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Organoleptic Quality and Nutritional Content of Mooka Cookies for Type II Diabetes Patients

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2D) is a non-communicable disease associated with dietary risk factors, including high saturated fat and sugar intake and low fiber intake.
Aims: This study aimed to evaluate the organoleptic quality and nutritional content of Mooka Cookies made from mocaf flour and dried okara as a potential snack for individuals with T2D.
Methods: An experimental study using a Randomized Complete Block Design compared three formulations: F1 (70:30%), F2 (50:50%), and F3 (30:70%) mocaf flour and dried okara. Organoleptic evaluation involved 30 semi-trained panelists using a hedonic test. Nutritional content and antioxidant activity were analyzed at the BRIN Cisitu Laboratory. Data were analyzed using the Friedman test followed by the Wilcoxon test.
Results: F2 was the most preferred formulation, with significant differences in taste between F1 and F2 and texture between F1 and F3. Per 60 g serving, F2 contained 302.79 kcal energy (14%), 8.60 g protein (15%), 17.48 g fat (27%), 27.78 g carbohydrates (9%), and 3.75 g fiber (13%). The formulations met BPOM and Perkeni criteria for energy, protein, and fiber, but not fat and carbohydrates.
Conclusion: F2 was selected as the optimal formulation, although further adjustments to fat and carbohydrate contents are needed.

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1. Introduction

Type 2 Diabetes Mellitus (T2D) is a non-communicable disease characterized by hyperglycemia resulting from impaired carbohydrate metabolism (Nitzke *et al.*, 2024). Disease progression is associated with pancreatic β-cell dysfunction and damage (Raymond & Morrow, 2023) and may lead to vascular and neurological complications that increase the risk of mortality (Perkeni, 2024). In 2021, diabetes ranked eighth among the leading causes of death from non-communicable diseases worldwide,

accounting for 1.6 million deaths (WHO, 2024). Indonesia ranked fifth globally, with 20.4 million adults aged 20–79 years living with diabetes in 2024, and this number is projected to increase to 28.6 million by 2050 (IDF, 2025). Nationally, diabetes prevalence increased from 1.5% in 2018 to 1.7% in 2023 (Kemenkes BKPK, 2023; Kementerian Kesehatan RI, 2019), while the number of people with diabetes in Bandung City increased from 43,906 in 2020 to 44,218 in 2025 (Dinkes Jabar, 2026). These trends highlight the need for preventive strategies and dietary management to curb the increasing burden of T2D.

An unhealthy diet, characterized by high sugar and low fiber intake, is a modifiable risk factor for T2D (Perkeni, 2024). Cookies are commonly consumed as snacks; however, conventional products generally contain high levels of sugar and saturated fat and low levels of dietary fiber (Fitriana *et al.,* 2023). Therefore, alternative cookies with a more appropriate nutritional profile for individuals with T2D are needed. Functional foods contain components such as dietary fiber and antioxidants that may support health maintenance and the management of non-communicable diseases (Setiawan *et al.,* 2024; Temple, 2022).

Mooka cookies were developed using mocaf flour and dried okara as the main ingredients. Mocaf is fermented modified cassava flour with a higher dietary fiber content than wheat flour, at 6 g/100 g and 0.3 g/100 g, respectively (Kemenkes RI, 2020). The complex carbohydrates in mocaf may support its use as an ingredient for individuals with T2D because they require longer digestion to be converted into glucose (Dwitantika *et al.,* 2025).

Okara is a by-product of soybean processing that remains underutilized as a food ingredient. Most okara is used as animal feed or discarded as industrial waste (Asghar *et al.,* 2023). Only approximately 5% of okara is utilized for human consumption (Privatti *et al.,* 2024). However, 100 g of dried okara contains 29.2 ± 7.7 g of protein and dietary fiber (48.09 ± 6.9 g of insoluble fiber and 9.32 ± 5.4 g of soluble fiber) (Shinde *et al.,* 2025). Dried okara contains 0.5–1 mg/g of isoflavones (Silveria *et al.,* 2025). The dietary fiber and isoflavones in okara may support blood glucose regulation, while its antioxidant activity may help reduce oxidative stress associated with insulin resistance (Shinde *et al.,* 2025).

