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Original Research

Formulation and Sensory Evaluation of Cookies Based on Chicken Feet Bone Flour and Tofu Pulp Flour

Formulasi dan Evaluasi Sensoris Cookies Berbasis Tepung Tulang Ceker Ayam dan Tepung Ampas Tahu

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Abstract: The increasing production of food processing waste presents both environmental challenges and opportunities for sustainable food development. Certain animal and plant by-products, such as chicken feet bones and tofu pulp, are rich in nutrients and have potential as alternative food ingredients. However, successful utilization of these materials depends on their sensory acceptability. This study aims to develop cookie formulations incorporating chicken feet bone flour with tofu pulp flour and to evaluate their sensory acceptance levels. An experimental design was implemented with six cookie formulations: one control and five treatment formulations with varying proportions of chicken feet bone flour and tofu pulp flour. All flours were produced with a particle size of 100 mesh. Hedonic testing involved 50 panelists, all mothers of infants aged 6–12 months, who evaluated the cookies based on colour, aroma, taste, texture, aftertaste, and overall acceptability. The data collected were statistically analysed to identify differences in acceptance among formulations. The results indicated significant differences in panelists' acceptance levels for colour, aroma, taste, aftertaste, and overall preferences ($p < 0.05$). Conversely, no significant differences were noted in texture acceptance ($p > 0.05$). Among all treatments, the formulation coded 849 was the most preferred by panelists, containing 12 grams of chicken feet bone flour and 28 grams of tofu pulp flour. In conclusion, cookies formulated with appropriate proportions of chicken feet bone flour and tofu pulp flour can achieve favourable sensory characteristics. The selected formulation demonstrates strong potential for further development as a sustainable food product utilizing locally available waste-based ingredients.

Key word: formulation, sensory evaluation, chicken feet bone flour, tofu pulp flour, cookies

1. INTRODUCTION

The use of local food ingredients and agro-industrial by-products as raw materials for innovative food products is essential for sustainable food development. As the human population continues to grow, food waste from both animal and plant sources also increases, resulting in an inefficient food system [1]. Given the significant volume of by-products deemed waste, exploring innovative ways to utilize agricultural by-products is crucial. This approach can enhance added value, reduce environmental impact, and support the development of sustainable food products [2].

Indonesia is one of the countries with the highest levels of food waste globally. According to data from the Ministry of Environment and Forestry, food waste accounts for approximately 44% of the total national waste. Between 2000 and 2019, the estimated amount of food waste in Indonesia reached between 115 and 184 kilograms per capita per year. This situation has various negative impacts, including the loss of

nutritional content in food, increased environmental burdens, and economic losses [3]. In 2021, the Ministry of National Development Planning/BAPPENAS outlined a strategic direction for food loss and waste (FLW) management in Indonesia [4]. This direction emphasizes the importance of developing FLW management and utilization that supports a circular economy. One effective solution for reducing food waste is to create recycled food products through upcycling. This perspective emphasizes the efficient management of food loss and waste (FLW), transforming it into valuable and sustainable products. This method has the potential to foster innovations that support the realization of a zero-waste future [5].

One underutilized ingredient with significant potential is chicken feet. These feet offer a valuable opportunity as a source of minerals, particularly calcium [6,7]. When processed into flour, chicken feet bones are reported to be high in both calcium and protein, making them an excellent option for fortifying flour-based food products. Previous studies have shown that chicken bone flour can serve as a source of calcium and can be successfully incorporated into baked goods such as cookies and biscuits, which maintain acceptable sensory qualities [8]. Despite being an affordable and readily available source of calcium, chicken feet bones are often discarded or used only for making stock, leading to environmental concerns due to the resulting waste [7].

In addition to animal-based ingredients, plant by-products such as tofu pulp, also known as okara, play a significant role in various applications. Tofu by-products are often viewed as low-value agricultural waste due to their perishable nature and susceptibility to microbiological spoilage if not managed properly. However, these by-products are rich in organic compounds that can be easily broken down by microorganisms, making them suitable for use in human food products [9]. Specifically, okara is high in protein, dietary fiber, and essential minerals [10]. As soybean and tofu production in Indonesia continue to rise, so does the volume of tofu pulp generated, highlighting the need for processing innovations to enhance its value and reduce food waste [11]. Recent studies have demonstrated that tofu pulp (okara) flour can be used as a partial substitute for wheat flour in bakery products. This substitution boosts both fiber and protein content while preserving acceptable sensory qualities. The beneficial properties are attributed to its cellulose, hemicellulose, and lignin content [12,13].

