Journal of Health and Nutrition Research
Vol. 4, No. 2, 2025, pg. 390-401, https://doi.org/10.56303/jhnresearch.v4i2.374
Journal homepage: https://journalmpci.com/index.php/jhnr/index

e-ISSN: **2829-9760**

Effect of Partial Substitution of Beef with White Oyster Mushroom (*Pleurotus ostreatus*) on Nutritional Profile and Sensory Quality of Meatball Products

If'all[1]*, Nofrianto[1], Spetriani[1], Sitti Sabariyah[1], Siti Fathurahmi[1], Yuanita Indriasari[1], Asrawaty[1]

[1] Department of Agricultural Product Technology, Universitas Alkhairaat, Palu, Indonesia

Corresponding Author: ifall@unisapalu.ac.id

ORIGINAL ARTICLES

Submitted: 18 April 2025

Accepted: 3 May 2025

Keywords:
Beef Meatball, Nutritional Profile, Partial Substitution. Sensory Quality, White Oyster Mushroom

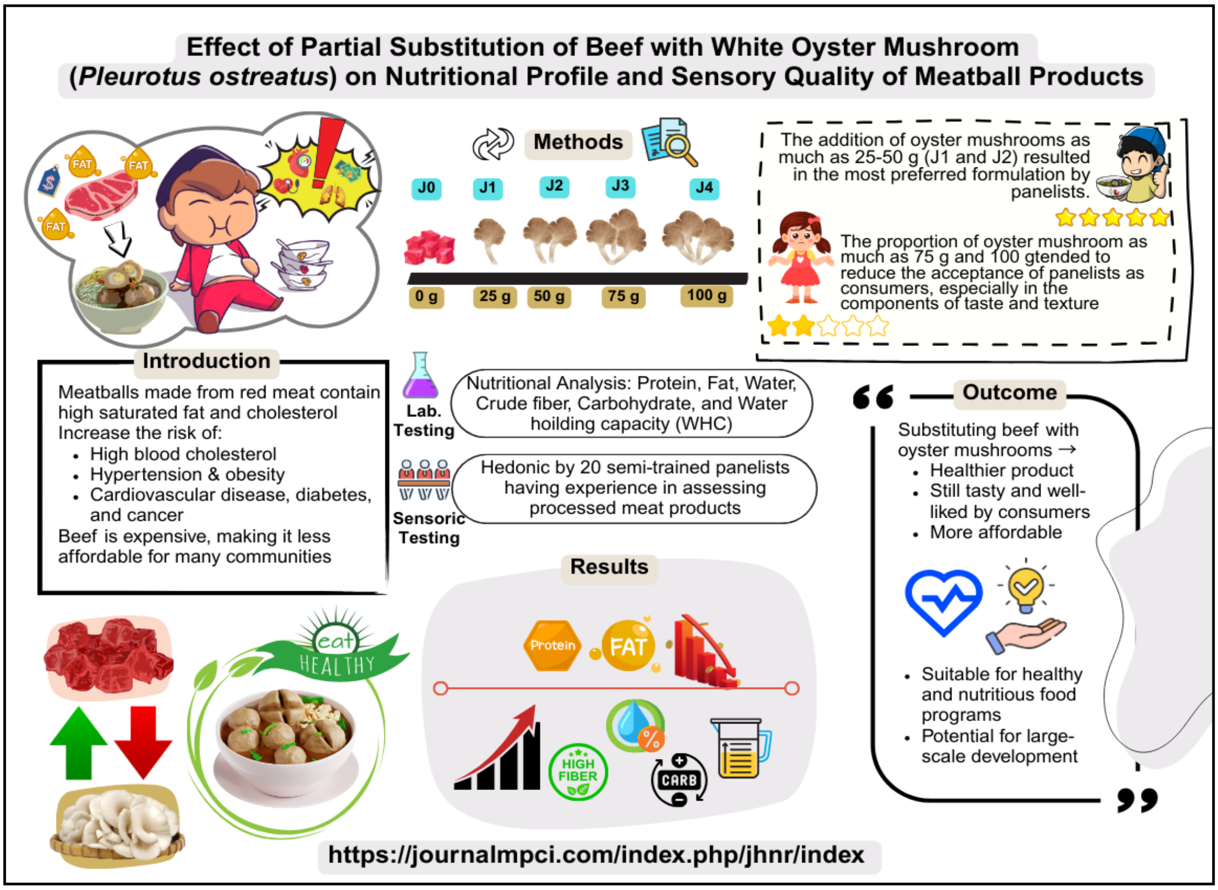
ABSTRACT

The increasing consumption of processed meat products has driven innovation in the partial substitution of raw materials with healthier, functional plant-based alternatives such as white oyster mushroom (*Pleurotus ostreatus*). This study aimed to evaluate the effect of partially substituting beef with oyster mushrooms on the nutritional profile and sensory quality of meatball products. A quantitative approach was employed using a Completely Randomized Design (CRD) with one factor and five treatment levels (J0–J4), each replicated three times. The treatments consisted of 0 g, 25 g, 50 g, 75 g, and 100 g of oyster mushrooms combined with 300 g, 275 g, 250 g, 225 g, and 200 g of beef, respectively. The results showed that increasing the proportion of oyster mushrooms significantly ($p < 0.05$) increased moisture content (from 28.57% to 35.37%), crude fiber (from 0.80% to 3.10%), carbohydrate content (from 2.50% to 4.80%), and water-holding capacity (from 55.50% to 68.10%). Conversely, protein and fat contents decreased significantly, with protein dropping from 18.50% (J0) to 13.00% (J4), and fat from 15.80% to 7.20%. Sensory evaluation using a hedonic test with 20 semi-trained panelists revealed that treatment J2 (50 g oyster mushroom + 250 g beef) received the highest scores for taste (3.90), aroma (3.95), texture (3.85), and color (3.95). Treatments with higher levels of mushroom substitution (J3 and J4) led to a significant decline in sensory acceptance, particularly in taste and texture. Therefore, partial substitution with up to 50 g of white oyster mushroom is recommended as an optimal level to improve the nutritional quality of meatballs without compromising sensory attributes, supporting the development of healthier and more functional meat-based products.

Key Messages:

- Partial substitution of beef with white oyster mushrooms can improve the nutritional quality of meatballs.
- The addition of oyster mushrooms as much as 25-50 g (J1 and J2) resulted in the most preferred formulation by panelists.
- Oyster mushrooms contribute to increased fiber and decreased fat in processed meat products.
