

Original Research Article

Nutritional Composition and Physical Properties of Cookies Formulated with Soybean Residue

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Abstract: The soybean residue is the main solid waste produced during soy milk and tofu production. A huge amount of soybean residue (okara) was produced and dumped in the municipal landfills thus creating an environmental problem. Hence, the use of by-products is an important strategy to valorise food-industrial productive chains. The okara comprises cellulose, hemicellulose, and lignin which can be utilised in the production of bakery goods like cookies. Therefore, this study was conducted to determine the effects of different percentages of okara used on the nutritional composition (moisture, ash, crude protein, crude fat and total carbohydrates) and physical properties (weight loss, thickness and hardness) of okara-containing cookies. The cookies were formulated according to the ratio between okara and wheat flour; F1 [control] (0:40), F2 (10:30), F3 (20:20) and F4 (30:10). The incorporation of okara significantly ($p < 0.05$) decreased the moisture content of cookies as compared to control. The highest ash content was recorded in F4 cookies. The study also found that different percentages of okara used did not significantly affect the protein content between F2, F3 and F4, however, F2 recorded significantly lower protein content when compared to control. Meanwhile, lower ($p < 0.05$) fat content was found in F2, F3 and F4 cookies when compared to control. The incorporation of okara significantly ($p < 0.05$) increased the carbohydrate content for F2, F3 and F4 cookies as compared to control. Regarding the physical properties of cookies, the highest values of hardness were shown in control samples followed by F2, F3 and F4 cookies. Meanwhile, no significant difference was found in weight loss for each sample. Overall, the present results indicated that the incorporation of soybean residue in cookie formulation improved the nutritional value in terms of total carbohydrates and slight impact on the physical properties of cookies.

Keywords: soybean residue; nutritional; physical properties

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1. Introduction

Cookies are consumed widely all over the world because of their convenience, nutritive value and shelf stability (Dharsenda *et al.*, 2015). Cookies often refer to a baked product that is generally prepared using three major ingredients: wheat flour, sugar, hydrogenated fats, and some minor ingredients such as additives and emulsifiers (Martínez *et al.*, 2022). Wheat flour is a key ingredient in cookies due to its high gluten content which functions to make the dough elastic and stretchy (Asadi *et al.*, 2021).

Nowadays, extensive studies have been conducted on the addition and incorporation of other ingredients in cookies production such as cookies prepared from wheat flour supplemented with cassava and water chestnut flours (Bala *et al.*, 2015), cookies produced from wheat flour and malted barley (*Hordeum vulgare*) bran blends (Ikuomola *et al.*, 2017), and cookies formulated with date seed powder (Najjar *et al.*, 2022).

Soybean residue (okara) is a byproduct of soy processing that are usually not utilised and end up in municipal landfills. It is a white or yellowish pulp consisting insoluble portion (shell, hull, or husk) of soybean (Asghar *et al.*, 2023). Okara is typically underutilised which is commonly being used for low-value products such as animal feed. According to a literature study by Kamble and Rani (2020), okara is a rich source of dietary fibre, protein, fat, minerals, and phytochemicals such as phytates, saponins, coumestans, phytosterols, lignans, and isoflavones. Okara can be used in the food sector to partially replace traditional flour, and it has the potential as a prebiotic agent to prevent obesity, hypercholesterolemia, and hyperlipidemia (Asghar *et al.*, 2023). Therefore, several research have been conducted on the application of okara in food products. For instance, research conducted by Hawa *et al.* (2018) reported a significant improvement in the nutritional composition such as protein and fibres of cookies prepared from okara, red teff and wheat flours. Meanwhile, a recent study by Liu *et al.*, (2021) reported that the addition of okara dietary fibre to the cookie dough had improved the dietary fibre content in the cookie.

