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Original Research

Development and Sensory Evaluation of Oat–Spinach Chicken Meatballs (SOATYAM)

Pengembangan dan Evaluasi Organoleptik Bakso Ayam Berbasis Oat dan Bayam (SOATYAM)

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Abstract: *Diabetes mellitus (DM) prevalence continues to rise both globally and in Indonesia, creating a need for food alternatives that are safe for blood glucose control. Meatball (bakso) is widely consumed in Indonesia but is typically high in fat and low in fiber, limiting its suitability for people with DM. This study aimed to analyze the organoleptic properties of chicken meatball formulated with oat flour and varying concentrations of spinach flour (SOATYAM) and to determine the most accepted formula among three treatments. A completely randomized design was used with three spinach flour concentrations, 5 g (F1), 10 g (F2), and 15 g (F3), combined with a constant proportion of oat flour. Sensory evaluation was conducted by 10 semi-trained panelists who rated the color, aroma, taste, texture, and aftertaste of all three formulas using a 5-point hedonic scale. Data were analyzed using the Friedman test, appropriate for repeated-measures sensory data, followed by Wilcoxon signed-rank post-hoc tests with Bonferroni correction where applicable. No significant differences were found among the three formulas for any sensory attribute (p>0.05). F1 consistently received the highest mean hedonic scores across all attributes, including overall acceptance (3.54 ± 0.70), followed by F2 (3.28 ± 0.82) and F3 (2.86 ± 0.79). These findings indicate that F1, containing the lowest proportion of spinach flour, showed a trend toward higher acceptance compared to F2 and F3, although the difference was not statistically significant, and has potential as a sensory-acceptable product for further development as a functional food. Further studies on nutritional composition, glycemic index, and shelf life are recommended.*

Key word: diabetes mellitus, functional food, meatball, oat flour, spinach flour

1. INTRODUCTION

Diabetes mellitus (DM) is a metabolic disorder characterized by chronic hyperglycemia resulting from impaired insulin secretion, insulin action, or both (1). The global burden of DM continues to rise. The International Diabetes Federation reported that approximately 589 million adults were living with diabetes in 2024, equivalent to one in every nine adults worldwide, with the figure projected to reach approximately 853 million by 2050 (2). In Indonesia, national DM prevalence based on blood glucose measurement increased from 10.9% in the 2018 Basic Health Research (Riskesdas) to 11.7% in the 2023 Indonesian Health Survey (SKI) (3). This increasing burden has encouraged greater interest in dietary approaches that complement conventional diabetes management. Functional foods have increasingly been recognized as an important dietary strategy for preventing and managing non-communicable diseases, including diabetes mellitus. In particular, foods rich in soluble dietary fiber have been shown to improve glycemic regulation, insulin sensitivity, and cardiometabolic health, making them promising components of diabetes dietary management (4).

People with DM often struggle to find food choices that comply with their dietary restrictions, particularly regarding fat, sugar, and calorie content (1). Beef meatballs are round, ready-to-eat products made from minced beef mixed with water, flour, fat, and spices, then processed through precooking, storage, and reheating, and they are widely appreciated as a traditional snack with rich nutrition, distinctive flavor, affordable price, and common use in hot pot dishes in China (5). Conventional meatball is generally high in fat and calories, which limits its suitability for people with DM. Variation in plant by-products used in meat formulations influences sensory attributes such as colour, texture, and flavour, highlighting the need for diversified formulations to meet consumer expectations and health-oriented demands (6). The incorporation of non-meat ingredients into processed meat products is widely applied not only to improve flavour, texture, colour, shelf life, and production efficiency, but also to enhance nutritional quality and support healthier product development (7).