Research on the use of mocaf flour and okara in cookies remains limited. Prabowo and Tanone (2025) developed mocaf- and okara-based cookies, but the product was not specifically intended for individuals with T2D. In contrast, previous studies developing mocaf-based foods for T2D have used other ingredients, such as black soybean in brownies (Hariadi *et al.,* 2023) and red bean in cookies (Dwitantika *et al.,* 2025). In addition, previous studies on mocaf- or okara-based cookies have generally used saturated fat sources, including margarine, butter, and palm oil.

This study aimed to develop Mooka cookies using mocaf flour and dried okara as an alternative snack for individuals with T2D and to evaluate their organoleptic characteristics and nutritional content. The novelty of this study lies in the combination of mocaf flour and dried okara in cookies specifically formulated for T2D, with canola oil as the primary source of unsaturated fat. The findings are expected to provide information on the potential use of mocaf and okara as functional food ingredients and support the development of snacks with a nutritional profile more appropriate for individuals with T2D.

2. Methods

2.1 Materials

The raw materials used in this study were mocaf flour (Mocafine), dried okara obtained from wet okara generated as a by-product of homemade soy milk production, canola oil (Tropicana Slim), eggs, peanut butter (Nine), palm sugar (Etawa Grow), and cocoa powder (Van Houten). All materials were obtained in Bandung, Indonesia.

2.2 Dried Okara Preparation

A total of 500 g of wet okara was pressed to remove excess water and then dried in an oven at 100°C for 120 minutes, with stirring every 25 minutes, on a baking tray lined with baking paper. The dried okara was then ground using a chopper (Silveria *et al.*, 2025; Tridtitanakiat *et al.,* 2023).

2.3 Mooka Cookies Preparation

55 g of eggs, 30 g of canola oil, 30 g of peanut butter, and 30 g of palm sugar were whisked together at low speed using an egg whisk. 70 g (70%), 50 g (50%), or 30 g (30%) of Mocaf flour, 30 g (30%), 50 g (50%), or 70 g (70%) of dried okara, and 15 g of cocoa powder were then added and mixed using a rubber spatula until a homogeneous dough was obtained. The dough was portioned into 10-g balls, flattened using a small container and spatula, and shaped into round cookies before being baked at 150°C for 10 minutes. The cookies were then cooled on a cooling rack for 10 minutes.

2.4 Organoleptic Test

The organoleptic test involved 30 undergraduate Nutrition students from the Institute Kesehatan Immanuel Bandung who were selected based on predetermined inclusion and exclusion criteria. The inclusion criteria were active undergraduate Nutrition students in their fifth semester or above who had completed courses in food technology and food quality assessment, had no sensory impairments, and were not ill or hungry during the test. The exclusion criterion was an allergy to peanuts or eggs. The organoleptic attributes evaluated were aroma, taste, color, texture, and overall acceptability using a 7-point hedonic scale (1 = extremely dislike, 7 = extremely like). Mooka Cookies samples were stored in zip-lock bags and labeled according to their respective formulations. Before the test, panelists were instructed on how to complete the questionnaire. The collected data were statistically analyzed to determine differences in organoleptic acceptance among formulations and to identify the most preferred formulation.

The descriptive sensory assessment used predefined descriptors to characterize selected sensory attributes, including color and sweetness. For this assessment, panelists were instructed to place a check mark (✓) next to the descriptor that best represented their perception of each sample. For example, the sweetness descriptor consisted of five categories: not sweet, slightly sweet, moderately sweet, sweet, and very sweet. Mooka Cookies samples were stored in zip-lock bags and labeled according to their respective formulations. Before the evaluation, panelists were instructed on how to complete the sensory evaluation forms. The hedonic data were statistically analyzed to determine differences in organoleptic acceptance among formulations, whereas the descriptive sensory data were summarized based on the frequency of responses for each descriptor to characterize the sensory attributes of each formulation.