Cookies are one of the most widely developed dry food products due to their relatively long shelf life, simple production process, and formulation flexibility with various substitute ingredients [14]. Sensory evaluation plays a crucial role in the development of cookies made from alternative ingredients, as consumer acceptance of colour, aroma, taste, texture, and overall preference significantly influences the product's success. Therefore, formulation studies accompanied by hedonic testing are essential to determine the optimal composition of ingredients that are sensory appealing to consumers [15].

There is still limited research on the combination of chicken feet bone flour and tofu pulp flour in a single food product, especially regarding formulation and sensory acceptance. This study aims to develop cookie formulations using chicken feet bone flour with tofu pulp flour and to assess the sensory acceptance of various resulting formulations. The findings from this research are expected to contribute scientifically to the advancement of cookies made from alternative local ingredients, providing a foundation for further studies on nutritional characteristics and the creation of innovative food products.

2. METHODS

This study was an experimental study with a one-way completely randomised design, using one control group and five cookie formulation treatments with chicken feet bone flour and tofu pulp flour substitutions. The experimental procedures were conducted in 2016. However, the data were reanalysed and interpreted in light of recent scientific literature. The main ingredients used in this study included chicken feet bone flour and tofu pulp flour made independently, and wheat flour. Additionally, to create the cookies, supporting ingredients such as sugar, margarine, eggs, and other components were adjusted according to the specific formulation of each treatment. The tools employed in this study included a pressure cooker for softening the ingredients, a meat grinder for initial grinding, a cabinet dryer for drying, a disc mill for refining the ingredients, 60 and 100-mesh sieves for standardising particle size, digital scales for weighing ingredients, a baking oven, and other supporting equipment used in the cookie-making process.

Production of Chicken Feet Bone Flour

Chicken feet bone flour was produced using a modified method based on previous studies [16]. Some minor adjustments were made to the boiling and drying processes. This modified method is still relevant and applicable for developing food products. The production of chicken feet bone flour consists of several stages. First, the chicken feet are cleaned to remove any dirt and blood residue. The yellow outer skin is then removed, and the feet are washed thoroughly with running water. After cleaning, the chicken feet are pressure-cooked for approximately one hour at a temperature of 121°C. Once the cooking process is complete, the feet are allowed to cool at room temperature, and the muscle is separated from the bones. Next, the bones are ground using a meat grinder to create a bone paste. This paste is then dried in a cabinet dryer at a temperature of 50°C for about seven hours. Once completely dried, the bones are ground again using a disc mill. After grinding, the material is sifted through a 60-mesh sieve and then a 100-mesh sieve to achieve a fine particle size similar to that of wheat flour.

Production of Tofu Pulp Flour

The tofu pulp flour was prepared using a method adapted from previous studies [17,18]. The tofu pulp is first drained and squeezed to reduce the water content, either manually using a filter cloth or using a press. Draining is carried out using a spinner to help reduce the water content. Next, the tofu pulp is steamed at 50°C for 15–20 minutes as a sterilisation process. After steaming, the tofu pulp is squeezed again to remove any remaining water, then dried using a drying cabinet at 50°C for approximately 7 hours. The dried tofu pulp is ground using a disc mill to produce flour, then sieved using a 60-mesh sieve, followed by a 100-mesh sieve to obtain flour with a uniform fineness.

Cookie Formulations and Ingredients

The study included one control formulation and five treatment formulations. In the control formulation, only wheat flour was used, with no substitutions. In the treatment formulations, wheat flour was partially replaced with varying amounts of chicken feet bone flour and tofu pulp flour, ensuring that the total weight of the flour remained constant (150 g), as outlined in Table 1.

Table 1. Cookie Formulation Based on Flour Composition (g)

Product Codes	Comparison of Ingredients (g)

	Wheat Flour	Chicken Feet Bone Flour	Tofu Pulp Flour
495	150	0	0
162	110	28	12
749	110	24	16
516	110	20	20
273	110	16	24
849	110	12	28

Cookies were prepared using a modified method based on previous studies by [19]. All ingredients, except for the substituted flours, were kept at consistent levels across the different formulations. The detailed ingredient composition for each formulation is presented in Table 2.

