ผลของความเข้มข้นของแซนแทนกัมและคาร์บอกซีเมทิลเซลลูโลสต่อคุณภาพของน้ำมังคุดชนิดขุ่น

Effect of xanthan gum and carboxymethyl cellulose concentration on quality of cloudy mangosteen juice

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บทคัดย่อ

อนุภาคกลุ่มหมอก (cloud particle) ปรากฏในรูปความขุ่นเป็นลักษณะของน้ำผลไม้ชนิดขุ่น เพื่อป้องกันการตกตะกอนและรักษาความเป็นกลุ่มหมอก (cloudiness) จึงศึกษาการเติมแซนแทนกัมและคาร์บอกซีเมทิลเซลลูโลส (CMC) ในน้ำมังคุด เมื่อเติมแซนแทนกัมเป็นสารให้ความคงตัวเพียงชนิดเดียว ความเข้มข้นของแซนแทนกัมมีผลต่อความหนืด ความสว่าง และความเป็นกลุ่มหมอก ($p \leq 0.05$) ขณะที่ความเป็นกรดเบสมีผลต่อความเป็นกลุ่มหมอก เพียงอย่างเดียว ($p \leq 0.05$) ความเข้มข้นต่ำสุดที่สามารถป้องกันการตกตะกอนของน้ำมังคุดชนิดขุ่นได้ คือ แซนแทนกัม 0.2%(w/v) ความหนืดของน้ำมังคุดที่ได้มีค่า 15.47±0.29 cP เพื่อลดความหนืดและรักษาเสถียรภาพของกลุ่มหมอกควรใช้ส่วนผสมของแซนแทนกัมและ CMC โดยส่วนผสมของแซนแทนกัม 0.10% (w/v) และ CMC 0.15-0.25%(w/v) ให้น้ำมังคุดที่มีความหนืดระหว่าง 4.32 - 5.16 cP และมีความเป็นกลุ่มหมอกต่ำที่สุด ขณะเก็บรักษา ความสว่างของน้ำมังคุดลดลงเล็กน้อยและมีความเป็นกลุ่มหมอกเพิ่มขึ้นเล็กน้อย อย่างไรก็ตามไม่มีตกตะกอนเกิดขึ้นในน้ำมังคุดที่พัฒนาขึ้นในการเก็บรักษาที่อุณหภูมิ 4°C เป็นเวลา 30 วัน

ABSTRACT

Cloud particles appearing in turbidity are a characteristic of cloudy juice. To prevent sedimentation and preserve cloudiness, xanthan gum and carboxymethyl cellulose (CMC) were added into mangosteen juice. When xanthan gum was used as a single stabilizer, its concentration significantly played role on viscosity, lightness and cloudiness ($p \leq 0.05$), while pH significant played only on cloudiness ($p \leq 0.05$). Minimum concentration that could be used to prevent sedimentation in cloudy mangosteen juice was 0.2% (w/v) of xanthan gum. The obtained juice had viscosity of 15.47±0.29 cP. To decrease the viscosity and maintain cloud stability, a mixture of xanthan gum and CMC should be used. The mixture of 0.10% (w/v) xanthan gum and 0.15 - 0.25% (w/v) CMC yielded the mangosteen juice with 4.32-5.16 cP viscosity and the lowest cloudiness. During storage, lightness of mangosteen juice was slightly decreased as well as cloudiness was slightly increased. However, sedimentation was not observed in the obtained juice during storage at 4°C for 30 days.

Key words: mangosteen, cloudy, juice, xanthan gum, CMC

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INTRODUCTION

Hydrocolloids have been widely used in beverage and juice, mostly to function rheological modifiers, suspension agents and stabilizers (Somogyi, 1996). Hydrocolloid interacted with protein in aqueous solution and influenced stability properties in three different ways. Low concentration of gum with net repulsive reaction led to miscibility, whereas high concentration with net attractive reaction led to coacervation (complexation). Thermodynamic incompatibility caused a separated phase of protein and hydrocolloid-riched phases (Dickinson, 2003).

