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Sensory Properties of Gluten-Free Cookies Produced From Okara and Almond Flour

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ABSTRACT

Okara is a fiber-rich by-product of soy milk production. The okara comprises cellulose, hemicellulose, and lignin, which can be utilised to produce bakery goods like cookies. Therefore, this study aimed to determine the sensory properties of gluten-free cookies produced from okara and almond flour. Four formulations were developed; 35% wheat flour (Control), 35% okara (F1), 30% okara with 5% almond flour (F2) and 20% okara with 5% almond flour (F3). The sensory analysis found that substituting wheat flour with okara and almond flour in cookie formulation significantly ($p < 0.05$) influences the majority of sensory attributes of cookies except colour. However, no significant difference ($p > 0.05$) was recorded for all sensory attributes among F1, F2 and F3 samples. Overall, the cookies produced using okara and almond flour recorded significantly ($p < 0.05$) lower scores for appearance, shape, taste, texture and overall acceptance as compared to control. The sensory scores obtained for gluten-free cookies (F1, F2 and F3) were within acceptable range. Hence, it can be concluded that acceptable sensory properties of gluten-free cookies can be obtained by substituting wheat flour with okara and almond flour, thus indicating that by-products such as okara have the potential to be used in the development of baked food products.

1.0 Introduction

Cookies are popular bakery products consumed by almost all levels of society due to their variety of taste, texture and digestibility. Cookies are available in different shapes and flavours to be enjoyed as a snack with a long shelf life. (Mohammadi *et al*., 2022). The main attributes that affect cookie quality are texture, flavour, and appearance, which are key factors in consumer acceptance (Fauad *et al*., 2020). Normally, cookies are prepared using refined wheat flour. The essential ingredients of these products are flour, fat/oil, sugar, water, and chemical leavening agents, such as baking soda (Ikuomola *et al*., 2017). Wheat flour is the main ingredient in cookies because it is rich in gluten. Gluten is a complex mixture of hundreds of related but distinct proteins, mainly gliadin and glutenin. However, dietary gluten unequivocally causes coeliac disease, an immune-mediated disease that affects about 1% of Western populations. Therefore, demand for commercial gluten-free food products is increasing due to rising prevalence.

These days, a healthy population is looking for gluten-free solutions, which has led to the market's growth in gluten-free products. Producing gluten-free food products, especially those

with acceptable functional and sensory properties, is a great challenge since gluten is responsible for the structure of these products. Recent studies have shown several gluten-free ingredients have been used to produce baked products. The ingredients such as germinated brown rice flour (Bolarinwa *et al*., 2019), chestnut flour (Mohammadi *et al*., 2022), sorghum and millet composite flour (Aljobair, 2022) and lentil flour (Hajas *et al*., 2022) have so far been used as an alternative for wheat flour in cookies recipe.

Almond flour is one of the most suitable ingredients for developing gluten-free products due to its high protein content and a special flavour in all dishes, making it a beneficial alternative to traditional wheat flour. Almond flour has a slightly sweet taste and offers many advantages, including a lower risk of bad cholesterol and insulin resistance. (Yildiz, & Gocmen, 2021). Almond flour also has a higher caloric content than wheat flour. (Martinescu *et al*., 2020).

Apart from that, okara could also be a useful ingredient in cookie formulation to replace wheat flour. Okara or soybean residue is a by-product obtained during the processing of soybeans for the production of soy milk (Asghar *et al*., 2023). Okara is typically underutilised and is only used for low-value products such as animal feed or disposed of in landfills (Kamble *et al*., 2020; Rahman *et al*., 2021). Okara contains mainly insoluble fibre and complex carbohydrates that provide a low glycemic index (Feng *et al*., 2021). Okara also contains isoflavones and, most importantly no gluten.

Incorporating a by-product, such as okara into baked foods can be recognised as a perfect solution to reduce the impact of food processing waste. Furthermore, the use of almond flour might enhance the nutritional value of the gluten-free cookies. However, obtaining desirable sensory characteristics of gluten-free cookies is challenging and thus requires optimal proportion between all the ingredients used in particular the okara and almond flour. Therefore, the purpose of this study was to determine the sensory properties of gluten-free cookies produced from okara and almond flour.

