As. J. Food Ag-Ind. **2009**, 2(04), 780-787

Asian Journal of Food and Agro-Industry

ISSN 1906-3040
Available online at www.ajofai.info

Research Article

Effects of hydrocolloids on quality of rice crackers made with mixed-flour blend

Natthakarn Nammakuna, Sajee Suwansri, Parita Thanasukan and Puntarika Ratanatriwong*

Department of Agro-Industry, Faculty of Agriculture Natural Resources and Environment, Naresuan University, Pitsanuloke, 65000 Thailand.

* Author to whom correspondence should be addressed, email: puntarikar@nu.ac.th

This paper was originally presented at Food Innovation Asia, Bangkok, Thailand, August 2009.
Received 23 June 2009, Revised 8 February 2010, Accepted 15 February 2010

Abstract

This research determined the effects of hydrocolloids on improving the quality of rice crackers made from a mixed flour blend. Rice flour was used as wheat substitute in the formulated flour blend. The hydrocolloids added at 1.5%, 3.0% and 4.5% w/w (rice flour basis) in samples were xanthan gum (XN), carboxymethylcellulose (CMC) and hydroxypropylmethylcellulose (HPMC). Non-hydrocolloid-added controls were 100% -rice flour (RF), 100%-wheat flour (WF) and formulated-flour (FF) crackers. Dough microstructure, physical and chemical qualities of samples were determined. There were significant differences in hardness, toughness, puffiness, moisture content a_w and colour, ($p \leq 0.05$) amongst samples with different types and usage levels of hydrocolloids. Addition of hydrocolloids increased moisture content ($p \leq 0.05$), which correlated to significantly higher a_w in treated samples as compared to all controls. The comparison of samples with similar hydrocolloid type showed that hardness, toughness and puffiness slightly increased with increasing hydrocolloid level. The puffiness result also complied with the dough microstructure that revealed the structure of dough with addition of hydrocolloids and controls. As compared to controls, samples with added CMC and HPMC at 1.5% and 3% significantly decreased hardness to be lower than FF ($p \leq 0.05$) and closer to WF. However, despite the puffiness result, addition of 4.5% CMC, 4.5% HPMC and all XN usage levels showed negative influence on texture as they were significantly harder than WF and FF ($p \leq 0.05$). In conclusion, hydrocolloid addition in the mixed-flour-blend rice cracker helped retaining sample moisture and gas-retention in dough while textural results suggested that CMC and HPMC could be used at an appropriate amount to improve rice cracker texture.

Keywords : snacks, food additives, wheat substitute, xanthan, CMC, HPMC, Thailand

---

Introduction

Rice, a major food crop in Thailand, is sold as milled rice and value-added products for domestic and exported consumption. Rice production in Thailand is much higher than wheat due to climatic conditions so substitution of rice flour for wheat flour in snacks or bakery products is highly reasonable for marketing and cost aspects [1]. Many value-added rice products including snacks and bakery products are developed in order to meet consumer demands. Owing to its differences from Japanese-style rice crackers and wheat crackers, rice crackers with rice flour as wheat substitute is a unique product in the snack market. However since gluten is the most important structure forming protein [2, 3], the absence of gluten in rice flour presents the technical difficulties in rice crackers. In an attempt to solve this problem, hydrocolloid additions are suggested to help increasing dough properties such as water absorption, gas retention and improving product properties such as texture and retarding starch retrogradation [1, 4]. Some hydrocolloids such as hydroxylpropylmethylcellulose (HPMC), carboxymethylcellulose (CMC) or xanthan gum have shown promising evidences in gluten-free formulations and rice bread [1, 5]. Thus, the objective of this research was to determine the effects of hydrocolloids on improving the physical and chemical properties of rice crackers made of mixed-flour blends.

