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Short Communication

Effect of xanthan gum/CMC on bread quality made from Hom Nil rice flour

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Abstract

Hom Nil rice is widely grown in the Northern of Thailand. It has tapering shape, dark purple color, soften texture after cooking and also good smell. Nowadays, there was an increasing interest for gluten-free products as the number of the celiac patient grows. Many researchers have been attempted to use rice flour to substitute wheat flour in bread. However, almost rice flour proteins have poor functional properties because it has no glutenin and gliadin to form gluten that giving a dough appearance and final quality. From previous researches were used hydrocolloids to improve characteristic of bread made from rice flour. Therfore, the objective of this study was to study the effect of xanthan gum and carboxymethylcellulose (CMC) on bread quality made from Hom Nil rice flour (HNRF). The results showed that moisture content, protein, ash, fat, carbohydrate and crude fiber content of the HNRF were 8.40%, 7.71%, 1.71%, 4.11%, 78.06% and 1.42%, respectively. The pasting temperature, trough, breakdown, final viscosity, peak viscosity, peak time and set back of HNRF were 86.28^{o}C, 1074 cP, 254 cP, 2207 cP, 1327 cP, 5.8 mins and 1133.5 cP, respectively. HNRF was used to produce bread with varied xanthan gum and CMC in ratios of 3:0, 2:1, 1.5:1.5, 1:2 and 0:3 respectively. The results showed that the ratio of xanthan gum and CMC at 1:2 provided the higher acceptable liking score than others ($p \leq 0.05$). The appearance, odor, softness, and overall acceptance of bread were 6.37, 6.03, 6.03, and 6.10 respectively. Moisture content, protein, ash, fat, carbohydrate and crude fiber content were 30.16%, 6.74%, 2.12%, 6.88%, 54.10% and 1.36%, respectively. Hardness, springiness and chewiness of the Hom Nil bread were 7.02 g, 0.73 mm and 1.81 gmm respectively.

Introduction

Bread was one of the major staple foods and was consumed daily in all parts of the world. Although a wide range of different types exist, the term ‘‘bread’’ usually refers to yeast-leavened wheat products. Nowadays, there was an increasing interest for gluten-free products as the number of the celiac patient grows. Celiac disease was a digestive disorder which damages the villi, tiny hair like projections in the small intestine that absorb nutrients due to an immunological reaction to gluten (Demirkesen *et al*., 2010). Celiac patients cannot tolerate the gliadin fraction of wheat and the prolamins of rye, barley, and oat, so it should to find alternative material replace using wheat flour for example rice flour. Over half of the world’s population uses rice as a staple food (Hager *et al*., 2012). In addition, rice had many unique functional properties, such as ease of digestion, bland taste and hypoallergenic properties (Kadan *et al*., 2003) and rice flour was one of the most suitable cereal flour for preparing gluten-free products due to its several significant properties such as, it had also very low level of protein, sodium, fat, fiber and high amount of easily digested carbohydrates (Demirkesen *et al*., 2010). It had many wide ranges to use, for example it exists in term of alternative bread. Hom Nil rice or Black Fragrant rice was widely grows in the northern of Thailand. It had tapering shape, dark purple color; soften texture after cooking and also good smell. Furthermore, Hom Nil rice contain high protein content about 12.5%, carbohydrate content about 70%, amylose content about 16%. Moreover it contains many minerals such as iron, zinc, copper, calcium, and potassium in high range when comparing with normal rice. Black rice possess high phenolic compounds and anthocyanins (0.04-8580 mgGAE/100g and 1.09-5101 mg/100g, respectively) (Tananuwong and Tewaruth, 2010; Yao *et al*., 2010). It contribute antioxidant activity, anti-inflammatory effect, and reduce the risk chronic diseases (Akkarachiyasit *et al*., 2010; Shipp and Abdel-Aal, 2010; Zhang *et al*., 2010; Kim *et al*., 2013). Rice flour proteins have poor functional properties (Rosell and Marco, 2008) because it has not glutenin and gliadin to form gluten that giving a specific appearance dough and quality of bread. Many researches use hydrocolloids to improve good characteristic of

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bread and also bread making properties. According to Mi *et al*., (1997), reported that the gum type such as hydroxypropylmethylcellulose (HPMC), locust bean gum, gaur gum, carrageenan, xanthan gum, and agar can help the formation of rice bread showing the optimum volume expansion, gel consistency and positively with springiness of rice bread.

