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Effects of hydrocolloid addition on the quality of cookies substituted wheat flour with sinin rice flour

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Abstract The effects of hydrocolloid addition on physical properties and organoleptic properties of wheat flour cookies substituted with Sinin rice flour were investigated. Hydrocolloids were added in cookies substituted wheat flour with Sinin rice flour (xanthan gum, inulin, guar gum, locust bean gum and glucomannan). Seven cookies (5 hydrocolloids W:S cookies, W:S cookie without hydrocolloid and wheat flour cookie) were evaluated for sensory descriptive and physical properties; geometric (diameter, thickness, spread ratio), texture profile analysis (Hardness) and 3-point bending (Fracture strength). Hardness and Fracture strength of cookie which added inulin were higher than other hydrocolloids cookies and W:S cookie without hydrocolloid, but lower than wheat flour cookie. Results from sensory descriptive analysis of cookies which added hydrocolloids using trained panel indicated that cookies had slick mouthfeel. The relationship between physical properties and sensory descriptive data were correlated by using Principal Component Analysis and Preference Mapping. The physical properties of cookies were closely linked with the texture ratings from the descriptive analysis. The consumer acceptance was evaluated for appearance, color, flavor, taste, texture and overall liking by 100 untrained-panelists. The 9-point hedonic scale was used to evaluated. Results showed that sensory data in term of flavour, taste, texture and overall liking of cookies which added xanthan gum was the highest score ($p < 0.05$).

Keywords: Cookie, Hydrocolloid, Inulin, Preference mapping, Rice flour

Introduction

Cookies are enjoyed all over the world for desserts. They were popularly consumed because their can serve as convenient meal replacements for rush time, grap-and-go consumers and they also more easily transported than other desserts such as cakes and pies. Development of new generation cookie products derived from diverse sources of non-wheat flour provides an alternative towards healthier products as consumers have become more

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concerned about health. The supplementation alternative ingredients in cookie formulation were to fortify the deficiency of nutritional value in wheat flour particularly essential amino acid, minerals, vitamins and dietary fiber. Several studies have been focused on the use of various sources of non-wheat flour to substituted wheat flour in cookie making include cassava/soybean/mango composite flours Chinma and Gernah, 2007); gluten-soy protein blends (Singh and Mohamed, 2007); barley flour (Gupta *et al*., 2011); Indian water chestnut (Singh *et al.,* 2010) and flaxseed flour (Khouryieh and Aramouni, 2012).

Rice is a major agricultural product of Thailand and its health benefits. Sinin rice is Thai rice that has black-purple color. It has anthocyanin which source of antioxidant. Currently, there is more research on the nutritional information and product development of Thai rice in food. Therefore, its use in many different food products, including snack (Ding *et al*., 2005; Chaiyakul *et al*., 2009); crackers (Keeratipibul *et al.,* 2008); breakfast cereals (Wanyo *et al.,* 2009); breads (Charoenthaikij *et al*., 2010); butter cakes (Chueamchaitrakun *et al.,* 2011); health bars (Norajit *et al*., 2011); and pasta (Marti *et al.,* 2010); Hom Nil rice snack (Sangnark *et al*., 2015); Flaky chinese pastry (Chysirichote and Mekrawee, 2018); especially in developing of food for gluten intolerant consumers (Sae-Ew *et al.,* 2007).

Hydrocolloids, commonly called gums, are a group of complex hydrophilic compounds or biopolymers. Hydrocolloids provide multiple quality improvements in many foods. Application in bakery products as bread additives, they improved the final product quality of both fresh and stored samples, acting as antistaling agents. Different hydrocolloids can be used for many reasons, depending on their individual functional properties (solubility, rheological properties, synergistic effect with other ingredients, etc.) and on the required properties in the finished product (Mandala *et al.,* 2008).

However, substituting non-wheat flour into the cookie formulation exerted adverse effects such as increase impaired physical and textural qualities and organoleptic properties. Many researchers found that hydrocolloids could be used to improve food texture, retard starch retrogradation, improve moisture retention and enhance the overall quality of bread products during storage (Rosell *et al*., 2001). For cookies, a limited number of researchers have been conducted on the use of hydrocolloid to improve quality and acceptability of the product. The objective of this study was to determine the effects of hydrocolloid addition on physical properties and organoleptic properties of wheat flour cookies substituted with Sinin rice flour.

