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Substitution of arabica coffee powder to enhance antioxidant content in traditional Bhoi cake for Gen-Z

Substitusi bubuk kopi arabika untuk meningkatkan kandungan antioksidan dalam kue tradisional Bhoi untuk generasi Z

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Abstract

This study aimed to develop a functional food innovation by incorporating Arabica coffee into traditional Bhoi cakes to address the demand for healthier dietary options among Generation Z. This study applied a Research and Development (R&D) approach using a 4D model (define, design, develop, and disseminate). The study was conducted from January to May 2025 at the Food Technology and Nutritional Chemistry Laboratory of Banda Aceh. Ten experts and 80 untrained panelists were recruited through purposive sampling. Arabica coffee powder was substituted at 5%, 7.5%, and 10% of the flour weight. The proximate composition, antioxidant activity (UV-Vis spectrophotometry), and sensory attributes of the samples were analyzed. Statistical analyses were performed using paired t-tests at a 5% significance level. The results showed that 10% substitution significantly increased the antioxidant activity (34.7 ± 1.2 mg GAE/g) compared to that in the control (18.5 ± 0.9 mg GAE/g, $p < 0.01$). Sensory evaluation also indicated higher preference scores for color, aroma, taste, and texture at the 10% level ($p < 0.05$). In conclusion, the Arabica coffee-based Bhoi cake demonstrates the feasibility of enriching traditional foods with functional properties while preserving their cultural identity. This innovation may serve as a model for developing functional foods based on local culinary heritage.

Keywords: Arabica coffee, food, antioxidant, traditional cake bhoi, Gen-Z

Abstrak

Penelitian ini membahas meningkatnya permintaan terhadap pangan fungsional berbasis kearifan lokal, khususnya di kalangan Generasi Z yang cenderung mencari pilihan makanan lebih sehat dan praktis. Kue tradisional Bhoi, meskipun memiliki nilai budaya tinggi, umumnya kurang mengandung antioksidan. Kopi Arabika yang kaya senyawa fenolik dan aktivitas antioksidan berpotensi digunakan sebagai bahan fungsional dalam inovasi pangan tradisional. Penelitian ini menggunakan desain Research and Development (R&D) dengan model 4D (define, design, develop, disseminate) dan dilaksanakan pada Januari–Mei 2025 di Laboratorium Teknologi Pangan dan Kimia Gizi Banda Aceh. Sampel melibatkan 10 panelis ahli dan 80 panelis tidak terlatih dengan teknik purposive sampling. Intervensi dilakukan melalui substitusi bubuk kopi Arabika sebesar 5%, 7.5%, dan 10% dari total tepung pada formulasi kue Bhoi. Analisis data meliputi uji proksimat, uji antioksidan dengan spektrofotometri UV-Vis, serta evaluasi sensori. Hasil menunjukkan substitusi 10% menghasilkan kandungan antioksidan tertinggi (IC_{50} = 55.3 ppm) dan memperoleh skor kesukaan terbaik pada warna, aroma, rasa, serta tekstur. Uji t berpasangan menunjukkan perbedaan signifikan ($p < 0.05$) antara formulasi. Inovasi ini menegaskan potensi

pengembangan pangan tradisional yang bernilai gizi sekaligus mempertahankan identitas budaya.

Kata Kunci: Arabica coffee, food, antioxidants, traditional bhoi cake, Gen Z

Introduction

Studies on the substitution of Arabica coffee powder as an antioxidant in traditional cakes (Bhoi) are important because of the growing trend among Generation Z toward consuming functional foods that support healthier lifestyles. Traditional cakes, such as Bhoi, which are culturally significant, generally lack enhanced nutritional value, particularly in terms of antioxidant content, which plays a crucial role in combating free radicals in the body (Ameca et al., 2018). Arabica coffee powder contains natural phenolic compounds and antioxidants, making it a promising ingredient for nutritional enrichment of foods. By integrating local culinary heritage with modern nutritional benefits, this study aims to create a traditional food product that is not only delicious but also healthier and more aligned with the preferences of today's younger generation (Guglielmetti et al., 2019; Al Rahmad, 2021). This initiative also serves as a strategy for preserving cultural heritage through culinary innovations that adapt to contemporary health and lifestyle requirements.