The present study was investigated to study effect of Xanthan gum/CMC on bread quality made from Hom Nil Rice Flour. The results from this study will be provided information concerning process, physical and chemical properties and also sensory evaluation of bread made from Hom Nil rice flour. This product will be an alternate choice of bakery product for consumer with celiac disease.

Materials and Methods

Materials

Hom Nil rice was obtained from Northern Thailand Origin Rice-Growing Farmer Group, Thailand. Ingredients for lab-prepared bread formulations were wheat flour (United Flour Mill Public Co.,Ltd, Thailand); instant dry yeast (S.I.Lesaffre, France); shortening (Katevanich industry Co.,Ltd, Thailand); sugar (Lin bran,TRR Group, Thailand); salt (TESCO brand, Thailand); bread improver (UFM Food Center Co.,Ltd, Thailand); CMC (F60 M) (Winner Group Enterprise Plc, Thailand); and xanthan gum (Winner Group Enterprise Plc, Thailand).

Hom Nil rice flour preparation

Hom Nil rice flour (HNRF) was washed with water for cleaning before placed in tray dry at 55ºC for 4 hours. After that kept it cool in ambient temperature before milling with Hammer mill for 3 times. The dried sample was ground using the hammer mill grinder with a 0.5-mm sieve. Hom Nil rice flour were passed through a 100-mesh sieve, packed in plastic bags and stored at room temperature until used (Lumdubwong and Seib, 2000).

Preparation of HNRF bread

Seven samples for this study included; five HNRF breads were prepared with varied amount of xanthan gum- to-CMC ratios 3:0, 2:1, 1.5:1.5, 1:2 and 0:3. Wheat flour and HNRF bread were used for comparison. All samples were prepared using 0.2% bread improver, 0.8% salt, 1% yeast, 2% milk powder, 2.5% egg, 3% gums with different ratios, 6.1% shortening, 9.1% sugar, and water was 27.5%, based on whole weight. Sift flour with milk powder, yeast and gum, then mix together with sugar and salt and dissolved in warm water (35ºC), kneaded all ingredients for 2 minutes at low speed and then mix at high speed for 5 minutes. Rest the dough in proofer machine at 30ºC with 85% relative humidity (RH) for 20 minutes. After that, Hom Nil dough was divided to 400 g and made a round shape before put into pans and place in a proofer machine again for 60 minutes at 30 ºC, 85% RH. The bread was baked for 25 minutes at 190 ºC. After the bread had been cooled on a rack for 1 h, they were packed in polyethylene bags for further analysis.

Physicochemical properties of HNRF

Flour was determined physical properties as $L^*a^*b^*$ (Color Quest XE - Hunter Lab, USA) and water activity (Novasina AWC500). Proximate analysis was determined as moisture content, fat, protein, ash and fiber content. Carbohydrate was determined by calculation (AOAC, 2000)

Pasting properties of HNRF was determined using a Rapid Visco-Analyzer (Newport Scientific, Warriewood, Australia). Each sample (3 g) was mixed with 25 g of distilled water in an RVA sample canister. The temperature was set at 50^{o}C, and the following 13.0 minute test profile was run: (1) held at 50^{o}C for 1.0 min, (2) linearly ramped up to 95^{o}c in 3.4 min, (3) held at 95^{o}C for 2.7 min, (4) linearly ramped down to 50^{o}C in 3.9 and (5) held at 50^{o}C for 2 min. The peak viscosity, holding viscosity, final viscosity and pasting temperature were determined by the analysis of Thermocline for window (TCW).