- The balance between health benefits and flavor is key in developing products that are accepted by consumers.
- Meatball formulations that are functional and still popular have great potential to be developed in the Indonesian market.

GRAPHICAL ABSTRACT



INTRODUCTION

Processed meat products such as meatballs have long been a staple in the Indonesian diet, enjoyed by people across various age groups and social backgrounds (1) ; (2). Their chewy texture, savory flavor and ease of preparation maket hem highly popular (3) ; (4) ; (5). But behind its popularity, meatballs that are consumed excessively in the long term without paying attention to the quality of the ingredients, can have a negative effect on health (6). In line with (7) who revealed that quality meatballs are characterized by appropriate ingredients with the right nutritional content. In addition, meatballs produced from red meat (pure beef or fatty meat) contain high levels of saturated cholesterol (8) ; (9), which contributes to increased blood cholesterol levels, hypertension, obesity and cardiovascular disease, diabetes and cancer (10) ; (11) ; (12). Moreover, the relatively high price of beef presents a challenge for some communities, making it less accessible for low-income consumers. This highlights the need for innovation in developing more affordable and functional meat products that retain nutritional value and sensory appeal, especially for health-conscious and economically disadvantaged populations (13).

One approach is partial substitution of beef with plant-based ingredients that offer similar nutritional and sensory properties. White oyster mushrooms (*Pleurotus ostreatus*) are a promising option, as they are rich in dietary fiber, contain essential amino acids, are low in fat and calories, and include bioactive compounds beneficial for digestion and immunity. Their fibrous, meat-like texture and mild flavor allow them to blend well with meat-based products such as meatballs (14) ; (15) ; (16); (17) ; (18). The chewy texture and meat-like fibers of oyster mushrooms make them an ideal alternative in the formulation of semi-meat products that can improve the functional quality of the product (19) ; (20). Not only the functional nutrition content is an advantage, but the mild flavor when consumed makes this white oyster mushroom suitable for combination with other processed meat products.

Although oyster mushrooms have been used successfully in products like nuggets, burgers, and

https://doi.org/10.56303/jhnresearch.v4i2.374

sausages, limited studies have examined their specific impact on the nutritional profile and sensory quality of meatballs (21) ; (22) ; (23) ; (24) ; (25). Therefore, this study aims to evaluate the effect of partially substituting beef with white oyster mushrooms in meatball formulations. The hypothesis is that moderate substitution levels will enhance nutritional value without significantly compromising sensory quality, making the product suitable for health-conscious and cost-sensitive consumers.