Materials and methods

Materials

Sinin rice was obtained from Local agricultural, Chiang Rai, Thailand. Ingredients for cookie formulations were: All purpose flour (Kite, UFM Food Centre Co., Ltd, Bangkok, Thailand); salted butter (Orchid®; Thai Dairy Industry Co., Ltd., Bangkok, Thailand); icing sugar (Dynasty; Dynasty Pacific Co., Ltd, Samut Sakhon, Thailand) eggs (Charoen Pokphand Foods Co., Ltd, Bangkok, Thailand); baking powder (Baker's Choice; Kim Chua Group Co., Ltd, Bangkok, Thailand); salt (Prung Thip®; Thai Refined Salt Co,. Ltd, Nakornratchasima, Thailand); vanilla flavor (Winner; Greathill Ltd., Part., Bangkoko, Thailand). Hydrocolloids were obtained from Thai Food and Chemical Co., Ltd, Bangkok, Thailand (Xanthan gum, Guar gum, Glucomanan, Locust bean gum) and NutritionSc Co., Ltd, Nakhinpathom, Thailand (Inulin).

Table 1. Ingredient of cookies (Modified from Sujittra, 2009)

Ingredients	Amount (%)
All purpose flour : Sinin rice flour	100
Butter Salted	54.8
Icing	42.8
Egg	11.9
Baking powder	0.66
Salt	0.55
Vanilla flavor	1.9
Hydrocolloids	1.0

Cookies preparation

Dry mixed (Sinin rice flour, wheat flour, baking powder and hydrocolloid) were sieved and placed. Wet mixed (Butter, icing, salt, egg and vanilla odour) were mix in together with mixer (Spar mixer model 800-B). Dry mixed was added into wet mixed and then, mixed them together with plastic spatula. Dough was put into the mold and placed it on the trays. Cookie dough was baked in the oven at 170^{o}C for 20 minutes. Finally cookie was placed and put it in the air-tight packaging after cookie had been cooled on the rack.

Physical properties

The thickness (T) and diameter (D) of cookies were measured using vernier caliper. The diameter of cookie was measured, then rotated by 90^{o}, and measured again. Five cookies were measured from each batch. Spread ratio was calculated by dividing the diameter by thickness of these cookies (D/T).

Hardness was conducted using Aluminium cylinder probe (P/3) with Texture analyzer (TA-XT2i). The texture analyzer was set to 'return to start' cycle. Pretest, test and post-test speed of 2, 0.5 and 10 mm/s were fixed, respectively. Measure force in compression was set of analysis. The max force was reported as hardness of the cookies.

Fracture strength (snap test) was conducted using a 3-point bending attached to texture analyzer. The setting of texture analysis was determined using the method of Singh *et al.* (2010). The maximum peak force (the force required to break the cookies) was reported as fracture strength of the cookies.

Sensory evaluation

Quantitative Descriptive Analysis was evaluated by 7 trained-panels with 15 centimeters intensity scale. Nine attributes (Table 2) were defined and agreed by panel. Each sample was labeled with 3-digit random number and order of sample presentation was randimised. Filtered water and unsalted crackers were used to cleanse their palate between samples. For the acceptance test (appearance, color, flavor, taste , texture and overall liking), cookies were evaluated by 100 untrained-panelists with 9-point hedonic scale. (Meilgaard *et al*., 2006).

Statistical analysis

Data analysis were subjected to analysis of variance (ANOVA) using SPSS version 17. Means were compared with Duncan's New Multiple Range Test. Correlation between physical properties and sensory descriptive data was used a principal component analysis and preference mapping. A biplot from principal components were created by the XLstat software (Addinsoft, Paris, France).

