การศึกษาเปรียบเทียบคุกกี้เนยลดไขมันที่มีไฮโดรคอลลอยด์ประเภทต่าง ๆ ต่อคุณสมบัติทางกายภาพและการประเมินทางประสาทสัมผัส

A Comparative Study of a Reduced-Fat Butter Cookie Containing Different Hydrocolloid Types on Physical Properties and Sensory Evaluation

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สาขาศึกษาทั่วไป คณะศิลปศาสตร์ มหาวิทยาลัยเทคโนโลยีราชมงคลรัตนโกสินทร์

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บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อศึกษาสมบัติวิทยากระแสของโดในขณะที่ให้ความร้อนในเตาอบ คุณสมบัติทางกายภาพและการประเมินทางประสาทสัมผัสของผู้บริโภคของคุกกี้เนยโดยแทนที่เนยด้วยไฮโดรคอลลอยด์ชนิดต่าง ๆ ดังนี้คือ กัวกัม แซนแทนกัม เบต้ากลูแคน และกัมอาราบิก รวมถึงตรวจสอบหน้าที่ในการใช้เป็นสารทดแทนไขมันในคุกกี้เนยที่ระดับความเข้มข้นแตกต่างกันโดยลดปริมาณเนยที่ใช้ลงตั้งแต่ 20% ถึง 50% การทดแทนเนยด้วยกัวกัมและเบต้ากลูแคนพบว่ามีคุณสมบัติทางกายภาพรวมถึงการยอมรับของผู้บริโภคดีกว่าแซนแทนกัมและกัมอาราบิก การวิเคราะห์ทางประสาทสัมผัสของคุกกี้เนยลดไขมันแสดงให้เห็นว่าการแทนที่เนยบางส่วนด้วยกัวกัมและเบต้ากลูแคนช่วยให้ผู้บริโภคยอมรับที่ระดับความเข้มข้น 50% ของปริมาณเนย

คำสำคัญ : คุกกี้เนย, ไฮโดรคอลลอยด์, สมบัติวิทยากระแสของโด, คุณสมบัติทางกายภาพ

Abstract

The objectives of this research are to study the current property of the dough while heated in the oven. Physical properties and sensory evaluation of butter cookies replacing butter with the following types of hydrocolloids: guar gum, xanthan gum, beta-glucan, and gum arabic. To examine the function of using as a fat substitute in butter cookies at different concentrations, the amount of used butter was reduced from 20% to 50%. Substitution of guar gum and beta-glucan found that the physical properties and consumer acceptance were better than xanthan gum and gum arabic. Sensory analysis of fat-reducing butter cookies shows that replacing some butter with guar gum and beta-glucan can be used up to 50% of butter without any effect on consumer's acceptability.

Keywords : butter cookie, hydrocolloids, dough's viscoelastic behavior, physical properties

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Introduction

Butter cookies were delicious food and popular for people in many festivals. The main butter cookie ingredient of butter cookies was a high amount of butter used (more than 20%) in recipes. Nowadays, there are some serious ingredient problems especially margarine, which was high in saturated fatty acids and *trans* fats and mono-and polyunsaturated fatty acid-enriched butter because both butter and margarine caused obesity, heart disease, high blood pressure, and other diseases including significant rise in the total serum cholesterol, and low-density lipoprotein (LDL)-cholesterol (Wood *et al*., 1993). Moreover, eating high fats content in foods caused high blood cholesterol in people taking some metabolic syndrome that made high bad cholesterol in the blood easily (Grundy, 2006). Dyslipidemia was a disease with blood lipid levels are higher than the prescribed values in type 2 diabetic patients which elevated triglyceride levels and decreased HDL cholesterol levels (Association, 2002). So people stay healthy as well as those who suffered from the disease have to avoid foods that were containing high saturated fatty acids and cholesterol.

