ผลของไฮโดรคอลลอยด์ต่อคุณภาพของสโคนจากแป้งข้าวปลอดกลูเตน

THE EFFECT OF HYDROCOLLOIDS ON THE QUALITY OF GLUTEN-FREE RICE SCONES

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Received: October 19, 2018; **Revised:** November 30, 2018; **Accepted:** December 27, 2018

บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อตรวจสอบผลของไฮโดรคอลลอยด์ชนิดต่างๆ ต่อคุณภาพของสโคนจากแป้งข้าวปลอดกลูเตน ไฮโดรคอลลอยด์ทั้ง 7 ชนิด ที่เติมลงไปเป็นส่วนผสมของสโคน ได้แก่ คาร์ราจีแนน คาร์บอกซีเมทิลเซลลูโลส กัวกัม โลคัสบีนกัม เพคติน โซเดียมแอลจิเนต และแซนแทนกัม พบว่า ค่าความชื้น ค่าความสว่าง (*L**) และค่าความแน่นเนื้อของสโคนจากแป้งข้าวปลอดกลูเตนที่เติมไฮโดรคอลลอยด์มีแนวโน้มเพิ่มขึ้นจากตัวอย่างควบคุม (ไม่เติมไฮโดรคอลลอยด์) โดยสโคนจากแป้งข้าวปลอดกลูเตนที่เติมแซนแทนกัมและคาร์บอกซีเมทิลเซลลูโลสมีค่าความแน่นเนื้อสูงมากกว่าสองถึงสามเท่าของตัวอย่างควบคุม การเติมกัวกัมและเพกตินลงในสโคนจากแป้งข้าวปลอดกลูเตนส่งผลให้ค่าปริมาตรจำเพาะสูงกว่าตัวอย่างควบคุมอย่างมีนัยสำคัญทางสถิติ ($P \le 0.05$) ในทางตรงกันข้าม การเติมแซนแทนกัมและคาร์บอกซีเมทิลเซลลูโลสส่งผลให้ค่าปริมาตรจำเพาะของสโคนจากแป้งข้าวปลอดกลูเตนต่ำกว่าตัวอย่างควบคุมอย่างมีนัยสำคัญทางสถิติ ($P \le 0.05$) การเติมไฮโดรคอลลอยด์จะนำไปสู่การลดลงของอัตราการแผ่ขยายตัวของสโคนยกเว้นกรณีที่เติมคาร์ราจีแนน การทดสอบความชอบจากผู้บริโภค (N=80) โดยวิธี 9-Point Hedonic Scale พบว่า คะแนนความชอบโดยรวมของสโคนจากแป้งข้าวปลอดกลูเตนมีค่าเพิ่มขึ้นเล็กน้อยเมื่อเติมไฮโดรคอลลอยด์ (คาร์บอกซีเมทิลเซลลูโลส โลคัสบีนกัมเพคติน และโซเดียมแอลจิเนต) โดยรวมการเติมแซนแทนกัม และคาร์บอกซีเมทิลเซลลูโลสมีผลต่อคุณภาพด้านเนื้อสัมผัสของสโคนจากแป้งข้าวปลอดกลูเตนมากกว่าไฮโดรคอลลอยด์ชนิดอื่นๆ ที่ใช้ในการศึกษานี้

คำสำคัญ: ไฮโดรคอลลอยด์ แป้งข้าว สโคนปลอดกลูเตน เนื้อสัมผัส อัตราการแผ่ขยายตัว

Abstract

The purpose of this research was to determine the effect of different hydrocolloids on gluten-free rice scones quality. Seven types of hydrocolloids including carrageenan (CN), carboxymethylcellulose (CMC), guar gum (GG), locust bean gum (LBG), pectin (PT), sodium alginate (SA) and xanthan gum (XG) were added in scone ingredients. It was found that moisture content, lightness (L^*) and crumb firmness of gluten-free rice scones with hydrocolloids additions tended to increase as compared to those of control (without hydrocolloids addition). Gluten-free rice scones with XG and CMC additions provided two to three times of firmness higher than that of control. GG and PT additions significantly increased specific volume of gluten-free scones than that of control ($P \leq 0.05$). In contrast, XG and CMC additions resulted in significantly lower specific volume of gluten-free scones than that of control ($P \leq 0.05$). Hydrocolloids additions brought about decreasing spread ratio of scones, with the exception of CN addition. According to consumer preference test (N=80) using 9-point hedonic scale indicated that slight increase in overall liking scores of gluten-free rice scones were observed when hydrocolloids (CMC, LBG, PT and SA) were added. Overall, XG and CMC additions effected on textural quality in a greater extent than other hydrocolloids used in this study.