Xanthan gum is an extracellular heteropolysaccharide, widely used in food industry due to its stability towards temperature, ionic strength, pH, enzymatic and chemical reactivity (Liang *et al*., 2006). Xanthan gum formed weak gels and exhibited mouth-feel. Thus, it has been widely used in healthy-lifestyle beverage to perceive natural juice feeling (Beristain *et al.,* 2006). Xanthan gum had high viscosity at low shear rate, thus it provided limitation in food application. When two anionic hydrocolloids were used, repulsion of protein-protein electrostatic was encouraged and reduced protein-hydrocolloid attraction. However, xanthan gum showed synergies with other natural water soluble polymers such as guar gum and locust bean gum, resulting in the increased viscosity (Dickinson, 2003).

CMC, a negative charge linear polymer, was stable in acid juice (Beristain *et al.,* 2006). It could be used to stabilize juice by an electrostatic repulsion with juice haze. However, stabilizing with CMC provided a clearer juice and brighter appearance (Somogyi, 1996). Thus, a mixture of xanthan gum and CMC would be an interesting alternative to maintain the cloudiness and turbidity in juice, but prevent sedimentation. Therefore, this research aimed to study the effect of xanthan gum, CMC and mixtures of xanthan gum and CMC on viscosity, lightness and cloudiness of cloudy mangosteen juice.

MATERIALS AND METHODS

1. Preparation of mangosteen juice

Mangosteen puree (Nuboon Co., Ltd.) was pretreated with 240 ppm pectinase (liquid form) for 60 min and heated at 90°C for 5 min to inactivate enzymatic reaction. Then the juice was filtrated with 50 μm membrane pore size and formulated with 2.5% (w/v) mangosteen hull solution (prepared from hull extract (Nuboon Co., Ltd.)) and grape juice (Bangkok Pattana Winery Co., Ltd.). The mangosteen juice was composed of 62% filtrated mangosteen puree, 35% hull solution and 3% grape juice.

2. Preparation of gum solutions

Solutions of xanthan gum and CMC (P.C. Intertrade Co., Ltd.) were prepared individually in flasks, gradually dispersing gum into reversed osmotic water with magnetic stirrer. Solutions were stirred until they became homogeneous. pH of mangosteen juice were adjusted to 3.5 and 4.0 (addition

of sodiumcitrate (Rama Production Co., Ltd.) in powder form). Then mangosteen juice was preheated to 70°C before adding the gum solutions. Finally, the juice with mixed solution was pasteurized at 85°C for 15 min.

3. Determination of quality of cloudy mangosteen juice with addition of either xanthan gum or CMC

Mangosteen juice with xanthan and CMC in concentration of 0.1, 0.2, 0.3 and 0.4% (w/v) were determined. Xanthan gum at least 0.2%(w/v) could prevent sedimentation in mangosteen juice stored at 4°C for 12 days (Figure 1a). In contrast, none of CMC concentration could stabilize the juice, appeared in hydrocolloid-aqueous phase sedimentation (Figure 1b). Therefore, xanthan was used as the stabilizer in this study.

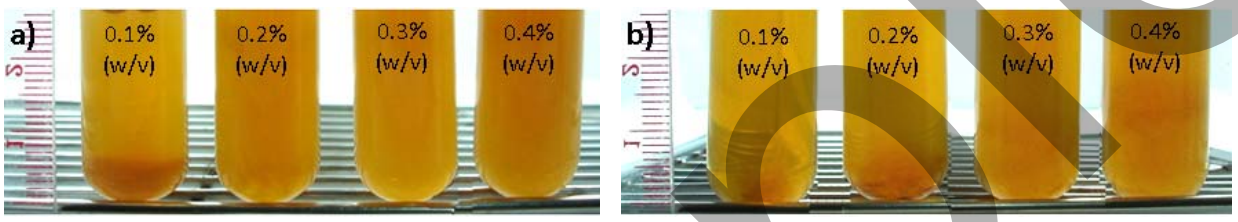

Figure 1 Mangosteen juice with addition of xanthan gum (a) and with addition of CMC (b) at day 12.