2.5 Nutritional Content Test

2.5.1 Moisture Content

Moisture content was determined gravimetrically by oven drying. Approximately 1–2 g of sample was placed in a pre-weighed weighing bottle and dried at 105 °C to constant weight. The sample was cooled in a desiccator and weighed, and moisture content was calculated from the weight loss.

2.5.2 Ash Content

Ash content was determined by gravimetric incineration. Approximately 1–2 g of sample was placed in a pre-weighed crucible and heated gradually until carbonized, followed by ignition at approximately 600 °C until a carbon-free ash was obtained. The crucible was cooled in a desiccator and weighed to constant weight. Ash content was expressed as a percentage of the sample weight.

2.5.3 Protein Content

Protein content was determined using the Kjeldahl method. Approximately 2–5 g of sample was digested with concentrated H_2SO_4 and catalyst until a clear digest was obtained. The digest was diluted, and a 10 mL aliquot was distilled with 30% NaOH, sodium thiosulfate, and zinc. The released ammonia was collected in 25 mL of 0.1 N HCl and titrated with standardized 0.1 N NaOH using phenolphthalein as an indicator. Protein content was calculated from the nitrogen content.

2.5.4 Fat Content

Fat content was determined by Soxhlet extraction. Approximately 5 g of powdered sample was extracted using diethyl ether or petroleum ether under reflux for at least 2 h. The solvent was removed, and the extracted fat was dried at 105 °C to constant weight. Fat content was calculated based on the weight of extracted fat relative to the sample weight.

2.5.5 Carbohydrate Content

Carbohydrate content was determined using the Luff–Schoorl method. Approximately 2 g of sample was subjected to direct analysis and acid hydrolysis to determine reducing sugars before and after weak and strong inversion. The hydrolyzed samples were reacted with Luff–Schoorl reagent under reflux, followed by addition of H_2SO_4 and KI. The released iodine was titrated with standardized $Na_2S_2O_3$ using starch as an indicator. Reducing sugars, sucrose, and starch contents were calculated from the difference between sample and blank titration volumes using the Luff–Schoorl conversion table.

2.6 Functional Characteristics

2.6.1 Crude Fiber Content

Crude fiber content was determined using the gravimetric method. Approximately 2 g of homogenized sample was subjected to sequential digestion with boiling H_2SO_4 for 30 min and boiling NaOH for 30 min, followed by filtration and washing with hot distilled water until free from acid and alkali. The residue was subsequently washed with alcohol, dried at 105–110 °C to constant weight, cooled in a desiccator, and weighed. Crude fiber content was calculated as the percentage of the dried residue relative to the initial sample weight.

2.6.2 Antioxidant Activity

Antioxidant activity was evaluated using the DPPH radical-scavenging assay according to AOAC (1995). Sample extracts were prepared in methanol at concentrations of 25, 50, and 125 µg/mL. Each sample (1.0 mL) was mixed with 1.0 mL DPPH solution (100 µg/mL) and 2.0 mL methanol, then incubated at 37 °C for 30 min in the dark. Absorbance was measured at 517 nm. Methanol and DPPH solution without sample were used as the blank and control, respectively, while quercetin (2–16 µg/mL) was used as the reference antioxidant. The assay was performed in duplicate. DPPH inhibition was calculated as $[(A_{control} - A_{sample})/A_{control}] \times 100$, and IC_{50} was determined by regression analysis.

2.7 Data Analysis

Data were analyzed using the Friedman test to determine differences in panelists' preference scores across all sensory attributes of Mooka cookies with different formulations. A significant Friedman test result (p-value < 0.05) was followed by the Wilcoxon Signed-Rank test with Bonferroni correction.

2.8 Experimental Design

This study employed a Randomized Complete Block Design (RCBD) with three formulations and three replications. The formulations were developed based on the optimization of the food product for the target group, namely patients with T2D. Therefore, the proportions of mocaf flour and dried okara

were selected to meet the dietary fiber requirements for individuals with T2D. The proportions of mocaf flour to dried okara were F1 (70%:30%), F2 (50%:50%), and F3 (30%:70%).