Results

Changes in physical properties of cookies on addition of hydrocolloids are shown in Table 3. Spread ratio of W:S (100:0) without hydrocolloid cookie had a low but not significant when compared to W:S (30:70) guar gum and W:S (30:70) xanthan gum. In comparison between W:S (30:70) without hydrocolloid and W:S (30:70) with hydrocolloid (inulin, guar gum, glucomannan, xanthan gum, locust bean gum), W:S (30:70) with hydrocolloid had harder than W:S (30:70) without hydrocolloids cookie. W:S (100:0) cookie had fracture strength higher than W:S (30:70) cookies. It had related with descriptive sensory in fracturability attribute as shown in Figure 1. The addition of hydrocolloid could increase fracture strength of W:S (30:70) cookies.

Table 2. Sensory descriptors, definitions, and references for texture characteristics of cookies

Descriptors	Definition	Anchored words	Reference and its intensity on a 15-pt scale	
First bite				
Hardness	Force required to bite through sample	Low-high	cracker (Ritz)[a]	5.0
			Bisuit stick(Glico Pretz roast)[b]	9.0
Crispness	The noise which the sample break	Low-high	cracker (Ritz)[a]	3.0
			Potato chip(Lay's Stax original)[c]	6.0
Fructurability	Force with which sample rupture	Low-high	cracker (Ritz)[a]	4.0
			Prawn cracker (Hanami)[d]	7.0
Chew down				
Cohesiveness of mass	Degree to which the mass holds together after mastication	Low-high	Prawn cracker (Hanami)[d]	4.0
			cracker (Ritz)[a]	7.0
Roughness	Degree of abrasiveness of sample's surface perceived by the tougue	Low-high	Bisuit stick(Glico Pretz roast)[b] cracker	4.0
			(Ritz)[a]	8.0
Moisture absorption	Amount of sample's absorption savila while mastication	Low-high	Rice crackers (Dozo) [e]	5.0
			cracker (Ritz)[a]	8.0
Slick mouthfeel	Degree of slick feel in sample while tasting	Low-high	Ayam Baked beans in tomato sauce [f]	5.0
Aftertaste				
Tooth packing	Amount of sample stuck in molars	Low-high	Potato chip(Lay's Stax original) [c]	3.0
Particles	Amount of particles left in mouth	Low-high	Potato chip(Lay's Stax original) [c]	2.5

[a] Ritz, Kraft Foods (Thailand) Ltd., Thailand
[b] Pretz, Thai Glico Co.,Ltd, Bangkok, Thailand
[c] Lay's , Pepsi-Cola (Thai) Trading Co., Ltd, Thailand
[d] Hanami, Friendship Co., Ltd, Bangkok, Thailand
[e] Dozo, Berli Jucker Public Co. Ltd, Bangkok, Thailand
[f] The Commercial Company of siam Ltd, Bangkok, Thailand

Table 4. Pearson correlation coefficients (*r*) among sensory descriptive data

Sensory attributes	Hardness	Crispness	Fracturability	Slick mouthfeel	Cohesiveness of mass	Roughness	Moisture absorption	Tooth packing	Particles
Hardness	1.000	0.734**	0.605**	-0.144	0.466**	0.349**	0.395**	0.062	-0.547**
Crispness		1.000	0.607**	-0.127	0.543**	0.269**	0.398**	-0.042	-0.469**
Fracturability			1.000	-0.283**	0.516**	0.289**	0.363**	0.058	-0.503**
Slick mouthfeel				1.000	0.195	-0.287**	-0.002	0.399**	0.320**
Cohesiveness of mass					1.000	0.203*	0.393**	0.300**	-0.100
Roughness						1.000	0.126	-0.099	-0.204*
Moisture absorption							1.000	-0.033	-0.256*
Tooth packing								1.000	0.362**
Particles	-0.547**	-0.469**	-0.503**	0.320**	-0.100	-0.204*	-0.256*	0.362**	1.000