Experiment was designed in CRD. The pasteurized mangosteen juice was stired then 16 ml juice was sampled out to measure viscosity and 20 ml to measure lightness and cloudiness. All experiments were conducted with 2 replications. The pasteurized mangosteen juice was determine apparent viscosity using Brookfield DVIII with UL-Adapter spindle at shear rate of 305.75 s^{-1}, for 6 min to reach the speed of 250 rpm, lightness (L*-value in CIE system (transmittance)) and cloudiness (absorbance at 660 nm.) using spectrophotometer (CM3500d, Minolta Co., Japan) with D65/10° light source. Wavelength accuracy in measuring cloudiness of the instrument was found to be approximately ±1.0 nm with wavelength repeatability equal to ±0.5 nm.

4. Determination of quality of cloudy mangosteen juice with addition of both xanthan gum and CMC

Experiment was designed using 3x4 factorial with 3 concentrations of xanthan gum (0.05, 0.10 and 0.15% (w/v)) and 4 concentrations of CMC (0.00, 0.05, 0.15, 0.25%(w/v)). All experiments were conducted with 2 replications.The pasteurized mangosteen juice was sampled to determine lightness (L*-value) and cloudiness (absorbance at 660 nm.) using spectrophotometer (CM3500d, Minolta Co., Japan) with D65/10° light source (transmittance).

Mangosteen juice was stored at 4°C for 30 days to monitor change of lightness and cloudiness. The data were analyzed using MANOVA (SPSS® version 12.0). Significant difference among treatments was determined at 95% level using Duncan test.

RESULTS AND DISCUSSION

1. Effect of xanthan gum and CMC on viscosity, lightness and cloudiness of mangosteen juice

All statistics in multivariate test (Table 1) were significant ($p \leq 0.05$). Therefore, MANOVA were analyzed. Concentration of xanthan gum significantly affected viscosity, cloudiness and lightness ($p \leq 0.05$). pH and interaction between xanthan gum concentration and pH played significant role on cloudiness($p \leq 0.05$). However, an interaction between xanthan gum concentration and pH did not play significant role on viscosity ($p > 0.05$).

Table 1 Multivariate tests of cloudy mangosteen juice.

Effect	Statistics	Value	F	P-value
Xanthan gum concentration	Pillai's Trace	1.043	9.801	0.00
	Wilks' Lambda	0.092	19.567[a]	0.00
	Hotelling's Trace	8.438	33.753	0.00
	Roy's Largest Root	8.261	74.348[b]	0.00
pH	Pillai's Trace	0.900	76.486[a]	0.00
	Wilks' Lambda	0.100	76.486[a]	0.00
	Hotelling's Trace	8.998	76.486[a]	0.00
	Roy's Largest Root	8.998	76.486[a]	0.00

[a] Exact statistic.

[b] The statistic is an upper bound on F that yields a lower bound on the significance level.

An increase in concentration of xanthan gum significantly increased viscosity and cloudiness but decreased lightness ($p \leq 0.05$). In addition, an increase in pH from 3.5 to 4.0 significantly increased cloudiness and decreased lightness in exception of 0.3% (w/v) xanthan gum (Table 2). This was probably because addition of 0.3% (w/v) xanthan gum may be adequate to appear opposite charge and form insoluble complex (Tolstoguzov, 1986) in mangosteen juice pH 3.5. Mirhosseini *et al.* (2008) reported that high absorbance was corresponded to the high level of cloudiness of emulsion. Therefore, the highest cloudiness that was observed in the mangosteen juice with 0.3%(w/v) xanthan gum implied the highest amount of colloid.