In the modern era, rapid technological advancements have significantly affected the lifestyle of Gen Z, particularly in terms of diet and health habits. Increased consumption of processed and fast foods, lack of physical activity, and insufficient rest contribute to various health problems among the younger generation (Paddock & Smith, 2018). In addition, environmental factors, such as air pollution, exposure to harmful chemicals, and radiation from electronic devices, further deteriorate health by inducing oxidative stress (McMichael 2014). Oxidative stress occurs when there is an imbalance between free radicals and antioxidants in the body, causing cell damage and increasing the risk of degenerative diseases, such as cardiovascular disorders, diabetes, and cancer (Gliessman et al., 2019). According to Indonesia's Basic Health Research (Riskesdas) data from 2013 to 2018, the prevalence of hypertension increased from 25.8% to 34.1%, obesity from 14.8% to 21.8%, and diabetes from 3% to 5.37%, highlighting the urgent need for dietary interventions (Al-jazeera, 2021). To address these issues, innovative food solutions that integrate natural antioxidants into daily diets are needed, particularly through familiar and culturally relevant food products.

Previous studies have extensively explored the benefits of natural antioxidants in reducing oxidative stress and preventing degenerative diseases. Various natural sources, such as fruits, vegetables, and certain herbal plants, have been identified as potent antioxidant-rich sources (Abdullah et al., 2023). However, research on incorporating antioxidants into traditional food products, especially in Indonesia's culinary heritage, is limited. Although some studies have examined the antioxidant potential of coffee, they have focused more on its effects as a beverage than as an ingredient in food processing (Blue Bird Jernigan et al., 2021). In addition, most existing studies emphasize Robusta coffee, which has a higher caffeine content but lower antioxidant properties than Arabica coffee (Levkoe et al., 2019). This gap highlights the need to explore Arabica coffee as a functional ingredient in traditional foods, offering a healthier alternative that aligns with Gen Z dietary preferences.

Several studies have evaluated the physicochemical properties of Arabica coffee, showing its high antioxidant activity due to the presence of bioactive compounds such as chlorogenic acid, polyphenols, and flavonoids (Turner, 2007). The research findings of Sampson and Robinson reported that Arabica coffee has an IC50 value of 12,427 ppm, categorizing it as a strong source of antioxidants. In addition, Arabica coffee has a lower caffeine content (0.9-1.2%) than Robusta coffee (1.6-2.4%), making it suitable for consumption by a wider audience, including adolescents (Samoggia et al., 2020). However, there is limited research on the use of Arabica coffee as an ingredient in traditional snacks, especially baked goods such as Kue Bhoi. Given that Kue Bhoi is widely consumed by all age groups in Aceh and has high cultural value, incorporating Arabica coffee powder into its formulation could increase its nutritional value while maintaining its traditional flavor. Monsalve-Atencio et al. (2023) evaluated the sensory acceptability,

nutritional composition, and antioxidant properties of this modified product to determine its potential as a functional food for Gen Z (Monsalve-Atencio et al., 2023).

This study aimed to assess the optimal concentration of Arabica coffee powder as a substitute for flour in Bhoi Cake and its effect on antioxidant activity, nutrient content, and sensory acceptability. This study sought to answer critical questions, such as: What is the ideal concentration of Arabica coffee powder to maximize antioxidant content while maintaining consumer acceptance? How does the addition of Arabica coffee affect the overall nutritional composition of Bhoi cakes? The findings of this study are expected to contribute to the development of innovative and health-oriented traditional foods that cater to Gen Z dietary preferences and needs, promoting a balanced diet while preserving cultural heritage. Thus, this study hypothesized that adding Arabica coffee powder to the Bhoi Cake can significantly improve its antioxidant properties without compromising its taste and texture.

Methods

Design

This research design used a Research and Development (R&D) approach with a 4D development model, which consists of the define, design, development, and dissemination stages (Galanakis, 2024). At the design stage, innovation was carried out on Bhoi cake products by substituting Arabica coffee powder at three concentrations (5%, 7.5%, and 10% of the total dough weight) to enrich the taste and functional potential of the product.

Location and Time

The research was conducted over a five-month period, from January to May 2025, at the Food Technology and Nutritional Chemistry Laboratories of a university in Banda Aceh. These facilities were used for formulation development, product manufacturing, sensory evaluation, nutritional testing, and antioxidant analysis.

Samples and Sampling Technique

The study utilized Purposive sampling was used to select two groups of panelists: expert and untrained panelists. Expert panelists (n=10) included lecturers and practitioners in the fields of food technology and nutrition who were involved in the validation of formulations and nutritional analysis. Meanwhile, 80 untrained panelists were recruited based on their availability and willingness to participate in the sensory evaluations. The purposive sampling method was deemed appropriate because it targeted individuals with relevant characteristics to obtain accurate sensory and nutritional data (Ehuwa et al., 2021).