Oats (Avena sativa) are recognized as a functional cereal due to their high β-glucan content, balanced proteins, and unique antioxidants such as avenanthramides. Their flour provides essential minerals including phosphorus, magnesium, iron, and zinc, while naturally containing low levels of saturated fat, sodium, and sugar, making them suitable for incorporation into health-oriented meat products (8). The soluble fiber β-glucan in oats has been acknowledged for its capacity to reduce postprandial glycemic response, and clinical trials consistently report measurable improvements in fasting and postprandial blood glucose among individuals with type 2 diabetes following regular oat consumption (9). Beyond its role in glycemic control, oat β-glucan has been widely utilized in functional food development because it improves water-holding capacity, texture, and overall nutritional quality in products such as bread, noodles, meat products, and dairy foods (10). Green spinach (Amaranthus tricolor L.) is another nutrient dense vegetable commonly consumed in Indonesia, rich in iron, calcium, magnesium, and vitamins A, B1, B2, C, and E, along with beta-carotene and dietary fiber (11). Spinach enrichment in bread enhances the levels of essential micronutrients such as magnesium, while simultaneously imparting a natural green hue to the crumb and crust, thereby improving both nutritional and visual qualities of the product (12).

Previous studies have examined the effect of oat or spinach addition on meatball organoleptic properties separately. The addition of green spinach puree to barracuda fish meatball was reported to affect color, aroma, and taste, although it did not significantly change texture (13). Red spinach leaf extract at varying concentrations was found to significantly affect the aroma, color, texture, and taste of chicken meatball (14). However, no previous study has evaluated the combined addition of oat flour and spinach flour in a single meatball formulation positioned specifically as a functional food for people with DM. Building on this gap, the present study aims to analyze the organoleptic properties of chicken meatball formulated with oat flour and varying concentrations of spinach flour (SOATYAM), and to determine the most accepted formula among the three treatments as a potential functional food alternative for people with diabetes mellitus.

2. METHODS

This study used a completely randomized design (CRD) with three treatments based on the concentration of spinach flour added to the meatball formulation, namely 5 g (F1), 10 g (F2), and 15 g (F3), while the proportion of oat flour and other ingredients was kept constant across treatments. Product preparation was conducted at the Food

Processing Laboratory and organoleptic testing was conducted at the Organoleptic Laboratory, Faculty of Health Sciences, Universitas Singaperbangsa Karawang. The main ingredients used were chicken meat, oat flour, cornstarch, spinach flour, chicken egg, fried shallot, garlic, salt, pepper, monosodium glutamate, sodium tripolyphosphate, and ice. Equipment used included a digital scale, chopper, stainless steel pot, measuring spoon, cutting board, knife, refrigerator and freezer, and stove. The complete composition of each formula is presented in Table 1.

Table 1. Composition of Oat-Spinach Meatball (SOATYAM) by Formula

Ingredient	Unit	F1	F2	F3
Chicken meat	g	300	300	300
Oat flour	g	80	80	80
Cornstarch	g	30	30	30
Spinach flour	g	5	10	15
Chicken egg	g	110	110	110
Fried shallot	g	10	10	10
Garlic	g	12	12	12
Salt	g	10	10	10
Pepper	g	2	2	2
Monosodium glutamate	g	5	5	5
Sodium tripolyphosphate	g	2	2	2
Ice	g	20	20	20
Total weight	**g**	**586**	**591**	**596**

Note: F1, F2, and F3 differ only in the amount of spinach flour added (5 g, 10 g, and 15 g respectively), while the proportions of all other ingredients are identical across formulas. Composition adapted and modified from Widyawati et al. (13).

Panelists were recruited using simple random sampling among undergraduate Nutrition Science students at University of Singaperbangsa Karawang who met the inclusion criteria. A total of 10 semi-trained panelists participated in this exploratory sensory study, and each panelist evaluated all three formulations (F1, F2, F3) in a single session. This decision is based on ISO guidelines, whick state that 10 panelists per session are sufficient to produce reliable sensory data, even though a larger number of candidates is usually recruited to anticipate possible absences (15). As this study involved minimal-risk sensory evaluation without invasive procedures, a formal ethical clearance number was not obtained. Nevertheless, all ethical precautions were obeserved: participation was voluntary, informed consent was obtained verbally from all panelists before testing, panelists were free to withdraw at any time, and confidentiality of individual responses was maintained throughout the study. The sensory evaluation involved minimal risk and was conducted under the supervision of the research team.

