Physical and Sensory Properties of Gluten-Free Modified Cassava Flour-Based Cookies

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ABSTRACT

Recently, food nutritionists and technologists have been challenged to develop gluten-free bakery products, namely cookies, cakes and breads. This study was performed to assess the physical and sensory properties of gluten-free cookies. Composite flour based on modified cassava flour (MCF) has been used to replace wheat flour (WF). The addition of isolated soy protein (ISP) and hydrocolloids such as xanthan gum (XG) or guar gum (GG) were previously reported to improve sensory quality of gluten-free cookies. The blending of MCF with rice flour (RF), ISP and XG or GG in different percentage to produce choco-chips cookies was reported in this study. Five formulations of cookies were prepared from: (a) control (100% WF), (b) MCF 70%, RF 25%, ISP 5%, XG 2% flour based, (c) MCF 70%, RF 25%, ISP 5%, XG 3% flour based, (d) MCF 70%, RF 25%, ISP 5%, GG 2% flour based, and (e) MCF 70%, RF 25%, ISP 5%, GG 3% flour based. Cookies were evaluated for physical analysis (diameter, thickness, spread ratio, breaking strengh and color analysis) and subjected to consumer acceptance by sensory analysis (color, flavor, texture, taste, and overall acceptability). Cookies prepared from 70% modified cassava flour, 25% rice flour, 5% isolated soy protein and addition of 2% xanthan gum were more acceptable than cookies prepared from other formulations and significantly different ($P \leq 0.05$) from control-wheat-flour cookies.

Keywords: Cookies, Gluten-free cookies, Modified cassava flour, mocaf

INTRODUCTION

The total population in Indonesia was reported at 245.9 million people in 2012. It represented about 3.51% of the world´s total population and number four biggest population country in the world (Statistic Indonesia, 2012). The great population demands a huge value of staple food. Rice and wheat are the staple food in Indonesia so that the demand for rice and wheat keeps increasing. It results in higher value of imported rice and wheat. This problem can lead to the dependence on imported food that endangers Indonesia's food security. To assure food security, the government of Indonesia supports the sustainable intensification of other locally grown crops production as well as food diversification. Food which commonly made from wheat flour is substituted with other locally grown crop flour.

The substitution of wheat flour with gluten-free composite flour in bakery product is expected to design a product which meets customer acceptance in physical and sensory characteristic.

Cassava *(Manihot esculenta)* is a staple food of Indonesian people, besides rice, wheat, and corn. Cassava grows well under critical conditions of water and soil nutrition. Cassava is also tolerant to drought and pest attacks. It has harvesting time from 6 to 18 months after planting so that farmers are allowed to keep the roots in the ground until needed. Cassava production in Indonesia has increased from 17,2 million in 1993 to 23,4 million in 2014 (Statistic Indonesia, 2015). Cassava can be converted to produce many food products, such as food for direct consumption, cassava chips, cassava flour, cassava starch flour and modified cassava flour (mocaf). The mocaf is more acceptable than the regular cassava flour because the sensory characteristic of mocaf is alike wheat flour (white, soft and cassava odorless). Mocaf is also lower price than rice flour and around the same price with wheat flour. Sustainable intensification of cassava production needs for commitment. The formulation of cookies made from mocaf has not yet fully developed. Our preliminaries research showed that the total substitution of mocaf to the wheat flour resulted in a product having a less acceptable sensory characteristic, especially for texture. To support the intensification of cassava production, it is necessary to improve the quality of bakery product made from mocaf.

The use of soy-flour as an improver in cookies is well known in improving dough handling characteristics. Besides that, soybean flour was used to improve the protein quality (Okoye *et al*. 2008). According to Obadina *et al.* (2014), the cassava cookies with the addition of soy-flour were accepted by the consumers in the sensory characteristic of color, taste, and crispiness but not for the texture. The addition of non-starch hydrocolloids such as xanthan gum to gluten-free flours was reported to mimic the viscoelastic properties of gluten (Lazaridou *et al*., 2007). Other hydrocolloids, such as pectin and guar gum was also reported (Funami *et al*., 2005)

The objective of the study was to design composite flour comprising of mocaf, rice flour, isolated soy protein, xanthan gum or guar gum. The composite flour is baked into choco-chips cookies. The physical analysis and sensory evaluation of the composite flour choco-chips cookies were determined.