2.0 Literature review

2.1 Gluten free baked products

The monitoring effectiveness of female corporate leaders is more pronounced during the anti-corruption campaign period. The market for gluten-free products has grown in recent years due to its rising popularity among consumers who follow a gluten-free diet as well as those with medical needs. Gluten-free food is defined by the U.S. Food and Drug Administration as food that is either entirely free of gluten or does not include any of the following ingredients; wheat, wheat flour, or wheat starch. In other words, goods labelled as gluten-free should either not contain gluten at all or have less than 20 parts per million of gluten (Xu *et al*., 2020). Previous research has been extensively studied on gluten-free products made from various gluten-free flours such as germinated brown rice flour (Bolarinwa *et al*., 2019), chestnut flour (Mohammadi *et al*., 2022), sorghum and millet composite flour (Aljobair, 2022) and lentil flour (Hajas *et al*., 2022).

Apart from bread, noodles, and pasta, chemically leavened gluten-free products, particularly cookies, biscuits, and crackers account for a large portion of baked goods. A study by Xu *et al*. (2020) found that people with celiac consumed more gluten-free cookies and crackers rather than gluten-free bread. Because gluten was absent from the dough products, large amounts of carbohydrates, sugar, and fat were used to balance the texture and suggest binding forces. As a result, gluten-free food products have lower levels of protein and dietary fiber but higher levels of carbohydrate, sugar, and fat (Fauad *et al*., 2020). Most of the gluten products were found to have a poor texture and weak flavour, which was caused by the lack of gluten protein (Xu *et al*., 2020). Hence, the removal of gluten in producing a gluten-free product requires intricate study to ensure it does not compromise with their textural and sensory attributes.

2.2 Okara

Okara is a by-product of soybean processing build up that remains after pureed soybeans are filtered to make soymilk or soybean curd that has gained attention in recent years due to its high nutritional value and potential applications in the food and feed industries. However, soybean residue is often considered a source of waste (Plazzotta *et al*., 2022). In terms of its impact on the environment, soybean residue can affect soil nitrogen cycling and crop yields. It can reduce the amount of residual inorganic nitrogen available for the next crop. Additionally, the fermentation process of soybean residue during the rainy season can generate toxic concentrations because it contains high moisture content, soybean residue is more susceptible to fermentation, which can have negative environmental impacts (Roquette *et al*., 2023).

Fresh okara contains around 81.7%~84.5% dampness. The chemical composition of okara will depend on the sum of water stage extricated from the ground soybean and whether advanced water was included to extricate leftover extractable components. It moreover depends on the cultivar of soybean and the generation strategies (Feng *et al*., 2021). According to 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. These compounds have various therapeutic and physiological properties, including antioxidant action, cardiovascular disease prevention, and chemo-preventive effects for cancer patients. 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).

Nowadays, okara is commonly used in various dishes, such as unohana, which is a classic Japanese side dish made from sauted okara (tofu fibre) and various vegetables like carrots and mushrooms. It is a popular Japanese home-style simmered dish made of assorted vegetables, shiitake mushroom, hijiki seaweed, and soy pulp. Okara is also a versatile ingredient in vegetarian and vegan cooking, serving as a nutritious addition to baked goods and as an egg substitute. Additionally, okara is suitable for gluten-free diets and is known for its low cost, low-calorie count, and high dietary fibre content, making it an ideal food for weight management and overall health.

2.3 Almond flour

Almond flour is a healthy substitute for conventional wheat flour because it is high in protein content. Almonds are an excellent source of lipids (53-56%) and proteins (16-22%), as well as a variety of minor bioactive substances like tocopherols and antioxidants. Almond flour contains a high dietary fibre content, which makes it a good choice for baking applications. Almond flour offers a distinctive flavour when incorporated into food products. A previous study by Yildiz and Gocmen (2021) found that the addition of almond flour produced acceptable sensory properties of the gluten-free cookies. Furthermore, the addition of almond flour is known to improve the protein content, amino acid profile, and dietary fibre composition of baked goods (Martinescu *et al*., 2020. According to Yildiz and Gocmen (2021), almond flour contains high levels of monounsaturated oleic acid and polyunsaturated linoleic acid which have a positive effect on human health, such as regulating blood lipid profiles and reducing the risk of cardiovascular diseases. Hence, it can be seen that the incorporation of almonds in producing gluten free products could enhance the nutritional profile of the gluten-free baked products.