** Correlation was significant at $p < 0.01$.
* Correlation was significant at $p < 0.05$.

Table 3. Diameter, Thickness and Spread ratio of cookies

Sample	Diameter (mm)	Thickness (mm)	Spread ratio	Hardness (N)	Fracture strength (N)
W:S (100:0) without hydrocolloid	40.60[abc]	10.30[a]	3.94[b]	29.16[a]	37.13[a]
W:S (30:70) without hydrocolloid	40.10[bc]	9.63[c]	4.17[a]	14.35[c]	14.15[d]
W:S (30:70) inulin	40.88[ab]	9.50[c]	4.30[a]	16.51[b]	20.30[b]
W:S (30:70) guar gum	41.28[a]	10.36[a]	3.98[b]	15.64[bc]	16.59[c]
W:S (30:70) glucomannan	41.55[a]	9.95[b]	4.18[a]	16.11[b]	16.41[c]
W:S (30:70) xanthan gum	39.64[c]	10.18[ab]	3.90[b]	15.61[bc]	17.95[c]
W:S (30:70) locust bean gum	40.12[bc]	9.44[c]	4.25[a]	15.69[bc]	16.92[c]

* W:S was cookie prepared from flours containing proportions of wheat flour (W): Sinin rice flour (S)

[a, b, …] Value in the same column with different letters are significant different ($p < 0.05$)

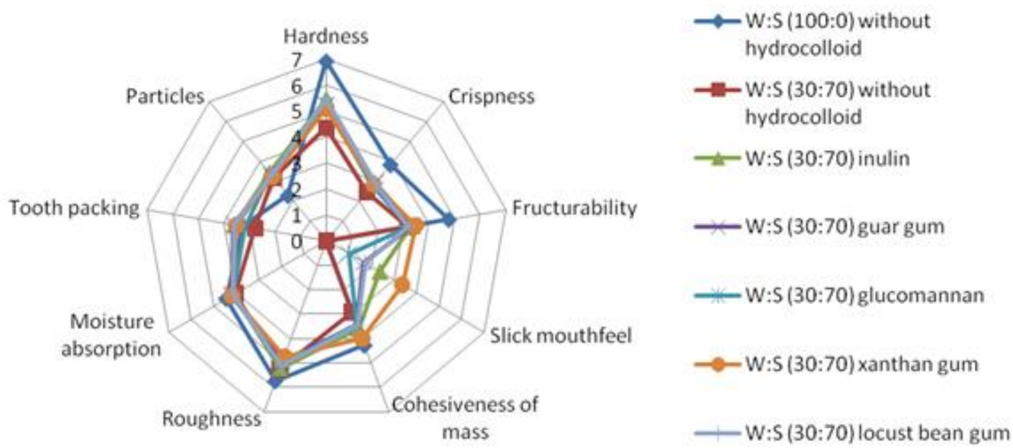

Figure 1. Effect of hydrocolloid addition on the sensory descriptive attributes of cookies

The evaluation sensory quantitative descriptive analysis (QDA) was made by 7 trained panels, who were used to establish the profiles of the cookie with/without hydrocolloid. The consensus vocabulary developed 9 attributes of cookies included first bite (hardness, crispness, fracturability), chew down (cohesiveness of mass, roughness, moisture absorption, slick mouthfeel) and aftertaste (tooth packing and particles). The intensity ratings of attribute were scored on a line of 15 cm. Effect of hydrocolloids on sensory properties of W:S (30:70) cookie was analysed by trained panel and given in Figure 1.

W:S (100:0) had the highest intensity rating of hardnesss, crispness and fructurability related to texture properties of the product. W:S cookie without hydrocolloid which has the lowest hardness and fracture strength. W:S cookie with inulin has higher hardness and fracture strength than other cookies but lower than wheat flour cookie. For the slick mouthfeel, the intensity rating of slick mouthfeel of cookies showed significant different ($p < 0.05$). The cookies which added hydrocolloid had a slick mouthfeel when compare with cookies without hydrocolloid particularly W:S (30:70) xanthan gum had the highest intensity rating of slick mouthfeel. W:S (100:0) cookie and W:S (30:70) without hydrocolloid cookie were the lowest intensity rating of slick mouthfeel.

Fracturability was highly correlated with crispness and hardness ($r = 0.605\text{-}0.734$, Table 4). This can be used to explain observation that the W:S (100:0) cookies exhibited significantly higher fracturability, crispness and hardness than other cookies.