Hydrocolloids have good functional attributes such as thickeners, gelling agents, emulsifiers, stabilizers, fat replacers, clarifying agents, flocculating agents, clouding agents, and whipping agents (Li & Nie, 2016), and used in small amounts in the recipe. Addition hydrocolloids in food as a fat replacement was the best approach to improve health through dietary fiber increase, reduction of calorie diet, digestive system improvements and prebiotic activity (Mudgil & Barak, 2013). Hydrocolloids were derived or extracted from plant exudates (gum arabic, tragacanth, karaya), seeds (guar and locust bean gum), microorganism (xanthan gum, beta-glucan), seaweed extracts (agar, carrageenan and alginates) and some chemical modification (methyl cellulose, hydroxy propyl cellulose, hydroxy propyl methyl cellulose, methyl ethyl cellulose and carboxy methyl cellulose). Moreover, beta-glucan was extracted from high plants cell walls constituents which presented in cereal seeds with higher amount (barley, oat, rye, wheat, etc.), in mushrooms (*Pleurotus ostreatus*, *Ganoderma lucidum*, *Lentinula edodes*, *Grifola frondosa*), in bakery yeast cell walls (*Saccharomyces cerevisiae*), in seaweed and in bacteria (Mikuš *et al*., 2014). They were reported that barley beta-glucan decreased evidence of cardiovascular and diabetes risk (Pins & Kaur, 2006), lowering cholesterol in the blood with oat bran cereal containing beta-glucan (Karmally *et al*., 2005), immune-modulating by protect against infection, cancer and newly for therapeutic potential combined with cancer therapy (Murphy *et al*., 2010). Moreover, yeast-derived β-glucan isolated from *Saccharomyces cerevisiae* improved immune defense system in human clinical trials (Stier *et al*., 2014).

Cookies were a baked product which was commonly consisted of three major components, flour, sugar, the fat and low final amount of water, for instance. These ingredients were mixed together with other minor components to form a dough (Baltsavias *et al*., 1999). In case of reducing-fat in butter cookie, hydrocolloids were one thing that people will add to the cookie dough with used less technique and machine used. It was not used the techniques of emulsion filled gel because no reduction of fat using oils like other systems. There was report about fat replacement in shortbread cookies using an emulsion filled gel based on inulin and extra virgin olive oil (Giarnetti *et al*., 2015). Therefore, it was the only addition of hydrocolloids in the system. It is reported that CMC (Carboxy Methyl Cellulose) in cookies made with buckwheat flour had been found to help in handling and less cracked the cookie surface (Hadnađev *et al*., 2013). In general, the characteristics of a high-quality butter cookie was the adequate hardness but able to fracture when chewed in the mouth, a high spread ratio (diameter/thickness), yellow color, attractive appearance (no cracked on the surface), pleasant flavor and long shelf life. Due to lower water content, cookie dough was generally more elastic-dominant behavior and less extensible in comparison to bread dough. Since cookie dough rheology characterization during heat was related to dough handling during shaping and texture, it was a very important parameter in cookie quality evaluation.

Surprisingly, especially in view of current interest in reduced-fat butter cookies with hydrocolloids, rheological behavior especially thermomechanical profile of cookies dough as a function of the temperature of cookie doughs has been largely ignored. There is report about hydrocolloidal fiber composite made from rice bran can be used as fat reduced in a cookie base on the oscillatory shear (Inglett *et al*., 2004). Basically, during baking, the heat did not stir up the cookie so much until change the shape, but there was a spread of the cookie. When the cookies start to ripen and most of the water has evaporated, the cookies begin to set and start to stop dispersing. Thus, cookie doughs were studied by viscoelastic properties to compare elastic-dominant behavior and viscous-dominant behavior of dough during heat as in the oven with low frequency in the range of linear viscosity range. So that the aim of this work was to study the rheological behavior of cookie doughs and followed by physical properties and sensory evaluation in reduced-fat butter cookie by hydrocolloids: beta-glucan, guar gum, xanthan gum and gum arabic. Finally, the results are discussed in view of rheological behavior compared with physical properties and sensory evaluation.

Methods

1. *Materials*

Beta-glucan (innovacan™: purified yeast cell wall 1,3/1,6-beta glucan) was purchased from Specialty Natural Products (Chonburi, Thailand). Guar gum, xanthan gum and gum arabic were obtained from CHEMIPAN (Bangkok, Thailand). Commercial wheat flour and sodium bicarbonate ($NaHCO_3$) obtained from the local market was used for the studies. Butter (blends unsalted) was obtained from Thai Dairy Industry (Ayuthaya, Thailand) while salt, granulated sugar, and vanilla were purchased from a local market. All reagents were purchased from Sigma Aldrich unless otherwise stated.