Oat flour was prepared by selecting good quality oat, grinding it, sieving it through an 80 to 100 mesh sieve, and packaging it in an airtight container. Spinach flour was prepared by washing fresh spinach leaves, blending them with water at a 1:1 ratio, spreading the puree on an aluminum foil lined tray, and drying it using a tray dryer at 60°C. Meatball production followed four stages, meat grinding, mixing of ingredients into dough, shaping, and cooking in boiling water for approximately 15 minutes.

Each formulation was coded and presented to panelists in randomized order. Panelists assessed aroma, taste, color, texture, and aftertaste using a 5-point hedonic scale ranging from 1 (strongly dislike) to 5 (strongly like). Data were processed using Microsoft Excel and analyzed with IBM SPSS Statistics version 25.0. Because each of the 10 panelists evaluated all three formulations, a repeated-measures approach was applied. The Friedman test was used to compare the three formulas for each sensory attribute, followed by the Wilcoxon signed-rank test with Bonferroni correction for pairwise comparisons when the Friedman test indicated a significant difference ($p<0.05$).

3. RESULTS

A total of 10 semi-trained panelists evaluated the organoleptic properties of chicken meatball formulated with oat flour and three concentrations of spinach flour (F1, F2, F3) using a 5-point hedonic scale. The mean hedonic scores for color, aroma, taste, texture, aftertaste, and overall acceptance are presented in Table 2.

Table 2. Mean Hedonic Scores of Oat-Spinach Meatball (SOATYAM) by Treatment

Sensory Attribute	F1	F2	F3	Friedman p-value
Color	3.70 ± 1.16	3.50 ± 0.71	3.20 ± 0.79	0.161
Aroma	3.40 ± 1.08	2.70 ± 0.95	2.80 ± 0.79	0.123
Taste	3.70 ± 1.16	3.70 ± 1.25	2.90 ± 1.03	0.087
Texture	3.70 ± 0.95	3.50 ± 0.97	2.70 ± 0.95	0.102
Aftertaste	3.20 ± 1.23	3.00 ± 0.82	2.70 ± 0.68	0.331
Overall	3.54 ± 0.70	3.28 ± 0.82	2.86 ± 0.79	0.050*

Note: F1 = meatball with 5 g spinach flour, F2 = 10 g spinach flour, F3 = 15 g spinach flour, combined with a constant proportion of oat flour. Values are presented as mean ± standard deviation on a 5-point hedonic scale (1 = strongly dislike, 5 = strongly like).

No significant difference was found among the three formulas for any individual sensory attribute ($p>0.05$). F1 consistently received the highest mean score across all attributes, color, aroma, taste, texture, and aftertaste, and also recorded the highest overall acceptance score (3.54 ± 0.70), followed by F2 (3.28 ± 0.82) and F3 (2.86 ± 0.79).

4. DISCUSSION

The small number of panelists (n = 10) limits the statistical power and generalizability of these findings, and should be considered when interpreting the descriptive trends discussed below. The visual change in SOATYAM from light green to dark green as spinach flour increased did not translate into a significant difference in panelists' preference ($p = 0.161$), probably because the spinach flour concentrations evaluated differed only slightly. F1 obtained the highest color score, as its appearance was closest to that of conventional chicken meatballs. This finding is consistent with a previous study reporting that increasing spinach concentration in chicken meatballs tended to reduce panelists' color acceptance because the product appearance became less similar to conventional meatballs (14). Increasing the proportion of spinach flour did not produce noticeable differences in aroma ($p = 0.123$). Although spinach has a distinctive aroma that may influence product acceptance, the cooking process likely reduced its intensity, making the aroma differences among formulations less noticeable. F1 still obtained the highest aroma score, consistent with a previous study reporting that increasing spinach concentration in chicken meatballs tended to reduce panelists' acceptance of product aroma (14). These results suggest that using spinach flour at a moderate level can maintain the aroma of the product within an acceptable range.