Table 5. Mean consumer acceptance scores of cookies

Sample	Appearance	Color^{ns}	Flavor^{ns}	Taste	Texture	Overall liking
W:S (30:70) without hydrocolloid	6.29^{a}	6.02	6.38	6.18^{ab}	5.69^{b}	5.89^{b}
W:S (30:70) inulin	6.21^{ab}	6.01	6.23	6.28^{a}	5.67^{b}	5.96^{ab}
W:S (30:70) guar gum	6.07^{b}	5.88	6.26	6.32^{a}	5.72^{ab}	5.89^{b}
W:S (30:70) glucomannan	6.12^{ab}	5.96	6.12	5.88^{b}	5.43^{b}	5.58^{c}
W:S (30:70) xanthan gum	6.29^{a}	6.02	6.42	6.45^{a}	6.02^{a}	6.23^{a}
W:S (30:70) locust bean gum	6.13^{ab}	5.98	6.38	6.44^{a}	5.76^{ab}	6.02^{ab}

$^{a, b, \dots}$ Value in the same column with different letters are significant different (*$p < 0.05$*)

^{ns} Value in the same column are not significant *($p \geq 0.05$)*

The consumer acceptance (100 untrained-panelists) were requested to evaluate 6 samples (cookies with/without hydrocolloids) by using 9-point hedonic scale. A summary of the responses is shown in Table 5, it would appear that consumers preferred W:S (30:70) xanthan gum mostly, followed by W:S (30:70) locust bean gum, and then W:S (30:70) inulin, respectively. For the taste and texture attributes, it would appear that consumers preferred W:S (30:70) xanthan gum mostly. For the color and flavor attributes, it would appear that no significant difference was found in consumer acceptance.

Figure 2. Cookies prepared from the composite flours containing wheat flour (W) : Sinin rice flour (S)

W:S (30:70) without hydrocolloid cookie had more uneven pore distribution in cookie compared to the W:S (100:0) (Figure 2) which related to hardness and fracture strength value in physical and sensory properties. Meanwhile, W:S (30:70) cookie with hydrocolloid had same size pore distribution compared to W:S (100:0) cookie.

Partial least square (PLS) regression was used to develop the model for overall liking (Figure 3). The Quantitative descriptive analysis (hardness, crispiness and fracturability) and the instrumental texture measurements of cookies (hardness and fracture strength) were measured and used as independent variables (X-data). The overall liking of 7 developed cookies were measured during the sensory evaluation with 100 consumers (Table 5) and used as dependent variables (Y-data). The result showed that the higher in hardness, crispiness and fracturability with some slight in slick mouthfeel were more liked. The least overall liking was found with W:S (30:70) with glucomannan cookie (5.58) followed by W:S (30:70) without hydrocolloid cookie (5.89).