Addition of 0.2% (w/v) xanthan gum provided the mangosteen juice with the lowest viscosity of 15.47 ± 0.29 cP, when pH was at 3.5. However, its viscosity was higher than the recommended viscosity of cloudy juice (11.5 cP) reported by Will *et al.* (2008). Therefore, a mixture of xanthan gum at lower concentration and CMC were added in the mangosteen juice (pH 3.5) to determine the possibility to decrease the viscosity of mangosteen juice.

Table 2 Main effect of xanthan gum concentration and pH of cloudy mangosteen juice on viscosity, lightness and cloudiness.

Xanthan gum concentration	pH	Viscosity (cP)	Lightness	Cloudiness
0.20 %(w/v)	3.5	15.47±0.29^{d}	44.88±0.52^{a}	0.464±0.008^{d}
	4.0	16.42±1.88^{c}	44.33±0.23^{b}	0.474±0.004^{bc}
0.25 %(w/v)	3.5	20.45±0.45^{b}	44.63±0.08^{ab}	0.468±0.003^{cd}
	4.0	20.29±0.18^{b}	43.40±0.10^{c}	0.495±0.002^{a}
0.30 %(w/v)	3.5	23.82±0.52^{a}	43.38±0.12^{a}	0.490±0.001^{a}
	4.0	24.09±0.48^{a}	44.56±0.05^{ab}	0.480±0.002^{b}

$^{a-d}$ Means within the same column followed by different letters were significantly different ($p \leq 0.05$).

2. Effect of mixtures of xanthan gum and CMC on viscosity, lightness and cloudiness of mangosteen juice

Gum concentrations of 0.05X, 0.05X+0.05C, 0.05X+0.15C and 0.05X+0.25C led to precipitation (Figure 2). Hydrocolloid-aqueous phase separation could be explained by thermodynamic incompatibility of hydrocolloid and component in beverage (Dickinson, 2003). Xanthan gum alone provided higher separated hydrocolloid phase (Figure 2a) than mixtures of xanthan and CMC (Figure 2 b-d) did. This was probably because xanthan gum was rich in disperse phase while continuous phase was solely CMC (Boyd, 2005). The mangosteen juice with the addition of 0.10% xanthan gum (Figure 2e) appeared a collared ring in the middle of the tube. Moreover, the mangosteen juice with addition of 0.10% xanthan gum and 0.05% CMC (Figure 2f) appeared a precipitate of pulp at the bottom after storage at 4°C for 30 days. Therefore, these concentrations were not used for further study.

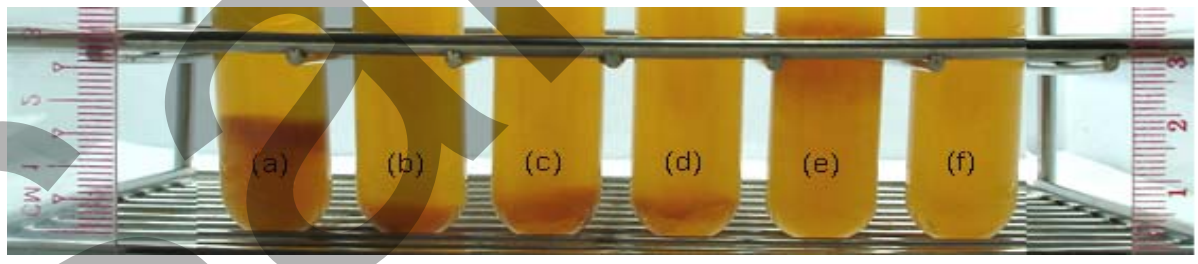

Figure 2 Sedimentation of a mixture of xanthan gum (x) and CMC (C) in concentrations of 0.05X (a), 0.05X+0.05C (b), 0.05X+0.15C (c), 0.05X+0.25C (d), 0.10X (e), 0.10X+0.05C%(w/v) (f).