Materials and Methods

Flours and ingredients

All treated rice cracker formulations used mixed flour blend as a replacement of total wheat flour in the original formulation. Mixed flour blend formulation consisted of 4 flour types including Thai rice flour variety Surin1 (Chaijalearn Co., Ltd., Bangkok, Thailand), wheat flour (local market, Pitsanulok, Thailand), waxy rice flour variety RD6 (Jewhoksang Co., Ltd., Lampang, Thailand) and pregelatinize tapioca starch (Bangkok Starch Co., Ltd., Bangkok, Thailand). The research controls were non-hydrocolloid-added crackers made of different flour sources including 100% rice flour (RF), 100% wheat flour (WF), and formulated flour (FF) using mixed flour blend. The remaining ingredients of crackers purchased from local market (Supahp Baker, Phitsanulok, Thailand) were salt, sugar, milk powder, palm oil, glucose syrup, baking powder, margarine, dry yeast, ammonia powder, lecithin, flavor better milk, vanilla, corn flour and tapioca flour. Three types of hydrocolloids including hydroxypropylmethylcellulose (HPMC) [Methocel-K4M] xanthan gum (XN), carboxymethylcellulose (CMC) and (Bronson & Jacobs International Co., Ltd., Bangkok, Thailand) were added at 1.5%, 3.0% and 4.5% (rice flour basis) in treated samples.

Cracker preparation

All formulated samples were made of mixed flour blend with addition of hydrocolloids at various levels (FF+hydrocolloids). The dough preparation for both hydrocolloid-treated and control crackers were divided into two parts. Firstly, 50% flour, sugar and water were blended with a 6-speed mixer (KitchenAid model 5SS, St. Joseph, MI, USA) at 3rd speed for 5 min before adding yeast. The mixture was blended for 7 min, then proofed dough at 25-30^{o}C for 60 min before adding to the second mixture. The second mixture consisted of margarine, baking powder, ammonia powder, lecithin, salt, milk powder, palm oil, glucose syrup, flavor better milk and vanilla were well blended before adding the first dough and the rest of flour. The mixture was then blended in the mixer at 4th speed for 7 min followed by proofing dough at 25-30^{o}C for 60 min. Proofed dough was kneaded, sheeted, layered and cut to a cracker size of 5x5x0.2 cm (WxLxH). Cracker was subsequently baked in the oven at 200^{o}C for 7-8 min, and was cooled at 25-30°C for 60 min. Samples were packed in sealed polyproplylene bags and stored at room temperature until being determined.

Quality determination of dough and crackers
Physical and chemical properties of samples including moisture content, water activity (a_w), texture and color were determined. The measurements of moisture content and water activity (a_w) of samples were determined in three replicates using a moisture meter model Sartorius MA40 (Sartorius, Inc., Goettingen, Germany) and an water activity meter model Novasina RS 200 (Novasina, Axair Ltd., Pfaffikon, Switzerland), respectively. Hardness and toughness of samples were determined in ten replicates using the universal testing machine model 441 (Instron, Ltd., Buckinghamshire, England). Colour was determined in CIE system (L*, a*, b*, hue angle and chroma) by a colour reader model CR-10 (Konica Minolta sensing Inc., Osaka, Japan). The thickness of cracker before and after baking was determined by a vernia caliper in five replicates, and sample puffiness (%) was calculated from difference in thickness using Eq. 1.

$$\%\,\text{puffiness} = \frac{(\text{thickness of baked cracker} - \text{thickness of cracker dough})}{\text{thickness of cracker dough}} \times 100 \qquad \text{(Eq.1)}$$

The dough microstructure was studied using a scanning electron microscope Model 1455VP (Leo Electric Systems, Cambridge, UK). Prior to SEM study, cracker dough samples was cut to size 10×10 mm, freeze dried, and kept in a dessicator until further use. Dough sample was mounted on a slide and separately placed on a sample holder using double-sided scotch tape. The internal structure was faced upward and sputter-coated with gold (2 min, 2 mbar) before being transferred to the microscope where it was observed in vacuum at an accelerating voltage of 5 kV.

Two different sets of samples were used to analyze the quality of samples. The dough microstructure, physical and chemical properties of hydrocolloid-treated samples were compared with non-hydrocolloid-added controls which were made of rice flour (RF) as negative control, wheat flour (WF) as positive control and formulated flour (FF) as formulated control without hydrocolloid addition.