Keywords: Hydrocolloids, Rice Flour, Gluten-Free Scone, Texture, Spread Ratio

Introduction

Celiac disease is a genetically-determined chronic inflammatory intestinal disease induced by gluten in wheat, barley, rye etc. It was also induced by an environmental precipitant, gluten in genetically susceptible person. Patients with celiac symptom suffer with food restrictions because of reducing diversification of their diet by lack of choices of gluten-free cakes, breads, pastas and confectionery. A gluten-free diet is essential for patients having celiac disease. Gluten-free baked products, which lack a gluten matrix, are of poor technological quality. Currently, many of the gluten-free baked products that are available in the marketplace, exhibiting poor mouth-feel and flavour [1-4].

Scone is a small biscuit like cake or a quick bread. In general, scone made with gluten flour (wheat and barley). Scone is a popular product in Ireland, UK, USA and elsewhere. They are consumed by people of all ages and are characterized by a soft texture and sweet flavour [5]. In recent years, several researches have been increasingly interested in gluten-free baked products, mainly involving the approach of hydrocolloids into a gluten-free flour base [2, 6]. Hydrocolloids can also be used as a gluten replacer because of their character to stabilize the products and improve their texture [7]. The presence of hydroxyl group in the structure of hydrocolloids helps in the retention of water through hydrogen bonding resulting in higher water binding capacity and higher viscosity of dough. This property plays an important role for imitation of wheat gluten which has been removed from many gluten-free bakery products [8]. Therefore, addition of hydrocolloids could help in improving gluten-free scone quality, especially textural characteristics.

Rice flour is one of the most suitable flours used for replacing wheat flour in gluten-free products [3, 9-10]. It has little flavor and widely utilized in many Asian food products. Not only its properties but also availability makes it possible for industrial scale application [3].

Objectives

The objective of this study was to examine the effect of hydrocolloids on physical, chemical and sensory properties of gluten-free rice scone.

Methods

Materials for gluten-free rice scone preparation

Rice flour (Erawan Brand; Cho Heng Rice Vermicelli Factory Co., Ltd.), fresh whole egg, refined sugar (Mitr Phol Sugar Corp., Ltd), salt, unsalted butter (Allowrie; KCG Corporation), fresh milk, double-action baking powder, emulsifier (UFM Food Centre Co., Ltd.) were purchased from the local markets. Seven different hydrocolloids including carrageenan; kappa (CN), carboxymethylcellulose (CMC), guar gum (GG), pectin; high methoxyl pectin from apple (PT), sodium alginate (SA) and xanthan gum (XG) were purchased from Union Chemical 1986 (Bangkok, Thailand). Locust bean gum; extracted from the endosperm of carob tree (LBG) was purchased from Ingredient Center (Bangkok, Thailand).

Scone preparation

Dry ingredients containing hydrocolloid (1% of rice flour basis) or without hydrocolloid (control) were premixed on mixer pot by plastic paddle; then, unsalted butter was added and mixed for 1 min at speed 1 by mixer (KitchenAid, Model 5K5SS, USA); and then fresh egg, fresh milk and emulsifier were added and mixed one more minute at speed 1 to enhance mixing. After 30 min at $4\pm2^{\circ}C$ resting, the dough was rolled out to a thickness of 2.5 cm. A round cutter (3.8 cm diameter) was used to cut out the dough into pieces which were then placed on a baking tray. The tops of scones were brushed with the beaten egg mixed with fresh milk (1:1). The scones were baked for 18 min at $180\pm2^{\circ}C$ (QL Series automatic gas oven, Thailand) and left to cool for 30 min on wire rack at room temperature for further analysis. Five replications from each of two sets of baking were analyzed for quality attributes and their mean values were reported.

Methods for gluten-free rice scone determination

Moisture content

Moisture content of scone was measured by drying the samples in a hot air oven (Hot-Air Oven, Binder, USA) at $105\pm2^{\circ}C$. Moisture content (%MC) of scone was calculated as follows [11]:

$\%MC = [(W_{wet} - W_{dry}) / W_{wet}] / 100$

where W denotes weight (g).