The okara from soymilk processing contains high moisture content, thus making it susceptible to spoiling. According to Kamble and Rani (2020), fresh okara contains 80.25% moisture content, 7.91% protein and 6.22% fat, thus making it more perishable. Therefore, the best alternative is to recycle the okara immediately after the soymilk processing and turn it into a part of the ingredient in food production. Since the okara contains an appreciable amount of nutrients and can be obtained from a byproduct, it has the potential to be converted into a cost-effective ingredient in food products. According to Asghar *et al.* (2023), okara can be used in food applications as an ingredient or as a whole food. Research conducted by Momin *et al.* (2020) has also shown significant improvement in nutritional composition such as protein of biscuits containing 2, 4, 6 and 8% okara flour.

Therefore, the objective of this study was to determine the nutritional composition and physical properties of cookies formulated with okara (10, 20, and 30%).

2. Materials and Methods

2.1 Materials

All ingredients (wheat flour, brown sugar, salted butter, corn flour, baking powder and vanilla essence) used to prepare cookies were purchased from local markets in Muar, Johor, Malaysia. Other than that, okara was prepared in the laboratory. The wet okara was collected from the local soymilk manufacturer and immediately dried using a dehydrator machine at a temperature of 70°C for 15 h. Upon completion of drying, the okara was ground and sieved to obtain a fine texture. The collected okara was stored in an airtight container prior to further processing.

2.2 Cookies Preparation

Cookies were prepared according to the method of Bala *et al.* (2015) with slight modifications. The ingredients used for cookies are mentioned in Table 1. Four formulations were developed; 40% wheat flour (F1), 10% okara: 30% wheat flour (F2), 20% okara: 20% wheat flour (F3), 30% okara: 10% wheat flour (F4). The percentage of okara used in this study was based on a preliminary experiment to choose the percentage that gives good textural and sensorial properties besides the previous studies. In the mixing bowl, the materials were added in a specific order. Initially, butter and brown sugar were mixed in a mixer for 2 min. Corn flour, baking soda, vanilla essence, okara, wheat flour and water were added and mixed until homogenised. After that, the dough was kneaded and flattened to a uniform thickness of 0.5 cm. Then, it was cut into a round shape of 6 cm in diameter. The cookies were baked in a convection oven at 170°C for 10 min. The cookies were cooled at room temperature for 2 hr and then packed in polypropylene bags before further analyses.

Table 1. Formulation for the cookie production using wheat flour and okara.

Ingredients	F1 (%)	F2 (%)	F3 (%)	F4 (%)
Okara	0	10	20	30
Wheat Flour	40	30	20	10
Water	22	22	22	22
Brown sugar	18	18	18	18
Salted butter	15	15	15	15
Corn flour	3	3	3	3
Baking powder	1	1	1	1
Vanilla essence	1	1	1	1
Total	100	100	100	100

2.3 Nutritional Composition Analysis

The proximate contents of the cookies were determined according to the official method as described by the American Association of Cereal Chemists (AACC) (2000). Oven drying (AACC method 08-01), Kjeldahl's (AACC method 44-15A), semi-continuous solvent extraction method (AACC method 46-13) and dry ashing (AACC method 30-25) were used to analyse moisture, crude protein, crude fat and ash, respectively. The total carbohydrate

content was estimated by difference [Total carbohydrate (%) = 100% - % (Moisture + Ash + Crude protein + Crude fat)].

2.4 Thickness of Cookies and Weight Loss

The thickness of cookies was measured using a vernier calliper at three different places in each cookie and the average was calculated for each. The weight of the cookies before and after baking was taken to calculate weight loss.

2.5 Hardness of Cookies

The hardness of cookies was determined according to the method described by Egea *et al.* (2014) with slight modifications. The instrument setting was: test mode, normal; pre-test speed, 0.1 mm/s; test speed, 5 mm/s; distance, 8 mm, trigger force, 7 g. Each cookie sample was placed horizontally on a platform and cut in half, using a knife-shaped probe (3 mm thick). The maximum force required to break a single cookie was recorded and the average value of five cookies for each formulation was reported.