Statistical analysis
Experimental design in this research was a Completely Randomized Design (CRD). The main effect was hydrocolloid type. In this case, three types of hydrocolloid were used. Each type was added in three usage levels. All treatments were duplicates. Data was statistically analyzed using the analysis of variance (ANOVA) test and sample difference was analyzed by Duncan' s Multiple Range Test (DMRT) at 95% confidence level.

Results and Discussion

Effect of different hydrocolloids on physical and chemical properties
Rice cracker samples made of mixed flour blend with rice flour partially substituted were prepared with adding various hydrocolloids. The physical and chemical properties of treated samples were determined and shown in Table 1. They were compared with non-hydrocolloid-added controls including rice flour (RF) as negative control, wheat flour (WF) as positive control and formulated flour (FF). All samples had significant differences in moisture content, water activity (a_w), hardness, toughness and puffiness ($p \leq 0.05$). Addition of hydrocolloids and the amount usage showed increasing in the moisture content of samples

Table 1. Physical and chemical properties of rice crackers from different hydrocolloids.

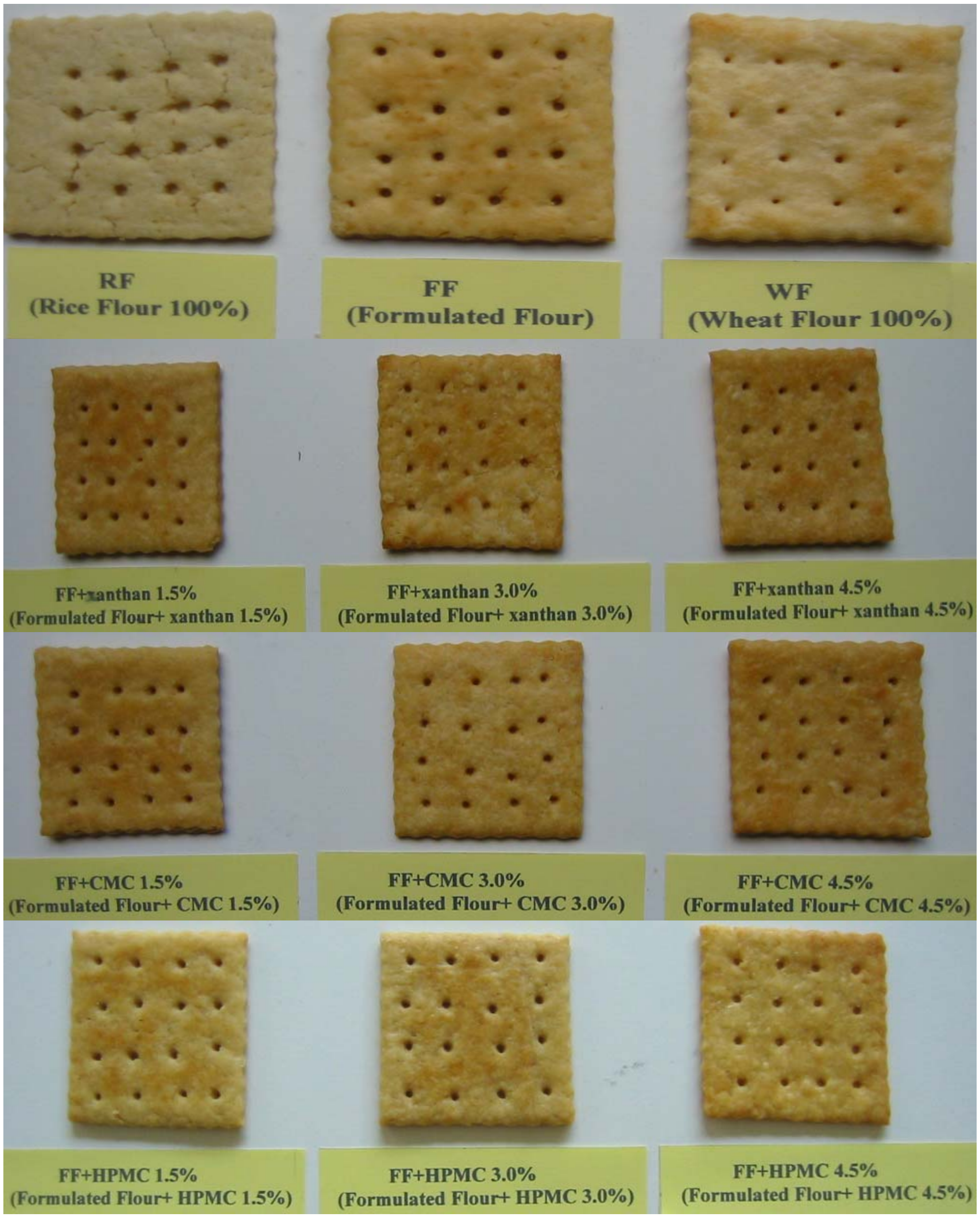
Samples	Properties				
	%MC	a_w	Hardness (Kg.f)	Toughness (Kg.f/mm^2)	Puffiness (%)
RF	3.52±0.06^{f}	0.20±0.01^{i}	0.76±0.15^{h}	0.0013±0.001^{e}	20.33±8.53^{c}
WF	5.60±0.04^{cd}	0.38±0.01^{f}	2.04±0.24^{g}	0.0018±0.001^{cde}	60.33±4.72^{a}
FF	5.17±0.23^{d}	0.34±0.01^{h}	3.12±0.20^{e}	0.0020±0.0003^{cd}	54.55±4.07^{a}