3. Results and Discussion

3.1 Organoleptic Test Results

The organoleptic test results, including color, taste, aroma, texture, and overall acceptability, are shown in Table 1.

Table 1. Mooka Cookies Organoleptic Test Results

Formulation	Organoleptic Attributes				
	Color	Taste	Aroma	Texture	Overall
F1	4.40 ± 1.4	4.23^{a} ± 1.7	4.70^{a} ± 1.5	4.11^{a} ± 1.5	4.73^{a} ± 1.4
F2	4.87 ± 1.5	5.07^{b} ± 1.6	5.17^{a} ± 1.4	5.30^{ab} ± 1.4	5.37^{a} ± 1.4
F3	4.73 ± 1.5	4.93^{ab} ± 1.5	5.23^{a} ± 1.2	5.07^{b} ± 1.4	5.13^{a} ± 1.3

Description: Different superscript letters indicate significant differences at p-value < 0.05 based on the Wilcoxon Signed-Rank test with Bonferroni correction. No superscript letters are shown for the color attribute because the differences were not significant (p-value > 0.05).

Mooka cookies color tended to be dark brown in F2 and F3, whereas F1 had a lighter brown color. This finding is consistent with Prabowo and Tanone (2025), who reported that the color of cookies became lighter with increasing use of mocaf flour. The brown coloration across all formulations was influenced by the use of palm sugar and cocoa powder, as well as the Maillard reaction and caramelization during baking. The Maillard reaction occurs between amino acids and reducing sugars during heating and is characterized by the formation of brown pigments (Al-abbasy *et al.,* 2024; Hosry *et al.,* 2025), whereas sugar caramelization can produce a brown color at temperatures above 140°C (Rahayuningtyas *et al.,* 2025). Based on the descriptive organoleptic evaluation, F2 had the highest mean color preference with a score 4.87, and was perceived as having a darker brown color than F1 and F3. However, the difference in color preference among formulations was not statistically significant ($p > 0.05$). Since color was assessed based on panelists' visual perception, the slight differences in perceived color may reflect individual differences in visual perception. Overall, the different proportions of mocaf flour and dried okara did not result in a significant difference in color preference among the formulations.

The taste of Mooka cookies was rated by the majority of panelists as moderately sweet, mainly owing to the inclusion of palm sugar. Statistical testing demonstrated a significant difference ($p < 0.05$) in taste acceptance between F1 and F2. Formulation F2 received the highest mean score of 5.07, which is consistent with Prabowo and Tanone (2025), who reported the highest preference for a formulation containing equal proportions of mocaf and okara flour. The 50:50 ratio may have provided a more balanced taste by combining the characteristics of mocaf and okara. As the proportion of okara increased, its characteristic flavor may have become more noticeable, potentially affecting taste acceptance at higher incorporation levels. Despite the general perception of moderate sweetness, several panelists reported that all formulations were insufficiently sweet and had a subtle bitterness. This sensation may have been associated with the cocoa powder, which is naturally characterized by a bitter taste (Sarkar *et al.,* 2024).

Significant differences in aroma preference were observed among the formulations (p-value < 0.05). However, the post-hoc Wilcoxon test indicated no significant differences in pairwise comparisons. The relatively close mean aroma preference scores, ranging from 4.70 to 5.23, suggest that the overall aroma acceptability across the three formulations was comparable, with F3 scoring the highest mean of 5.23. Descriptively, all formulations exhibited a moderately nutty to distinctly nutty aroma, without displaying a dominant off-flavor or "beany" odor. This indicates that the perceived nutty aroma primarily represented the characteristic profile of dried okara, which remained acceptable to the panelists.

Yuniartini and Nugrahani (2024) noted that legume-based ingredients often generate a beany flavor. This off-flavor can be mitigated through thermal treatment, which inactivates the lipoxygenase (LOX) enzyme, as well as the application of masking agents (Wang *et al.,* 2021). In this study, the okara processing and cookie baking steps likely facilitated the reduction of the beany odor, while the incorporation of cocoa powder and palm sugar imparted chocolate and caramel aromas, effectively acting as masking agents.