W_{wet} = Weight (g) of sample befroe drying

W_{dry} = Weight (g) of sample after drying

Water activity

Water activity of scone was determined at 25°C using a water activity meter (Aqualab Series 4TE, Decagon Devices, Inc., Pullman, Washington, USA).

Diameter, thickness and spread ratio

Diameter and thickness of each scone sample was measured with a vernier caliper. Spread ratio was calculated by dividing the diameter of scone by scone thickness.

Specific volume

Specific volume of scone was determined by the rapeseed displacement method [12].

Crumb colour

Crumb colour was determined with a Hunter Lab) MiniScan XE Plus ,USA). Colour values were recorded as L^* = lightness (0 = black, 100 = white), a^* ($-a^*$ = greenness, $+a^*$ = redness) and b^* ($-b^*$ = blueness, $+b^*$ = yellowness). Triplicated readings were carried out at room temperature from different positions of crumb and mean values were recorded. Total colour difference as compared to control (ΔE^*) was calculated as follows [13]:

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Crumb texture

Crumb texture was assessed using a texture analyzer (TAXT2*i*, Stable Micro Systems, Surrey, UK). A slice of scone crumb (1.5 cm thick) was prepared for texture profile analysis (TPA) with cylindrical probe diameter of 25 mm. The test was performed at a speed of 3 mm/sec to compress the scone crumb to 40% of its original height (Adapt from Rößle; et al.) [5]. The parameters obtained from the curves were firmness (N), gumminess (N), chewiness (N), cohesiveness and springiness.

Sensory evaluation

Hedonic score was applied for sensory tests which were conducted with 80 untrained panelists consisting of students and staff of Silpakorn university, Nakhon Pathom, Thailand. Gluten-free rice scones were evaluated on appearance, colour, odour, texture, taste and overall liking. The scale was a 9-point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = dislike extremely).

Statistical analysis

Analysis of variance (ANOVA) was performed on the data using the SPSS V.10 statistical software package (SPSS (Thailand) Co., Ltd.). Duncan's new multiple range was used to evaluate the significance of mean values differences ($P \leq 0.05$).

Results

Effect of hydrocolloids additions on physical and chemical properties of gluten-free rice scones

Moisture content, water activity (a_w), thickness, diameter and spread ratio are shown in Table 1. Moisture content of gluten-free rice scones with CMC, GG, LBG and XG were significantly higher ($P \leq 0.05$) than that of gluten-free rice scone without hydrocolloid (control) while CN, PT and SA were not significantly different ($P > 0.05$) in moisture content. Water activity (a_w) of gluten-free rice scones varied in the range of 0.8621-0.8838. CMC and GG additions resulted in the gluten-free rice scones with highest water activity (a_w) ($P \leq 0.05$).

The gluten-free rice scones with hydrocolloids additions presented significant ($P \leq 0.05$) decrease in diameter when compared with the control sample. Thickness values of gluten-free rice scones were in ranges of 27.71-31.63 mm. Gluten-free rice scones with XG and CMC were significantly higher ($P \leq 0.05$) in thickness than control. Spread ratio (ratio of the average value of diameter by average value of thickness of scones) of gluten-free rice scones with CMC, GG, LBG, PT, SA and XG additions were significantly lower ($P \leq 0.05$) than that of control except that of CN addition was not significantly different ($P > 0.05$) in spread ratio. Gluten-free rice scones with and without hydrocolloid addition are shown in Figure 1.

Table 1. Physical and chemical properties of gluten-free rice scones.