FF+xanthan 1.5%	5.40±0.08^{cd}	0.49±0.004^{d}	3.52±0.33^{d}	0.0021±0.001^{c}	38.18±4.69^{b}
FF+xanthan 3.0%	5.47±0.02^{cd}	0.46±0.002^{e}	5.05±0.27^{b}	0.0033±0.001^{b}	54.91±5.51^{a}
FF+xanthan 4.5%	7.20±0.22^{a}	0.56±0.002^{a}	6.53±0.41^{a}	0.0044±0.001^{a}	57.09±5.98^{a}
FF+CMC 1.5%	5.54±0.16^{bc}	0.50±0.002^{c}	2.69±0.18^{f}	0.0020±0.001^{c}	52.73±9.96^{ab}
FF+CMC 3.0%	4.23±0.33^{e}	0.40±0.004^{g}	2.77±0.39^{f}	0.0021±0.001^{c}	55.64±8.29^{a}
FF+CMC 4.5%	7.20±0.36^{a}	0.55±0.01^{a}	4.40±0.31^{c}	0.0030±0.001^{b}	54.91±5.51^{a}
FF+HPMC 1.5%	6.31±0.34^{b}	0.47±0.01^{e}	2.76±0.22^{f}	0.0014±0.001^{de}	52.73±4.45^{ab}
FF+HPMC 3.0%	7.21±0.35^{a}	0.55±0.01^{a}	2.83±0.15^{f}	0.0020±0.0002^{cde}	54.18±6.08^{ab}
FF+HPMC 4.5%	6.22±0.33^{b}	0.53±0.002^{b}	3.20±0.45^{e}	0.0016±0.001^{cde}	57.82±9.48^{a}

Remarks: Different letters in the same column indicate statistical differences ($p \leq 0.05$). RF, WF and FF were controls which were made of 100% rice flour, 100% wheat flour and formulated flour blend, respectively.

that also complied with increases in the water activity (a_w) of all hydrocolloid-added samples when comparing to rice-flour and formulated-flour controls. Control sample made of rice flour showed some roughness and cracks on its dry surface appearance as compared to hydrocolloid-added samples and other controls (Fig. 1a-1d). This result was expected because hydrocolloids is known to help increasing the water holding capacity of samples due to the chemical structure of hydrocolloids and their interaction with the food ingredients [1, 6].