MATERIALS AND METHODS

Materials. Materials used for experimental work were wheat (*Triticum aestivum*) flour (WF), modified cassava flour (MCF), rice (*Oryza sativa*) flour (RF), margarine, butter, isolated soy protein (ISP), guar gum (GG), xanthan gum (XG), powder sugar, egg yolk, chocolate powder, dark chocolate compound, and choco chip. Modified cassava flour was purchased from Putri 21, Gunung Kidul, Yogyakarta. Isolated soy protein was obtained from

Shandong Crown Soya Protein Co. Ltd. Guar gum was obtained from Hindustan Gum & Chemicals Limited. Xanthan gum was obtained from CV. Nura Jaya. And other materials were purchased from commercial stock in the local market in Yogyakarta.

Cookies preparation. Cookies were prepared from different blends of flour and hydrocolloids (xanthan gum or guar gum). The composition of the ingredients used in the manufacture of cookies was shown in Table 1. Margarine, butter, powder sugar and egg yolk were mixed until light, fluffy and creamy. Wheat flour and modified cassava flour were roasted until slight brown. Wheat flour, modified cassava flour, rice flour, isolated soy protein, and xanthan gum/guar gum were added to the cream dough and blended well. Then chocolate compound and chocolate powder were added and mixed until a stiff paste batter was obtained. Around 12 grams batter was dropped by spoon and set around 4,5 cm in diameter. Choco-chips were placed on the top surface of the dough. The batter was baked at 160 ºC for 16 minutes for control sample or 22 minutes for other samples. The well-baked biscuits were cooled to room temperature and stored in LDPE pouches inside air tight container until further use for sensory evaluation, and physical analysis.

Table 1. Ingredients composition used in cookies samples

Ingredients (g)	Control	XG-2	XG-3	GG-2	GG-3
Wheat flour	100	-	-	-	-
Modified cassava flour	-	70	70	70	70
Rice flour	-	25	25	25	25
Isolated soy protein	-	5	5	5	5
Xanthan gum	-	2	3	-	-
Guar gum	-	-	-	2	3
Margarine	50	50	50	50	50
Butter	25	25	25	25	25
Powder sugar	50	50	50	50	50
Egg yolk	17	17	17	17	17
Dark chocolate compound	25	25	25	25	25
Chocolate powder	5	5	5	5	5
Choco-chips	8	8	8	8	8

Control contain 100% WF. Sample XG-2 contain MCF 70%, RF 25%, ISP 5%, XG 2% flour based. Sample XG-3 contain MCF 70%, RF 25%, ISP 5%, XG 3% flour based. Sample GG-2 contain MCF 70%, RF 25%, ISP 5%, GG 2% flour based. Sample GG-3 contain MCF 70%, RF 25%, ISP 5%, GG 3% flour based.

Physical analysis. Physical parameters such as diameter (D), thickness (T), spread factor (SF) were determined according to American Association of Cereal Chemist (AACC) procedure (2000). The diameter of cookies was measured by placing six cookies edge to edge horizontally and rotating 90° for duplicate reading and taking average diameter. Thickness was measured by stacking six cookies on top of each other and taking average thickness. All the measurement were done in two replicates of six cookies. Spread ratio was calculated by dividing the average value of diameter by average value of the thickness of cookies. Spread factor was calculated as the ratio of the spread ratio of the control sample to that of the composite samples.

Textural determination. Compression test to measure the maximum breaking strength (N) in the cookies was performed using a Texture Analyzer with a 0.02 N pre-load force and test speed of 10 mm/min. Cookies were compressed in the texturometer until breaking. Two replicates were obtained to measure the average value.

Color analysis. Colors of cookies were measured instrumentally using a chromameter Konica Minolta CR 400. Results were expressed in L*a*b* color model. L* values measure lightness from black to white (0 to100), a* values measure greenness when negative and redness when positive. And b* values measure blueness when negative and yellowness when positive. All the measurements were made in duplicate.

Sensory evaluation. Hedonic scale rating was used for evaluation of cookies samples. Sensory attributes like color, flavor, texture, taste, and overall acceptability were evaluated by 50 semi-trained panelists. Cookies samples were evaluated after 24 hours. Cookies samples were presented in coded low-density polyethylene (LDPE) pouches. The order of samples was randomized. Tap water was provided to rinse the mouth between the evaluation. The panelists were instructed to evaluate the sensory attributes using 7-Point Hedonic Score System. The panelist gives score 7-1 to the product, ranging from 'like extremely' to 'disliked extremely' to find out the most suitable composition of cookies.

