อสมบัติทางเคมีกายภาพของแป้งข้าวและคุณภาพของเส้นก๋วยเตี๋ยว

Effect of acetic acid on the physicochemical properties of rice flour and the quality of rice noodle

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บทคัดย่อ

ศึกษาผลของกรดอะซิติกในช่วงความเข้มข้น 0-2 เปอร์เซ็นต์ต่อสมบัติทางด้านความหนืด ความชื้น ค่าความเป็นกรดด่าง สี เนื้อสัมผัสและโครงสร้างพื้นผิวของเส้นก๋วยเตี๋ยวพบว่าการใช้สารละลายกรดอะซิติกเป็นตัวทำละลายในน้ำแป้งจะส่งผลให้ค่าความหนืดสูงสุด ค่าความหนืดลดลง และค่าเซตแบคของแป้งเปียกมีค่าเพิ่มขึ้น และทำให้ความหนืดต่ำสุด ความหนืดสุดท้าย และอุณหภูมิการเกิดเจลาทิไนเซชันของแป้งเปียกมีค่าลดลงเมื่อเทียบกับแป้งที่ใช้น้ำกลั่นเป็นตัวทำละลาย ($p\leq0.05$) การเติมกรดอะซิติก (0-2เปอร์เซ็นต์) ไม่ส่งผลต่อค่าความชื้นของเส้นก๋วยเตี๋ยว ($p>0.05$) ค่าความเป็นกรดด่างของสารละลายแป้งและเส้นก๋วยเตี๋ยวมีค่าต่ำลงเมื่อใช้สารละลายกรดอะซิติกเป็นตัวทำละลาย นอกจากนั้นเส้นก๋วยเตี๋ยวที่ได้จะมีค่าความขาว แรงต้านทานการดึงและความสามารถในการดึงยืดจนขาดของเส้นก๋วยเตี๋ยวเพิ่มขึ้น จำนวนรูที่เกิดขึ้นที่โครงสร้างพื้นผิวของเส้นก๋วยเตี๋ยวจะมีจำนวนเพิ่มขึ้นเมื่อความเข้มข้นของกรดอะซิติกมากกว่า 1 เปอร์เซ็นต์

ABSTRACT

The effect of acetic acid (0-2% acetic acid) on the pasting properties, moisture content, pH value, the color, texture and surface structure of rice noodle were investigated. The results of pasting properties of rice flour indicated that peak viscosity, breakdown and setback of rice flour pastes increased, while trough viscosity, final viscosity and pasting temperature decreased with the presence of acetic acid ($p\leq 0.05$). The use of acetic acid (0-2%(v/v)) have no effect on the moisture content ($p>0.05$). The pH of rice flour slurries and pH of rice noodle were significantly decreased with the presence of acetic acid. Whiteness, tensile strength and elongation at break (%*E*) of rice noodle increased with the presence of acetic acid. Number of pores at surface structure of rice noodle increased when acetic acid was higher than 1%.

Key words: Rice flour, Rice noodle, Acetic acid, Texture, Pasting properties

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INTRODUCTION

Rice noodle, produced from rice flour and water, is widely consumed in Asia. In Thailand, rice noodle can be categorized by size as “Sen Yai”, a wide flat rice noodle, “Sen Lek”, a medium flat rice noodle, and “Sen mee” (rice vermicelli). The good rice noodle should have white color, opaque and elastic. Fresh rice noodle has a short shelf-life, so the use of food preservative is common in industry. However, nowadays consumers are preferred the natural preservative than the artificial one. Chitosan, the natural preservative is good alternative. Chitosan has a wide spectrum of antimicrobial activity against both bacteria and fungi (Juneja *et al*., 2012). However, chitosan is insoluble in water but can only be dissolved in acid. Acetic acid is usually used to dissolve chitosan because it enhances the antimicrobial activity of chitosan. Nevertheless, the presence of acetic acid may affect the quality of food. A lot of researches reported that rice cooked with acetic acid has more glossiness, transparent, stickiness and softness than rice cooked with water (Kasai *et al*., 2001; Ohishi *et al*., 2007 and Ghasemi *et al*., 2008). In order to use chitosan in rice noodle, it needs to understand the effect of acetic acid on the quality of rice noodle. There are no reports about the effect of acetic acid on the quality of rice noodle. Hence, this work aimed to investigate the effect of acetic acid on the pasting properties of rice flour and the quality of rice noodle.

