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Physical Properties, Proximate Analysis, and Sensory Characteristics of Gluten-free Cookies Made from Rice Flour and Okara

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Abstract: *Okara is an agro-waste yielded after liquid extraction of tofu and soymilk production. It contains protein, fiber, carbohydrates, and minerals making it a potential nutritious ingredient for foods. However, several million tonnes of okara are made and discharged annually after tofu and soymilk processing, leading to environmental and economic impacts. In addition, rice is also considered a stable cereal in the Cambodian diet, so rice flour is mixed with okara flour to innovate a new formulation of cookies. Therefore, the purpose of this study was to vary and analyze the quality of gluten-free cookies using different percentages of okara flour incorporated with rice flour. The control cookie was prepared only from rice flour. The cookies containing okara were prepared by substituting the rice flour at either 40, 50, or 60% (w/w). The control sample and formulated cookies were analyzed for their physical analysis (moisture content, water activity, ash content, spread factor, and color), proximate compositions (crude fiber, fat, protein, and carbohydrate), and sensory evaluation (9 points hedonic scale). The results show that the moisture content of gluten-free cookies slightly declined with more addition of okara ($p > 0.05$), ranging from 1.72 to 4.37%. The water activity of cookies dropped with addition of okara from 40% to 60%, ranging from 0.2753 to 0.3175. The ash content of the control sample and three formulated cookies had no significant difference ($p > 0.05$), ranging from 1.18 to 1.68%. For the color of gluten-free cookies, the lightness (L*) decreased from 70.55 to 61.16, while redness (a*) increased from 6.04 to 9.24, as well as the yellowness (b*) increased from 31.85 to 34.55 when more percentages of okara flour were added ($p < 0.05$). In addition, the spread factors varied from 3.47 to 3.98 ($p < 0.05$). All cookies contain crude fiber, fat, protein, and carbohydrate of 1.68 to 4.01%, 16.16 to 21.36%, 4.62 to 13.28%, and 57.95 to 71.99%, respectively. For the result of sensory evaluation, the mixture of okara flour and rice flour with 50:50 (w/w%) had a good result for overall acceptability with an average score of 6.90 ($p > 0.05$). These results provide the feasibility that gluten-free cookies can be manufactured by incorporating okara flour with rice flour However, more experiments to improve the texture and shelf life of cookies by using different materials of packaging and adding stabilizers are recommended in the next studies.*

Keywords: Soybean residue; Cookies; Soymilk production; Sensory evaluation; Spread factor

1. INTRODUCTION

Gluten-free cookies are sweet and made with gluten-free grains that become popular because they act as transporters for key nutrients, cholesterol-free, easy to make, ready-to-eat, and have a long shelf life [1]. The global market size for cookies is predicted to be around 44.01 billion US dollars by 2025 and increase at a compound annual growth rate of 5.3% during the forecast period [2]. Cookies are typically made with wheat flour that contains less essential nutrients but it is a good source of fat and carbohydrates [3]. Aside from wheat flour, cookies can also be enriched with various flours from almonds, pea, walnut, tapioca, potato, soybean, chickpea, taro, sorghum, maize, barley, buckwheat, and millets, especially rice flour that is high in protein, fiber, and minerals [4,5].

Rice flour (*Oryza sativa*, L.) is widely used in gluten-free cookie production. Rice flour contains a high level of starch and dietary fiber, which are the majority of digestible carbohydrates in the human diet, energy sources and important for intestinal maintenance [6]. Rice flour is a really good source of

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carbohydrates, protein, fat, and vitamin B complexes such as niacin, riboflavin, and thiamine. In general, rice grain contains 12% water, 75-80% starch, and only 7% protein with a full complement of amino acids. Rice dominates a remarkable of Cambodia's undiversified agricultural sector and it is an important crop to the Cambodian economy. In Cambodia, rice production grew by 0.68% from 10,886,000 tonnes in 2019 to 10,960,000 tonnes in 2020 [7].