Table 2. Cookie Ingredients

Ingredients	Control Cookie	Treatment Cookies (Chicken Feet Bone Flour and Tofu Pulp Flour)				
	495	**162**	**749**	**516**	**273**	**849**
Chicken feet bone flour (g)	0	28	24	20	16	12
Tofu pulp flour (g)	0	12	16	20	24	28
Wheat flour (g)	150	110	110	110	110	110
Powdered sugar (g)	100	100	100	100	100	100
Salt (g)	1	1	1	1	1	1
Egg (g)	50	50	50	50	50	50
Vegetable oil (ml)	100	100	100	100	100	100
Total (g)	400	400	400	400	400	400

Sensory (Hedonic) Evaluation

A sensory evaluation was conducted using a hedonic test to assess consumer acceptance of cookies. Fifty untrained panelists, all mothers of infants aged 6 to 12 months living in Ratu Jaya Village, Depok City, participated in this study. These participants represent the target consumers for the product. The use of untrained panelists is appropriate for acceptance tests aimed at evaluating general consumer preferences rather than for descriptive sensory attribute analysis. The cookies were evaluated based on colour, aroma, taste, texture, aftertaste, and overall acceptability, using a five-point hedonic scale ranging from "strongly dislike" to "strongly like." The samples were coded with random numbers and served in a random order, with each cookie weighing approximately 5 grams. Drinking water was provided to neutralize the taste between samples.

Data Analysis

Statistical analysis of sensory data was performed using one-way analysis of variance (ANOVA). When significant differences were observed, Duncan's Multiple Range Test was utilized as a post-hoc analysis. A significance level of $p < 0.05$ was employed.

Ethical Considerations

This study was conducted according to ethical principles for research involving human participants. Participation was voluntary, and informed consent was obtained from all participants before the sensory evaluation. All participants were informed about the purpose of the study, and we ensured that data confidentiality was maintained. The study presented minimal risk and did not involve any invasive procedures.

3. RESULTS

The processing of chicken feet bones led to the production of a fine and uniform flour after drying and sieving through a 100-mesh screen (the flour appears brown in colour). This series of processing steps effectively reduced both the moisture content and particle size, resulting in a powder that is suitable for incorporation into cookie formulations. Similarly, tofu pulp flour (appears bone white), obtained through steaming, pressing, drying, and milling, also resulted in a fine and homogeneous powder after being sieved through a 100-mesh screen. These properties suggest that both flours have the appropriate physical characteristics to serve as alternative food ingredients. The visual characteristics of the flours are showed in Figure 1.

Figure 1. The Visual Characteristics of Chicken Feet Bone Flour (Left) and Tofu Pulp Flour (Right)

Cookie formulations were prepared by mixing eggs, powdered sugar, and salt until a homogeneous and aerated batter was achieved. Gradually, wheat flour and oil were incorporated into the mixture. Next, chicken feet bone flour and tofu pulp flour were added and mixed until everything was evenly distributed. The dough was then molded and baked at 70°C for 90 minutes. Each batch of cookie dough weighed approximately 400 g and yielded 310 g of baked cookies, with an average weight of 5 g per unit, resulting in 62 cookies per formulation. All six cookie formulations were subsequently subjected to hedonic sensory evaluation. The appearance of cookies from all formulations is presented in Figure 2.

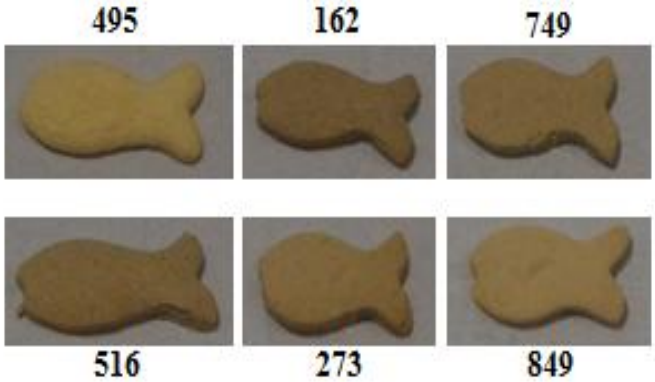

Figure 2. Formulated Cookie Products (as per code)

Hedonic Test

The panelists in this study consisted of fifty mothers with babies aged between 6 and 12 months. The ages of the mothers ranged from 18 to 42 years, with 96% of them being housewives. The mothers expressed preferences for different flavours: 21

participants (42%) preferred sweet flavours, 10 participants (20%) preferred salty flavours, and 19 participants (38%) favored savory flavours.