2. *Cookies preparation*

Replacement of butter with various hydrocolloids namely, guar gum, xanthan gum, gum arabic and beta-glucan containing 0.5%, 0.6%, 0.7%, 0.8% was substituted for 20%, 30%, 40%, and 50% of the butter by weight, respectively (Table 1). The concentration of gums should not be used more than 1% made the cookies too hard. The ingredients were mixed together using the KM240 stand mixer (KENWOOD, China). Control cookie sample using wheat flour with and without hydrocolloids were prepared in different proportions (Table 1) as a description in many reports especially butter content (Chauhan *et al*., 2015). Briefly, hydrocolloids (guar gum, xanthan gum, gum arabic and beta-glucan) were mixed with a distilled water until totally disperse and then mixed with butter in a stand mixer (KENWOOD, China) for 2 min. Subsequently, the powdered sugar was mixed for 3 min, then the powdered material (sodium bicarbonate, salt, and vanilla) dissolved in distilled water and was added for mixing in 1 min. Consequently, the sieved wheat flour was added and mixing continued for 15 min. After mixing, the dough samples were stored in the refrigerator for 24 h at 8 °C in order to hydration fully with added hydrocolloids (Hadnađev *et al*., 2013). For the limited water content in a cookie, there have reported about the amount of enough water from farinograph characteristics of the wheat flour-bran blends (Sudha *et al*., 2007). Next, the dough rested to room temperature and was processed by sheeting to a thickness of 0.7 cm. Consequently, the dough was cut using a stainless mold and cookie dough was baked for 12 min at 170 °C in a commercial electrical oven followed by cooling for 2 h and packaging in a high-density polyethylene bag.

Table 1 Ingredients of cookie dough with different amounts of fat

	Percentage of hydrocolloids substituted for butter in butter cookies				
Ingredients (grams)	control	20%	30%	40%	50%
Wheat Flour	112.5	112.5	112.5	112.5	112.5
Sodium bicarbonate	1.3	1.3	1.3	1.3	1.3
Salt	1.1	1.1	1.1	1.1	1.1
Butter	57.5	46	40.3	34.5	28.8
Sugar	50	50	50	50	50
Vanilla	1.9	1.9	1.9	1.9	1.9
gums	0	0.5	0.6	0.7	0.8
water	25	36	41.7	47.3	53.0

3. *Viscoelastic behavior*

The fresh cookie doughs were used for dynamic oscillatory rheological measurement by a stress-controlled rheometer (Physica MCR 301, Anton Paar GmbH, Ostfildern, Germany) with parallel-plate geometry using a cover to prevent evaporation at high temperature. The linear viscoelastic regime was established for each sample by a deformation sweep at a constant frequency (10 rad/s) to determine the maximum deformation attainable between 0.01 and 100 % strain at 25°C and at 80°C. The temperature sweeps at a constant deformation (0.03% strain) and 10 rad/s within the linear viscoelastic range were used in the rheological analysis. The temperature sweep tests were performed from 50 to 180°C with a heating rate of 18°C min^{-1}. Elastic modulus (G'), loss or viscous modulus (G") and tan δ as a function of temperature were recorded and checked for reproducibility for each experiment. G' is the elastic modulus, related to the material response as a solid. G" is the dynamic viscous or loss modulus, related to the material response as a fluid. The loss modulus/storage modulus (tan δ) was calculated using the loss modulus divided by the storage modulus. Each measurement was carried out in triplicate.

4. *Physical methods*

4.1 Physical characteristics

The physical characteristics of cookies such as diameter, thickness, spread ratio, and hardness were evaluated (Zoulias *et al*., 2000). Cookie break strength was measured by a texture analyzer (TA.XT-Plus, Stable Micro System, UK) in penetration mode with a cylinder of 2 mm diameter probe plunged 3 mm at 2 mm/s equipped with a 5 kg load cell which used to perform texture profile analysis. All experiments were conducted in a controlled temperature room at 25 °C. The compression depth was held constant at 3 mm in all samples. The instrument automatically recorded the force-time curve. The resistance to penetration was measured by the maximum force showed on the texture analysis which corresponds to the hardness value (Bourne, 1978). Texture analysis was conducted after 24 h, at 25 °C. Five to six replicates were conducted in all samples.

4.2 Water activity

The water activity of cookies was measured using a water activity meter (AquaLab, Model 3TE, Decagon Devices Inc., Pullman, WA). Each measurement was carried out in triplicate.

4.3 Peroxide value

Cookies were storage up to 30 days in high-density polyethylene at ambient conditions. Peroxide value was determined by using conventional iodometric titration with thiosulfate (AACC, 2000). Each measurement was carried out in triplicate.