2.4 Statistical Analysis

Results are expressed as means with standard deviations of analysis performed in triplicate. One-way analysis of variance and Tukey's test were used to establish the significance of differences among mean values at $p \leq 0.05$. The statistical analyses were performed using SPSS software (Ver. 22) (IBM Corporation).

3. Results and Discussions

3.1 Nutritional Composition

The proximate composition of cookies formulated with okara (10%, 20% and 30%) is shown in Table 2. The substitution of okara for wheat flour significantly ($p < 0.05$) decreased the moisture content of cookies as compared to control. The decreased in moisture content of okara-containing cookies probably due lack of water binding capacity affected by the lower amount of wheat flour. Wheat flour contains gluten protein that forms a matrix which helps hold in the melted fat and sugar (Momin *et al.*, 2020). A similar study by Ho and Abdul Latif (2016) reported cookies added with pitaya peel flour ranging from 5 to 15% had lower moisture content compared to control. Another study by Park *et al.* (2015) found that okara dough cookies had lower water-holding capacity which resulted in lower moisture content.

Table 2. Nutritional composition of cookies.

Parameter	F1 (control)	F2	F3	F4
Moisture (%)	6.52 ± 0.03 ^a	4.36 ± 0.04 ^c	3.48 ± 0.10 ^d	5.48 ± 0.07 ^b
Ash (%)	1.12 ± 0.50 ^b	1.59 ± 0.19 ^b	1.79 ± 0.19 ^b	2.71 ± 0.10 ^a
Crude protein (%)	10.10 ± 0.70 ^a	7.34 ± 0.05 ^b	8.95 ± 1.27 ^{ab}	8.93 ± 0.22 ^{ab}
Crude fat (%)	20.67±0.58 ^a	15.00±2.65 ^b	11.78±0.14 ^b	11.75±0.12 ^b
Total carbohydrate (%)	61.59±0.55 ^b	71.70±2.59 ^a	74.00±1.29 ^a	71.13±0.32 ^a

Data are mean ± SD of triplicate (n = 3). Different superscripts in a row indicate a significant difference ($p < 0.05$).

Table 2 indicated that the highest ($p < 0.05$) ash content for cookies containing 30% okara (F4), and no significant difference ($p > 0.05$) were found between F1, F2 and F3. The result of this study indicated that the ash content of the cookies increased gradually with the increasing percentage of okara even though it was not statistically significant. The higher ash content in okara-containing cookies may be associated with the presence of higher ash content in okara than in wheat flour. Previous studies reported the ash content for dry okara and wheat flour are 3.85% and 0.70%, respectively (Ocheme *et al.*, 2018; Kamble & Rani., 2020). In general, ash content represents the inorganic residue (minerals) remaining after ignition and complete oxidation of organic matter (Guimarães *et al.*, 2020).

Based on Table 2, the crude protein content of cookies prepared from 10%, 20% and 30% okara recorded no significant difference ($p > 0.05$). However, wheat-based cookies recorded higher crude protein content as compared to F2. This is due to a higher amount of wheat flour used. A similar study by Park *et al.* (2015) found that cookies containing the highest value of wheat flour will result in the highest value of protein content. The findings conform with the report of Ikuomola *et al.* (2017) for the increasing trend of the protein content (11.21 to 15.64%) in cookies produced from wheat flour and malted barley bran. The protein content obtained in this study was within range as compared to other studies. Research conducted by Ostermann-Porcel *et al.* (2017) showed the protein content of cookies incorporated with 15%, 30% and 50% okara ranged from 5.40 to 12.84%.

The present study indicated that cookies formulated with okara had lower crude fat content as compared to wheat-based cookies (Table 2). The crude fat content of cookies containing 10, 20 and 30% okara ranged from 11.75 to 15 %. The findings were in line with the research conducted by Hawa *et al.* (2018) which reported that the fat content of cookies added with okara flour ranged from 13.2% to 18.2%. The study also found that increasing the okara flour content in cookies can reduce the amount of fat, thus lowering the overall fat content of the cookies. Therefore, incorporating okara into the cookie recipe resulted in a lower fat content.