3.0 Methodology

3.1 Materials

All ingredients for preparation of the cookies (wheat flour, corn flour, almond flour, butter, icing sugar, chocolate compound, sodium bicarbonate, vanilla essence and salt) were brought from local store in Muar, Johor, Malaysia. Other than that, okara flour 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 hours. Upon completion of drying, the okara

was grinded and sieved to obtain a fine texture. The collected okara was stored in an airtight container prior to further processing.

3.2 Cookies preparation

Cookies were prepared following the method of Bolarinwa *et al*. (2019) with slight modifications. Table 3.2 listed ingredients used for the cookies. Four formulations were developed; 35% wheat flour (Control), 35% okara (F1), 30% okara with 5% almond flour (F2) and 20% okara with 5% almond flour (F3). Specific order of the ingredients has been added in the mixing bowl. Initially, butter and icing sugar were mixed in a mixer for 2 min. Corn flour, sodium bicarbonate, vanilla essence, salt, okara, almond flour and water were added and mixed for 3 min. In the end, the chocolate compound was added and continually mixed until homogenisation. The dough was then worked into a uniform 0.5 cm thickness by kneading and flattening it. It was then cut into a 6 cm diameter round form. The cookies then, were baked at 170°C for 10 min using the cooking oven. The cookies were allowed to cooled for 2 hr within the room temperature and it then packed in polypropylene bags prior to further analyses.

Table 3.2: Formulation for cookies

Ingredients	Control (%)	F1 (%)	F2 (%)	F3 (%)
Wheat flour	35	-	-	-
Okara flour	-	35	30	20
Almond flour	-	-	5	15
Water	21	21	21	21
Butter	12	12	12	12
Icing sugar	17	17	17	17
Chocolate compound	6	6	6	6
Corn flour	3	3	3	3
Vanilla essence	2.5	2.5	2.5	2.5
Sodium bicarbonate	2.5	2.5	2.5	2.5
Salt	1	1	1	1

3.2 Sensory evaluation

For the sensory evaluation of the cookies, the test was runned following the method described by Ikuomola et al. (2017). The cookies were freshly baked prior to the sensory evaluation. The panel members were randomly given cookie samples that had been coded with a three-digit number. A nine-point hedonic scale was used to rate each characteristic (appearance, color, shape, taste, texture, and overall acceptance): 1 representing extreme dislike, 5 representing neither dislike nor like, and 9 representing great liking. In all, fifty untrained panelists took part in the research.

3.3 Statistical analysis

All statistical analyses were performed using SPSS software (Ver. 22) (IBM Corporation). One-way analysis of variance (ANOVA) was performed on the data to identify the significant differences between the treatments. The experiment's whole set of data was presented as mean ± standard deviation (SD). It was deemed statistically significant when $P < 0.05$.

4.0 Results and Discussion

Numerous consumer tests were carried out to assess a product's acceptance prior to its commercial release. Sensory analysis is an approach to determine consumer acceptance towards product attributes such as appearance, colour, shape, taste and texture. Generally, the average scores gained from each attribute indicate how much consumers like the products. Later, the data obtained will be further assessed, thus subsequently helping to analyse the overall sensory attributes of the developed products.