The remained six mixtures of xanthan gum and CMC concentrations including 0.10X+0.15C, 0.10X+0.25C, 0.15X, 0.15X+0.05C, 0.15X+0.15C and 0.15X+0.25C were brought to evaluate viscosity, lightness and cloudiness. Table 3 illustrated that variation of mixtures of xanthan gum (0.10 and 0.15% (w/v)) and CMC (0.00, 0.05, 0.15 and 0.25% (w/v)) had no effect on lightness value ($p>0.05$). An increase in xanthan gum concentration could increase viscosity significantly ($p \leq 0.05$). Addition of CMC

to 0.15%w/v xanthan gum significantly increased viscosity of mangosteen juice ($p \leq 0.05$). However, an increase in CMC did not increase the viscosity, when it was applied with 0.10% (w/v) xanthan gum. The study of Boyd (2005) showed that the addition of low concentrations of CMC (<1%) into xanthan gum had no effect on the viscosity parameter. In contrast, Fonseca *et al.* (2009) found the synergistic effect of a ternary combination of xanthan gum, CMC and propylene glycol alginate (PGA) and suggested that it was due to an interaction between CMC and protein. Increased xanthan gum concentration provided the mangosteen juice with the increased cloudiness. However, addition of mixtures of xanthan gum and CMC provided lower cloudiness than addition only xanthan gum did ($p \leq 0.05$). This may be the protein-hydrocolloid attraction effect when two anionic hydrocolloids were used (Dickinson, 2003). In contrast, when CMC was added in the mangosteen juice in cooperate with xanthan gum, higher concentrations of CMC increased cloudiness in juice. Likewise, Mirhosseini *et al.* (2008) found an increase in cloudiness of orange flavor beverage emulsion when the concentration of CMC was increased. Therefore, to obtain lowest cloudiness and acceptable viscosity (not more than 11.5 cP), the mixture of 0.10 %w/v xanthan gum and 0.15-0.25 %w/v CMC should be added to the mangosteen juice.

Table 3 Main effect of xanthan gum and CMC concentration of cloudy mangosteen juice on viscosity, lightness and cloudiness.

Xanthan gum (%w/v)	CMC (%w/v)	Viscosity (cP)	Lightness	Cloudiness
0.10	0.15	5.16±0.20^{c}	56.67±0.86^{a}	0.251±0.004^{d}
	0.25	4.32±0.09^{c}	57.43±1.00^{a}	0.264±0.123^{d}
0.15	0.00	5.83±1.34^{bc}	57.24±0.44^{a}	0.284±0.002^{a}
	0.05	5.24±0.05^{bc}	57.68±0.57^{a}	0.267±0.001^{c}
	0.15	6.81±0.04^{ab}	57.97±0.05^{a}	0.270±0.001^{bc}
	0.25	7.56±0.76^{a}	57.58±0.03^{a}	0.272±0.001^{b}

$^{a-d}$ Means within the same column followed by different letters were significantly different ($p \leq 0.05$)

3. Change of lightness and cloudiness of cloudy mangosteen juice during storage.

During storage at 4°C, lightness of mangosteen juice was slightly decreased but cloudiness was slightly increased, as shown in Figure 3. This was coincided with the study of cloudiness in cloudy apple juice (Ibrahim *et al.*, 2011). However, no sedimentation was observed during storage at 4°C for 30 days.