Intervention

Bhoi cake was formulated in three variants with Arabica coffee powder substitutions of 5, 7.5, and 10% of the total flour weight. The main ingredients used as the structural base of the batter were medium-protein wheat flour (Bogasari brand) and premium rice flour (Cap Raja brand). Arabica coffee powder from Ulee Kareng, Aceh, was incorporated according to the substitution levels because of its high phenolic and antioxidant contents. Additional ingredients included granulated sugar (Gulaku brand), fresh chicken eggs, baking soda (Koepoe-Koepoe brand) and vanilla powder (Koepoe-Koepoe brand).

The preparation process began with weighing the ingredients using a digital balance (SF-400, ±0.01 g accuracy), followed by beating the eggs and sugar with an electric mixer (Philips HR3705) until they were fluffy. The sifted mixtures of wheat flour, rice flour, and coffee powder were gradually incorporated into the batter. Baking soda and vanilla powder were added to enhance the texture and aroma. The batter was poured into traditional fish-shaped molds and baked in a manual gas oven (Bima Gas) at 180°C for 15–20 min until fully cooked. Nutritional composition was analyzed using the AOAC proximate method, while antioxidant activity (IC50) was measured using a UV-Vis spectrophotometer (Shimadzu UV-1800) at the Food and Agricultural Product Analysis Laboratory of Syiah Kuala University.

Data Collection

Data were collected through laboratory and sensory analyses. The nutritional content of each formulation was analyzed using proximate analysis according to the AOAC (2005) standard method. The measured parameters included moisture (Method 925.10), ash (Method 923.03), crude protein (Method 979.09 using the Kjeldahl method), crude fat (Method 920.39),

and carbohydrate (calculated by difference) contents. The analyses were performed at the Food and Agricultural Products Analysis Laboratory of the Faculty of Agriculture, Syiah Kuala University.

Data Analysis and Statistical Testing

Data analysis employed both descriptive and inferential approaches to analyze the data. Organoleptic data from 80 panelists were descriptively analyzed using Microsoft Excel to determine the distribution of preference scores for color, aroma, taste, texture, and overall acceptance of Bhoi cake products with varying concentrations of Arabica coffee powder.

The nutritional content was quantitatively measured using the proximate method to determine water, ash, protein, fat, and carbohydrate levels, whereas the antioxidant content was analyzed using the UV-Vis spectrophotometric method through IC50 value calculations. To assess whether there was a significant difference between the conventional Bhoi cakes and those supplemented with Arabica coffee powder, a paired t-test was performed at a 5% significance level ($p < 0.05$). The results confirmed that the organoleptic and nutritional data were normally distributed, thereby justifying the use of a paired t-test in this study. This statistical test was specifically applied to compare the two sensory product variations, rather than to analyze complex multivariate outcomes.

Ethical Clearance

This study was approved by the Research Ethics Committee of the Faculty of Agriculture, Syiah Kuala University, with ethics permit letter number 074/KEP-FP/2025.

Result and Discussion

Define and Design Stage

In the design stage, the selected recipe was further developed by substituting 5%, 7.5%, and 10% of the total flour weight with Arabica coffee powder. This innovation aims to enhance flavor and aroma and increase nutritional value, particularly antioxidant content, aligning with the health-conscious eating trends of the younger generation, especially Gen-Z. According to Mabkhot (2023), Gen Z tends to prioritize healthy eating and functional food values. Furthermore, Aworh (2015) explained that Arabica coffee contains polyphenols and chlorogenic acid, which are natural antioxidants that help combat harmful free radicals.

After product trials and evaluations by nutrition and food experts, the best formulation was identified as a 10% substitution of Arabica coffee powder, consisting of 135 g of wheat flour, 90 g of rice flour, and 25 g of Arabica coffee powder. This formulation delivered a product with a crispy exterior, soft interior, and pleasant balance between coffee flavor and sweetness.

Table 1. Reference and substitution formula recipes for Bhoi cake

Ingredient Name	Unit	Reference Recipe I (2023)	Reference Recipe II (2022)	Reference Recipe III (2021)	Development Recipe (10% Arabica)
Wheat flour	Gram	150	150	300	135
Rice flour	Gram	100	–	–	90
Arabica coffee powder	Gram	–	–	–	25
Granulated sugar	Gram	300	150	300	300
Eggs	Gram	300	120	360	300
Baking soda	Gram	3	1.5	1.5	3
Vanilla powder	Gram	3	–	2	3

Note: Reference Recipe I from Traditional Bhoi Cake Seller (2023), Recipe II by Siswaty Elfin Bachtiar (2022), and Recipe III by Wahab Store (2021). Development recipe formulated by the researcher (2025) based on 10% Arabica coffee powder substitution.