Statistical analysis revealed a significant difference in texture preference between F1 and F3. Sensory description showed that F1 and F2 were moderately crunchy, while F3 was rated as highly crunchy and relatively hard. These findings are consistent with Hariadi *et al.* (2023), who reported that higher incorporation of black soybean flour increased product hardness. This behavior is likely attributed to the high water-binding capacity of dried okara, which may affect post-baking textural attributes. F2 received the highest mean score of 5.30, suggesting that the 50:50 mocaf to okara ratio provided a more acceptable balance of crunchiness and hardness. In contrast, the maximum okara content in F3 led to a denser and firmer cookie texture, whereas the higher proportion of mocaf flour in F1 produced a more crumbly texture. Panelist feedback confirmed that F3 was overly hard, highlighting the need to optimize the dried okara ratio in future formulations. Thus, the intermediate okara proportion in F2 may have provided a more desirable textural balance than the extreme proportions in F1 and F3.

Overall preference represents the panelist's holistic evaluation of the product based on all sensory attributes, namely color, taste, aroma, and texture (Dwitantika *et al.,* 2025). The Friedman test showed a statistically significant difference in overall acceptability among formulations (p-value < 0.05). Nevertheless, post-hoc Wilcoxon pair-wise analyses indicated no significant differences between individual pairs, suggesting similar overall acceptance levels. With mean scores falling within the range of 4.73–5.37, all formulations were deemed acceptable by the panelists. F2 achieved the highest mean rating 5.37 and was selected as the overall most favored formulation.

3.2 Nutritional Content Test Results

3.2.1 Moisture Content

Moisture content refers to the amount of water present in food and can affect its texture, freshness, quality, and shelf life (Agustin *et al.,* 2022). The test result in Table 2 showed that moisture content increased with increasing proportions of dried okara, consistent with Fadhila *et al.* (2024), who found an increase in moisture content with increasing proportions of okara flour, with the highest moisture content of 4.01% observed in the formulation containing 30% okara.

Table 2. Mooka Cookies Moisture Content

Formulation	Moisture Content (%)
F1	2.93 ± 0.04
F2	3.04 ± 0.03
F3	5.15 ± 0.02

Description: Values are presented as mean ± standard deviation (SD) per 100 g of cookies.

This increase may be attributed to the high water-holding capacity (WHC) of okara, which is associated with its porous and hygroscopic structure that enables water absorption and retention during processing (Kamble & Rani, 2020; Yadav & Vandana, 2023). The higher the moisture content of a food product, the greater the risk of quality deterioration due to increased activity of spoilage microorganisms (Nugroho, 2024). According to BPOM RI (2019), the maximum moisture content for cookies is 5%. F1 (2.93%) and F2 (3.04%) met this standard, whereas F3 5.15% exceeded the limit.

3.2.2 Ash Content

Ash content represents the mineral or inorganic fraction remaining after thermal oxidation of food materials, with higher ash content indicating a greater mineral content (Kristiandi *et al.,* 2021). The result presented in Table 3 showed that ash content increased with increasing proportions of dried okara, consistent with Dunya *et al.* (2023) and Prabowo and Tanone (2025).

Table 3. Mooka Cookies Ash Content

Formulation	Ash Content (%)
F1	2.82 ± 0.02
F2	2.89 ± 0.75
F3	2.94 ± 0.03

Description: Values are presented as mean ± standard deviation (SD) per 100 g of cookies.

This increase may be related to the contribution of inorganic components from dried okara to the formulations. Dried okara was reported to contain 3.48 ± 1.46 g ash/100 g, while mocaf flour contains 1.3 g/100 g (Kemenkes RI, 2020; Shinde *et al.,* 2025). However, the increase in ash content in the present study indicates a higher total inorganic residue with increasing dried okara proportion and does not necessarily indicate an increase in any specific mineral.

3.2.3 Protein Content

Protein is an essential macronutrient involved in various physiological processes (Ajomiwe *et al.,* 2024). Dietary protein may stimulate insulin secretion, increase satiety, and support glycemic control (Nagy *et al.,* 2026). The results in Table 4 showed that protein content increased with increasing proportions of dried okara.