A consistent decrease in taste scores was observed as spinach flour concentration increased, although this trend did not reach statistical significance ($p = 0.087$, range 2.90–3.70). This pattern may be related to the proportion of non-meat ingredients, known to influence the taste characteristics of processed meat products. A similar finding has also been reported in chicken meatballs substituted with red lentil flour, where increasing the proportion of non-meat ingredients affected the taste characteristics of the product (16). The absence of significant differences may have been influenced by the relatively narrow range of spinach flour concentrations and the limited number of panelists, reducing the statistical power to detect sensory differences. F1 obtained the highest texture score and was perceived as most similar to conventional chicken meatballs, although differences among formulations were not statistically significant ($p = 0.102$). This may be explained by the constant amount of oat flour used across all formulations: the soluble β-glucan in oat is known to improve water-holding capacity, emulsion stability, and gel formation in meat products and meat analogues (17). In addition, spinach has been reported to improve water-binding capacity and maintain the texture of meat products at certain substitution levels (18). The contribution of oat flour to the basic structure of SOATYAM was therefore likely greater than the effect of spinach flour variation, resulting in no significant texture differences among the formulations. F3, containing the highest amount of spinach flour, tended to produce a stronger aftertaste than F1, although this difference did not reach statistical significance ($p = 0.331$, range 2.70–3.20). This trend may be related to the higher concentration of spinach-derived compounds present in the final product. Spinach contains several phytochemicals, particularly polyphenols and flavonoids, which can contribute to bitterness and leafy flavor, while oxalates and chlorophyll may also contribute to earthy notes and aftertaste in spinach-based food products (12). Previous research on spinach-enriched bread also reported that increasing spinach concentration resulted in more bitterness and unpleasant aftertaste, leading to lower sensory acceptance at higher levels of spinach addition (12). However, because the difference in spinach flour concentration among the formulations in this study was relatively small (5–15 g), these changes were likely not sufficient to produce statistically significant differences in aftertaste.

Although the Friedman test indicated a borderline result for overall acceptance ($p = 0.050$), the Wilcoxon post-hoc test with Bonferroni correction found no significant pairwise differences, suggesting that all formulations were perceived as similarly acceptable overall. This absence of consistent significant differences may be attributable to the limited number of panelists and the relatively narrow range of spinach flour concentrations tested, making sensory differences difficult to detect statistically. In addition, using the same proportion of oat flour in all formulations was likely to help maintain the overall sensory characteristics of the product. Similar findings have also been reported in meatballs partially substituted with white oyster mushroom, where the substitution did not produce significant sensory differences (19). Despite the absence of statistically significant differences, the consistent trends observed across the formulations provide useful insights for future product development. F1, which contained the lowest concentration of spinach flour, consistently obtained the highest mean scores for all sensory attributes, suggesting that a moderate level of spinach flour combined with oat flour is better able to maintain the sensory characteristics expected by consumers of chicken meatballs. However, the potential health benefits of SOATYAM, including its possible role in blood glucose control for people with diabetes mellitus, remain theoretical at this stage. Any claim that SOATYAM is a functional food for diabetes requires further studies, including nutritional composition analysis, glycemic index evaluation, and assessment of the bioactivity of β-glucan in the final product. Therefore, SOATYAM has the potential to be developed as a food product with acceptable sensory characteristics and promising prospects as a functional food. However, its potential benefits for diabetes management still need to be confirmed through further nutritional analyses, bioactivity studies, and clinical trials.

5. CONCLUSION

This study found that the addition of oat flour and spinach flour did not significantly affect the color, aroma, taste, texture, or aftertaste of chicken meatball ($p>0.05$) when evaluated using a statistical approach appropriate for repeated-measures sensory data. Among the three formulations tested, F1, containing the lowest proportion of spinach flour (5 g) combined with oat flour, showed the highest mean hedonic scores across all sensory attributes, indicating a trend toward higher acceptance, although the differences were not statistically significant. This findings suggest that chicken meatball enriched with oat flour and a modest proportion of spinach flour is sensorially acceptable and may serve as a candidate for further development as a funcional food. Howefer, because this study only evaluated organoleptic properties, it cannot yet be concluded that the product is suitable as a diabetes specific food alternative. Further research is recommended to evaluate the nutritional composition, glycemic index, and shelf life of the selected formula to support its potential application as a functional food product.

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