METHODS

Experimental research conducted using a one-factor Completely Randomized Design (CRD), namely the percentage of white oyster mushroom substitution for beef which was carried out from November 2024 to March 2025 at the Analysis and Quality Laboratory of the Faculty of Agriculture, Alkhairaat University. This study consisted of 5 levels of treatment with 3 replications so that a total of 15 experimental units were obtained (5 x 3 = 15). The treatment of 5 levels of white oyster mushroom substitution formulations into meatball dough is presented in Table 1.

Table 1. Composition of white oyster mushroom substitution for beef in the treatment of making meatball products

Treatment	Beef Fresh (g)	White Oyster Mushroom (g)
J0	300	0
J1	275	25
J2	250	50
J3	225	75
J4	200	100

The main ingredients used in making the meatballs include fresh lean beef, fresh white oyster mushrooms (Pleurotus ostreatus), tapioca flour, ice cubes, chicken eggs, garlic, shallots, table salt, and ground pepper. The addition of white oyster mushrooms was done at five levels: 0 g (J0), 25 g (J1), 50 g (J2), 75 g (J3), and 100 g (J4), replacing part of the beef in the formulation. The fresh beef was sourced from RPH Tavanjuka Palu, while the white oyster mushrooms were obtained from Usaha Jamur Sumber Urip Palu. All ingredients were acquired from local markets in fresh and consumable condition. The tools used in the process of making meatballs are digital scales, meet grinder, plastic basin, baking sheet, spatula, stove and pan and digital thermometer, while for chemical analysis using an oven, soxhlet extraction tool, moisture content measuring instrument.

The formulation of ingredients in making meatballs refers to the modified (26). Substitution of white oyster mushrooms with 5 treatments (J0-J4) with varying levels (0% 25%, 50%, 75%, and 100%). Other ingredients such as (tapioca flour, ice cubes, eggs, and other spices) were retained to evaluate the proportion of mushrooms and meat substituted. The composition of the raw materials used in the substitution of each treatment is presented in Table 2.

Table 2. Formulation of meatball ingredients with variations in white oyster mushroom substitution

Ingredients	Treatment				
	J0	J1	J2	J3	J4
Beef fresh (g)	300	275	250	225	200
White oyster mushroom (g)	0	25	50	75	100
Tapioca flour (g)	200	200	200	200	200
Ice cube (g)	100	100	100	100	100
Eggs (piece)	2	2	2	2	2
Garlic (g)	4	4	4	4	4
Shallots (g)	4	4	4	4	4
Salt (g)	3	3	3	3	3
Ground pepper (g)	1	1	1	1	1

The procedure for making meatballs refers to the method (27) which is modified by several stages.

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The first stage of oyster mushrooms to be used is first washed in running water until clean, then soaked in hot water ± 10 minutes, remove and drain. Next, the beef is cut into pieces the size of a knuckle to facilitate the grinding process. Then beef and oyster mushrooms are ground until smooth using a meat grinder (the proportions are adjusted to the treatment) in Table 1, while the control (beef is ground without the addition of oyster mushrooms). Next, mix the other ingredients, namely tapioca flour, ice cubes, eggs, garlic and shallots, salt, and ground pepper. The dough mixture is stirred until homogeneous and formed into meatball balls the size of a knuckle (± 3 cm in diameter) to be boiled in boiling water for ± 10 minutes at a temperature of ± 1000C until it floats, then removed and cooled at room temperature. The complete procedure for making meatballs is presented in the form of a flowchart (Figure 1).

Nutritional analysis was conducted using chemical parameters, namely protein, fat, water, crude fiber, carbohydrate, and water binding capacity (WHC). Moisture content was determined using the oven method at 105°C until constant weight (28). Protein content was analyzed using the Kjeldahl method (29), fat content was determined by the Soxhlet method (30), crude fiber was analyzed according to the gravimetric method (31). Carbohydrate was calculated by the Luff-Schoorl Method (32), while water binding capacity (WHC) by the centrifugation method (33). The sensory test refers to the method of (34) ; (35) conducted by 20 semi-trained panelists having experience in assessing processed meat products. Twenty semi-trained panelists were selected based on their familiarity and prior experience with evaluating processed meat products. The panelists consisted of university students and staff (10 males and 10 females), aged between 21 and 35 years. All panelists had previous involvement in food product testing or related academic activities and were able to differentiate basic sensory attributes such as taste, aroma, texture, and appearance. Their semi-trained status was appropriate for hedonic evaluation purposes, as they were capable of providing consistent preference-based feedback using a 5-point hedonic scale (1 = strongly dislike, 5 = strongly like). Assessment was conducted in a panel room that was controlled for lighting, temperature, and odor interference.