Colour Attribute
An analysis of variance (ANOVA) revealed that the proportions of chicken feet bone flour and tofu pulp flour significantly affected the colour of the cookies ($p < 0.05$). The results demonstrated notable differences in colour scores among the various cookie treatments. Further analysis using Duncan's multiple range test ($\alpha = 0.05$) identified two distinct groups. Cookies coded 495, 273, and 849 did not differ significantly from one another, while cookies coded 162, 749, and 516 also exhibited no significant differences within their group. However, significant differences in colour were observed between these two groups.

Aroma Attribute
The analysis of variance (ANOVA) indicated that the proportion of chicken feet bone flour and tofu pulp flour significantly affected the aroma of the cookies ($p < 0.05$). These results show that there are notable differences in aroma scores among the different cookie treatments. Using Duncan's multiple range test ($\alpha = 0.05$), two distinct aroma groups were identified. Cookies labeled 495, 273, and 849 did not show significant differences from each other, while cookies labeled 162, 749, and 516 also exhibited no significant differences within their group. However, significant differences in aroma were found between these two groups.

Taste Attribute
An analysis of variance (ANOVA) showed that the proportions of chicken feet bone flour and tofu pulp flour significantly affected the taste of the cookies ($p < 0.05$). There were notable differences in taste scores among the various cookie treatments. According to Duncan's multiple range test ($\alpha = 0.05$), cookies labeled 162, 749, and 516 did not show significant differences in taste. Similarly, cookies coded 273 and 849 also exhibited no significant differences from each other. However, cookie 495 had a significantly different taste compared to the other five treatment cookies.

Texture Attribute
The analysis of variance (ANOVA) demonstrated that the proportions of chicken feet bone flour and tofu pulp flour did not significantly affect the texture of the cookies ($p > 0.05$). The ANOVA results showed no significant differences in texture scores among the various cookie treatments ($p = 0.701$). Since no significant differences were found, further analysis with Duncan's multiple range test was not necessary.

Aftertaste Attribute
The analysis of variance (ANOVA) depicted that the proportion of chicken feet bone flour and tofu pulp flour significantly affected the aftertaste of the cookie treatments ($p < 0.05$). There were notable differences in aftertaste scores among the various cookie treatments. According to Duncan's multiple range test ($\alpha = 0.05$), cookie 749 did not significantly differ from cookies 162 and 516. Additionally, no significant differences were found between cookie 516 and cookies 749, 495, 273, and 849. However, cookie 162 had a significantly different aftertaste compared to cookies 495, 516, 273, and 849.

Overall Preference
Analysis of variance (ANOVA) explained that the proportion of chicken feet bone flour and tofu pulp flour had a significant effect on the overall liking of the treatment cookies ($p < 0.05$). Significant differences in overall preference scores were observed among

the cookie treatments. Duncan's multiple range test (α = 0.05) indicated no significant differences in overall preference between cookies 516 and cookies 162, 749, and 273; between cookie 273 and cookies 516 and 849; and between cookie 849 and cookies 273 and 495. However, cookies 162 and 749 showed significantly different overall liking scores compared to cookies 495, 273, and 849.