4.4 Color measurement

The colors of the wheat flour-hydrocolloids composite cookies were evaluated by using Hunter colorimeter Model D 25 optical Sensor (Hunter Associates Laboratory Inc., Reston, VA., U.S.A). The color of samples was recorded in L^*, a^* and b^* parameters which L^* defines lightness, a^* defines redness to greenness and b^* denote yellowness to blueness (CIE International Commission on Illumination & Colorimetry). Each measurement was carried out in triplicate.

5. *Sensory evaluation of cookies*

The organoleptic properties of the reduced-fat butter cookies such as the color, taste, texture, and overall acceptance were evaluated by a total of 50 semi-trained for sensory attributes and 100 untrained panelists for overall acceptability. A large number of untrained panelists was used to determine preference before becoming a new product in the market to cover the lashings of consumers. In the case of untrained panelists, the number of women and men who participated in this test were 50 and 50, respectively. Results obtained by untrained panelists were usually less precise and replicable than those obtained by trained panelists. This research used semi-trained panelists to taste cookies with varying concentrations of butter, color, and texture in order to distinguish the results clearly. For semi-trained panelists, the number of women and men who participated in this test were 25 and 25, respectively. The panelists were instructed to rinse their mouth thoroughly with potable water to cleanse the mouth between samples. The samples were evaluated based on the 9-point hedonic scale with 1 representing the least score (dislike extremely) and 9 representing as the highest score (like extremely).

6. *Statistical analysis*

Data were analyzed by one-way analysis of variance with Tukey's test. The significance of differences between the mean values was indicated at the 95% confidence level.

Results

Effect of hydrocolloids on rheological properties of cookie dough

According to the thermomechanical properties of cookie doughs with and without hydrocolloids, namely guar gum, xanthan gum, gum arabic, and beta-glucan, were studied between 50 °C and 176 °C. The loss tangent or tan δ (the ratio of G''/G') is used to check properties of dough rheology and characteristics. Herein, these values were used to separate the elastic-dominant behavior and viscous-dominant behavior of dough. Improvement of the viscoelastic properties of dough by incorporation of hydrocolloid in the dough was expected due to increased viscoelastic properties of polysaccharides in limited water content (cookie dough). Beta-glucan exhibited the lowest loss tangent values among the added hydrocolloids and control (Figure 1). Moreover, beta-glucan showed the most enhanced elastic properties by observing the rapid increase in loss tangent value when increasing the temperature near 100 °C in a similar way as to control sample.

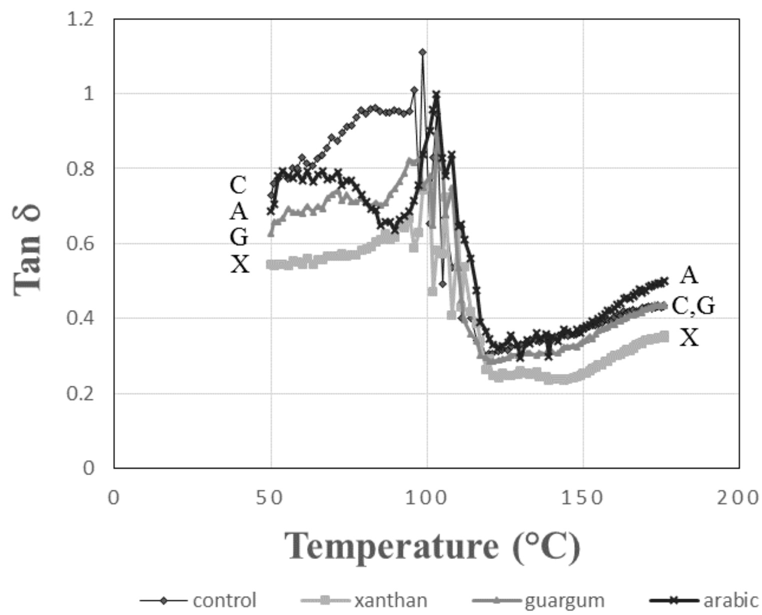

Figure 1 Thermomechanical profile of cookies dough as a function of the temperature described by mean of tan δ values of cookies dough with full-fat butter, control (C). Samples were prepared by reducing the amount of butter, 40% using guar gum (G), 40% using xanthan gum (X), 40% using gum arabic (A), and 40% using beta-glucan (B). The tan δ values are expressed as mean.