Data analysis

Data were analyzed using variance analysis (ANOVA) α = 95% confidence level. If there was a significant difference between treatments, it was followed by Duncan's Multiple Range Test (DMRT) to determine the best treatment. Data processing was performed using SPSS statistical software version 25.

RESULTS

Based on Table 3. Beef that is partially substituted with white oyster mushrooms has a significant effect on the chemical composition of the meatballs produced. Treatment J0 (without the addition of white oyster mushroom/control) gave the best protein content of 18.50 ± 0.20% compared to other treatments (J1 = 17.80 ± 0.15%, J2 = 16.30 ± 0.18%, J3 = 14.80 ± 0.22% and J4 = 13.00 ± 0.25%). This is thought to be because the entire protein content produced from the J0 treatment comes from pure beef which naturally contains higher animal protein. There is a tendency that the higher the proportion of oyster mushrooms added, the lower the protein content of the meatballs produced.

Table 3. Nutritional profile (chemical composition) of meatball products at various levels of white oyster mushroom substitution

Treatment	Protein (%)	Fat (%)	Water (%)	WHC (%)	Crude fiber (%)	Carbohidrates (%)
J0 (0 g)	18.50 ± 0.20^{e}	15.80 ± 0.12^{e}	28.57 ± 0.16^{a}	55.50 ± 0.30^{a}	0.80 ± 0.05^{a}	2.50 ± 0.10^{a}
J1 (25 g)	17.80 ± 0.15^{d}	13.90 ± 0.10^{d}	30.33 ± 0.15^{b}	58.70 ± 0.35^{b}	1.20 ± 0.08^{a}	3.10 ± 0.12^{b}
J2 (50 g)	16.30 ± 0.18^{c}	11.60 ± 0.08^{c}	34.54 ± 0.17^{c}	62.00 ± 0.40^{c}	1.80 ± 0.10^{b}	3.60 ± 0.15^{c}
J3 (75 g)	14.80 ± 0.22^{b}	9.30 ± 0.09^{b}	35.17 ± 0.18^{d}	65.30 ± 0.45^{d}	2.40 ± 0.12^{c}	4.20 ± 0.18^{d}
J4 (100 g)	13.00 ± 0.25^{a}	7.20 ± 0.11^{a}	35.37 ± 0.20^{d}	68.10 ± 0.50^{e}	3.10 ± 0.15^{d}	4.80 ± 0.20^{e}

Note: Different superscript letters (a, b, c, d, e) within the same column indicate significant differences at $p < 0.05$ according to Duncan's Multiple Range Test

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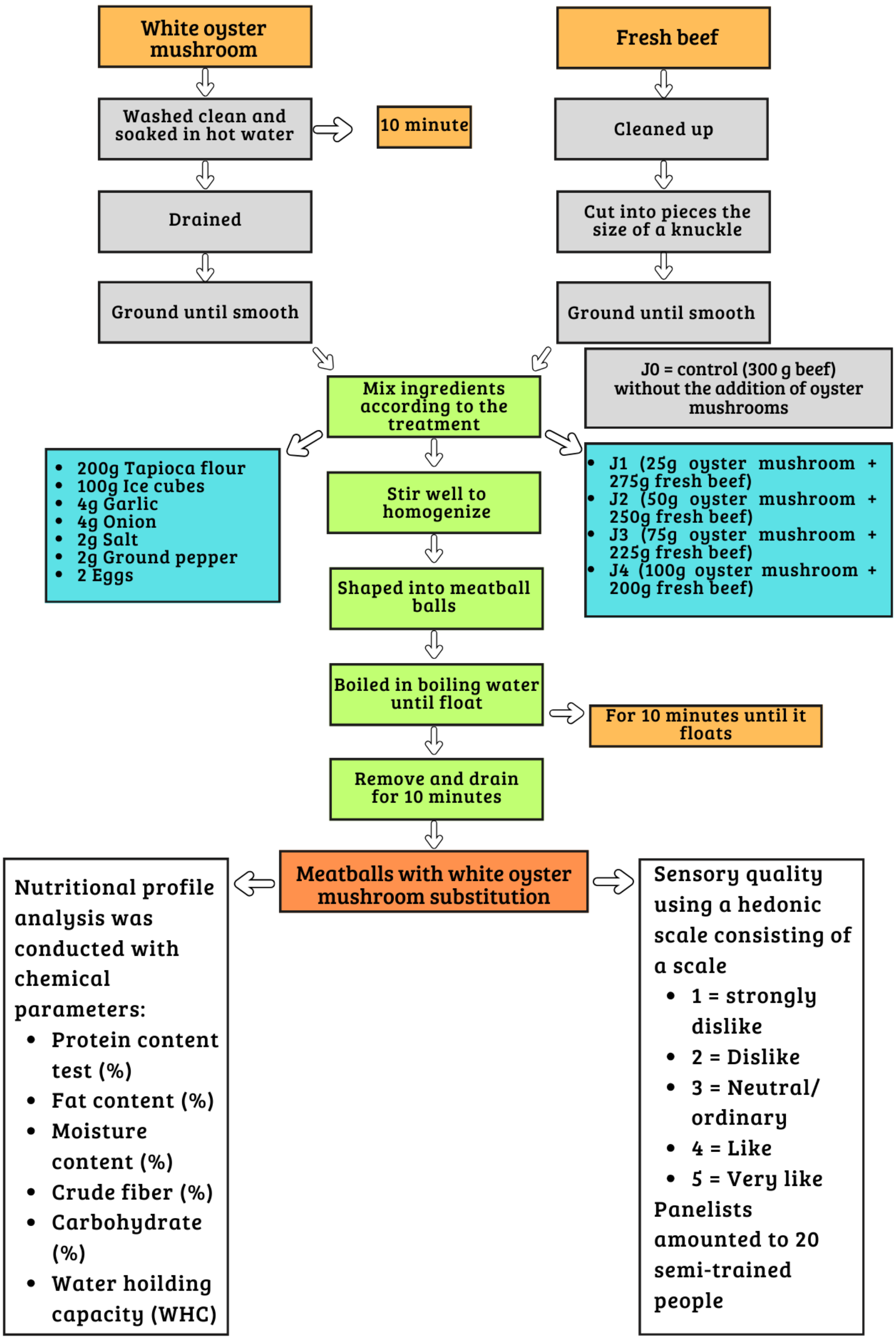