Table 3. Distribution of Hedonic Test Results by Various Formulations

Organoleptic Indicators	Cookie Codes 495	Treatment Cookies					P-value
		162	749	516	273	849	
Colour	4.10	3.08	3.42	3.42	3.88	3.84	0.000
Aroma	4.06	2.96	3.12	3.32	3.76	3.92	0.000
Taste	4.46	3.10	3.30	3.48	4.04	3.90	0.000
Texture	3.64	3.52	3.58	3.42	3.72	3.66	0.701*
Aftertaste	4.08	2.90	3.28	3.70	3.94	4.00	0.000
Overall	4.38	3.34	3.46	3.66	3.96	4.08	0.000
Average	**4.12**	**3.15**	**3.36**	**3.50**	**3.88**	**3.90**	

ANOVA test: *) Significant if p-value <0.05

The average results of the hedonic test (Table 3) indicated that the cookies most preferred by participants were the control cookies, labeled as cookies 495. In contrast, the cookies made from a combination of chicken feet bone flour and tofu pulp flour, identified as cookies 849, also received a high level of preference.

4. DISCUSSION

This study represents an initial step toward the valorisation of poultry by-products through the production of chicken feet bone flour. The conversion of chicken feet bones into flour improved their physical stability and shelf life, making them more suitable for incorporation into food products compared to their fresh form. While this study did not specifically analyse the detailed mineral composition of the flour, its successful application in bakery products suggests that it possesses the necessary functional characteristics for food formulation [8]. Incorporating chicken feet bone flour into cookie recipes has influenced the sensory attributes, particularly in terms of texture and overall acceptability. This suggests that the particle size and processing method of the flour are critical factors affecting product quality. Reducing the particle size of bone flour significantly can enhance its techno-functional properties, including the bioavailability of protein and calcium [20]. Previous research has demonstrated that mineral-rich by-product flours can affect dough structure, volume, and mouthfeel, which aligns with the sensory responses observed in this study [21].

Tofu pulp is a food product that contains a high level of water and moisture, approximately 93%, which makes it susceptible to spoilage if not processed quickly [22]. This elevated water content creates an ideal environment for the growth of microorganisms, particularly bacteria and fungi, leading to unpleasant odors and increased acidity during storage. Additionally, the rapid enzymatic activity and microbial fermentation in fresh tofu pulp can further reduce its sensory quality and safety [23]. In this study, tofu pulp was used as the raw material and was processed

immediately after collection to minimize the risk of microbiological damage and quality deterioration. The initial treatment involved steaming followed by drying, which significantly reduced the moisture content of the material. This reduction inhibited microbial growth and decreased unpleasant odors. These conditions support the research findings, indicating that the tofu pulp flour produced can be used in food products without causing any unusual odors and remains acceptable in terms of sensory properties. Furthermore, processing tofu pulp into a dry form, such as flour, is essential for reducing its water content, inhibiting microbial growth, and extending its shelf life. Steaming and drying have proven effective in suppressing microbial contamination and minimizing undesirable odors in tofu pulp. This makes the pulp safer and more suitable as a substitute ingredient in various food products, including bread, gluten-free bread, biscuits, waffles, cookies, and doughnuts. Using dried tofu pulp can enhance texture and taste while also providing health benefits such as improved gut health and weight management [12,24].

Panelists' taste preferences play a crucial role in sensory testing because the tastes favored by consumers significantly affect their acceptance of food products, particularly bakery items like cookies [25]. Hedonic testing measures panelists' levels of enjoyment for various sensory attributes, such as taste. Previous studies have indicated that sensory responses, especially taste, are strongly correlated with consumer preferences during product evaluations [26]. In this study, panelists' taste preferences were categorized into three main groups: sweet, savory, and salty. The majority of panelists preferred sweet flavors (42%), followed by savory (38%) and salty (20%). These differences in preferences likely impacted the sensory taste results and overall scores in the hedonic test, as variations in consumer taste preferences are closely linked to the overall liking of a product.

Based on previous findings indicating that the number of categories in a hedonic scale does not significantly affect product preference ranking when panelists are attentive, a hedonic sensory evaluation was conducted in this study to assess consumer acceptance of cookie formulations [27]. Six cookie formulations were evaluated using a hedonic taste test to determine the most preferred and accepted product. The analysis focused on average scores for various sensory indicators, including colour, aroma, flavour, texture, aftertaste, and overall acceptability. The formulation with the highest average score was chosen for nutritional analysis. The results of the hedonic test indicated that cookie 495, which was based on wheat flour and served as the control, had the highest level of acceptability, achieving an overall average score of 4.12. This suggests that conventional cookies are still preferred over those made with alternative ingredients. Consistent with earlier studies, the lower acceptance of cookies made with alternative ingredients might be due to their unique flavour and aroma profiles, which are less familiar to consumers than traditional wheat-based formulations [28].