The consumption of soy food in most countries has increased the amount of soybean residue, namely okara. Okara flour is also suitable for cookie preparation due to its smooth taste, colorless, high nutritional value, and easily digestible carbohydrate [8]. Okara is an insoluble component obtained after the liquid extraction of soy-product production. It primarily contains fiber, protein, and fat. Fresh okara contains 80% water, 3.5 to 4.0% protein, and the majority of the water-soluble and insoluble components are derived from soybeans. However, dry okara contains 10% fat, 55% crude fiber, 30% protein, 4% ash, and considerable levels of vitamins [9,10]. According to Shi et al. [11], around 1.1 to 1.2 kg of okara is produced for each kilogram of soybeans used in tofu production. Another study estimated that 170,000 tonnes of okara can be made from one million tonnes of soymilk when a soybean-to-water ratio of 1:7 is used [10]. As a result, several million tonnes of okara are made and discharged annually. Thus, the incorporation of okara in cookie production becomes more interesting for researchers because of its value addition which increases the nutritional value of cookies and decreases the environmental impact [12]. However, the texture and taste of cookies could be worse in terms of the percentage of okara flour used. Moreover, the incorporation of okara with rice flour in gluten-free cookies has not yet been conducted. Hence, this study aims to vary and determine the properties of gluten-free cookies using different percentages of okara flour addition to rice flour.

2. METHODOLOGY

2.1. Materials

Fresh okara was obtained from tofu processing at a private company (Phnom Penh, Cambodia). And other ingredients such as sugar (Mitr Phol, Thailand), butter (Anchor, New Zealand), egg, rice flour (Double lion brand, Sunly Industry LTD., Cambodia), milk powder, modified starch, baking powder (McGarrett, Thailand), and salt were purchased from markets and supermarkets in Phnom Penh, Cambodia.

2.2. Okara flour preparation

Fresh okara was dried at 60 °C to reach a moisture content of around 7% in dry basis using a hot air oven (Memmert UN75, Schwabach, Germany). After that, the dried okara was milled using a blender (DR-999, International, Thailand) and sieved using 250 µm mesh. The Okara flour was vacuum-packed and kept at room temperature for further use.

2.3. Formulation of mixing flours

Table 1 provides information on the formulation of mixing flour to make cookies. There are three formulations of mixing flour which were the combination of rice flour (60, 50, and 40 %) and okara flour (40, 50, and 60 %). Moreover, 100 % of rice flour was used to make cookies as a control condition.

Table 1 Different formulations of cookies

Flours (%)	Sample code			
	Control	F1	F2	F3
Rice flour	100	60	50	40
Okara flour	-	40	50	60

2.4. Cookie preparation

Cookies were produced with slight modifications from the method described by Offia-olua [13]. All the ingredients (okara flour, sugar, butter, egg, rice flour, milk powder, modified starch, baking powder, and salt) were mixed together until they were homogenized. After mixing all ingredients, the dough was shaped and baked at 190 °C for 15 min and cooled to room temperature before packaging.

2.5. Proximate analysis of gluten-free cookies

2.5.1. Determination of fiber content

The fiber content was done with slight modification from the method described by Basharat et al. [14]. First, 1 g of sample was boiled in 360 mL of 1.25% H_2SO_4 for 30 min and was washed with hot distilled water. Then, sample was digested in 360 mL of 1.25% NaOH for 30 min and washed with hot distilled water. The residue obtained was dried in an oven (Memmert UNE400, Germany) at 105°C to a constant mass and was then put in a muffle furnace (Nabertherm B180, Germany) at 550 ºC for 4h and cooled in a desiccator.

$$\text{Fiber (\%)} = \frac{(W2 - W1) - (W4 - W3)}{W} \times 100 \quad \text{(Eq. 1)}$$

where:

W = the weight of the sample (g)
W1 = the weight of the fiber bag (g)
W2 = the weight of the sample after drying (g)
W3 = the weight of the crucible (g)
W4 = the total weight of the crucible with ash (g)

2.5.2 Determination of fat content

Fat content was tested using the soxhlet extraction (SER 148, VELP Scientifica, Italy) based on AOAC method (920.39) [15]. In brief, 2 g of sample was placed in cellulose thimbles followed by the addition of hexane into a thimble cup which was attached to the soxhlet apparatus. Then, the thimble cups with fat residue were dried at 105 °C for 2h, cooled in a desiccator, and cups with fat residue were weighed.

$$\text{Fat content (\%)} = \frac{m_1 - m_2}{m_3} \times 100 \qquad \text{(Eq. 2)}$$

where:
m_1 = the mass of the cup with fat residue (g)
m_2 = the mass of the empty cup (g)
m_3 = the mass of the sample (g)

2.5.3. Determination of protein content

Total nitrogen was analyzed at Research and Innovation Center (Phnom Penh, Cambodia) by the Kjeldahl method and was multiplied by 6.25 to obtain total protein content (method 960.52).