Figure 1. Flowchart of making meatballs with various substitutions of white oyster mushrooms
Source: Personal illustration using *Canva software* (https://www.canva.com/)

The same thing in the analysis of fat content (Table 3), showing a decrease in fat content along with an increase in the proportion of oyster mushrooms given, from 18.50 ± 0.20% in the treatment (J0) to 7.20 ± 0.11% treatment (J4). This decrease can be explained that oyster mushrooms have a low fat content compared to beef so that the substitution of beef with these ingredients has a good impact on reducing fat

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content in meatball products. Oyster mushrooms contain 1.7% - 2.2% fat (36) ; (37). Meanwhile, the parameters of moisture content, crude fiber, carbohydrate, and water binding capacity increased as the proportion of mushrooms in the dough increased. Moisture content (J0) 28.57 ± 0.16% increased to 35.37 ± 0.20% in treatment J4 (100g white oyster mushroom + 200g fresh beef). This interaction correlates with oyster mushroom, which is characterized by high water content due to its ability to absorb water effectively.

An increase also occurred in the water binding capacity parameter from 55.50 ± 0.30% (J0) to 68.10 ± 0.50% (J4), indicating a higher ability of the dough formulation matrix to retain liquid, potentially resulting in a softer and juicier meatball product texture. Crude fiber content ranged from 0.80 ± 0.05% to 3.10 ± 0.15% and carbohydrate content ranged from 2.50 ± 0.10% to 4.80 ± 0.20% which also experienced a progressive increase (Table 3). This reflects that oyster mushrooms play a role in fulfilling nutrition as an additional source of fiber in processed meat products. Food ingredients that contain fiber are very good for consumer health in meeting daily fiber needs (38). White oyster mushrooms contain 43-60% complex carbohydrates (beta-glucan and chitin) which provide health benefits and function as fiber in the human body (39). Although there is a decrease in protein along with the addition of the proportion of white oyster mushrooms in the dough, it is still tolerable at a certain level of substitution. The formulation of the proportion of oyster mushroom up to 50 g (J2) is considered the optimal point in producing meatballs that have a balance between nutritional value and functional potential without significantly sacrificing nutritional quality.

The results of sensory quality analysis (organoleptic test) in Table 4 show that the treatment of white oyster mushroom substitution in various treatments has a significant effect even though it is not significantly different from the sensory attributes of meatball products (taste, texture, aroma, and color).