All cookies containing okara recorded significantly higher ($p < 0.05$) total carbohydrate content as compared to wheat-based cookies. Meanwhile, no significant difference ($p > 0.05$) in total carbohydrate content was found in cookies produced using different percentages of okara. The results obtained were comparable with other studies. A study conducted by Ostermann-Porcel *et al.* (2017) showed the total carbohydrate of cookies incorporated with okara ranged from 55.24 to 71.54%. The authors also found that the higher incorporation of okara resulted in a decrease in total carbohydrate content which is in contrast with the present findings. The higher total carbohydrate of okara-based cookies is probably due to the high fibre content in okara as reported by Kamble and Rani (2020), the crude fiber content for dried okara was 17.9%.

3.2 Physical Properties

Based on Table 3, cookies that contain 20% and 30% okara had a significantly lower thickness than other samples. The decrease in thickness might be due to the lower gluten hydration during the mixing process. Gluten hydration is an essential step in baking in which the gluten proteins is activated and form protein strands that are able to hold more water. The increased amount of okara which is high fibre had interfered with the formation of protein strands. In addition, it also can lead to a denser dough and less homogeneous texture that causes the cookies to shrink and become less able to expand (Liu *et al.*, 2021).

Table 3. Physical properties of cookies.

Parameter	F1 (control)	F2	F3	F4
Thickness (mm)	3.38 ± 0.73 ^{ab}	4.90 ± 0.95 ^a	2.57 ± 0.25 ^b	1.80 ± 0.44 ^b
Weight loss (g)	2.19 ± 0.33 ^a	2.50 ± 0.36 ^a	2.48 ± 0.08 ^a	2.37 ± 0.07 ^a
Hardness (g)	130 ± 6.00 ^a	93.00 ± 4.00 ^b	87.00 ± 2.00 ^{bc}	79.33 ± 3.21 ^c

Data are mean ± SD of triplicate (n = 5). Different superscripts in a row indicate a significant difference ($p < 0.05$).

There was no significant difference in weight loss among all formulations (Table 3). The results indicated that partial substitution of okara for wheat flour did not affect the weight loss of cookies after baking. The presence of gluten in formulation helps in the formation of a protein matrix thus capable of holding the melted fat and sugar during baking (Momin *et al.*, 2020). The findings agree with the report of Ho and Abdul Latif (2016) that no significant difference in weight loss between cookies prepared from wheat flour and pitaya peel flour blends.

The hardness values of the cookies analysed using the analyser are shown in Table 3. The increased percentage of okara had significantly reduced the hardness of cookies. This is probably due to the decrease in protein content as stated in Table 2. The protein content particularly gluten is responsible for forming strong bonds with other proteins in the flour, creating elasticity and structure in the dough. This elasticity allows the dough to expand during baking, resulting in a more homogeneous and evenly cooked product. Hence, higher

hardness in wheat-based cookies as compared to cookies formulated with okara flour. These results are in accordance with Park *et al.* (2015) who reported an increase in the hardness of the dough with a corresponding increase in the protein content. According to Asadi *et al.* (2021), the hardness of cookies can be influenced by the interplay of protein and starch, as well as the type and concentration of ingredients used.

4. Conclusions

In conclusion, the cookies prepared from 10%, 20% and 30% of okara had higher carbohydrate content and lower fat content than the control cookies. Increased substitution of okara for wheat flour significantly increases the ash and decreases the moisture content of cookies. However, it did not affect the protein content of composition cookies. The present study also found that an increase in the amount of okara in cookies results in a decrease in hardness. Apart from that, the incorporation of okara did not affect the weight loss of cookies. Overall, the present results indicated that cookies formulated with soybean residue had improved the nutritional content by increasing the carbohydrate and lowering the fat content of cookies. Thus, it can be concluded that okara can be a good alternative to wheat flour in producing cookies with high total carbohydrates, besides it could help substantially reduce the wastage of the by-product.

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Conflicts of Interest: The authors declare no conflict of interest.

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