Statistic. Experiments were repeated two times, the results were subjected to analysis of variance (ANOVA). The significance of difference between the average values was evaluated using Duncan comparison test ($P \leq 5\%$).

RESULTS AND DISCUSSION

Cookies composition

Our preliminaries research revealed that the total substitution of wheat flour to modified cassava flour in choco-chips cookies resulted in unacceptable sensory characteristic, especially for texture. This research studied the incorporation of hydrocolloids such as xanthan gum and guar gum in the production of choco-chips cookies. Control cookies were made from 100% wheat flour. All samples cookies (XG-2, XG-3, GG-2 dan GG-3) were made from composite flour of 70% modified cassava flour, 25% rice flour and 5% isolated soy protein. The four samples were differed in the concentration of hydrocolloid. XG-2 and XG-3 used 2% and 3% xanthan gum, respectively. And GG-2 and GG-3 used 2% and 3% guar gum, respectively.

Physical analysis

The physical properties of cookies prepared from different blends of flours were shown in Table 2. There were no significant differences ($P>5\%$) between diameter as well as thickness of composite formulation cookies compared to those of control sample. The diameter of all types of cookies ranged from 4.85 to 5.14 cm. The thickness of cookies varied from 1.03 to 1.12 cm. The spread ratio of cookies ranged from 4.36 to 4.71 showing no significant difference between samples (P>5%). It indicated that the addition of 2% hydrocolloid (both xanthan gum and guar gum) increased the spread ratio. The spread factor showed no significant difference between samples. It showed that the addition of hydrocolloid 2% to 3% contributes to the same physical properties between composite flour cookies and wheat flour cookies. No changes in these physical parameters were desirable because otherwise, the final shape of the cookies would have been changed and thus, not appealing to consumers. The spread ratio was important to assess the quality of the biscuits (Bose and Shams-Ud-Din, 2010). Biscuits with high spread ratio values are better (Eissa *et al.,* 2007).

The gluten-free cookies increased the hardness of cookies compare to control cookies. But there was no significant difference (P>5%). Gluten-free cookies formulation without any improver (isolated soy protein and hydrocolloids) were reported to increase the cookies hardness significantly (Aziaah *et al*., 2012 and Sarabhai *et al*., 2014). It agreed with our preliminaries research when wheat flour was substituted by 100% modified cassava flour without the addition of isolated soy protein and hydrocolloid, the texture of the cookies was harder significantly.

Table 2 showed that the incorporation of hydrocolloid in the gluten-free formulation slightly increased the cookies hardness, but it was proved to be no significant different with control cookies. The present study revealed that the addition of hydrocolloid had no adverse effects on the physical parameters of cookies.

Table 2. The physical characteristics of cookies

Sample	Diameter, cm	Thickness, cm	Spread Ratio	Spread Factor	Breaking Strength, N
Control	4.85^a	1.03^a	4.69^a	1.00^a	3.29^a
XG-2	5.07^a	1.08^a	4.71^a	0.96^a	6.37^a
XG-3	4.88^a	1.12^a	4.36^a	1.08^a	6.51^a
GG-2	5.14^a	1.03^a	5.00^a	0.94^a	3.53^a
GG-3	4.88^a	1.06^a	4.60^a	1.02^a	3.47^a

Columns with the same superscripts are not significantly difference at P ≤ 0.05. Control contain 100% WF. Sample XG-2 contain MCF 70%, RF 25%, ISP 5%, XG 2% flour based. Sample XG-3 contain MCF 70%, RF 25%, ISP 5%, XG 3% flour based. Sample GG-2 contain MCF 70%, RF 25%, ISP 5%, GG 2% flour based. Sample GG-3 contain MCF 70%, RF 25%, ISP 5%, GG 3% flour based.

Color measurement

The effect of gluten-free cookies formulation on color measurement of cookies was presented in Table 3. The color of top and bottom surface of cookies was a very important characteristic in the initial acceptability of a tested product by consumers (Zucco et al., 2011).