Dough development

After mixing the flour with overall ingredients, put the 400 g dough into aluminium chamber. Measurement the first height of dough in mm (h1), and then rest this chamber in proofer (30 ºC, 85% RH) for 60 min, (t) (Hager *et al*., 2012). After that, measure the last height (h2) and weight of dough and calculate the expansion of dough following the equation:

$$\text{Dough development} = [(h2-h1)/t]^{*}100.$$

Density of bread

Loaf of bread was measured by using seed displacement method with sesame. The empty pan was filled with sesame and volume of sesame determined by graduated cylinder (V1). The bread was replaced in pan and filled with sesame. The volume of sesame determine by graduated cylinder (V2). The bread was weighed after removal from the pan and calculate density of bread.

Texture of crumb

Crumb of bread was determined by using Texture Analyzer (TPA) equipped with a 25 kg load cell and 36-mm aluminum cylindrical probe. The setting used were a test speed of 5mm/s to compress the middle of the bread crumb to 50% of its original thickness (25 mm thickness) (Hager *et al.*, 2012). Hardness, springiness and chewiness were determined. After that three loaf per batch ware analyzed on day 0, and day 5 of storage. Rate of staling was calculated using the following equation:

Staling rate = (crumb hardness of day 5 – crumb hardness of day 0) / crumb hardness of day 0)

Sensory evaluation

Thirty panelists were recruit from Chiang Rai area, Thailand. The central location test (CLT) was conducted at Mae Fah Luang University. The bread were evaluated by 30 panelists including students in Mae Fah Luang University. Bread was cut in slices (1x3 cm). Panelists were instructed to visually evaluate for appearance and odor, then take at least three-fourths of bread, and slowly masticate the product before providing acceptability ratings for softness, springiness, taste and overall liking, all on a 9-point hedonic scale (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely). Each sample was labeled with a 3-digit random number and the order of sample presentation was randomized to avoid biases. Filtered water was provided to cleanse their palate between samples during tasting.

Statistical analysis

Quality measurement data from 3 replications were subject to analysis of variance (ANOVA) as well as Duncan's multiple range test for determination of difference between the samples ($p < 0.05$) using SPSS 16.0 (SPSS Inc., Chicago, U.S.A.).

Results and Discussion

Physicochemical Properties of Hom Nil rice flour

The chemical composition (Table 1) of Hom Nil rice flour after milling had moisture, ash, fat, protein, and crude fiber content and were 8.40%, 1.71%, 4.11%, 7.71%,1.42% and 78.06% respectively. The color of Hom Nil rice flour was pale-purple color. L^*, a^* and b^* were 63.89, 2.44 and 4.33 respectively Pasting properties of HNRF were showed in Table 2. The high value of peak viscosity exhibit from large granules of Hom Nil rice flour that may related to changing continue phase of flour to be paste was hard (Deffenbaugh and Walker, 1989). Setback was a measure of recrystallization of gelatinized starch during cooling that may be due to the amount and the molecular weight of amylose contain of Hom Nil flour leached from the granules (Ashogbon and Akintayo, 2012). The final viscosity was high value that related to amount of amylose inside flour was high.

Table 1. Chemical and physical properties of Hom Nil rice flour

Properties	Values
Chemical properties	
% Moisture	8.40±0.13
% Ash	1.71±0.02
% Fat	4.11±0.03
% Protein	7.71±0.33
% Crude fiber	1.42±0.39
% Total carbohydrate	78.06
Physical properties	
L*	63.89±1.42
a*	2.44±0.17
b*	4.43±0.33

Table 2. Pasting properties of Hom Nil rice flour.

Pasting properties	values
Peak viscosity (cP)	1327.00 ± 33.23
Trough (cP)	1074.00 ± 8.49
Break down (cP)	253.00 ± 24.75
Final viscosity (cP)	2207.50 ± 9.19
Setback (cP)	1133.50 ± 0.71
Pasting temperature (°C)	86.28 ± 0.04
Peak time (minutes)	5.80

Bread properties

Table 3 showed that wheat bread had the highest percentage of dough development because it had gluten network to entrap gas during proofing, but other formulas was rather low values that indicates that the viscoelastic properties of wheat dough are superior (Hager *et al.*, 2012). For the gluten-free bread HNRF and HNRF with ratio Xanthan gum:CMC (0:3) are closely to wheat value. This different can be explained by the high amount of bran particles presented in the dough, which penetrated gas cell cause leaks.