According to the texture sample, rice-flour control was the most crumbly, least expansion and most brittle that cracked readily, where the rest of hydrocolloid-added FF samples and FF control were harder and tougher than WF (Table 1). This was due to the lack of gluten in rice flour since gluten is the most important structure forming protein [2, 3]. The FF control with wheat flour partially substitute had slightly harder and tougher texture with less expansion than WF. All cracker samples with hydrocolloids were puffier than RF, but only some of hydrocolloid-treated samples had higher puffiness than FF. This complied with texture result that addition of hydrocolloid helped improving texture of FF samples. Some hydrocolloid-treated samples, especially with 1.5% addition, showed reductions of the hardness and toughness to be closer to WF. This result agreed with other scientific reports that hydrocolloids help increasing water absorption and gas retention of dough so specific properties of baked products such as texture were improved [1, 2]. However, texture of samples adding hydrocolloids at 4.5% were too hard and too tough. This may be due to the fact that dough system becomes too rigid to incorporate gas [2], and xanthan is also reported to unexpectedly decrease the height of wheat-flour dough [6]. It is explained that the interaction between these hydrocolloids and protein in wheat flour may conversely limit the free expansion of wheat dough during proofing [6].

Effect of incorporating hydrocolloids on color of treated samples comparing to controls was presented in Table 2. According to the CIE value (L*, a*, b*), color rice-flour-substitute crackers with hydrocolloid addition were slightly darker than WF and FF controls with the color shade (hue angle) slightly more reddish-brown than yellow-brown as both controls. However, the color intensity (chroma) of hydrocolloid-treated samples was decreased to be closer to WF. Despite the color value measured by instrumental method, both FF crackers with- and without- hydrocolloids showed slight differences in color and surface appearance from WF as illustrated in Fig. 1.



(a)

(b)

(c)

(d)

Figure1. Effects of hydrocolloids on the surface appearance of mixed-flour blend rice crackers comparing (a) controls: 100% rice flour (RF), 100% wheat flour (WF) and formulated flour blend (FF) to samples with additions of (b) xanthan, (c) CMC, and (d) HPMC at various levels.

Table 2. Effect of hydrocolloids on color of mixed-flour blend rice crackers shown by values of L*, a*, b*, hue angle and chroma.

Samples	Colour parameter				
	L*	a*	b*	Hue angle	chroma
RF	60.63±0.07^{b}	3.39±1.45^{g}	29.04±0.55^{bcd}	83.45±2.70^{a}	29.24±0.71^{bcd}
WF	64.89±0.34^{a}	5.66±0.46^{f}	31.39±0.63^{ab}	79.78±0.81^{b}	31.89±0.34^{b}
FF	61.74±1.65^{b}	9.66±1.08^{de}	33.33±1.03^{a}	73.77±1.21^{c}	35.56±1.32^{a}
FF+xanthan 1.5%	51.09±1.74^{g}	9.70±1.74^{de}	28.57±2.08^{cde}	70.91±2.62^{d}	30.25±1.80^{bc}
FF+xanthan 3.0%	50.06±2.13^{g}	11.79±0.72^{a}	26.93±2.49^{cde}	66.23±2.30^{f}	29.42±2.29^{bcd}
FF+xanthan 4.5%	53.73±2.52^{f}	10.94±1.08^{bcd}	27.99±2.53^{cde}	70.64±3.19^{d}	29.68±2.19^{bcd}
FF+CMC 1.5%	54.49±2.28^{ef}	11.00±1.28^{abcd}	26.48±2.16^{de}	67.05±3.24^{ef}	28.72±2.23^{cd}
FF+CMC 3.0%	60.18±2.12^{bc}	11.69±1.18^{ab}	29.48±2.68^{bc}	68.25±2.81^{def}	31.75±2.50^{b}
FF+CMC 4.5%	58.00±1.33^{cd}	10.08±1.27^{cde}	28.10±2.12^{cde}	68.21±1.88^{def}	30.28±2.27^{bc}
FF+HPMC 1.5%	53.51±2.03^{f}	9.74±1.83^{de}	27.48±2.21^{cde}	68.36±2.83^{def}	29.61±2.48^{bcd}
FF+HPMC 3.0%	55.79±1.46^{def}	11.24±1.58^{abc}	26.75±2.37^{cde}	69.42±2.08^{de}	28.61±2.66^{cd}
FF+HPMC 4.5%	56.53±1.78^{de}	9.24±1.53^{e}	25.88±1.42^{e}	70.44±2.29^{d}	27.50±1.77^{d}