Sample	Moisture (%)	Water activity (a_w)	Diameter (W, mm)	Thickness (T, mm)	Spread ratio (W/T)
Control	17.32 ± 0.41^{de}	0.8640 ± 0.0049^{bc}	49.75 ± 1.28^{a}	28.37 ± 2.01^{c}	1.76 ± 0.13^{a}
CN	17.59 ± 0.26^{de}	0.8699 ± 0.0155^{b}	48.40 ± 1.56^{b}	27.71 ± 1.38^{c}	1.75 ± 0.13^{a}
CMC	19.92 ± 0.42^{a}	0.8838 ± 0.0182^{a}	42.57 ± 0.97^{e}	30.47 ± 1.15^{b}	1.40 ± 0.08^{d}
GG	18.34 ± 0.51^{b}	0.8826 ± 0.0169^{a}	45.92 ± 1.32^{c}	28.20 ± 0.94^{c}	1.63 ± 0.08^{bc}
LBG	18.19 ± 0.74^{bc}	0.8693 ± 0.0199^{bc}	45.55 ± 1.59^{cd}	28.56 ± 0.72^{c}	1.60 ± 0.06^{bc}
PT	17.16 ± 0.51^{e}	0.8621 ± 0.0167^{c}	47.99 ± 1.43^{b}	28.84 ± 1.13^{c}	1.67 ± 0.09^{b}
SA	17.78 ± 0.78^{cd}	0.8712 ± 0.0185^{b}	44.66 ± 1.07^{d}	28.42 ± 1.45^{c}	1.57 ± 0.09^{c}
XG	18.46 ± 0.31^{b}	0.8707 ± 0.0199^{b}	40.18 ± 0.82^{f}	31.63 ± 0.95^{a}	1.27 ± 0.04^{e}

Notes: CN, carrageenan; CMC, carboxymethylcellulose; GG, guar gum; LBG, locust bean gum; PT, pectin; SA, sodium alginate and XG, xanthan gum. Values followed by different letters within a column are significantly different ($P \leq 0.05$).

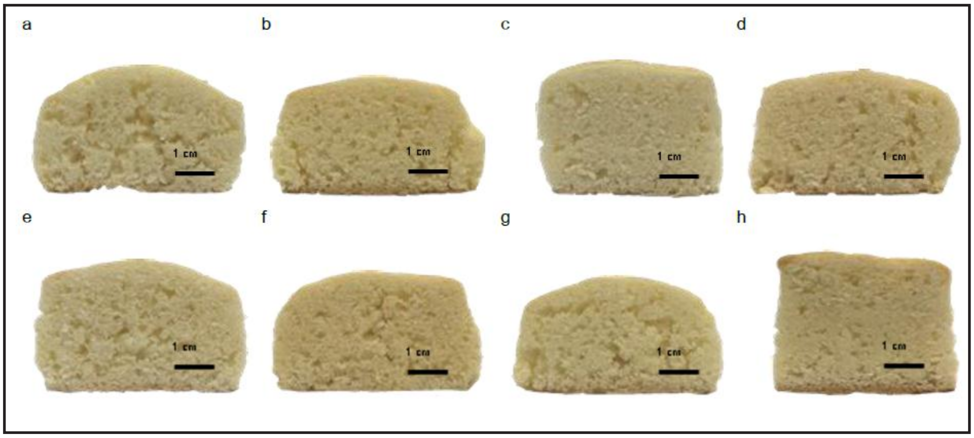

Figure 1. Gluten-free rice scones with different hydrocolloids additions; a) control, b) CN, carrageenan;c) CMC, carboxymethylcellulose; d) GG, guar gum; e) LBG, locust bean gum; f) PT, pectin; g) SA, sodium alginate; h) XG, xanthan gum.

Effect of hydrocolloids additions on specific volume of gluten-free scones

As shown in Figure 2, gluten-free rice scone with GG presented the highest specific volume followed by PT, LBG, SA and CN, while CMC and XG additions resulted in the lowest specific volume of scones.

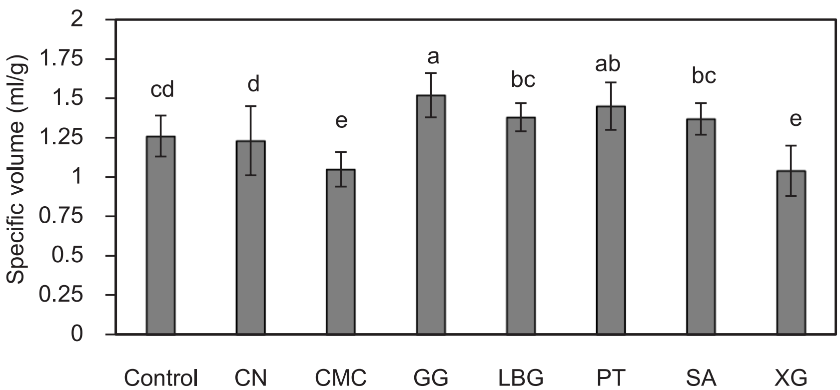

Figure 2. Specific volume (ml/g) of gluten-free rice scones; CN, carrageenan; CMC, carboxymethylcellulose; GG, guar gum; LBG, locust bean gum; PT, pectin; SA, sodium alginate and XG, xanthan gum. Bars with different letters indicate significantly different ($P \leq 0.05$).