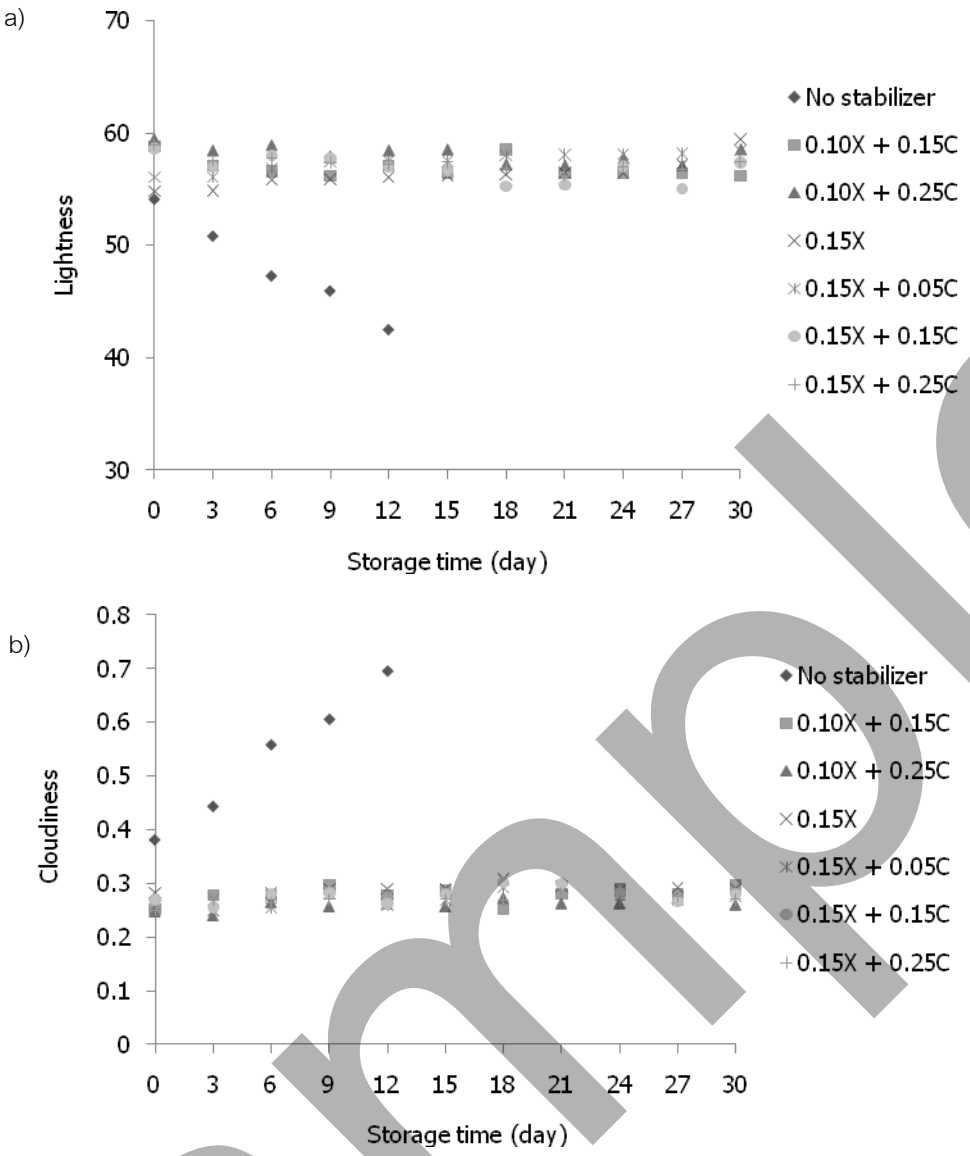

Figure 3 Lightness (a) and cloudiness (b) of the mangosteen juice during storage at 4°C for 30 days.

CONCLUSION

Xanthan gum could increase cloudiness of cloudy mangosteen juice significantly ($p \leq 0.05$). However, addition of xanthan gum increased viscosity to become higher than the recommended viscosity of juice. Therefore, mixtures of xanthan gum and CMC were used to produce the juice with stability of cloudiness and acceptable viscosity. The mixture of 0.10% (w/v) xanthan gum and 0.15-0.25% (w/v) CMC could produce the mangosteen juice with the viscosity of 4.32-5.16 cP and lowest cloudiness. During storage at 4°C, lightness and cloudiness of the mangosteen juice with addition of the mixed gum was slightly changed. Nonetheless, no sedimentation was observed in the obtained mangosteen juice during storage at 4°C for 30 days.

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