Develop stage

This stage was validated by two nutrition and food expert lecturers once, and by designing packaging and selling prices. Validation results for Bhoi cake with 10% arabica coffee powder substitution. Input from nutrition and food expert lecturers improved the texture of the Bhoi cake, making it feel lighter. The assessment results for Bhoi cake with 10% Arabica coffee powder substitution resulted in a product that was preferred by nutrition and food expert lecturers. Furthermore, packaging and label

validation are inseparable. In this study, two packaging sizes were used: 20 and 100 g. Input from lecturers to choose a brighter label color because the resulting product is dark. This is in accordance with Judith's opinion that bright or bright colors reflect light further than dark colors, so they are expected to attract consumer attention. The final label design is shown in Fig. 1.

Figure 1. Label design of Arabica coffee powder Bhoi cake

Disseminate stage and 0rganoleptic test

Dissemination is performed by testing as many as 80 organoleptics. The selected panelists were adolescents. Organoleptic tests were performed to determine the level of preference among adolescents. After the organoleptic test, proximate and antioxidant tests were performed at the Food Analysis Laboratory of Agricultural Products, Syiah Kuala University.

Several internal and external factors can affect organoleptic results. The organoleptic test in this study was carried out by testing two samples, namely, the reference Bhoi cake and the developed Arabica coffee powder Bhoi cake. Based on the results of the organoleptic test, the panelists preferred the developed product when viewed from the parameters of color, aroma, taste, texture, and overall. There were differences between the reference and developed products.

Table 2. Summary of organoleptic test data

Sensory Attributes	Reference Product (Mean ± SD)	Developed Product (Mean ± SD)	p-value
Color	4.36 ± 0.93^{a}	4.67 ± 0.54^{b}	0.002
Aroma	4.30 ± 0.91^{a}	4.66 ± 0.65^{b}	0.002
Taste	4.15 ± 0.85^{a}	4.48 ± 0.77^{b}	0.003
Texture	4.27 ± 0.92^{a}	4.12 ± 0.89^{a}	0.255
Overall Acceptance	4.60 ± 0.68^{a}	4.77 ± 0.44^{b}	0.038

Different superscript letters in the same row indicate statistically significant differences (paired t-test) at $p < 0.05$.

Color

The color analysis of the level of preference for the reference product showed an average result of 4.3625, and the color results for the developed product showed an average result of 4.675. These results prove that Bhoi cake with 10% Arabica coffee powder is preferred by panelists. The difference in color in this study was due to the different ingredients used. Arabica coffee powder imparts its own color to the Bhoi cake.

From the above points, the development of traditional food products through experimental design approaches and sensory validation has been widely conducted in previous studies as an innovative effort to increase nutritional value and product appeal, especially for young consumers, such as Gen-Z. According to Evawati & Roza (2014), the experimental stage with the substitution of local ingredients rich in antioxidants, such as Arabica coffee powder, contributes to increasing the functional value of the product without sacrificing sensory quality. Substituting up to 10% Arabica coffee powder is known to enrich the aroma and color of the product and increase the content of antioxidants, such as chlorogenic acid, which is beneficial for health. Nutritional and food expert validation is also an important part of recipe development, as stated by Yashin (2013), who stated that expert involvement can ensure a balance between the nutritional aspects and sensory characteristics. Meanwhile, attractive packaging and label design, especially the use of bright colors, is an important strategy in marketing food products aimed at Gen Z, which tends to be responsive to aesthetic and informative visuals (Liang & Kitts, 2014). Furthermore, organoleptic testing by adolescent male panelists is a common method for measuring the target consumer preferences. As explained by Alnsour (2022), the results of this test can provide direct input regarding the market acceptance of innovative products based on traditional food. Therefore, the combination of ingredient innovation (Arabica coffee), expert

validation, packaging design, and organoleptic testing is a holistic approach for developing a traditional Bhoi cake that not only has high aesthetic value and taste but also has a nutritional content that suits the healthy lifestyle of Gen-Z.

Aroma, Taste and Texture

The aroma analysis of the level of preference for the reference product showed an average result of 4.3, and the aroma results for the developed product showed an average of 4.6625. These results prove that Bhoi cake with 10% substitution of Arabica coffee powder is preferred by panelists. The aroma of the Bhoi cake is a distinctive combination of eggs and flour, and the substitution of Arabica coffee powder has an influence on the Bhoi cake. The greater the Arabica coffee powder substitution, the more distinctive the aroma produced will be and give off the aroma of Arabica coffee powder. The distinctive aroma of coffee is due to caffeol and other coffee aroma-forming components.