MATERIALS AND METHODS

1. Preparation of rice flour

Rice grains (Leung11 cultivar, collected in November 2009) were purchased from a rice mill in Kalasin, Thailand. Rice flour was prepared from rice kernels following modified method of Ngamnikorn and Songsermpong (2011). Rice grains were soaked in water for 4 hours using ratio of water to rice 2:1 (w/w). The samples were ground using Colloid mill (CTE-80). Then, rice flour slurry was poured into a thick cloth bag and centrifuged in a basket centrifuge to remove the excess water. After that, the sediment of wet flour was dried in tray dryer at 45^{o}C for 12 hours. The dried rice flour was screened with 100 mesh sieve (Retsch, Germany), packed in plastic bags and stored at 4^{o}C.

2. Effect of acetic acid on the pasting properties of rice flour

The pasting properties of rice flour mixed with distilled water or 0%, 0.5%, 1%, 1.5% and 2% acetic acid (v/v) were measured by a Rapid Visco Analyzer (RVA4, Newport Scientific, Australia) according to AACC standard method No. 61-02.01 (AACC, 2000). All measurements were conducted in triplicate.

3. Effect of acetic acid on the properties of rice noodle

3.1 Preparation of rice noodle

Rice flour slurries (40% dry basis) were prepared by mixing rice flour with either distilled water (control), 0.5%, 1.0%, 1.5% or 2% (v/v) acetic acid. They were equilibrated at room temperature for 3 hours. Then, 60g of slurry was poured evenly on a stainless tray and steamed for 3 minutes. The tray was removed from the steamer and left at room temperature for 3 minutes. After that, the cooked rice sheet was turnovered and left for 3 minutes. The noodle sheets were cut into size 180 mm x15 mm.

3.2 Moisture content of rice noodle

The moisture content of rice noodle samples were measured according to AOAC method 935.29 (AOAC, 2000) in hot air oven at 105^{o}C.

3.3 pH value of rice flour slurry and rice noodle

The pH of rice noodle samples were measured according to AOAC method 943.02 (AOAC, 2000).

3.4 The color of rice noodle

Rice noodle sheets were cut into size 45mmx15 mm. The color of rice noodle were measured using a colorimeter (Miniscan XE, USA) based on the CIE system with color values of L*, a* and b*. The whiteness index (WI) of each sample was calculated using the following equation (Prasert and Suwannaporn, 2009)

$$WI = 100- [(100-L^*)^2 + a^{*2}+b^{*2}]^{1/2} \quad (1).$$

The whiteness of each rice noodle was averaged from three rice noodle sheets. All measurements were conducted in triplicate.

3.5 Tensile strength and elongation at the break

Tensile strength of a noodle (180mmx15 mm) was measured using Lloyd Instrument (LRX, Intro enterprise, USA).The load cell size was 10 N and pulling speed was 100 mm/min. Tensile strength and the percent elongation at the break of rice noodle was calculated using the following equation (Bourtoom and Chinnan, 2008)

$$\text{Tensile strength} = \text{Maximum force} / \text{the initial specimen cross-sectional area} \quad (2)$$

$$\text{Elongation at break (\%)} = 100 \times (d_{after} - d_{before}) / d_{before} \quad (3).$$

Tensile strength and elongation at the break of each rice noodle was averaged from ten rice noodle strands. All measurements were conducted in triplicate.

3.6 Surface structure of rice noodle

Rice noodle were cut into size 5mmx15 mm for observing the surface structure using stereomicroscope (S8APO, Laica, Singapore) with 40X magnification. All measurements were conducted in triplicate.

4. Statistical analysis

Analysis of variance (ANOVA) was used to analyze the data and significant differences between the treatment means were compared at the 95% significant level (Duncan's new multiple range test) by using SPSS version 12.