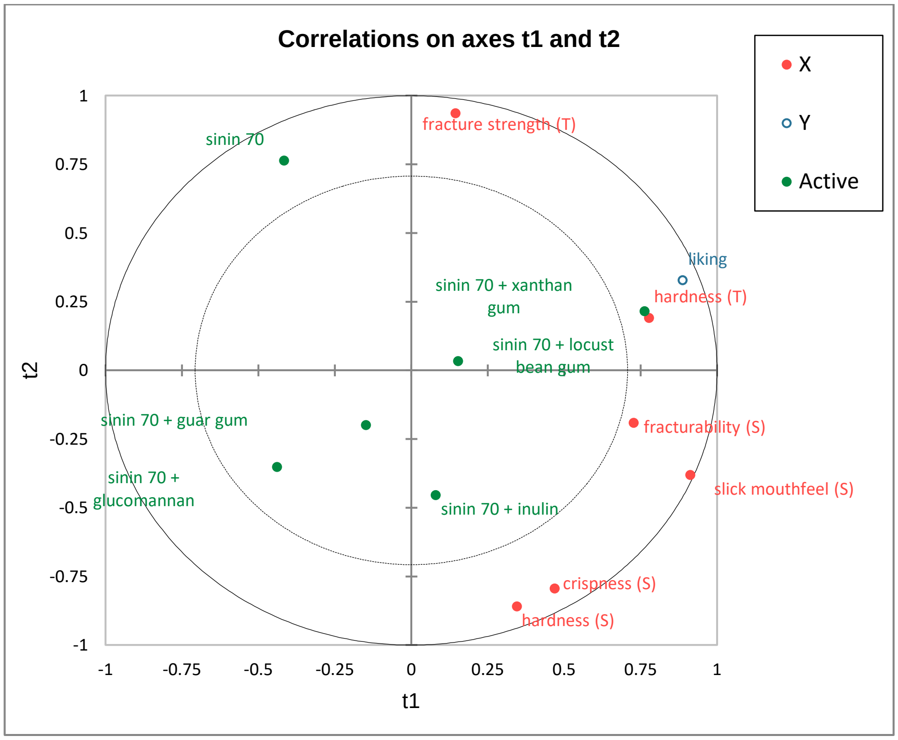

Figure 3. PLS Regression of the physical and descriptive sensory analysis with overall liking for developed cookies

W:S (30:70) cookie which added hydrocolloid was harder than W:S (30:70) cookie without hydrocolloid. Therefore, the use of hydrocolloid could be decreased a brittle of cookie which substituted wheat flour with sinin rice flour. W:S (30:70) cookie with xanthan gum was the highest sensory acceptance score (flavor, taste, texture, and overall liking) and most preferred by 100 untrained-panelists.

Discussion

Hydrocolloids have been widely used in food technology as food additives for good functional attributes such as thickeners, gelling agents, emulsifiers, stabilizers, fat replacers, and whipping agents (Li and Nie, 2016). In the bakery industry, these compounds help to improve food texture and moisture retention, and also to retard starch retrogradation (Kohajdov á and Karovičová, 2009).

W:S (100:0) cookie had fracture strength higher than W:S (30:70) cookies. Similar trend with Saha *et al*. (2011) studied on the effect of Biscuits prepared from flour composites containing 60:40 and 70:30 (w/w) finger millet: wheat flour, the result showed that biscuit with higher wheat flour had lower breaking strength and higher fracturability.

The result showed that the addition of different gums significantly increased cookie hardness and fracture strength, slightly increased thickness and cookie diameter and improved the sensory scores. It is similar to Kaur *et al*. (2015) and Thejasri *et al.* (2017) studied on the effect of various gums on buckwheat flour, quinoa, or millet flour. Spread ratio, calculated as a ratio of diameter to thickness, decreased with the inclusion of gum in the gluten-free flour except for gum Arabic and cress seed gum which showed a spread ratio statistically the same as for the control. The least spread ratio was found with okra (6.13) followed by flaxseed (6.78) gum. Kraithong and Rawdkuen (2020) reported that an increase in expansion ratio refers to the disruption or swelling of starch granules, contributing to the greater water absorption as well as more flexibility of the final product structure.

Regarding the hardness of cookies, we have found a significant increase in the cookie with addition of hydrocolloid. In the previous study, the hardness values of cookies increased in addition to hydroxypropyl methylcellulose with okara starch (Park *et al.*, 2015). Oliver *et al*. (1995) reported that a weakening in dough strength reduced biscuit hardness. Similar result reported form other composite flours like barley-wheat flours (Gupta *et al*., 2011). Most probably this diverse behavior can be attributed to the different composition and physicochemical properties of the flours used in the present stud A benefit of hydrocolloid is that it can be improved texture of cookies. All the cookies with hydrocolloids underwent increase in fracture strength values same direction as the hardness values increased. In general, the characteristics of a high-quality 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. However, the optimum value of fracture strength and hardness must be determined by using sensory score from the consumer acceptability.

Gimeno *et al.* (2004) reported that hydrocolloids such as xanthan gum (XG) have the ability to improve the volume, structure, and texture of expanded cereal products, due to their effects on moisture sorption capacity of the matrix and rheological properties. Therefore, the addition of hydrocolloids significantly improved the shape, structural and textural uniformity of the cookies. Benkadri *et al*. (2018) reported that the sensory scores when using xanthan gum were not significantly different when used at 1 and 1.5%, implying that xanthan gum use is a viable alternative to achieve both the proper technological properties required for the industrial production of the dough and obtaining biscuits with moisture, a_w, dimensions, and textural properties similar to those of wheat flour.

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