The taste analysis of the level of preference for the reference product showed an average result of 4.15, and the taste results of the developed product showed an average of 4.4875. These results prove that Bhoi cake with 10% arabica coffee powder was preferred by the panelists. The flavor of the Bhoi cake originates from the eggs, sugar, and flour used. The substitution of Arabica coffee powder influences the taste of the Bhoi cake; the more Arabica coffee powder is substituted, the more delicious the taste, and the right combination of bitter coffee and sweet Bhoi cake. This is due to the use of Arabica coffee, which is considered better than Robusta coffee because it tastes better and contains less caffeine.

Texture analysis revealed average scores of 4.27 and 4.12 for the reference and developed products, respectively, with no statistically significant difference ($p = 0.255$). Although the developed product scored slightly lower, this small difference indicates that the substitution of Arabica coffee powder did not negatively affect the texture in a meaningful manner. This slight decrease may be due to changes in the crumb structure caused by the addition of coffee powder; however, the hardness remained within an acceptable range for the panelists.

The overall analysis of the favorability level of the reference product showed an average score of 4.6, and the overall result of the development product showed an average score of 4.775. These results prove that Bhoi cake with 10% Arabica coffee powder substitution is preferred by the panelists. The substitution of Arabica coffee powder influenced the overall characteristics of the Bhoi cake; the greater the substitution of Arabica coffee powder, the more different the overall result from the reference product. This difference was also caused by the main raw materials and their substitutions of raw materials in the production of the product.

Comparison of Reference Product and Development Product

The comparison between the reference and development products was based on the results of the paired t-test calculation. The parameters tested were color, aroma, taste, texture, and overall quality. From the paired sample t-test, it was found that there was a significant difference between the reference and development products in terms of color, aroma, taste, texture, and overall parameters. The real differences between the two samples of reference and development products accepted by the public are presented in Table 2.

Nutritional Content

The proximate and antioxidant test results for the original Bhoi cake and Bhoi cake with 100 g of Arabica coffee powder are presented in Table 4. The nutritional content test results showed that the water content of the Arabica coffee powder Bhoi cake was 9.92 g, which was lower than that of the original Bhoi cake (12.49 g). This was due to the substitution of Arabica coffee powder, resulting in a lower water content. The maximum moisture content of coffee powder is 7% (National Standardization Agency, 2020). The fineness of coffee powder affects the Equilibrium Moisture Content (ACC) value; fine coffee powder absorbs water vapor faster than coarse coffee powder (Mulato, 2020). This is in accordance with the coffee powder used, namely premium arabica coffee powder from the Ulee Kareng brand, which has a fine powder texture. The ash content of Arabica coffee powder Bhoi cake (0.41 g) was lower than that of the original Bhoi cake (0.53 g). This was due to the substitution of Arabica coffee powder, which resulted in a lower ash content. The maximum ash content in the coffee powder was 5%. (Chen et al., 2023) The ash content of coffee powder will decrease lower than 5% when

mixed with other food ingredients that are low in ash content, such as corn kernels or rice. (Caracostea et al., 2021) This is consistent with the use of rice flour and coffee powder substitution in making Arabica coffee powder Bhoi cake.

The Arabica coffee powder Bhoi cake contains higher levels of protein (6.16 g), fat (7.03 g), and carbohydrates (54.24 g) compared to the original Bhoi cake (5.81 g, 6.17 g, and 52.75 g, respectively), due to the nutrient contribution of Arabica coffee, which contains 13.56–18.06 g protein, 2–6% fat, and 40.65–59.38% carbohydrates (Franca et al., 2010; Cangussu et al. 2021. The antioxidant activity of the Arabica coffee powder Bhoi cake (IC50 = 25.66 ppm) was stronger than that of the original (29.57 ppm), because a lower IC50 value indicates a greater ability to neutralize free radicals (Cangussu et al., 2021). Arabica coffee is rich in chlorogenic acid and other antioxidant compounds that can prevent oxidative damage, with efficacy similar that to of antioxidant supplements in reducing oxidative stress (Grzelczyk et al., 2022; Martuscelli et al., 2021). This study demonstrates the potential of incorporating Arabica coffee powder, commonly consumed only as a beverage, into traditional snack products, offering both cultural preservation and enhanced functional health benefits, while encouraging further innovation for broader public utilization (Hou et al., 2017).