Table 4. Mooka Cookies Protein Content

Formulation	Protein Content (%)
F1	11.97 ± 0.44
F2	14.33 ± 0.54
F3	14.77 ± 2.11

Description: Values are presented as mean ± standard deviation (SD) per 100 g of cookies.

The increase may be attributed to the higher protein content of dried okara, which contains 29.2 ± 7.7 g/100 g compared with 1.2 g/100 g in mocaf flour (Kemenkes RI, 2020; Shinde *et al.,* 2025). Similarly, Fadhila *et al.* (2024) found that the formulation containing the highest proportion of okara flour 30% had the highest protein content, at 17.09%. In this study, the protein content ranged from 11.97–14.77 g/100 g, with F3 showing the highest protein content. Although the protein content of Mooka cookies was lower than that reported by Fadhila *et al.* (2024), the increasing trend with higher okara proportions was similar. According to BPOM and Perkeni guidelines, the recommended protein content for adult snacks is 6–9 g/serving. Per serving (60 g) of all formulations met this range, with protein contents of 7.18, 8.60, and 8.86 g/serving for F1, F2, and F3, respectively.

3.2.4 Fat Content

Fat is an essential component of cell membranes that provides energy, essential fatty acids, and facilitates the absorption of fat-soluble vitamins A, D, E, and K (Meijaard *et al.,* 2022). The quality and quantity of dietary fat are closely associated with glycemic control and cardiovascular risk in patients with T2D. Consumption of saturated fatty acids (SAFA) may increase the risk of and exacerbate insulin

resistance, whereas replacing SAFA with unsaturated fatty acids (PUFA/MUFA) may improve glycemic regulation and insulin sensitivity (Olive *et al.,* 2024). The results in Table 5 showed that fat content increased with increasing proportions of dried okara, consistent with Dunya *et al.* (2023), who found that the formulation containing the highest proportion of okara flour 80% had the highest fat content, at 19.28%, while the lowest proportion of okara flour 0% had the lowest fat content with 15.02%. In this study, the fat content ranged from 28.07–36.23 g/100 g, with F3 showing the highest fat content.

Table 5. Mooka Cookies Fat Content

Formulation	Fat Content (%)
F1	28.07 ± 0.07
F2	29.12 ± 0.12
F3	36.23 ± 0.50

Description: Values are presented as mean ± standard deviation (SD) per 100 g of cookies.

This increase may be attributed to the higher fat content of dried okara (9.25 ± 6.56 g/100 g) compared with mocaf flour (0.6 g/100 g) (Kemenkes RI, 2020; Shinde *et al.,* 2025). According to BPOM and PERKENI guidelines, fat intake from snacks for adults should range from 6.7–10.05 g/serving. Per serving (60 g) of all formulations exceeded this range, with fat contents of 16.84, 17.48, and 21.74 g/serving for F1, F2, and F3, respectively. Therefore, the relatively high fat content represents a limitation of the current formulation for use as a snack for individuals with T2D. Individuals with T2D are also at increased risk of dyslipidemia (Perkeni, 2024). Thus, dietary fat intake should be appropriately controlled, with saturated fat limited to <7% of total energy intake, PUFA contributing <10% of total energy, and the remaining fat intake primarily derived from MUFA (Persagi & ASDI, 2024). Future formulation optimization may consider reducing the amount of added oil to lower the total fat content while maintaining the sensory acceptability and physical characteristics of Mooka cookies.

3.2.5 Carbohydrate Content

Carbohydrates are the main source of energy and include sugars and starches (Slavin & Engstrom, 2024). The results in Table 6 showed that carbohydrate content decreased with decreasing proportions of mocaf flour.

Table 6. Mooka Cookies Carbohydrate Content

Formulation	Carbohydrate Content (%)
F1	47.21 ± 0.18
F2	46.30 ± 0.19
F3	37.86 ± 0.20

Description: Values are presented as mean ± standard deviation (SD) per 100 g of cookies.