Effect of hydrocolloids on physical properties of cookie

Gum arabic exhibited the highest diameter value and spread ratio among added hydrocolloids followed by beta-glucan, guar gum and xanthan gum, respectively (Table 2). Gum arabic had a high viscoelastic property, however, the spread ratio was higher than that of other gums. The presence of gum arabic in cookie dough which was difficultly cohesive for shaping. Therefore, the dough with gum arabic substitution, which was shaped with rolling pin or cookie press by resulted in cookies with irregular shape than other cookies with hydrocolloids. After being taken out of the oven, gum arabic makes cookies more dispersion than other types of gum. So that reduced-fat cookie with gum arabic was difficult to control a shape of the cookie during the process.

Table 2 Physical characteristics, water activity and peroxide value of cookies containing different hydrocolloids were at a condition of 40% fat reduction.

Parameters	Control	Guar gum	Xanthan gum	Gum arabic	beta-Glucan
Diameter (cm)	4.08 ± 0.08^{a}	3.93 ± 0.29^{a}	3.93 ± 0.58^{a}	4.40 ± 0.17^{b}	3.95 ± 0.07^{a}
Thickness (cm)	0.73 ± 0.03^{a}	0.95 ± 0.00^{b}	0.97 ± 0.06^{b}	0.80 ± 0.00^{a}	0.74 ± 0.02^{a}
Spread ratio	5.22 ± 0.28^{a}	4.14 ± 0.03^{b}	4.00 ± 0.10^{b}	5.50 ± 0.21^{a}	5.24 ± 0.26^{a}
Hardness (N)	10.83 ± 0.90^{a}	11.77 ± 0.49^{a}	13.11 ± 2.05^{a}	21.81 ± 1.14^{b}	10.93 ± 0.80^{a}
Water activity	0.43 ± 0.01^{d}	0.66 ± 0.01^{b}	0.68 ± 0.01^{a}	0.55 ± 0.01^{c}	0.56 ± 0.01^{b}
Peroxide value (mEq/kg)	1.96 ± 0.49^{c}	1.78 ± 0.48^{c}	12.87 ± 0.49^{a}	9.31 ± 0.46^{b}	1.66 ± 0.44^{c}

Values are expressed as mean ± standard deviations (n = 4); values in the same row followed by different letters are significantly different (p<0.05). *Control: Control cookies prepared by wheat flour without hydrocolloids.

Reduced-fat cookies with hydrocolloids prepared in this study had higher water activity than control, but these values are lower than the critical point that affect cookie storage. The peroxide value can be used for determining the onset of rancidity in mayonnaise (Wills & Cheong, 1979). During 90 days at 25 °C, there was no change dramatically in peroxide value (data not showed). From the results of peroxide value after 1 month, xanthan gum and gum arabic shown high value when compared with other gums. It made the butter cookies not suitable for fat reduction because it kept less shelf life. Xanthan gum and gum Arabic did not help the rancidity of cookies due to a lot of pore at the surface of the cookie caused oxidative rancidity during storage. However, the peroxide values attained in our hydrocolloids as compared to cookies with and without flaxseed (Rajiv *et al*., 2012) makes it an interesting because of low peroxide value except for xanthan gum.

Based on analysis of L^* value of all formulas, the values were similar. However, the b^* value showed that the yellow to blue color of the cookies with the substitution of fat by hydrocolloids was significantly reduced (p< 0.05) due to a low amount of butter except beta-glucan (Table 3).

Table 3 Color parameters of cookies containing different hydrocolloids were at a condition of 40% fat reduction.

Parameters	Control*	Guar gum	Xanthan gum	Gum arabic	Beta-glucan
L^*	48.37 ± 0.49^{a}	51.51 ± 0.38^{a}	49.20 ± 0.36^{a}	48.23 ± 0.26^{a}	50.23 ± 0.34^{a}
a^*	5.98 ± 0.03^{a}	4.38 ± 0.10^{b}	5.50 ± 0.27^{a}	5.23 ± 0.25^{a}	4.55 ± 0.09^{b}
b^*	25.63 ± 0.19^{b}	22.03 ± 0.05^{c}	22.49 ± 0.14^{c}	24.62 ± 0.20^{b}	28.23 ± 0.23^{a}

L^*: Light to dark; a^*: red to green; b^*: yellow to blue

*Control: Control cookies prepared by wheat flour without hydrocolloids. Values (mean ± standard deviations; n = 3) in the same row followed by different letters are significantly different (p<0.05).