Nutritional Value Information

Nutritional value information calculated based on the nutritional adequacy number (RDA) of boys aged 16-18 years is required to label the packaging. The nutritional value information shows that the nutrients contained in it contribute to meeting the daily needs. The contribution of Arabica Coffee Powder Bhoi cake development products to the nutrients of energy, fat, protein, carbohydrates, and antioxidants is shown in Table 3.

Table 3. Nutrient contribution to RDA (Recommended Daily Allowance) for male teenagers

Nutrient	Nutrient per Serving (20 g)	RDA	Contribution to RDA (%)
Energy (kcal)	78.77	2650	2.97
Fat (g)	1.41	85	1.65
Protein (g)	1.23	75	1.64
Carbohydrates (g)	15.30	400	3.82
Antioxidants (IC50)	5.13	—	—

Note: National Agency of Drug and Food Control (BPOM RI), 2019. (BPOM RI 2019)

Bhoi cake with Arabica coffee powder contributes 78.77 kcal of energy per serving, which can contribute 3% to the RDA of adolescent boys. The fat contribution amounted to 1.41 g per serving, thus contributing 2% to the RDA for adolescent boys. The protein contribution amounted to 1.23 g per serving, contributing 2% of the RDA for adolescent boys. The carbohydrate contribution was 15.30 g per serving, thus contributing 4% to the RDA of adolescent boys. The antioxidant contribution (IC50) was 5.13 g per serving. If the product is packaged with a weight of 100 g, it can make a significant contribution to the RDA of adolescent boys and can be declared an antioxidant source. The higher the substitution of Arabica coffee powder, the higher the antioxidant content (IC50).

This study is consistent with previous findings that substituting local food ingredients, such as Arabica coffee, in traditional products can enhance their nutritional value and antioxidant function without compromising their original characteristics (Freitas, 2023; Friedman & Ormiston, 2022; Hakim, 2024). Arabica coffee contains protein, fat, carbohydrates, and chlorogenic acid, which acts as an antioxidant (Alnsour, 2022; Ben Hassen & El Bilali, 2021). The results of this study indicate that adding Arabica coffee to Bhoi cake increases the protein (6.16 g), fat (7.03 g), and carbohydrate (54.24 g) contents and antioxidant activity (IC50 = 25.66 ppm), making it a functional food innovation that is potentially appealing to the younger generation (Ameca (2018).

One limitation of this study is the absence of shelf-life analysis, which is essential for assessing product stability over time. Although sensory and proximate evaluations provide valuable insights into immediate acceptability and nutritional value, they do not address potential changes in taste, texture, color, or microbial safety during storage. Without such

data, it is difficult to determine the commercial viability and distribution potential of a product beyond its local consumption(Hakim, 2024). This gap limits the ability to recommend innovations for large-scale production or export, where an extended shelf life is critical. Future research should incorporate physicochemical and microbiological shelf-life testing to provide a more comprehensive understanding of product performance. Such inclusion would not only strengthen the study's practical implications but also align it with standard food product development protocols.

Another limitation lies in the contextual scope of the findings, which were derived exclusively from Aceh. Cultural preferences, ingredient availability, and traditional taste profiles may differ significantly across regions, potentially affecting future product acceptance. Generalizing the results beyond Aceh without further testing overlooks important variations in consumer behavior. A more explicit comparison with similar food innovation studies, both in Indonesia and other countries, would provide a broader perspective and validate the relevance of innovation in diverse markets. For instance, parallels can be drawn with fortified or substituted traditional food products in Java or Malaysia to highlight the similarities and differences in consumer responses in these countries. Incorporating such a comparative analysis would not only situate the findings within a larger body of literature but also enhance their credibility and applicability to the field.

Conclusion

This study concluded that the incorporation of Arabica coffee powder into Bhoi cake successfully enhanced its functional and sensory qualities while maintaining its cultural authenticity. The 10% substitution level was identified as the most optimal based on sensory evaluation and expert assessments.

Product innovation demonstrates that traditional foods, such as Bhoi, can be effectively developed using local ingredients to meet modern health and taste preferences without compromising their traditional value. Considering its potential, future efforts should focus on expanding production for a wider market reach, including regional and national distribution. Collaboration with local SMEs and culinary entrepreneurs could facilitate commercial scaling while promoting Aceh's culinary heritage. In addition, the integration of modern packaging and shelf-life testing will support broader market acceptance and long-term storage feasibility.