2.5.4. Determination of total carbohydrate

Total carbohydrate (CHO) content was calculated by using the following equation.

$$\text{CHO (\%)} = 100 - (A + P + F + CF + M) \qquad \text{(Eq. 3)}$$

where:

A = ash content (%)
P = protein content (%)
F = fat content (%)
CF = crude fiber content (%)
M = moisture content (%)

2.6. Physical analysis for gluten-free cookies
2.6.1. Determination of moisture content

In brief, 3 g of ground sample were weighed using an electronic balance (XB 120A, Precisa, Switzerland) in an aluminum dish and placed in a drying oven (Memmert UNE400, Germany) at 105°C until reaching a constant mass After drying, the dish was kept in a desiccator for 15 min to cool to room temperature [16]. Then, reweight the dish with the dried sample and calculated by the following formula:

$$\text{Moisture content (d.b\%)} = \frac{W1 - W2}{W2} \times 100 \qquad \text{(Eq. 4)}$$

where:

W1 = the weight of dish with sample before drying (g)
W2 = the weight of dish with sample after drying (g)

2.6.2. Determination of water activity (a_w)

The water activity was evaluated using a water activity meter (Aqualab 4TE, Benchtop). Around 2 g of sample were placed on a small plate and measured at the ambient temperature. The result was recorded when reading constantly on the screen.

2.6.3. Determination of ash content

Two grams of sample were weighed in a porcelain crucible that had previously been subjected to constant weight, and the crucible was placed in a muffle oven. (Nabertherm B180, Germany) at 550 °C for 5h until complete calcination [16]. The crucible was then cooled down in a desiccator for 15 min and the ash content was determined by the following formula:

$$\text{Ash content (\%)} = \frac{W3 - W1}{W2} \times 100 \qquad \text{(Eq. 5)}$$

where:
W1 = the weight of crucible (g)
W2 = the weight of the sample (g)
W3 = the total weight of the crucible with ash (g)

2.6.4. Color measurement

The color of cookies was analyzed using a portable colorimeter (Chroma CR400, Konica-Minolta Ltd., Osaka, Japan) by CIELAB coordinates (L*, a*, b*). A white tile was used to calibrate the chronometer with the standard Y = 86.5, x = 0.3156, and y = 0.3232. Color measurement was done on the surface of two cookies per treatment randomly.

2.6.5 Spread factor determination

The spread factor of samples was calculated by dividing the diameter (widths) by the thickness of the cookies. The widths and thickness of cookies were analyzed by using a caliper.

$$\text{Spread factor} = \frac{\text{Widths}}{\text{Thickness}} \qquad \text{(Eq. 6)}$$

2.7. Sensory evaluation

The sensory evaluation was performed using a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely). Seventy-two untrained panelists (31 men and 41 women) varying between 18 to 25 years of age were selected to test for appearance, taste, mouth feel, odor, texture (crispiness, hardness), and overall acceptability of cookies. In the Food Science and Technology Laboratory, the panel members were collected randomly from the university community. To conduct sensory analysis, the samples were placed in a clean serving cup with three digital codes, and panelists were given a cup of water to rinse their mouths in between evaluations. The data was collected and discussed statistically [17].

2.8 Statistical analysis

All the assays were measured at least in duplicate, and the results were expressed as the mean ± standard deviation (SD). One-way ANOVA was performed to compare between control and formulated samples for each parameter using IBM® SPSS Statistics version 29 (SPSS Inc., USA) and Duncan's multiple range test (DMRT) with a confidence interval of 95% to determine significant differences between physical properties, proximate composition, and sensory evaluation ($p < 0.05$) [18].