Effect of hydrocolloids additions on crumb colour of gluten-free rice scones

Crumb colour of gluten-free rice scones are shown in Table 2. In general, a lower L^* value indicates a darker crumb, a^* positive value is associated with crumb redness, whereas a higher b^* positive value leads to higher crumb yellowness. Crumb lightness (L^*) values of gluten-free rice scone with CN, GG, PT and SA additions were similar to that of control (P>0.05). Gluten-free rice scones with CMC, LBG and XG additions showed a lighter (L^*) crumb (P≤0.05). Total colour difference (ΔE^*) ranged from 1.06 to 3.97. Especially, total colour difference (ΔE^*) of gluten-free rice scones with CMC, LBG and XG additions were in excess of 3 units when compared with the control.

Table 2. Crumb colour of gluten-free rice scones.

Sample	L^*	a^*	b^*	ΔE^*
Control	69.03 ± 3.52^{c}	0.03 ± 0.13^{d}	11.95 ± 0.84^{e}	-
CN	69.25 ± 2.09^{c}	0.13 ± 0.07^{cd}	12.98 ± 0.48^{bcd}	1.06
CMC	72.05 ± 1.73^{ab}	0.28 ± 0.08^{b}	13.50 ± 0.49^{ab}	3.40
GG	70.58 ± 1.88^{bc}	0.20 ± 0.10^{bc}	13.35 ± 0.55^{abcd}	2.10
LBG	72.87 ± 1.57^{a}	0.12 ± 0.09^{cd}	12.95 ± 0.41^{cd}	3.97
PT	69.13 ± 1.63^{c}	0.58 ± 0.16^{a}	13.48 ± 0.77^{abc}	1.63
SA	70.06 ± 2.22^{bc}	0.10 ± 0.07^{d}	12.90 ± 0.30^{d}	1.40
XG	71.67 ± 0.77^{ab}	0.25 ± 0.06^{b}	13.66 ± 0.20^{a}	3.15

Notes: CN, carrageenan; CMC, carboxymethylcellulose; GG, guar gum; LBG, locust bean gum; PT, pectin; SA, sodium alginate and XG, xanthan gum. Values followed by different letters within a column are significantly different (P≤0.05).

Effect of hydrocolloids additions on crumb texture of gluten-free rice scones

Crumb textural parameters are shown in Table 3, Considering overall results, it was found that hydrocolloids additions increased crumb texture (firmness, springiness, cohesiveness, gumminess and chewiness) of gluten-free rice scones. In this study, XG addition resulted in the gluten-free rice scone with the highest crumb firmness, cohesiveness, gumminess and chewiness followed by CMC, while XG and CMC additions resulted in the gluten-free rice scones with the highest crumb springiness (P≤0.05).

Table 3. Crumb texture parameters of gluten-free rice scones.

Sample	Firmness (N)	Springiness	Cohesiveness	Gumminess (N)	Chewiness (N)
Control	14.76 ± 1.23^{d}	0.55 ± 0.07^{c}	0.15 ± 0.05^{c}	2.25 ± 0.87^{c}	1.29 ± 0.61^{c}
CN	14.72 ± 2.22^{d}	0.60 ± 0.07^{bc}	0.19 ± 0.06^{c}	2.80 ± 1.05^{c}	1.68 ± 0.64^{c}
CMC	34.62 ± 4.03^{b}	0.80 ± 0.03^{a}	0.28 ± 0.05^{b}	9.90 ± 2.57^{b}	7.96 ± 2.25^{b}
GG	17.44 ± 1.99^{cd}	0.61 ± 0.05^{b}	0.16 ± 0.03^{c}	2.81 ± 0.79^{c}	1.75 ± 0.63^{c}
LBG	17.59 ± 2.50^{c}	0.60 ± 0.06^{bc}	0.15 ± 0.04^{c}	2.72 ± 1.20^{c}	1.67 ± 0.86^{c}
PT	17.84 ± 3.52^{c}	0.60 ± 0.06^{bc}	0.17 ± 0.04^{c}	2.96 ± 1.00^{c}	1.81 ± 0.69^{c}
SA	16.52 ± 2.70^{cd}	0.57 ± 0.06^{bc}	0.15 ± 0.03^{c}	2.49 ± 0.75^{c}	1.44 ± 0.50^{c}
XG	45.74 ± 3.63^{a}	0.78 ± 0.01^{a}	0.37 ± 0.05^{a}	16.76 ± 2.81^{a}	13.06 ± 2.17^{a}