Table 4. Average score of sensory quality of meatballs with white oyster mushroom substitution in various treatments

Treatment	Taste	Texture	Aroma	Colour
J0 (0 g)	3.75 ± 0.12^{a}	3.55 ± 0.10^{a}	3.85 ± 0.09^{a}	3.80 ± 0.10^{a}
J1 (25 g)	3.90 ± 0.11^{a}	3.80 ± 0.08^{a}	3.95 ± 0.10^{a}	3.95 ± 0.08^{a}
J2 (50 g)	3.90 ± 0.10^{a}	3.85 ± 0.07^{a}	3.95 ± 0.09^{a}	3.95 ± 0.07^{a}
J3 (75 g)	3.40 ± 0.13^{c}	3.10 ± 0.10^{c}	3.50 ± 0.11^{c}	3.45 ± 0.12^{c}
J4 (100 g)	2.90 ± 0.15^{d}	2.80 ± 0.14^{d}	3.00 ± 0.13^{d}	3.10 ± 0.12^{d}

Source: Primary data (2025)
Different superscript letters (^{a},^{c},^{d}) within the same column indicate significant differences at $p < 0.05$ according to Duncan's Multiple Range Test. Treatments with the same letter are not significantly different from each other, while treatments with different letters show significant differences in their sensory attributes.

Treatments J1 (25g white oyster mushroom + 275g beef) and J2 (50g white oyster mushroom + 250g beef) showed the highest scores for all sensory attributes compared to J0 (control) obtained the highest scores for all parameters compared to control (J0) and other treatments. Meatballs substituted with white oyster mushroom at a moderate level are still well accepted by panelists. When viewed from the parameters of taste and aroma, treatments J1 and J2 also gave the best scores of 3.90 ± 0.11 and 3.95 ± 0.10 for treatment J1, while treatment J2 obtained a score of 3.90 ± 0.10 for taste while the aroma was 3.95 ± 0.09. Although the proportion of oyster mushrooms added was limited (in treatments J1 and J2), it was able to contribute a natural umami flavor without damaging the basic characteristics of the meatball product. In contrast, if the proportion of oyster mushrooms is higher (treatment J4), the scores obtained on sensory quality decrease in all organoleptic attributes tested, ranging from 2.80 ± 0.14 to 3.10 ± 0.12 (Table 4).

It is suspected that this decrease is due to the more dominant texture flavor and aroma of oyster mushrooms that spoil the taste of meatballs. However, there is a possibility that there is a change in the composition of fat in the meatball product which affects the overall enjoyment of taste. The same pattern is also seen in the meatball texture parameter, treatment J1 gives the highest meatball texture with a score of 3.80 ± 0.08, while the lowest score is obtained in treatment J4 which is 2.80 ± 0.14. The characteristics of meatballs based on aroma parameters gave the highest score in the J1 treatment of 3.95 ± 0.10, while the lowest score in the J4 treatment was 3.00 ± 0.13. as well as the color parameters of the meatballs produced, meatballs with the best color score were obtained in the J1 treatment of 3.95 ± 0.08 and the color score

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seen in the J4 treatment of 3.10 ± 0.12.

The trend formed from the results of statistical analysis obtained a normal curve-shaped correlation (parabolic) indicates the addition of oyster mushrooms in a balanced or moderate amount is able to improve the sensory quality of the meatball products produced, while the addition of an excessive proportion of oyster mushrooms actually reduces the sensory quality of the panelists as consumers (Figure 2).

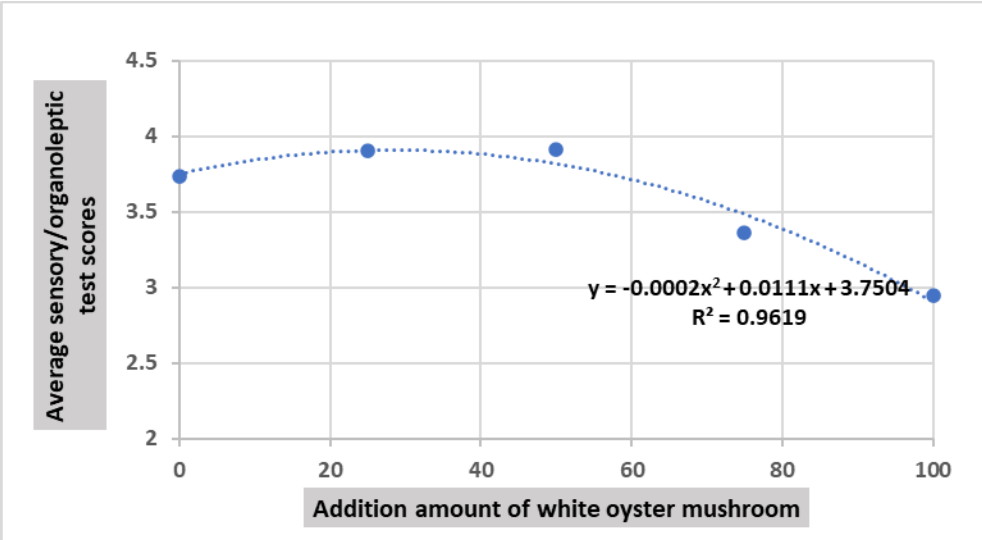

Figure 2. Parabolic curve of the relationship between white oyster mushroom addition and sensory quality score based on organoleptic test of meatball products.