Effect of hydrocolloids on surface characteristics of cookie

Surface characteristics of cookies are also an important quality parameter (Figure 2). Incorporation of hydrocolloids up to 40 percent fat reduction increased pore area and surface cracks especially xanthan gum and gum arabic however, guar gum and beta-glucan decreased the number of surface cracks when compared with other hydrocolloids and control. Therefore, beta-glucan improved the surface characteristic by decrease the pore of the surface until no large pore present and did not have any surface creaking pattern. There have been reported that the surface characteristic of butter cookies partially replaced with beta-glucan can reduce the cracking of the cookie surface (Chaisawang *et al*., 2019).

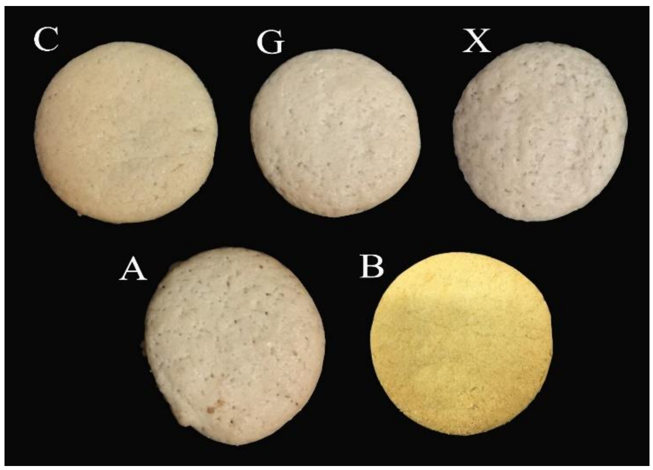

Figure 2 Effect of different types of hydrocolloids on the shape and top surface appearance prepared

with full fat content (C), reduced 40% using guar gum (G), reduced 40% using xanthan gum (X), reduced 40% using gum arabic (A), and reduced 40% using beta-glucan (B).

Sensory Evaluation

Sensory properties of food products play an important role in consumer acceptance. Therefore, our goal is not only to improve the functionality of cookies, but also to produce acceptable cookies from sensory evaluations in reduced fat butter cookies. Sensory evaluation of fat substitution using hydrocolloids in butter cookies is shown in Table 4. For overall acceptance, results from non-trained testers tend to be less accurate and less replicable (Arifin *et al*., 2010). In fact, the judging of non-trained testers is extremely valuable before launching a new fat reduction cookie into the market. Sensory evaluation results showed that color, texture and overall acceptance were affected. On the other hand, when hydrocolloid addition exceeded 50% when compared to the control sample, a significant reduction of the characteristics of cookies.

The butter flavor in butter cookies was very important to consumer preferences and acceptance of butter cookies. Gum arabic and xanthan gum were not good for the surface because it was difficult to bite, which was a comment from consumers. When the replacement level increases from 30% to 50%, the cookies become a harder and lower surface score. These results were consistent with the results specified in Table 2 for overall acceptance. The score was reduced when increasing the number of hydrocolloids in cookies. However, the tendency of overall acceptance in beta-glucan and guar gum had slowly decreased compared to gum arabic and xanthan gum.