The color of the cookie surfaces came from non-enzymatic browning (Maillard) reactions between reducing sugars and amino acids as well as from starch dextrinization and sugar caramelization (Chevallier et al. 2000). The lightness (L*) of the cookies ranged from 40.53 to 45.89, showing no significant difference between sample (P>5%). The redness (a*) and yellowness (b*) also showed no significant difference (P>5%). Bala *et al.* (2015) reported that increased substitution of wheat flour with cassava and water chesnut flour reduced the lightness. This research indicated that the addition of hydrocolloids does not affect the color of cookies surface.

Table 3. Color characteristic of cookies

Sample	L*	a*	b*
Control	40.53^{a}	15.67^{a}	21.62^{a}
XG-2	45.89^{a}	15.49^{a}	24.31^{a}
XG-3	46.69^{a}	15.75^{a}	25.12^{a}
GG-2	40.64^{a}	16.72^{a}	25.22^{a}
GG-3	44.74^{a}	14.96^{a}	23.10^{a}

Columns with the same superscripts are not significantly difference at $P \leq 0.05$. Control contain 100% WF. Sample XG-2 contain MCF 70%, RF 25%, ISP 5%, XG 2% flour based. Sample XG-3 contain MCF 70%, RF 25%, ISP 5%, XG 3% flour based. Sample GG-2 contain MCF 70%, RF 25%, ISP 5%, GG 2% flour based. Sample GG-3 contain MCF 70%, RF 25%, ISP 5%, GG 3% flour based.

Sensory evaluation

The results of the sensory evaluation were shown in Table 4. The control from wheat flour had the value of 6.8 rated the smallest overall acceptability, while modified cassava flour based cookies had the highest overall acceptability value of 8.2. Cookies made with xanthan gum 2% had higher overall acceptability than cookies made from xanthan gum 3%, guar gum 2% and guar gum 3%. The results showed that cookies from composite flour have high overall acceptability, but the value decreased if the percentage of hydrocolloid (xanthan gum or guar gum) increased. The addition of 2% xanthan gum in XG-2 sample had the highest value for texture and color. Color is an important parameter to correctly assess the baked biscuits (Hussain *et al.,* 2006).

Table 4. Mean sensory evaluation of cookies samples

Sample	Color	Flavor	Texture	Taste	Overall Acceptability
Control	6.8^{d}	7.2^{b}	6.8^{b}	7.0^{d}	6.8^{c}
XG-2	8.3^{a}	7.7^{a}	8.2^{a}	8.0^{a}	8.2^{a}
XG-3	7.5^{bc}	7.8^{a}	7.3^{b}	7.6^{bc}	7.5^{b}
GG-2	7.6^{b}	7.7^{a}	6.9^{b}	7.5^{b}	7.4^{b}
GG-3	7.0^{cd}	7.4^{ab}	6.8^{b}	6.9^{cd}	7.1^{bc}

Average of 50 semi-trained panelists using 7-Point Hedonic Score System. Columns with the same superscripts are not significantly difference at $P \leq 0.05$. Control contain 100% WF. Sample XG-2 contain MCF 70%, RF 25%, ISP 5%, XG 2% flour based. Sample XG-3 contain MCF 70%, RF

25%, ISP 5%, XG 3% flour based. Sample GG-2 contain MCF 70%, RF 25%, ISP 5%, GG 2% flour based. Sample GG-3 contain MCF 70%, RF 25%, ISP 5%, GG 3% flour based.

The results also showed that choco-chips cookies made from improving agent xanthan gum had higher acceptance in color, flavor, texture, taste and overall acceptability than that of guar gum. The addition of these hydrocolloids (xanthan gum and guar gum) to modified cassava flour-based composite flour is promising as they do not alter the sensory characteristic of choco-chips cookies.

CONCLUSIONS

Gluten-free flour combinations could be used to produce good quality cookies with acceptable physical and sensory qualities. It is advantageous to Indonesia in order to decrease the dependency to imported wheat flour. The incorporation of xanthan gum and guar gum of 2 – 3% in the gluten-free choco-chips cookies formula (70% modified cassava flour, 25% rice flour and 5% isolated soy protein) resulted in improved physical and sensory qualities. The most acceptable choco-chips formulation was 70% mocaf, 25% rice flour, 5% isolated soy protein and 2% xanthan gum.

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