RESULTS AND DISCUSSION

1. Effect of acetic acid on the pasting properties of rice flour

The pasting properties of rice flour are shown in Table1. Peak viscosity of samples with acetic acid was higher than sample without acetic acid. Trough viscosity and final viscosity of rice flour decreased with increasing the concentration of acetic acid. Ohishi *et al*. (2007) reported that the final viscosity of the rice paste with acetic acid was lower than that with distilled water. The final viscosity of the paste related to the quality of cooked rice when it was cooled. The decrease of final viscosity indicated that cooked rice with acetic acid might exhibit less tendency of retrogradation. Therefore, the decrease of final viscosity of rice noodle with acetic acid suggested that it may retrograde slower than samples without acetic acid. Breakdown of rice flour paste increased with increasing the concentration of acetic acid because the structure of the starch granule with increasing acetic acid was more fragile and less stability to resist shear force during stirring and heating. Setback of rice flour paste with the presence of acetic acid was higher than sample without acetic acid, but setback decreased with increasing the concentration of acetic acid. Ohishi *et al*. (2007) studied the effect of acetic acid on the pasting properties of rice flour. They reported that setback of rice flour pastes decreased while breakdown increased with increasing the concentration of acetic acid. This result is similar to the present work results expect that setback is conflict. This is because breakdown of noodle with the presence of acetic acid in the present work was very low. Pasting temperature decreased with increasing of the concentration of acetic acid may be due to the starch granules became fragile easier in acetic acid solution (Ghasemi *et al*., 2008).

Table 1 Pasting properties of rice flour with the various concentrations of acetic acid

Treatments	Viscosity (RVU)					
	Peak Viscosity	Trough Viscosity	Break down	Final Viscosity	Setback	Pasting Temp (°C)
Control	305.92±4.54a	279.39±2.90e	26.53±1.64a	394.28±2.50e	114.89±0.67a	90.52±2.43a
0.5%acetic acid	316.97±1.47b	205.61±2.81d	111.36±2.21b	345.56±2.86d	139.94±1.05d	88.98±0.98a
1.0%acetic acid	319.19±3.92b	190.19±2.06c	129.00±4.68c	325.50±1.16c	135.31±2.30c	88.38±0.55b
1.5%acetic acid	318.25±2.48b	169.36±3.71b	148.89±5.20d	303.58±1.18b	134.22±3.34bc	88.10±0.48b
2.0%acetic acid	321.75±4.76b	156.47±5.98a	165.28±5.40e	287.14±5.76a	130.67±2.98b	87.30±0.52b

RVU = Rapid Visco Unit

[abc] Values with different superscripts within a column indicate significant difference, ANOVA and Duncan tests ($p \leq 0.05$)

2. Effect of acetic acid on moisture content and pH value of rice noodle

Moisture content of all samples was not significantly different ($p>0.05$) (Table2). This implies that the concentration of acetic acid used in this work has no effect on the moisture content of rice noodle. The pH of rice flour slurries were significantly decreased with increasing the concentration of acetic acid ($p \leq 0.05$). However, pH value of rice noodle with acetic acid was significantly different with control sample.

Table 2 Moisture content and pH value of rice noodle with the various concentrations of acetic acid

Parameters	Treatments				
	control	0.5%acetic acid	1.0%acetic acid	1.5%acetic acid	2.0%acetic acid
Moisture content	56.15±0.89a	56.69±0.61a	56.73±0.07a	57.18±0.85a	57.34±1.87a
pH (rice flour slurry)	5.78±0.03e	3.88±0.04d	3.73±0.05c	3.58±0.03b	3.49±0.01a
pH (rice noodle)	6.25±0.13b	4.09±0.36a	4.04±0.20a	3.81±0.32a	3.72±0.33a

[abce] Values with different superscripts within a row indicate significant difference, ANOVA and Duncan tests ($p \leq 0.05$)

3. Effect of acetic acid on the color of rice noodle

Color of rice noodle is an important factor in terms of general appearance and consumer acceptance. The results showed that the whiteness of rice noodle increased with the presence of acetic acid in rice noodle (Table3) because of the decrease of b* (yellow) values. This result is similar with the use of acetic acid to bleaching rice flour (Pakornsomboon, 2007). The author reported that the whiteness of rice noodle made from rice flour bleached by acetic acid and citric acid increased due to the decrease of maillard reaction in the presence of acid.

Table 3 Color of rice noodle with the various concentrations of acetic acid

Parameters	Treatments				
	control	0.5%acetic acid	1.0%acetic acid	1.5%acetic acid	2.0%acetic acid
L*	87.07±0.20b	86.78±0.77b	86.62±0.48b	84.96±0.48a	85.00±0.51a
a*	-1.44±0.19a	-1.2±0.20a	-1.12±0.15a	-1.29±0.14a	-1.23±0.14a
b*	4.07±1.28b	1.78±0.73a	1.90±0.77a	2.05±0.61a	2.00±0.67a
whiteness	94.46±0.80a	95.75±0.39b	95.7±0.46b	95.41±0.29b	95.45±0.33b

[ab] Values with different superscripts within a row indicate significant difference, ANOVA and Duncan tests ($p \leq 0.05$)