Since the amount of palm sugar was kept constant across formulations, differences in carbohydrate content were primarily attributed to the varying proportions of mocaf flour and dried okara. This finding is consistent with Hariadi *et al.* (2023), who reported that higher proportions of mocaf increased carbohydrate content. This may be attributed to the higher carbohydrate content of mocaf flour (85 g/100 g) compared with dried okara (50.76 ± 11.48 g/100 g) (Kemenkes RI, 2020; Shinde *et al.,* 2025).

According to BPOM and Perkeni guidelines, carbohydrate intake from snacks for adults should range from 32.5–48.75 g/serving. Per serving (60 g) of all formulations were below this range, with carbohydrate contents of 28.33, 27.78, and 22.72 g/serving for F1, F2, and F3, respectively. The lower carbohydrate content in Mooka cookies was accompanied by increased dietary fiber and protein content

with increasing proportions of dried okara. A similar finding was reported by Fadhila *et al.* (2024), who found that the formulation with the highest proportion of okara flour had the lowest carbohydrate content and the highest fiber and protein contents. This similar pattern suggests that increasing the proportion of okara may contribute to a nutritional profile characterized by lower carbohydrate and higher fiber and protein contents.

3.2.6 Energy Content

Energy in food is primarily derived from carbohydrates, proteins, and fats (Toro *et al.,* 2021). Carbohydrates and proteins provide 4 kcal/g, while fat provides 9 kcal/g (Roberts & Flaherman, 2022). The energy content of Mooka cookies shown in Table 7 increased with increasing proportions of dried okara, which may be attributed to the corresponding increase in protein and fat content.

Table 7. Mooka Cookies Energy Content

Formulation	Energy Content (kcal)
F1	489.35 ± 1.85
F2	504.65 ± 0.28
F3	536.57 ± 8.05

Description: Values are presented as mean ± standard deviation (SD) per 100 g of cookies.

Since fat provides more energy per gram than protein and carbohydrates, the increase in fat content may contribute substantially to the higher energy content. This finding is consistent with Dunya *et al.* (2023), who reported that increasing okara flour proportions increased the energy content of cookies along with protein, fat, ash, and fiber contents. Similarly, Wickramarathna and Arampath (2003) found that bread containing okara had higher energy content than bread without okara, which was associated with its protein and fat content. According to BPOM and Perkeni guidelines, the energy content of snacks for adults should range from 215–322.5 kcal/serving. Per serving (60 g) of all formulations met this range, with energy contents of 293.61, 302.79, and 321.94 kcal/serving for F1, F2, and F3, respectively.

3.3 Functional Characteristics

3.3.1 Fiber Content

Dietary fiber can be classified into soluble dietary fiber (SDF) and insoluble dietary fiber (IDF), which play important roles in metabolic and gastrointestinal health (Bakr & Farag, 2023). SDF can help slow glucose absorption and support glycemic control, while IDF contributes to gastrointestinal health (Lesa *et al.,* 2023). The results showed in Table 8 for fiber content increased with increasing proportions of dried okara.

Table 8. Mooka Cookies Fiber Content

Formulation	Fiber Content (%)
F1	6.09 ± 1.41
F2	6.25 ± 1.40
F3	7.79 ± 0.03

Description: Values are presented as mean ± standard deviation (SD) per 100 g of cookies.

This finding is consistent with Dunya *et al.* (2023), who reported an increase in fiber content with increasing okara flour proportions in cookies. Similarly, Fadhila *et al.* (2024) and Hariadi *et al.* (2023) reported higher fiber content in products with greater proportions of okara or soybean-based ingredients. This increase may be attributed to the higher fiber content of dried okara (52.6 ± 11.02 g/100 g) compared

with mocaf flour (6 g/100 g) (Kemenkes RI, 2020; Shinde *et al.,* 2025). According to Perkeni (2024), the recommended daily dietary fiber intake for adults with T2D ranges from 20–35 g, and snacks contribute approximately 10–15% of daily energy requirements. Based on these recommendations, the dietary fiber content of a snack can be estimated to range from 2–5.75 g per serving, calculated based on 10% of 25 g and 15% of 30 g. All Mooka cookie formulations fell within this range per serving (60 g), with fiber contents of 3.66, 3.75, and 4.67 g/serving for F1, F2, and F3, respectively.