Table 2: Sensory properties of cookies produced using different percentage of okara and almond flour

Characteristics	Control (WF35%)	F1(OF35%)	F2(OF35%-AF5%)	F3(OF20%AF15%)
Appearance	6.66 ± 2.11[a]	5.46 ± 1.60[b]	5.46 ± 1.72[b]	5.69 ± 1.98[ab]
Colour	6.40 ± 2.17[a]	5.31 ± 1.53[a]	5.91 ± 1.81[a]	5.57 ± 1.95[a]
Shape	7.03 ± 1.71[a]	5.57 ± 1.56[b]	5.86 ± 1.48[b]	5.91 ± 1.88[b]
Taste	7.06 ± 1.94[a]	5.17 ± 1.58[b]	5.54 ± 1.77[b]	5.37 ± 2.25[b]
Texture	7.03 ± 1.96[a]	5.31 ± 1.49[b]	5.57 ± 1.56[b]	5.89 ± 1.95[b]
Overall acceptance	7.34 ± 1.80[a]	5.54 ± 1.76[b]	5.91 ± 1.56[b]	5.91 ± 2.06[b]

Data are mean ± standard deviation of 50 replicates (n = 50). Different superscripts in a row indicate a significant difference (p < 0.05)

In this study, different percentages of okara and almond flour were used to replace the wheat flour in cookie formulation. Table 2 indicates that substituting wheat flour with okara and almond flour in cookie formulation had a significant (p < 0.05) influence on the majority of sensory attributes of cookies except colour. Overall, the cookies produced using okara and almond flour recorded significantly (p < 0.05) lower scores for appearance, shape, taste, texture and overall acceptance as compared to control. This is due to the evaluators were able to visually discriminate the samples solely based on their colour and shape that irregular which this can clearly detected by the appearance of the cookies.

Similarly, a previous study by Man et al. (2021) also found that the partial substitution of wheat flour with flaxseed flour in biscuit formulation had decreased the appearance attribute of biscuits. Another study also showed that cookies produced using red teff and okara as replacements for wheat flour had lower scores for the majority of sensory attributes tested (Ahmed et al., 2018). Furthermore, the lower sensory scores for cookies made from okara are probably due to beany flavour. According to the Ostermann-Porcel et al. (2017), it stated that the beany flavour in legume flours could reduce the acceptability of the baked product. Thus, this could explained the lower scores of the cookies made from the Okara.

The present study also found no significant difference (p > 0.05) for all sensory attributes among F1, F2 and F3 samples (Table 2). This might indicate the use of different okara and almond flour percentages depicted no significant change in sensory attributes of gluten-free cookies. The result was in line with the previous study that showed there are no significant differences for the sensory attributes between cookies made using gluten-free flour (Aljobair, 2022). According to Ostermann-Porcel et al. (2017), when high addition of okara (up to 50%), it could give negative impact toward the products in term of the colour, aroma, taste and overall acceptability compared to other samples. In contrast, the present study used 20-35% okara in the formulation thus resulting in an acceptable score for all sensory attributes. Overall, the sensory scores obtained for each attribute of okara based cookies ranged from 5 to 6, corresponding to “neither like nor dislike” and “like moderately” according to the 9-point hedonic scale used.

5.0 Conclusion and future research

The present study showed that it could be possible to produce gluten-free cookies with acceptable sensory properties through the substitution of wheat flour with okara and almond flour. The sensory analysis revealed that there was no significant difference in sensory properties (colour, shape, taste, texture, overall acceptance) among the three gluten-free cookie formulations (F1, F2, F3). The results also found that gluten-free cookies produced had significantly lower scores for most of the sensory properties such as appearance, taste, texture and overall acceptance when compared to cookies that contain gluten. Nevertheless, the gluten-free cookies produced were still in the acceptable sensory scores range. In conclusion, the substitution of wheat flour to produce gluten-free cookies had a significant impact on the sensory properties of cookies. Based on this study, it is highly recommended that further research should be done to determine the nutritional composition and physical properties of okara based cookies.

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Author Contributions

Mohamad Afifi Ismail: Conceptualization, writing review and editing; **Siti Nurhaziqah Bahrin:** Conceptualization, writing review and editing, conducted experiments and collected and analysed the result data; **Muhammad Akhmal Yunos:** Conceptualization, writing review and editing, conducted experiments and collected and analysed the result data.

Conflicts of Interest

The manuscript has not been published elsewhere and is not under consideration by other journals. All authors have approved the review, agree with its Submission and declare no conflict of interest in the manuscript.

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