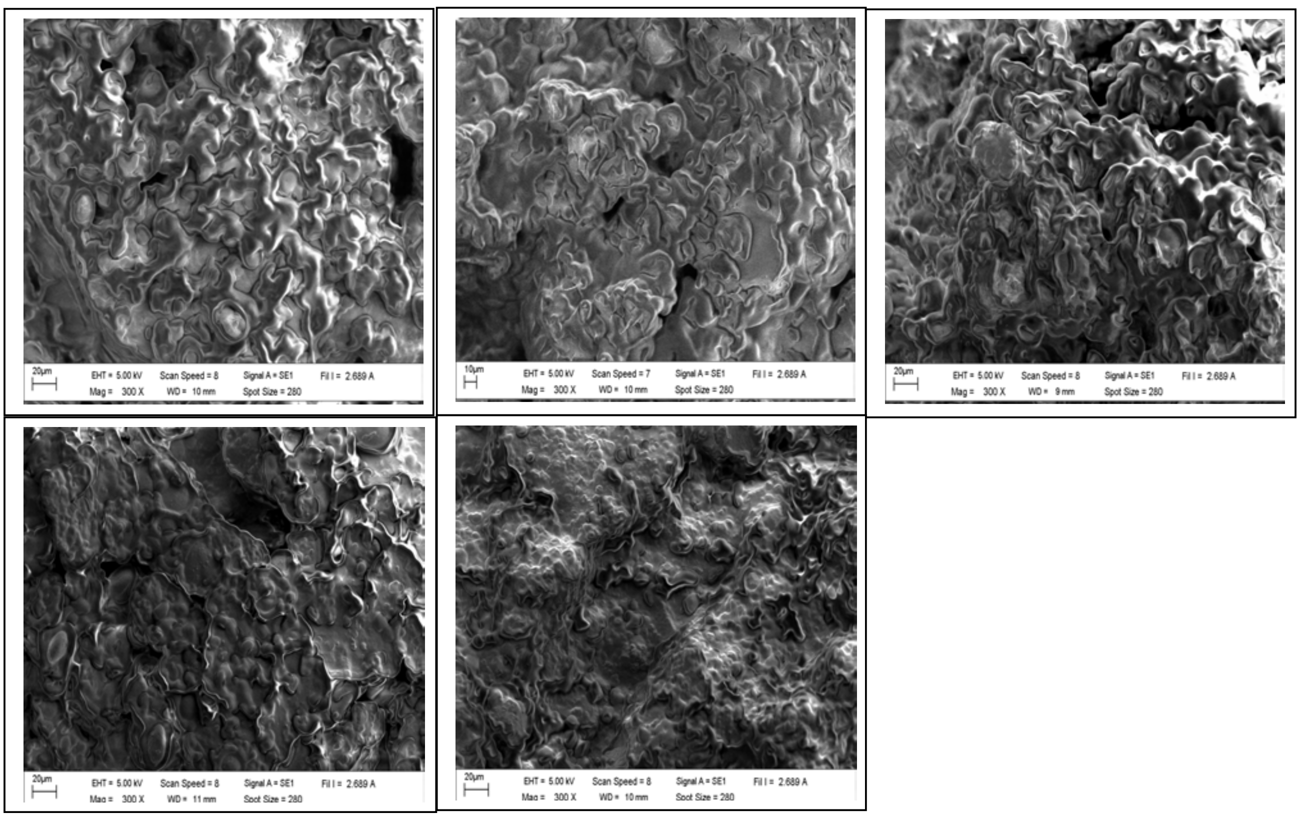


Figure 2. Dough microstructure (magnification 300x) of formulated rice crackers with 1.5% various hydrocolloid additions and controls. (a)-(e) were xanthan (XN), carboxymethylcellulose (CMC), hydroxymethylpropylcellulose (HPMC), 100% wheat flour (WF) and 100% rice flour (RF) controls, respectively.