3.3.2 Antioxidant Activity

Antioxidants are molecules or compounds that protect cells from oxidative damage by neutralizing reactive oxygen species (ROS) (Chandimali *et al.,* 2025). Chronic hyperglycemia in T2D can increase oxidative stress (OS) through ROS production, which may damage pancreatic β-cells and vascular tissues. Okara contains daidzein and genistein, which are classified as antioxidant compounds (Lesa *et al.,* 2023). Thermal processing can alter the chemical form and stability of soybean isoflavones and other antioxidant compounds. Thermal processing can convert soybean isoflavone glycosides into aglycones, such as genistein, which have stronger antioxidant activity due to their free hydroxyl groups that can scavenge free radicals (Kim *et al.,* 2025). Despite the potential antioxidant properties of okara, Table 9 shows that all formulations had very weak antioxidant activity (>200 ppm).

Table 9. Mooka Cookies Antioxidant Activity

Formulation	IC_{50} (ppm)
F1	270.78 ± 0.01
F2	250.51 ± 0.01
F3	235.22 ± 0.01

Adebowale *et al.* (2025) reported stronger antioxidant activity with increasing okara proportions in composite flour. However, the flour was analyzed before baking. Fadhila *et al.* (2024) also found that increasing okara proportions increased isoflavone content. These findings suggest that the presence of isoflavones does not necessarily result in strong antioxidant activity after processing. Hariadi *et al.* (2023) similarly reported weak antioxidant activity in black soybean brownies, which was associated with heat processing. Excessive heating may alter phenolic compounds, including flavonoids, and reduce antioxidant activity (Rumicha *et al.,* 2025).

The relatively weak DPPH radical-scavenging activity may also have been influenced by the interval between sample preparation and laboratory analysis. However, because storage duration was not included as an experimental factor in the present study, its specific contribution to antioxidant activity could not be determined. Further studies should therefore evaluate antioxidant activity immediately after processing and under controlled storage conditions to clarify the effects of processing and storage on the antioxidant properties of Mooka cookies.

4. Conclusions

All Mooka cookie formulations were generally acceptable to the panelists. No significant differences were found in color preference, while significant differences were observed in taste (F1 vs. F2) and texture (F1 vs. F3). Aroma preference differed significantly based on the Friedman test, although no significant differences were found in pairwise Wilcoxon comparisons. F2 obtained the highest mean overall acceptability score (5.37), but was not significantly different from the other formulations in pairwise comparisons.

F2 (50% mocaf flour and 50% dried okara) was the most preferred formulation based on the overall acceptability indicator, providing 302.79 kcal energy (14%), 8.60 g protein (15%), 17.48 g fat (27%), 27.78 g carbohydrates (9%), and 3.75 g crude fiber (13%) per serving (60 g). The fat contribution per

serving was relatively high, whereas the carbohydrate contribution was relatively low compared with the respective recommended daily values. The antioxidant activity of F2 was relatively low. Further reformulation may be considered, particularly by optimizing the levels of canola oil and cocoa powder, to improve the nutritional and sensory characteristics of the product. Future studies should measure antioxidant activity immediately after processing and during controlled storage to clarify the potential effect of storage on the antioxidant activity of Mooka cookies.

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6. Conflict of Interest Declaration

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirm that this manuscript is original and free from plagiarism.

7. Author Contribution Statement

This journal uses Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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Hari Hariadi		x					x							x

Please mark (x) the CRediT roles of each author in the table above.

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

8. Generative AI Statement

The authors acknowledge the use of ChatGPT (OpenAI) during the preparation of this manuscript to assist with discussing research ideas, refining scientific discussions, and improving language, grammar, and readability. The AI-generated suggestions were critically reviewed and revised by the authors. The authors take full responsibility for the accuracy and integrity of the final manuscript.

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