Table 4 Sensory attributes and consumer acceptability of butter cookies

Samples*	Parameters				
	Surface appearance	Colour	Butter flavor	Texture	Overall acceptance
Control	7.72 ± 0.07^{a}	7.60 ± 0.10^{a}	7.50 ± 0.10^{a}	7.44 ± 0.10^{a}	7.63 ± 0.22^{a}
G30	7.34 ± 0.04^{b}	7.01 ± 0.04^{c}	7.10 ± 0.10^{b}	7.21 ± 0.07^{a}	6.13 ± 0.10^{b}
G40	6.22 ± 0.07^{b}	6.04 ± 0.06^{c}	6.75 ± 0.05^{c}	6.77 ± 0.08^{b}	5.80 ± 0.06^{c}
G50	5.11 ± 0.12^{b}	5.01 ± 0.07^{c}	5.43 ± 0.30^{d}	6.42 ± 0.09^{c}	4.04 ± 0.14^{d}
X30	5.78 ± 0.14^{d}	6.35 ± 0.20^{d}	7.23 ± 0.30^{b}	6.18 ± 0.13^{a}	6.13 ± 0.17^{b}
X40	4.65 ± 0.16^{d}	5.36 ± 0.10^{d}	5.70 ± 0.10^{d}	5.67 ± 0.25^{b}	5.28 ± 0.09^{d}
X50	3.22 ± 0.23^{d}	4.33 ± 0.12^{d}	5.35 ± 0.05^{e}	6.24 ± 0.18^{c}	3.70 ± 0.14^{e}
A30	6.55 ± 0.25^{c}	6.37 ± 0.14^{b}	7.26 ± 0.30^{b}	6.38 ± 0.19^{c}	5.10 ± 0.20^{b}
A40	5.33 ± 0.17^{c}	5.23 ± 0.15^{b}	6.65 ± 0.22^{c}	3.79 ± 0.18^{d}	4.60 ± 0.14^{c}
A50	4.34 ± 0.12^{c}	4.11 ± 0.12^{b}	5.14 ± 0.17^{e}	2.12 ± 0.19^{e}	3.18 ± 0.09^{e}
B30	7.71 ± 0.16^{b}	7.52 ± 0.06^{c}	7.08 ± 0.12^{b}	7.13 ± 0.17^{a}	7.22 ± 0.07^{b}
B40	6.63 ± 0.12^{b}	7.21 ± 0.08^{c}	6.81 ± 0.23^{c}	6.62 ± 0.13^{b}	6.04 ± 0.07^{b}
B50	6.24 ± 0.13^{b}	6.28 ± 0.05^{c}	5.55 ± 0.25^{d}	5.54 ± 0.12^{c}	5.28 ± 0.09^{d}

Value are mean ± standard deviation. Mean with different superscript letters within the same column differ significantly (p<0.05). [*]Control: Butter Cookies control recipes were prepared using butter but without hydrocolloid.; G30, G40 and G50: Cookies were compensated with 30%, 40%, and 50% substituting guar gum for butter.; X30, X40 and X50: Cookies were compensated with 30%, 40%, and 50% substituting xanthan gum for butter.; A30, A40 and A50: Cookies were compensated with 30%, 40%, and 50% substituting gum arabic for butter; B30, B40 and B50: Cookies were compensated with 30%, 40% and 50% substituting beta-glucan for butter.

Discussion

From the results of dough's viscoelastic properties, some researchers demonstrated that the addition of barley beta-glucan to bread dough resulted in a resistance to the extension of dough (Brennan & Cleary, 2007). In our results, the rheograms showed that loss tangent of gum arabic was higher than guar gum, xanthan gum, and beta-glucan, respectively in the range of temperature between 50 °C and 70 °C. Dough with gum arabic incorporation compared with other gums was found to be more sticky and difficult to a sheet. This is why the loss tangent value of the gum arabic was higher than other gums resulted in hard cookies. Surprisingly, after 100 °C, the loss tangent values of added hydrocolloids were decreased and become closed together especially guar gum, beta-glucan, and control sample. Gum arabic resulted in a significant increase in the loss tangent rather than other gums due to an extended conformational structure of the molecules, gum arabic could reinforce a three-dimensional network of cookie dispersion better than beta-glucan, guar gum and xanthan gum. However, there were some reports, xanthan gum could reinforce a three dimensional network structure of the starch pastes better than guar did (Ross-Murphy, 1995) and also found in wheat flour system (Rojas *et al*., 1999). However, it was reported that xanthan gum can cover the starch granule throughout during heating (Chaisawang & Suphantharika, 2006). This may explain that the amylose released from the starch granule was low, resulting in a less dense three-dimensional structure compared with other gums. Moreover, results of gluten-hydrocolloids interaction obtained for dough with guar gum would state good compatibility between guar gum and the gluten network good than xanthan gum (Linlaud *et al*., 2010). During 170 to 175 °C, xanthan gum and gum arabic were out of range when compared with control. Between 140 to 150 °C, however, xanthan gum was not closed to the control and other gums. Therefore, the type of gums added to the cookie dough influenced the viscoelastic properties during heating by increasing viscous of cookie dough. It can imply that temperature used in the oven influenced to the viscoelastic properties of cookie dough. In case of setting the oven temperature to 170 °C, in fact, an inside cookie was less temperature, so at 150 °C was an appropriate temperature for comparison of elastic-dominant behavior of the cookie during measured by rheometer. For this result, the loss tangent values from rheometer corresponded to the hardness value from texture analyzer shown below (Table 2). It means that the rheological property of cookie dough can predict the quality of cookies in the final product.

In the case of beta-glucan, the size of the cookie slots does not need to recalculate because the distribution values did not differ significantly. It can be implied that fat reduction using beta-glucan has no effect on the distribution of cookies. For thickness, cookies containing guar gum and xanthan gum had relatively higher thickness value and was significantly increased at 33 percent. The height of the cookie was useful due to reducing costs in the cookie making the process.