3. RESULTS AND DISCUSSION

3.1. Characteristics of okara and rice flours

The quality of okara flour and rice flour was evaluated before being incorporated into cookie production (Table 2). Regarding the result of nutritional value, okara flour had 22.87% fiber, 22.15% fat, 39.67% protein, and 12.32% carbohydrate content. In addition, fat, fiber, protein, and carbohydrate content in rice flour was 0.44%, 10.77%, 6.89%, and 83.23%, respectively. According to this study, the moisture content of okara flour and rice flour was 7.13% and 13.33% ($p < 0.05$). The water activity of okara flour was no significant difference ($p > 0.05$) from rice flour. The water activity of okara and rice flours was 0.55 and 0.62, respectively. Okara flour and rice flour had an average ash content of 3.48% and 0.38% ($p < 0.05$), respectively. The result was similar to the study of El-Reffaei et al. [19] that the ash content of okara flour was 3.70%. The larger level of ash content in okara was higher in essential elements such as phosphorus, calcium, potassium, zinc, copper, and iron, which absolutely improves the nutritional quality of cookies using okara [20]. According to the result of this study, the lightness of okara flour was lower than rice flour which can decrease the lightness of cookies when incorporated with more amount of okara flour. In general, the variation in okara composition may cause by the soymilk preparation process (particularly the grinding step) and the quality of raw materials such as seed variety and quality.

Table 2 Characteristics of okara and rice flours

Parameters		Okara flour	Rice flour
Fiber content (d.b%)		22.87 ± 0.008^b	10.77 ± 0.3^a
Fat content (d.b%)		22.15 ± 0.15^b	0.44 ± 0.01^a
Protein content (d.b%)		39.67 ± 0.12^b	6.89 ± 0.3^a
Carbohydrate (d.b%)		12.32 ± 0.14^a	83.23 ± 0.08^b
Moisture (d.b%)		7.13 ± 0.58^a	13.33 ± 0.09^b
Water activity		0.55 ± 0.00^a	0.62 ± 0.00^a
Ash content (d.b%)		3.48 ± 0.03^b	0.38 ± 0.01^a
Color	L^*	65.57 ± 0.99^a	90.34 ± 0.06^b
	a^*	0.75 ± 0.02^b	-0.06 ± 0.04^a
	b^*	15.74 ± 0.24^b	2.81 ± 0.04^a

The mean value with different superscript in the same row indicates the statistically significant difference ($p < 0.05$)

3.2. Proximate composition of gluten-free cookies

Table 3 shows the result of proximate compositions of gluten-free cookies. The fiber content of the control, F1, F2, and F3 samples was 1.68%, 3.89%, 3.93%, and 4.01%. The result was in agreement with the study of Ostermann-porcel et al. [12] who reported the fiber content of cookies prepared from the mixture of okara flour and manioc flour ranged from 1.32 to 3.93%.

For fat content, mean values was 16.16%, 19.33%, 19.73%, and 21.36% for control, F1, F2, and F3 samples, respectively. According to Ostermann-porcel et al. [12] , the fat content of cookies was found between 15.40 and 22.10%. The fat content found in this study has met the quality of Standard National Indonesia SNI 01-2973-2011 where a minimum fat content is 9.50%.

The protein content of control, F1, F2, and F3 samples was 4.62%, 10.46%, 11.97%, and 13.28%, respectively. The result indicates a positive effect of using okara flour in cookie production. The result was in agreement with the report of Momin et al. [21], in which the protein content of cookies increased with increasing levels of okara flour. The results of this study proves that okara flour contains larger protein content (39.67%) than rice flour (6.89%), which contributes to higher protein content with an increased level of okara flour in cookie production. The presence of protein content in gluten-free cookies qualified the standard of cookies where the minimum protein content is 5% reported by the Standard National Indonesia SNI 01-29732011.

The carbohydrate content of control, F1, F2, and F3 samples decreased with higher replacement of okara flour which was 71.99%, 61.40%, 59.76%, and 57.95%, respectively. This was caused by the lower carbohydrate content of okara flour (12.32%) compared to rice flour (83.23%) and the existence of different content of protein, fat, fiber, ash, and moisture in the cookies.

Table 3 Proximate compositions in dry basis (d.b%) of gluten-free cookies

Samples	Fiber (%)	Fat (%)	Protein (%)	CHO (%)
Control	1.7 ± 0.5^a	16.2 ± 0.2^a	4.6 ± 0.1^a	72.0 ± 0.2^d
F1	3.9 ± 0.7^b	19.3 ± 0.0^b	10.5 ± 0.0^b	61.4 ± 0.1^c
F2	3.9 ± 0.03^b	19.7 ± 0.0^c	11.9 ± 0.1^c	59.7 ± 0.1^b
F3	4.0 ± 0.6^b	21.4 ± 0.1^d	13.3 ± 0.2^d	57.9 ± 0.1^a