The control cookies were used as a basis for comparing panelists' preference responses between the innovative product and a commonly consumed product. Generally, consumers tend to prefer familiar foods due to the influence of sensory experiences and past consumption habits [29]. Wheat flour, the primary ingredient in traditional cookies, produces a well-known flavour, making these cookies more readily accepted than those made with relatively new ingredients like chicken feet bone flour and tofu pulp flour. Moreover, cookies formulated with chicken feet bone flour and tofu pulp flour substitutes showed lower levels of acceptance, possibly related to unfamiliar sensory characteristics. Research indicates that the use of alternative ingredients in baked goods can significantly affect taste, aroma, and colour, which may require

consumers to adapt [25].

Among the cookies tested, the 849 cookies were the most favoured, receiving an average score of 3.9. These cookies are made with 12 grams of chicken feet bone meal and 28 grams of tofu pulp flour, which contribute to a more balanced sensory profile. The findings suggest that a smaller proportion of chicken feet bone flour and a larger proportion of tofu pulp flour are more acceptable. Research shows that incorporating alternative protein ingredients into bakery products can significantly affect sensory characteristics such as taste, aroma, and colour. It's important to carefully evaluate these factors due to their potential impact on consumer acceptance [30]. Moreover, adding more tofu pulp flour can help achieve a cookie texture that resembles cookies made without substituting chicken feet bone flour and tofu pulp flour. The addition of tofu pulp reduces the gelatinisation ability of starch due to competition for water binding by insoluble fibres, thereby limiting the formation of starch gel networks. This condition contributes to a more brittle and crispy texture in the final product compared to the starch-rich control [10,17].

The results of the ANOVA test indicated that there were no significant differences in texture attributes between the formulations ($p > 0.05$). This lack of differentiation was likely due to the assessment being performed by untrained panelists using a hedonic approach, which may have resulted in the textural differences between products being insufficiently sensitive for statistical detection. Additionally, the variations in the formulations fell within a relatively uniform texture range that was deemed acceptable by consumers. Generally, the texture of cookies is dense, primarily because of the dietary fiber present in the formulations. Dietary fiber significantly affects the rheological properties of food matrices, increasing viscosity and structural firmness as fiber content rises [31]. However, in formulations containing a higher proportion of tofu pulp flour, the cookies tended to be more brittle and easier to crumble. This suggests limited starch network formation due to competition for water binding from the fiber. Moreover, using vegetable oil as a substitute for margarine contributes to a softer and crispier cookie texture, as liquid oil is more effective at lubricating the dough matrix compared to solid fat. Food texture plays a crucial role in the oral and digestive processes and can influence the duration of consumption and overall food acceptance. Foods with a harder, chewier, or thicker texture have been shown to affect consumption behaviour and potentially reduce energy intake by altering sensory perception and acceptance [32].

In terms of colour, 849 cookies were found to be brighter than those made with a higher proportion of chicken feet bone flour. Increasing the amount of chicken feet bone flour in cookie recipes can lead to a darker colour due to enhanced Maillard browning reactions between proteins and reducing sugars during baking. This change in colour may decrease consumer acceptance, as colour is a significant factor in initial sensory perception. Similar effects have been observed in cookies made with protein-rich ingredients, which tend to be less light in colour and have lower visual appeal [33].

One limitation of this study is that the sensory data were collected in 2016. However, the formulation principles and hedonic evaluation methods continue to be relevant for current food product development.

5. CONCLUSION

Among the treatment cookies, formula 849 was the most selected and preferred based on colour, aroma, taste, texture, aftertaste, and overall preference, achieving an average score of 3.90 (the most accepted). The development of cookies made from chicken feet bone flour and tofu pulp flour highlights the potential for using local food ingredients and by-products in innovative food products. The findings suggest that, with proper formulation, these cookies can satisfy consumer sensory preferences, presenting opportunities for local food diversification and sustainable ingredient use. This product concept can be further developed for commercial production with a broader target market. However, additional studies are recommended to assess the nutritional content, physical properties, shelf life, and consumer acceptance on a larger scale to ensure product quality and market readiness.

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