Notes: CN, carrageenan; CMC, carboxymethylcellulose; GG, guar gum; LBG, locust bean gum; PT, pectin; SA, sodium alginate and XG, xanthan gum. Values followed by different letters within a column are significantly different (P≤0.05).

Effect of hydrocolloids additions on sensory quality of gluten-free rice scones

Mean sensory scores for the appearance, colour, odour, texture, taste and overall liking of the gluten-free rice scones are shown in Table 4. It was found that control (gluten-free rice scones without hydrocolloid addition) and gluten-free rice scones with hydrocolloids additions were significantly different ($P \leq 0.05$) in appearance and colour. CMC addition resulted in the highest appearance liking score of gluten-free rice scone. Gluten-free rice scone with and without hydrocolloid addition did not differ significantly ($P>0.05$) in odour, texture, taste and overall liking scores. Overall liking score of gluten-free scones with CMC, LBG, PT and SA were 6.0, 6.1, 6.1 and 6.0, respectively.

Table 4. Sensory liking scores of gluten-free rice scones (N=80).

Sample	Appearance	Colour	Odour	Texture	Taste	Overall liking
Control	6.3 ± 1.5^{b}	6.7 ± 1.2^{ab}	6.5 ± 1.5^{a}	5.3 ± 2.0^{a}	5.6 ± 1.7^{a}	5.9 ± 1.4^{a}
CN	6.4 ± 1.6^{b}	6.4 ± 1.5^{b}	6.4 ± 1.5^{a}	5.3 ± 1.8^{a}	5.8 ± 1.5^{a}	5.7 ± 1.5^{a}
CMC	7.0 ± 1.2^{a}	6.8 ± 1.3^{ab}	6.5 ± 1.1^{a}	5.7 ± 1.8^{a}	5.6 ± 1.6^{a}	6.0 ± 1.5^{a}
GG	6.6 ± 1.4^{ab}	6.7 ± 1.4^{ab}	6.2 ± 1.4^{a}	5.4 ± 1.6^{a}	5.6 ± 1.6^{a}	5.5 ± 1.3^{a}
LBG	6.9 ± 1.3^{ab}	7.0 ± 1.3^{ab}	6.5 ± 1.3^{a}	5.6 ± 1.7^{a}	5.9 ± 1.7^{a}	6.1 ± 1.6^{a}
PT	6.3 ± 1.5^{b}	6.7 ± 1.4^{ab}	6.4 ± 1.5^{a}	5.9 ± 1.9^{a}	6.2 ± 1.7^{a}	6.1 ± 1.6^{a}
SA	6.6 ± 1.3^{ab}	7.1 ± 1.1^{a}	6.5 ± 1.2^{a}	5.5 ± 1.5^{a}	5.7 ± 1.4^{a}	6.0 ± 1.5^{a}
XG	6.6 ± 1.4^{ab}	7.0 ± 1.2^{a}	6.5 ± 1.1^{a}	5.6 ± 1.5^{a}	5.5 ± 1.5^{a}	5.7 ± 1.4^{a}

Note: CN, carrageenan; CMC, carboxymethylcellulose; GG, guar gum; LBG, locust bean gum; PT, pectin; SA, sodium alginate and XG, xanthan gum. Values followed by different letters within a column are significantly different ($P \leq 0.05$).

Conclusions and Discussion

The addition of hydrocolloids (CN, CMC, GG, LBG, PT, SA and XG) resulted in different effects on qualities of gluten-free rice scones. Addition of XG and CMC led to gluten-free rice scone with high crumb firmness, increased moisture content and lightness, decreased spread ratio and specific volume. Adding CMC in gluten-free scone resulted in increasing liking scores for the appearance of gluten-free rice scone. Overall, hydrocolloids additions in gluten-free scone slightly improved sensory scores.