The mean value with different superscript in the same column indicates the statistically significant difference ($p < 0.05$)

3.3. Physical characteristics of gluten-free cookies

3.2.1. Moisture content of gluten-free cookies

The result of moisture content of cookies is shown in Fig. 1. The moisture content of cookies decreased with more addition of okara flour ($p > 0.05$). The control cookies had an average moisture content of 4.37%, while samples F1, F2, and F3 were 3.42%, 2.99%, and 1.72%, respectively. The moisture content of all samples was within the standard of freshly baked biscuits, ranging from 1 to 5% [22]. A previous study by Grizotto et al. [23] reported similar results for biscuits made with partial replacement of wheat flour with okara flour which the moisture content of cookies, ranged from 2.89% to 3.24%. In addition, the moisture content of cookies increased due to a larger volume of water required during dough making for high fiber and protein content [24]. Therefore, cookies incorporated with okara flour that contains a larger protein content can absorb more moisture than cookies produced with flour consisting of lower protein. According to the result of this study, the moisture content of okara flour was significantly lower than rice flour, resulting in the moisture content decreased when more okara flour was added to cookies.

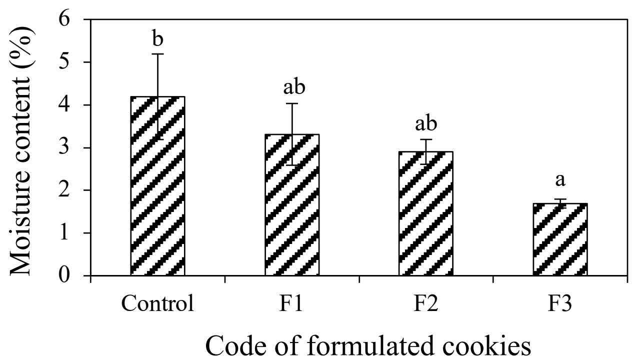

Fig. 1. The moisture content in different cookies formulated. Graph bars with different superscript letters (a, b) differ significantly from each other ($p < 0.05$).

3.2.2. Water activity of gluten-free cookies

Water activity of samples is presented in Fig. 2. The water activity of three formulated cookies had a significant difference ($p < 0.05$) compared to the control with an average of 0.3175.

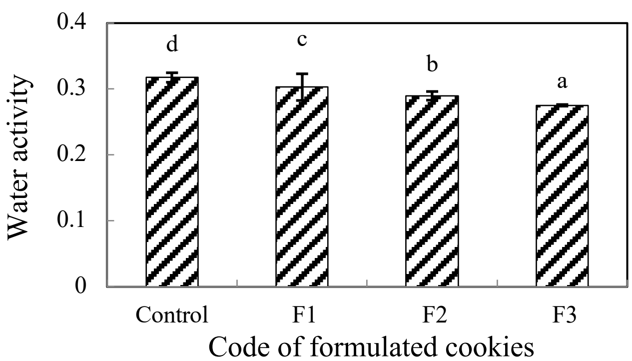

Fig. 2. The water activity in different cookies formulated. Graph bars with different superscript letters (a, b) differ significantly from each other ($p < 0.05$)

The result shows that the water activity was 0.3029 ± 0.02, 0.2897 ± 0.006, and 0.2753 ± 0.001 for samples F1, F2, and F3, respectively. Water activity in freshly baked biscuits was typically around 0.3 [25]. A previous study by Červenka et al. [26] stated that water activity measured the free moisture of biscuits which ranges between 0.10 and 0.53. Since the result of water activity of all formulations was lower than 0.6, they were considered microbiologically stable, even though some of the components may undergo chemical and biochemical reactions. Based on the result of this study, the water activity of cookies was dramatically impacted by the level of okara addition.

3.2.3. Ash content of gluten-free cookies

The ash content of formulated cookies had no significant difference ($p > 0.05$) from the control which was 1.18% as shown in Fig. 3. The trend of ash content slightly increased with an average of 1.50%, 1.62%, and 1.68% for samples F1, F2, and F3, respectively. The result indicates that the ash content of cookies increased with the addition of okara flour. This was in agreement with the report of Hawa et al. [1] for cookies prepared with okara, red teff, and wheat flour, and the ash content slightly increased from 1.2% to 2.4%. An increase in ash content of cookies is due to a high amount of ash in okara compared to rice flour. Okara flour contains high amounts of minerals such as calcium (126 mg/100 g), phosphorus (313 mg/100 g), and potassium (286 mg/100 g), with a moderate level of zinc (3.14 mg/100 g), copper (0.77 mg/100 g), and iron (4.45 mg/100 g) [20]. Also, the ash content in okara flour (3.23%) was higher than in rice flour (0.23%), causing a larger ash content when okara flour was added to cookies.