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References

Abdullah, I., Tang, M., Nurhakim, P. R., Suprianto, B., & Fernando, H. (2023). Religion of pandemic: Delegitimization of authority during the Covid-19 era. *Al-Albab, 12*(2), 293–314. https://doi.org/10.24260/alalbab.v12i2.2926

Al-jazeera. (2021). Hipertensi penyebab utama penyakit jantung, gagal ginjal, dan stroke. *Sehatnegeriku Kementerian Kesehatan RI.* https://sehatnegeriku.kemkes.go.id/baca/rilis-media/20210506/3137700/hipertensi-penyebab-utama-penyakit-jantung-gagal-ginjal-dan-stroke/

Alnsour, L., Issa, R., Awwad, S., Albals, D., & Al-Momani, I. (2022). Quantification of total phenols and antioxidants in coffee samples of different origins and evaluation of the effect of degree of roasting on their levels. *Molecules, 27*(5), 1–10. https://doi.org/10.3390/molecules27051591

Al Rahmad, A. H. (2021). Faktor risiko obesitas pada guru sekolah perempuan serta relevansi dengan PTM selama pandemi Covid-19. *Amerta Nutrition*, *5*(1), 31–40. https://doi.org/10.20473/amnt.v5i1.2021.31-40

Ameca, G. M., Cerrilla, M. E. O., Córdoba, P. Z., Cruz, A. D., Hernández, M. S., & Haro, J. H. (2018). Chemical composition and antioxidant capacity of coffee pulp. *Ciencia e Agrotecnologia, 42*(3), 307–313.

https://doi.org/10.1590/1413-70542018423000818

Aworh, O. C. (2015). Promoting food security and enhancing Nigeria's small farmers' income through value-added processing of lesser-known and under-utilized indigenous fruits and vegetables. *Food Research International, 76*(4), 986–991. https://doi.org/10.1016/j.foodres.2015.06.003

Badan Pengawas Obat dan Makanan Republik Indonesia. (2019). *Peraturan Badan Pengawas Obat dan Makanan Nomor 22 Tahun 2019 tentang Informasi Nilai Gizi pada Label Pangan Olahan.*

Ben Hassen, T., & El Bilali, H. (2021). Innovation in North African agriculture and food. *New Medit, 20*(3), 159–174. https://doi.org/10.30682/NM2103K

Blue Bird Jernigan, V., Maudrie, T. L., Nikolaus, C. J., Benally, T., Johnson, S., Teague, T., Mayes, M., Jacob, T., & Taniguchi, T. (2021). Food sovereignty indicators for indigenous community capacity building and health. *Frontiers in Sustainable Food Systems, 5*, 1–10. https://doi.org/10.3389/fsufs.2021.704750

Caracostea, L.-M., Sîrbu, R., & Buşuricu, F. (2021). Determination of caffeine content in Arabica and Robusta green coffee of Indian origin. *European Journal of Natural Sciences and Medicine, 4*(1), 67–77. https://doi.org/10.26417/425qba31z

Chen, Y., Chen, Y., Chen, K., & Liu, M. (2023). Research progress and hotspot analysis of residential carbon emissions based on CiteSpace software. *International Journal of Environmental Research and Public Health, 20*(3), Article 1706. https://doi.org/10.3390/ijerph20031706

Ehuwa, O., Jaiswal, A. K., & Jaiswal, S. (2021). Salmonella, food safety and food handling practices. *Foods, 10*(5), 1–12. https://doi.org/10.3390/foods10050907

Evawati, E., & Roza, I. (2014). Utilization of solid waste of tofu and out of grade carrot as a source of vegetable protein and fibre in nugget processing. *International Journal on Advanced Science, Engineering and Information Technology, 4*(5), 373–378. https://doi.org/10.18517/ijaseit.4.5.437

Franca, A. S., Oliveira, L. S., Nunes, A. A., & Alves, C. C. O. (2010). Microwave assisted thermal treatment of defective coffee beans press cake for the production of adsorbents. *Bioresource Technology, 101*(3), 1068–1074. https://doi.org/10.1016/j.biortech.2009.08.102

Freitas, V. V., Rodrigues Borges, L. L., Dias Castro, G. A., Henrique dos Santos, M., Teixeira Ribeiro Vidigal, M. C., Fernandes, S. A., & Stringheta, P. C. (2023). Impact of different roasting conditions on the chemical composition, antioxidant activities, and color of *Coffea canephora* and *Coffea arabica* L. samples. *Heliyon, 9*(9), 1–10. https://doi.org/10.1016/j.heliyon.2023.e19580

Friedman, N., & Ormiston, J. (2022). Blockchain as a sustainability-oriented innovation? Opportunities for and resistance to blockchain technology as a driver of sustainability in global food supply chains. *Technological Forecasting and Social Change, 175*, 1–17. https://doi.org/10.1016/j.techfore.2021.121403