Effect of hydrocolloid addition on dough microstructure

Fig.2 (a)-(e) represented the comparison of dough microstructure from those of WF and RF controls and 1.5%-hydrocolloid-added samples. Only dough microstructure of FF samples with 1.5% hydrocolloids were shown because their hardness and toughness were closer to WF. It was visible in all samples (Fig.2a-2d) except RF (Fig. 2e) that starch granules were embedded in the matrix. In WF or positive control, the starch granules clearly appeared to be wrapped by protein matrix (Fig. 2d), which corresponded to its being the highest puffiness shown in table 1. This is because gluten, as an essential structure-building protein, contributes to qualities of bakery products [1, 4, 8]. As for rice flour crackers (RF), starch granules were seen but dough structure was indistinguishable (Fig. 2e) due to the fact that rice flour is widely known as lacking gluten. Therefore, dough structural formulation is primarily due to starch gelatinization which ultimately results in many large pores in dough [7] and final product with brittle structure and cracks on product surface [2, 7]. This complied with the noticeably dry surface appearance and cracks in RF control illustrated in Fig. 1 (a) although pores in rice dough in this study were not as clearly visible as shown by [7] due to the limitation of an instrument.

Conclusions

Addition of hydrocolloids helped retaining moisture and gas-retention in dough so the physical and chemical qualities of rice crackers made of mixed flour blends were improved. The final products of hydrocolloid-added samples from formulated flour were less brittle, more puffy and softer with more moisture than both of non-hydrocolloid-added controls from rice flour and mixed flour blends. A selection of hydrocolloid types and its usage amount is crucial for improving product qualities. In this study, adding HPMC and CMC at 1.5% may help improve texture and color of rice crackers from mixed flour blends to be closer to wheat crackers.

Acknowledgements

Financial support from the Thailand Research Fund for TRF-Master Research Grants (MRG-WI055S077) and the 2009 Thailand Toray Science Foundation Grants are gratefully acknowledged. The authors were deeply thankful for the in-kind support from Sin Salee Snack & Biscuit Ltd., Part. Bangkok, Thailand and Faculty of Agriculture, Natural Resources and Environment, Naresuan University, Pitsanuloke, Thailand.

References

1. Lazaridou A., Duta D., Papageorgiou M., Belc N and Biliaderis C.G. 2007. Effects of hydrocolloids on dough rheology and bread quality parameters in gluten-free formulations. **Journal of Food Engineering**, 79, 1033-1047.

2. Sivaramakrishnan H.P., Senge B. and Chattopadhyay P.K. (2004). Rheological properties of rice dough for making rice bread. **Journal of Food Engineering**, 62, 37-45.

3. Ashwini A., Jyotsna R. and Indrani D. (2009). Effect of hydrocolloids and emulsifiers on the rheological, microstructural and quality characteristics of eggless cake. **Food Hydrocolloids**, 23, 700-707.

4. Rosell, C.M., Barcenas, M.E. 2005. Effect of HPMC addition on the microstructure, quality and aging of wheat bread. **Food Hydrocolloids**, 19, 1037-1043.

5. Therdthai N., Zhou W. and Jangchud K. (2007). Modeling of the relative humidity and temperature on proving rate of rice-flour-based dough. **Lebensmittel-Wissenschaft und-Technologie**, 40, 1036-1040.

6. Rosell C. M., Rojas A. J. and Benedito de Barber C. (2001). Influence of hydrocolloids on dough rheology and bread quality. **Journal of Food Hydrocolloids**, 15, 75-81.

7. Koh, W.L., Kasapis, S., Lim, M.K. and Foo, W.C. (2009). Structural enhancement leading to retardation of in vitro digestion of dough in the presence of alginate. **Food Hydrocolloids**, 23, 1458-1464.

8. Aibara, S., Ogawa, N. and Hirose, M. (2005). Microstructures of bread dough and the effects of shortening on frozen dough. **Bioscience Biotechnology Biochemistry**, 69(2), 397-402.