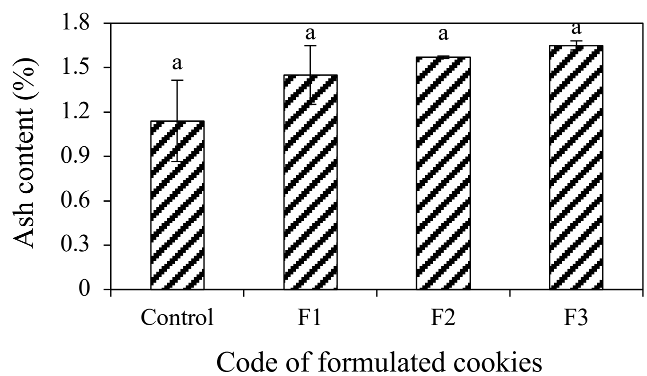

Fig. 3. The ash content in different cookies formulated. Graph bars with different superscript letters (a, b) differ significantly from each other ($p < 0.05$)

3.2.4. Color of gluten-free cookies

The difference color of cookies is indicated in Fig. 4. The surface color of cookies was influenced by the levels of okara flour replacement and had a significant difference ($p < 0.05$) among all color parameters (L^*, a^*, and b^*) between the three formulated cookies and the control sample. According to the result shown in Fig. 5, the lightness (L^*) of cookies dramatically decreased from 70.55 to 61.16, whereas the value of redness (a^*) and yellowness (b^*) significantly increased from 6.04 to 9.24 and 31.85 to 34.55 with more okara flour addition. The result indicates that once the color of cookies was tested, darkening was formed due to the okara addition. The result was in agreement with the study of Ostermann-porcel et al. [12] that the color of cookies produced from okara incorporated with manioc flour declined from 77.91 to 68.98, respectively. A similar study by Singh and Mohamed [27] revealed that the higher replacement of okara causes a darker color, while more red and yellow. The more redness and yellowness in cookies compared to the control because of the presence of phytochemical and crude fiber in okara. Moreover, the color of cookies rose due to the interaction of protein and sugar during baking, which result in a higher degree of Maillard reaction.

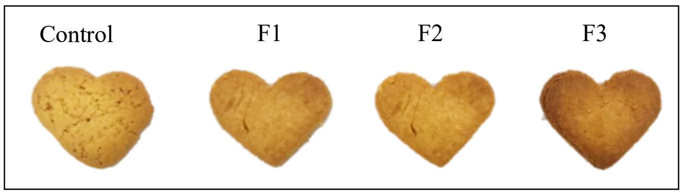

Fig. 4. Cookies with different flours formulated

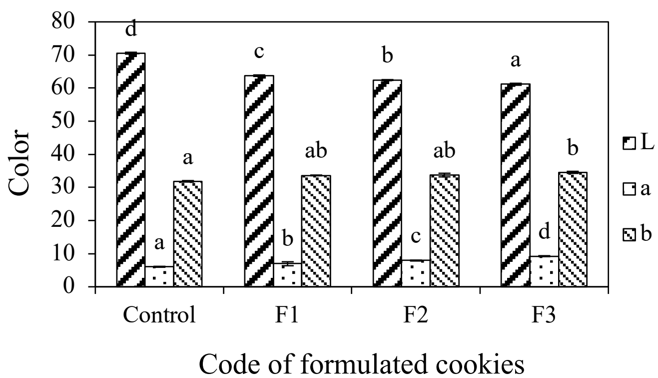

Fig. 5. Color parameter in different cookies formulated. Graph bars with different superscript letters (a, b) differ significantly from each other ($p < 0.05$)