Correlation analysis based on the coefficient on x2x2 which is negative (-0.0002) indicates that the resulting curve opens downward, thus forming a parabolic peak which means that a maximum point is formed where the highest organoleptic score is reached at a certain proportion of the amount of white oyster mushrooms, before decreasing again if the amount of oyster mushroom proportion given is excessive. R2=0.9619R2=0.9619 indicates that this model is very good at explaining the variation in the data (40) because the R2 value of 0.9619 is close to 1. This indicates that about 96% of the variation in sensory/organoleptic quality scores can be explained by the amount of oyster mushroom added to meatball products.

DISCUSSION

This study demonstrated that increasing the substitution of white oyster mushrooms in beef meatball formulations resulted in a gradual reduction in protein and fat content, accompanied by increases in moisture, crude fiber, carbohydrate content, and water-holding capacity (WHC). These changes align with previous findings that *Pleurotus ostreatus* contains high levels of dietary fiber, particularly chitin and β-glucan, and has low fat and caloric content, making it a suitable ingredient for developing healthier functional foods. Among them are the findings (41) that oyster mushrooms contain fiber (chitin) and low fat content so that they have the potential to be applied in the atherosclerosis diet lifestyle. P. ostreatus is one type of functional food that has a low calorie content, cholesterol-free because of the low fat content produced (42). Animal feed added with 300 mg kg-1 oyster mushroom (stem residue) can improve the performance of growth and meat quality of broilers (43). This shows that the nutritional content contained in white oyster mushrooms is very beneficial for health and fulfillment of public nutrition, but also beneficial for livestock. Furthermore (44) reported that the nutritional content contained in white oyster mushrooms based on proximate analysis is carbohydrates (43.42%), crude fiber (23.63%), crude protein (17.06%), ash (8.22%), fat (1.21%), vitamin B2 (92.97 mg/kg), non-essential amino acids (564.17 mg/100 g). Based on these findings, it can be assessed that white oyster mushrooms have a myriad of benefits as a

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potential functional food source in overcoming micronutrient deficiencies, especially in developing countries.

The reduced protein content observed with higher substitution levels may be attributed to the lower protein density in fresh oyster mushrooms compared to beef. Although dried mushrooms may contain higher protein levels, the fresh mushrooms used in this study contributed less to the total protein content. This is in line with (45) who reported that the protein content in catfish meatballs decreased as the proportion of oyster mushrooms given increased. Similarly, (46) revealed that the protein content in crackers decreased along with the addition of white oyster mushrooms in the crackers produced. The increase in crude fiber and WHC likely results from the structural polysaccharides present in mushroom cell walls, such as chitin-glucan complexes, which enhance moisture retention and modify texture. These properties positively affect juiciness and softness, especially at moderate substitution levels. However, excessive substitution (75 g and 100 g) resulted in undesirable sensory changes, including off-flavors and overly soft texture, which were less acceptable to the panelists. (47) revealed that chitin-glucan is found in many parts of the mushroom stalk which plays a role in maintaining the structure of mushroom cells. The combination of these two polysaccharides is the main component that makes up the inside of the mushroom cell wall. In addition, these two components play a role in increasing the product's ability to absorb and retain water, thus contributing to affecting the moisture and texture of the resulting product. (48) stated that the addition of mushrooms to food ingredients can increase antioxidant properties, water retention, provide a softer texture effect and juiciness, sensory appeal so as to meet the tastes of consumers who are currently increasing their awareness to choose a healthier lifestyle. (49) revealed that chicken meatloaf added with oyster mushrooms or merang mushrooms can significantly improve nutritional characteristics (color, pH, texture) ($p < 0.05$). This trend is consistent with previous studies in which increased mushroom incorporation in meat or cereal products led to reduced protein content but enhanced dietary fiber and functional properties.

Sensory evaluation showed that treatments J1 and J2 (25–50 g mushroom substitution) yielded the highest scores across all organoleptic attributes. Beyond this range, sensory scores significantly declined, particularly for taste and texture, suggesting that the mushroom's distinctive aroma and fiber content began to overpower the traditional meatball profile. This supports the idea that consumer acceptability is closely tied to maintaining recognizable sensory attributes of conventional meat products. In line with the results of research (50) which states that the addition of vegetable products (vegetable protein or fat) in meat products can reduce the level of consumer preference because it covers the distinctive taste of meat. However, this can be a healthier alternative solution and reformulation strategy where consumers are willing to pay a higher price to meet the need for natural synthetic meat products that are labeled clean and additive-free. Although mushroom substitution offers nutritional advantages, the shift in aroma, flavor, and color such as the paler appearance may reduce visual appeal. Therefore, ingredient substitution should be optimized not only for health value but also to align with consumer sensory expectations. This is particularly relevant when targeting health-conscious consumers who are open to reformulated products, as well as price-sensitive populations looking for affordable alternatives to pure meat products.