Regarding the hardness of cookies, we have found a significant increase in the cookie with gum arabic incorporation. In the previous study, the hardness values of cookies increased in addition to hydroxypropyl methylcellulose with okara starch (Park *et al*., 2015). In our formulation, the cohesiveness decreased from 0.005 for control to less than 0.001 so that we did not show cohesiveness and other values calculated form hardness value. According to some report, the enrichment of dough by fibers affects the texture properties especially increase in hardness and decrease in the cohesiveness of bread dough (Collar *et al*., 2007). It can be implied that the addition of gum arabic was not recommended because of the adverse effect on texture properties, particularly in increasing hardness. However, xanthan gum, guar gum, and beta-glucan were not affected by the hardness value when compared to gum arabic. Gum arabic may interact with other components especially starch and butter in our formulation causing an increase in texture more than other gums. In contrast, some studies reported that xanthan and guar gum in cookies were inappropriate for obtaining the desired shape of the flattened product (Devisetti *et al*., 2015).

The color of the cookie with xanthan gum had a low score (b^*: yellow to blue) compared to other hydrocolloids and was related to the color measurement results (Table 3). This was the reason why panelists gave a high rating on a cookie recipe from the sensory evaluation which was appropriated yellow rather than dark yellow or light yellow (color measurement). There were previous similar observations (Duta & Culetu, 2015) in which the high level of beta-glucan substitution in oat seeds results in higher acceptance of the panelists regarding the color characteristics. Xanthan gum and gum arabic had a low score in the flavor of butter and was greatly reduced when reducing the amount of butter. Such gum may interfere with the favor of cookies which was correlated to the amount of pore on the surface of cookies. However, gum arabic was able to preserve flavor when compared to guar gum because the gum arabic still tastes in the encapsulation system (Shiga *et al*., 2001), so why do panelists give the rating of gum arabic higher than xanthan gum. As a result, it can be indicated that beta-glucan and guar gum can maintain the flavor of butter after baking.

Addition of a sufficient amount of hydrocolloid, the water activity (Aw) increased because the hydrocolloid acts to hold water and evaporate during heated in the oven but not as much as the control formula without hydrocolloid. High water activity caused a shorter shelf life due to food spoiling, namely, osmophilic yeasts (Aw = 0.70) and xerophilic Mold (Aw = 0.65). In all formulations, the water activity was less than 0.69 so that most mold will not grow (Troller & Christian, 1978). As it was already shown, the addition of beta-glucan may decrease the shelf life of the product than guar gum.

From the results, beta-glucan and guar gum are good for consumers in terms of overall acceptance when compared to gum arabic and xanthan gum. This study showed the potential for the use of hydrocolloids in the development of reduced-fat in butter cookies. The aim of the development of a product that reduces butter is to substitute butter that uses beta-glucan and guar gum, which was more acceptable to consumers than filling with gum arabic and guar gum. Butter cookies have a good surface, butter smell, and yellow color were significantly acceptable by consumers. For this study, butter cookies made from fat-reducing cookies by beta-glucan and guar gum were accepted up to 50%, based on the sensory characteristics. Therefore, beta-glucan and guar gum can be used to replace butter in reduced-fat butter cookies better then xanthan gum and gum arabic. This research can encourage industrial and SME (Small and Medium Enterprises) to develop fat reduction cookies for consumers interested in health.

Conclusion

The substitution of beta-glucan in low-fat butter cookie dough resulted in elastic-dominant behavior, easy to handle and strong enough to resist sheeting, acceptable yellow color, and maintain satisfactory shape looks similar to a control recipe. Panelist rated that reduced-fat cookie prepared with beta-glucan with the highest quality followed by guar gum whereas cookies prepared from xanthan gum and gum arabic had a lowest sensorial score both of sensory attributes and consumer acceptability. Fat substitution with hydrocolloid was found to reduce fat content up to 50% and acceptance from the consumer using beta-glucan and guar gum. Some of the hydrocolloids, gum arabic and xanthan gum have not been accepted by consumers because of their surface appearance, color, butter flavor, texture and physical characteristics such as peroxide and spread values. Fat-reduced cookies with beta-glucan and guar gum can be commercially available and was a fat-reducing cookie for people who require low-fat foods better than xanthan and gum arabic.

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