4. Effect of acetic acid on the texture properties of rice noodle

Tensile strength is the maximum tensile stress of samples during the tension test (Bourtoom and Chinnan, 2008). Tensile strength of rice noodle increased when acetic acid was higher than 1%. The increase of this value indicated that the gel strength of rice noodle become stronger, which suggested that the crosslinking in gel may be enhanced by the presence of acetic acid. Elongation at break (%*E*) is an indication of rice noodle flexibility and extensibility. The result showed that the elongation at break of rice noodle increased when acetic acid was higher than 1%. This result is related to the final viscosity of rice because rice noodle with acetic acid may be exhibited less tendency of retrogradation than sample without acetic acid. Thus, the elongation at break of rice noodle increased with increasing the concentration of acetic acid.

Table 4 Textural properties of rice noodle with the various concentrations of acetic acid

Parameters	Treatments				
	control	0.5%acetic acid	1.0%acetic acid	1.5%acetic acid	2.0%acetic acid
Tensile strength (kPa)	48.15±3.92a	48.15±2.67a	63.46±4.34b	56.79±0.85b	63.46±5.66b
Elongation at break (%)	40.39±0.44a	38.90±0.69a	40.30±1.51a	47.36±2.54b	57.87±1.13c

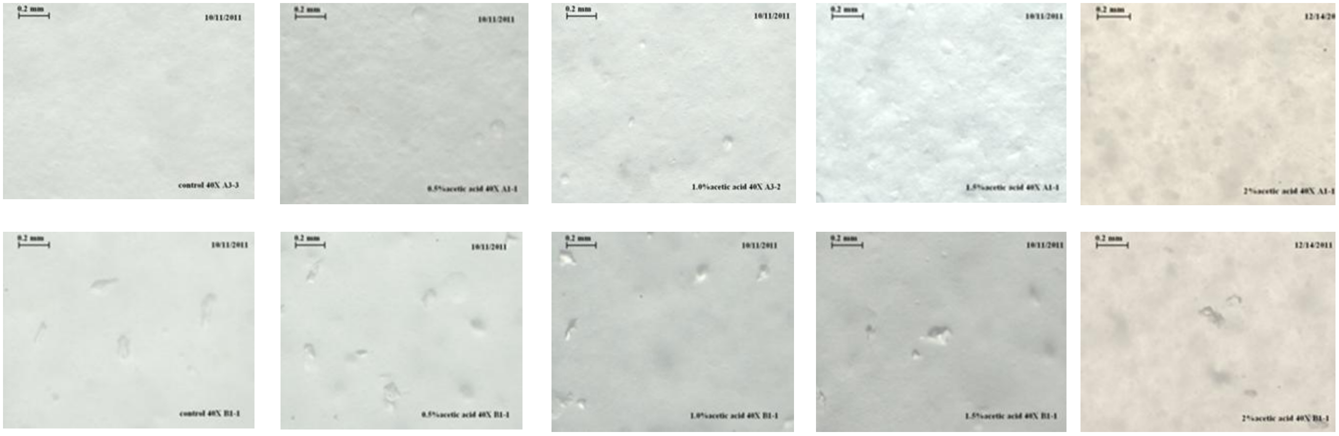
[abc] Values with different superscripts within a row indicate significant difference, ANOVA and Duncan tests ($p \leq 0.05$)

5. Effect of acetic acid on the surface structure of rice noodle

Figure 1 shows both rough and smooth surface structure of rice noodle with and without the presence of acetic acid. The number of pores at surface structure of rice noodle increased when acetic acid was higher than 1%. This may be attributed to the hydrolysis of starch in the presence of acid. The hydrolysis causes the weak gel structure of noodle, so water may evaporate from the acetic acid noodle surface easier than the control sample.

(A)

(B)



Distilled water | Acetic acid 0.5% | Acetic acid 1.0% | Acetic acid 1.5% | Acetic acid 2.0%

Figure 1 Surface structure of rice noodle observed under stereomicroscope with 40X magnification (A) Rough surface and (B) Smooth surface

CONCLUSION

Peak viscosity, breakdown and setback of rice flour pastes increased, while trough viscosity, final viscosity and pasting temperature decreased with the presence of acetic acid ($p \leq 0.05$). The use of acetic acid has no effect on the moisture content ($p > 0.05$) of rice noodle. The whiteness, the maximum tensile stress, elongation at break (%*E*) of rice noodle increased with the presence of acetic acid. The number of pores at surface structure of rice noodle increased when acetic acid was higher than 1%.

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