The texture produced from treatments J3 (3.10 ± 0.10) and J4 (2.80 ± 0.14) gave the lowest score. One of the factors causing this may be due to the reduced formation of protein tissue in the product, which affects the elasticity and elasticity of the meatballs produced. Oyster mushrooms with high dietary fiber content tend to weaken the gel structure in the product as a result the product becomes softer and less elastic. White oyster mushrooms have a unique aroma that is increasingly dominant and is considered disturbing by panelists when the substitution of a higher proportion of oyster mushrooms is given. In line with research conducted by (51) that the substitution of red bean flour and red spinach flour in basreng (fried meatballs) products based on organoleptic tests is less favored by consumers. The color of the meatballs produced from this study became paler with the addition of oyster mushrooms as the proportion given increased. The resulting meatball products become less attractive, thus reducing the visual appeal to consumers. Therefore, the addition of vegetable ingredients in a food product needs to pay attention to how consumer acceptance of the resulting product includes the content of the protein source, the

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functionality of the ingredients, production technology, and the health and environmental effects caused (52).

The treatment of substituting the proportion of 50 g white oyster mushrooms + 250 grams of fresh beef (J2 treatment) based on the results of the sensory quality test is a proportional limit that is still acceptable to panelists. The addition of mushrooms in a balanced/moderate amount proved to be able to improve the organoleptic impression of the panelists on the product. Conversely, the increasing proportion of substitution actually decreased the sensory quality of the product because it caused changes in sensory quality including (texture, aroma, and taste) which deviated from the characteristics of conventional meatballs. From an industrial perspective, incorporating mushrooms into meatball formulations up to 50 g per 250 g beef presents a feasible strategy for developing healthier, functional meat products. However, scalability requires further investigation into processing consistency, ingredient sourcing, and storage stability. The increased moisture content raises the potential for reduced shelf-life or faster spoilage, which may affect microbiological safety. Although oyster mushrooms contain natural antimicrobial compounds, future studies should explore how substitution levels influence microbial growth and product safety over time. The factors features and unique particle size distributions from beef used in this work could restrict the extension of the results to other beef products. It has been reported that the differences in beef cuts such as fat marbling, tenderness, and fat content are critical factors that influence the texture and overall quality of meat products (53). For instance, lean cuts such as round or flank would likely yield different sensory and nutritional characteristics than fattier cuts such as ribeye or chuck. This study has several limitations. First, the sensory evaluation involved a relatively small number of semi-trained panelists (n = 20), which may not reflect broader consumer preferences across age or demographic groups. Additionally, the research did not assess shelf-life stability or perform microbiological analysis, which are critical factors for commercial application. Future research should consider these aspects and investigate acceptability thresholds across diverse consumer segments to refine substitution strategies.

CONCLUSION

Partial substitution of beef with white oyster mushroom in meatball formulation had a significant impact on both the nutritional profile and sensory quality of the final product. As the proportion of oyster mushroom increased, protein and fat contents decreased, while moisture, crude fiber, carbohydrate content, and water-holding capacity increased. These changes are attributable to the natural characteristics of oyster mushrooms, which are low in fat and cholesterol-free, yet high in dietary fiber and water content. Sensory evaluation revealed that substitution levels up to 50 g of oyster mushrooms were well accepted by panelists, achieving the highest scores in taste, aroma, texture, and color attributes. However, higher substitution levels (75–100 g) led to a decline in sensory acceptability, likely due to the overpowering mushroom aroma and textural changes. Therefore, the level of substitution is a critical factor in balancing nutritional enhancement with consumer preference. Future studies should explore the long-term storage stability, microbiological safety, and sensory acceptability of mushroom-substituted meat products across broader demographic populations to support potential commercialization and public health applications.

FUNDING

This research received no external funding sources.

ACKNOWLEDGMENTS

The authors would like to thank all those who have been involved in assisting the implementation of this research from the initial stage to the preparation of articles for publication.

CONFLICTS OF INTEREST

All authors declare that there is no potential conflict of interest in the implementation or preparation of this research article.

https://doi.org/10.56303/jhnresearch.v4i2.374

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