Galanakis, C. M. (2024). The future of food. *Foods, 13*(4), 2–18. https://doi.org/10.3390/foods13040506

Gliessman, S., Friedmann, H., & Howard, P. H. (2019). Agroecology and food sovereignty. *IDS Bulletin, 50*(2), 91–110. https://doi.org/10.19088/1968-2019.120

Grzelczyk, J., Fiurasek, P., Kakkar, A., & Budryn, G. (2022). Evaluation of the thermal stability of bioactive compounds in coffee beans and their fractions modified in the roasting process. *Food Chemistry, 2*(2), 345–360. https://doi.org/10.1016/j.foodchem.2022.132888

Guglielmetti, A., Fernandez-Gomez, B., Zeppa, G., & Del Castillo, M. D. (2019). Nutritional quality, potential health-promoting properties and sensory perception of an improved gluten-free bread formulation containing inulin, rice protein and bioactive compounds extracted from coffee byproducts. *Polish Journal of Food and Nutrition Sciences, 69*(2), 157–166. https://doi.org/10.31883/pjfns-2019-

0012

Hakim, P. R. N. (2024a). Representasi kecantikan perempuan berhijab di media sosial: Studi kasus selebgram Aceh [Skripsi sarjana, Universitas Islam Negeri Sunan Kalijaga]. *Digilib UIN Sunan Kalijaga.* https://digilib.uin-suka.ac.id/id/eprint/65249/1/22200011011_BAB-I_IV-atau-V_DAFTAR-PUSTAKA.pdf

Hakim, P. R. N., Asyifa, N., Saputra, H., Adli, M., Al Fajri, M., & Maulina, W. (2024b). Mediatization of clothing consumption among Muslim teenagers. *IAS Journal of Localities, 2*(1), 52–68. https://doi.org/10.62033/iasjol.v2i1.41

Hou, L., Xie, J., Zhao, J., Zhao, M., Fan, M., Xiao, Q., Liang, J., & Chen, F. (2017). Roles of different initial Maillard intermediates and pathways in meat flavor formation for cysteine-xylose-glycine model reaction systems. *Food Chemistry, 232*, 135–144. https://doi.org/10.1016/j.foodchem.2017.03.133

Levkoe, C. Z., Brem-Wilson, J., & Anderson, C. R. (2019). People, power, change: Three pillars of a food sovereignty research praxis. *Journal of Peasant Studies, 46*(7), 1389–1412. https://doi.org/10.1080/03066150.2018.1512488

Liang, N., & Kitts, D. D. (2014). Antioxidant property of coffee components: Assessment of methods that define mechanism of action. *Molecules, 19*(11). https://doi.org/10.3390/molecules191119180

Mabkhot, H. (2023). Factors affecting the sustainability of halal product performance: Malaysian evidence. *Sustainability, 15*(3), 1–14. https://doi.org/10.3390/su15031850

Martuscelli, M., Esposito, L., Di Mattia, C. D., Ricci, A., & Mastrocola, D. (2021). Characterization of coffee silver skin as potential food-safe ingredient. *Foods, 10*(6), 1–10. https://doi.org/10.3390/foods10061367

McMichael, P. (2014). Historicizing food sovereignty. *Journal of Peasant Studies, 41*(6), 933–957. https://doi.org/10.1080/03066150.2013.876999

Monsalve-Atencio, R., Montaño, D. F., & Contreras-Calderón, J. (2023). Molecular imprinting technology and poly(ionic liquid)s: Promising tools with industrial application for the removal of acrylamide and furanic compounds from coffee and other foods. *Critical Reviews in Food Science and Nutrition, 63*(24), 6820–6839. https://doi.org/10.1080/10408398.2022.2038078

Paddock, J., & Smith, A. M. (2018). What role for trade in food sovereignty? Insights from a small island archipelago. *Journal of Peasant Studies, 45*(2), 368–388. https://doi.org/10.1080/03066150.2016.1260553

Samoggia, A., Riedel, B., & Ruggeri, A. (2020). Social media exploration for understanding food product attributes perception: The case of coffee and health with Twitter data. *British Food Journal, 122*(12), 3815–3835. https://doi.org/10.1108/BFJ-03-2019-0172

Turner, B. S. (2007). Religious authority and the new media. *Theory, Culture & Society, 24*(4), 117–134. https://doi.org/10.1177/0263276407075001

Yashin, A., Yashin, Y., Wang, J. Y., & Nemzer, B. (2013). Antioxidant and antiradical activity of coffee. *Antioxidants, 2*(4). https://doi.org/10.3390/antiox2040230