According to the effect of different hydrocolloids on gluten-free rice scones quality investigated, it was found that moisture content of gluten-free rice scones with hydrocolloids (CMC, GG, LBG and XG) were higher than that of gluten-free rice scone without hydrocolloid (control). The similar results were well supported and explained by Kaur; et al. [14] who reported that hydrocolloids (gum acacia, GG, gum tragacanth and XG) increased moisture content of gluten-free biscuits. Addition of XG resulted in gluten-free biscuits with maximum moisture content followed by GG incorporation. Hydrocolloids are hydrophilic polymers that make them high in water retention capacity [15]. Moisture contents among gluten-free rice scones with hydrocolloids additions were different. It may be due to different chemical structure and their interaction with the rest of food ingredients [16]. Water activity (a_w) of gluten-free rice scone with CMC and GG additions were the highest as a result of their higher water holding capacity associated with moisture content. Rosell; et al. [17] reported that increasing water activity (a_w) of wheat bread as well as moisture retention due to the higher water holding capacity of the hydrocolloids.

Spread ratio of gluten-free rice scones were decreased with CMC, GG, LBG, PT, SA and XG additions. Similarly, Kaur; et al. [14] found that gluten-free biscuits with hydrocolloids addition (gum acacia, GG, gum tragacanth and XG) resulted in lower spread ratio, especially, with gum tragacanth providing the lowest value followed by that with XG addition. The presence of hydroxyl group in the structure of hydrocolloids helps in the retention of water through hydrogen bonding resulting in higher water binding capacity and higher viscosity of dough. The higher viscosity, the lower the spread ratio of scones [8].

GG and PT additions increased specific volume of gluten-free rice scone, while CMC and XG additions decreased specific volume. Nevertheless, Lazaridou; et al. [18] reported that specific volume of gluten-free bread was improved with the presence of hydrocolloids (CMC, PT, agarose, XG and oat b-glucans), while XG added at 1% did not, as compared with control (gluten-free bread without hydrocolloid), and it was even decreased when XG was added at 2%. In a similar way, Mezaize; et al. [19] reported that addition of XG and CMC in gluten-free breads did not improve the specific volume, while GG and hydroxypropyl methylcellulose addition increased specific volume. It was explained that addition of CMC and XG made the dough system too rigid to incorporate gases to produce voluminous bread.

Addition of CMC, LBG and XG resulted in lighter crumb of gluten-free rice scones than that of control. Mohammadi; et al. [6] reported that hydrocolloids (CMC and XG) increased crumb lightness (L^*) in gluten-free bread. This could be attributable to the effect of the hydrocolloid on water distribution, which impacts on caramelization and maillard reaction. It should be considered that in higher water contents and during dilution of interactive materials (Table 1), the browning reaction of scone decreases (increasing lightness) [2]. In general, total colour difference (ΔE^*) was appreciable by the human eyes were; $\Delta E^*<1$ colour differences are not obvious for the human eyes; $1<\Delta E^*<3$ colour differences are not appreciate by the human eyes and $\Delta E^*>3$ colour are obviously different for the human eyes [20]. Thus, only for CMC, LBG and XG, the colour differences were appreciable by the human eyes ($\Delta E^*>3$).

Hydrocolloids additions increased crumb textural parameters of gluten-free rice scones. However, gluten-free rice scone with added XG had the highest crumb firmness followed by that with CMC added. In the same way, G๓mez; et al. [16] found that hydrocolloids additions affected textural parameters of yellow layer cakes, leading to firmer crumbs than those of the control cake. Rosell; et al. [17] working with wheat bread, reported that XG provoked a great increase of the crumb firmness. Higher values of firmness and other textural parameters in scones incorporated with CMC and XG were related to lower specific volume. As the specific volume of product decreased, its firmness tended to be increased [18]. Water retention capacity of hydrocolloids depends on their chemical structure and their reaction with the rest of other food ingredients which may result in different viscoelastic behavior and texture of bakery products [16].

Addition of hydrocolloids in gluten-free rice scones slightly increased sensory liking scores as compared with control. Overall liking scores of gluten-free rice scone with CMC, LBG, PT and SA were around 6.0 indicating consumers liked the product slightly. To improve sensory liking score, further improvement of gluten-free rice scones such as using combined hydrocolloids at varied concentrations is recommended.

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