Table 5 The sensory evaluation of gluten-free cookies

Samples	Color	Odor	Mouthfeel	Taste	Hardness	Crispiness	Overall liking
Control	7.14 ± 1.09^c	6.93 ± 1.17^c	6.79 ± 1.06^c	7.10 ± 1.22^c	6.55 ± 1.23^b	6.90 ± 1.26^b	7.11 ± 1.00^b
F1	6.67 ± 1.03^b	6.40 ± 1.34^b	6.31 ± 1.40^b	6.44 ± 1.53^b	6.57 ± 1.48^b	6.61 ± 1.45^b	6.67 ± 1.37^b
F2	6.86 ± 1.20^{bc}	6.50 ± 1.22^{bc}	6.72 ± 1.42^{bc}	6.82 ± 1.29^{bc}	6.53 ± 1.43^b	6.78 ± 1.33^b	6.90 ± 1.21^b
F3	6.10 ± 1.48^a	5.88 ± 1.48^a	5.51 ± 1.46^a	5.56 ± 1.59^a	5.39 ± 1.57^a	5.54 ± 1.55^a	5.68 ± 1.59^a

3.2.5. Spread factor of gluten-free cookies

Table 4 shows the result of the widths, thickness, and spread factor of cookies. The spread factor is an important characteristic to determine the quality of cookies. There was a significant difference ($p < 0.05$) in the spread factor with an addition of okara. Both widths and thickness of formulated cookies were lower than the control with an average of 36.3 mm and 9.11 mm. The addition of okara significantly decreased the widths and thickness of cookies compared to the cookies produced with only rice. Moreover, the spread factor of control, F1, F2, and F3 samples was found to be 3.98 ± 0.06, 3.62 ± 0.13, 3.56 ± 0.03, and 3.47 ± 0.03 ($p < 0.05$), respectively. The presence of okara that contains high protein and fiber interfered with the structure and gas retention, hindering the dough which leads to a reduction in cookie expansion [21]. Moreover, the spread factor decreased due to the water absorption by fiber and lower absorption by starch, leading to less gelatinization [6]. The presence of okara flour also leads to lower expansion during the starch gelatinization. The cookies with the highest spread ratios are the most desirable.

Table 4 The spread factor of gluten-free cookies

Samples	Widths (mm)	Thickness (mm)	Spread factor
Control	36.3 ± 0.62^b	9.11 ± 0.29^c	3.98 ± 0.06^c
F1	30.3 ± 0.14^a	8.57 ± 0.10^{ab}	3.62 ± 0.13^b
F2	30.5 ± 0.08^a	8.38 ± 0.26^a	3.56 ± 0.03^{ab}
F3	30.6 ± 0.27^a	8.82 ± 0.13^{bc}	3.47 ± 0.03^a

The mean value with different superscript in the same column indicates the statistically significant difference ($p < 0.05$)

3.4 Sensory evaluation of gluten-free cookies

The effect of 40% and 50% okara flour addition on the sensory characteristics of cookies was no significant difference ($p > 0.05$) from the control (Table 5). The cookies with 40% okara addition were slightly like according to panels with an average overall liking score of 6.67. Also, the cookie with 50% okara was the most accepted with an average overall liking score of 6.90. However, cookies incorporated with 60% okara had a significant difference ($p < 0.05$) from the control and had the lowest score among all attributes with average overall acceptability of 5.68. Therefore, up to 60% of okara flour had a negative impact on sensory evaluation and the result was in agreement with the study of Ostermann-porcel et al. [12]. Panelists noted that the cookies with 60% okara were graded as too dark in color, had a bitter taste, a little harder in texture, and had an aftertaste that was similar to the study of Yamsaengsung et al. [28]. The study here illustrates that okara addition has the potential to improve color, odor, mouthfeel, taste, hardness, and crispiness when added at an appropriate amount for gluten-free cookies. From the sensory test point of view, the optimum level of okara used to make gluten-free cookies was 50% to reduce soybean residue and economically helpful.

4. CONCLUSIONS

Cookies prepared from mixed okara (40, 50, and 60%) and refined rice flour performed better in terms of fiber, fat, protein, and carbohydrate content. Okara flour is regarded as a promising source of nutrients such as protein and fiber. Moreover, moisture content, water activity, ash content, color, and spread factor of all cookie formulations were within the acceptable limit. In addition, gluten-free cookies made from 50% of okara flour can be used to replace rice flour based on consumer acceptability. The substitution of okara flour as an ingredient in cookie production creates a new product from a by-product of soybean, saves the economy, and achieves waste reduction. The suggestion for future studies is that the texture and shelf-life of cookies should be improved by studying food stabilizers and different packaging materials.

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