Bread density was a major determinant of bread crumb structure and texture during storage. Bread of lower density initially had a lower elastic modulus, which remained low during storage. (Lagrain *et al.*,

Table 3. Dough development of bread with different ratios of Xanthan gum:CMC

Flour	Ratio Xanthan gum:CMC	Height before proofing (cm) (h1)	Height after proofing (cm) (h2)	Dough development (%)	Density of bread (g/cm^{3})
Wheat	-	4.63 ± 0.10^{b}	7.58 ± 0.16^{a}	4.92 ± 0.12^{a}	0.24±0.00^{e}
HNRF	-	3.11 ± 0.12^{d}	3.25 ± 0.18^{c}	0.23 ± 0.31^{e}	0.48±0.01^{bc}
HNRF	3:0	5.37 ± 0.21^{a}	5.72 ± 0.14^{b}	0.58 ± 0.15^{d}	0.84±0.03^{a}
HNRF	2:1	4.64 ± 0.19^{b}	4.94 ± 0.22^{c}	0.50 ± 0.30^{d}	0.50±0.03^{b}
HNRF	1.5:1.5	4.49 ± 0.06^{bc}	4.92 ± 0.49^{c}	0.71 ± 0.83^{d}	0.47±0.02^{c}
HNRF	1:2	4.24 ± 0.09^{c}	5.37 ± 0.18^{b}	1.81 ± 0.28^{c}	0.51±0.02^{b}
HNRF	0:3	3.02 ± 0.18^{d}	4.65 ± 0.14^{c}	2.71 ± 0.09^{b}	0.38±0.01^{d}

Values in column followed by the different letter are significantly different ($p<0.05$)

Table 4. Texture profile of bread and staling rate with different ratios of Xanthan gum:CMC

Flour	Ratios Xanthan gum:CMC	Hardness		Chewiness		Springiness		Staling rate
		Day 0	Day 5	Day 0	Day 5	Day 0	Day 5	
Wheat	-	9.07 ± 2.01^{b}	10.31 ± 2.71^{b}	6.62 ± 2.53^{a}	3.68 ± 1.51^{b}	1.02 ± 0.48^{a}	0.91 ± 0.05^{a}	0.28 ± 0.25^{g}
HNRF	-	11.26 ± 2.94^{a}	9.38 ± 2.63^{b}	4.11 ± 3.05^{b}	10.28 ± 10.23^{a}	0.76 ± 0.05^{b}	0.50 ± 0.05^{b}	0.89 ± 1.38^{a}
HNRF	3:0	6.85 ± 3.77^{c}	13.35 ± 4.89^{a}	3.89 ± 3.45^{b}	11.15 ± 8.77^{a}	0.56 ± 0.18^{c}	0.42 ± 0.10^{c}	0.65 ± 0.75^{c}
HNRF	2:1	4.56 ± 2.07^{d}	4.61 ± 1.55^{c}	2.13 ± 1.63^{c}	1.85 ± 1.30^{b}	0.65 ± 0.13^{bc}	0.37 ± 0.11^{d}	0.42 ± 0.59^{e}
HNRF	1.5:1.5	7.16 ± 2.42^{c}	5.69 ± 2.85^{c}	2.63 ± 1.48^{bc}	1.17 ± 0.86^{b}	0.75 ± 0.06^{b}	0.35 ± 0.07^{d}	0.35 ± 0.23^{f}
HNRF	1:2	7.02 ± 1.94^{c}	9.89 ± 7.00^{b}	1.81 ± 1.39^{c}	1.80 ± 2.49^{b}	0.73 ± 0.08^{b}	0.29 ± 0.08^{e}	0.59 ± 0.56^{d}
HNRF	0:3	6.91 ± 2.49^{c}	5.03 ± 3.14^{c}	1.28 ± 1.21^{c}	4.10 ± 7.31^{b}	0.77 ± 0.07^{b}	0.47 ± 0.05^{b}	0.67 ± 0.72^{b}

Values in column followed by the different letter are significantly different ($p<0.05$)

Table 5. Liking score of HNRF bread with different ratios of Xanthan gum:CMC

Flour	Ratio Xanthan gum:CMC	Appearance	Odor	Taste	Softness	Springiness	Overall acceptance
HNRF	-	5.83 ± 1.39^{c}	4.87 ± 1.50^{c}	3.80 ± 1.45^{d}	4.70 ± 1.44^{c}	5.07 ± 1.70^{b}	5.20 ± 1.35^{d}
HNRF	3:0	7.37 ± 1.33^{a}	5.57 ± 1.41^{abc}	4.70 ± 1.66^{bc}	5.80 ± 1.54^{ab}	5.93 ± 1.55^{a}	6.57 ± 1.17^{a}
HNRF	2:1	6.27 ± 1.31^{bc}	6.03 ± 1.75^{a}	4.83 ± 2.02^{b}	5.27 ± 1.86^{bc}	5.53 ± 1.80^{ab}	5.47 ± 1.63^{bcd}
HNRF	1.5:1.5	6.57 ± 1.33^{b}	5.90 ±1.47^{ab}	5.63 ± 1.83^{a}	6.07 ± 1.48^{a}	5.77 ± 1.57^{ab}	6.00 ± 1.39^{abc}
HNRF	1:2	6.37 ± 1.27^{bc}	6.03 ± 1.59^{a}	5.67 ± 1.67^{a}	6.03 ± 1.59^{a}	5.73 ± 1.60^{ab}	6.10 ± 1.47^{ab}
HNRF	0:3	5.90 ± 1.67^{c}	5.23 ± 1.70^{bc}	4.03 ± 1.56^{cd}	4.67 ± 1.54^{c}	5.00 ± 1.93^{b}	5.37 ± 1.63^{cd}

Values in column followed by the different letter are significantly different ($p<0.05$)

2013). From Table 3, wheat bread was the lowest value of density; it means that it was high elasticity in part of dough and bread. The good bread with ratio Xanthan gum:CMC (0:3) was lower density value than other gluten-free breads, because 3% of CMC can enlarge volume, decrease crumb falling and prevent collapse during baking process. Due to the lack of a cohesive protein matrix, elasticity and extensibility of the gluten-free batters was reduced and loaf volumes were low (Hager *et al.*, 2012), that related to density of bread was low.

The texture of the gluten-free and wheat breads, crumb hardness, springiness and chewiness were shown in Table 4. HNRF with ratio Xanthan gum:CMC (2:1) was the softest bread (4.56 g), but HNRF bread is the highest value of hardness. The hardness of HNRF with ratio Xanthan gum:CMC 3:0, 1.5:1.5, 1:2 and 0:3 were 6.85, 7.16, 7.02 and 6.91g respectively. Springiness value showed that wheat bread had the highest value (1.01 mm). Wheat bread had a chewiness of 6.62 gmm which was significantly higher value than gluten-free breads that occurring crumbly texture. The results of previous studies mentioned that Xanthan addition decrease area of bread cells (Ann-Sophie and Elke, 2013). It supported to dough development values were decrease. Furthermore, crumb hardness was increased upon Xanthan gum addition.

Sensory evaluation

The sensory evaluation of HNRF bread and HNRF bread with different ratios of hydrocolloid revealed that the bread samples were significantly different ($p \leq 0.05$) (Table 5). HNRF bread without Xanthan gum:CMC had the lowest score of all attributes. HNRF bread with ratio Xanthan gum:CMC (3:0) had the highest score of appearance and overall acceptance. The observed revealed that the addition of hydrocolloids improved HNRF bread properties that affected to acceptable.

Conclusion

This study revealed that it is possible to use Hom Nil rice flour made gluten free bread. Xanthan gum and CMC could be used to improve the bread quality. This product will be provided an alternate choice for consumer with celiac disease. Shelf life, consumer acceptance and purchase intent should be studied in the future to confirm their market potential for HNRF bread.

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