

Characteristics of Chicken Meatballs with the Addition of White Oyster Mushroom (*Pleurotus ostreatus*)

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ABSTRACT

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Processed products in the form of gels made from meat protein, can be beef, chicken, or fish are meatballs which are made from ground beef with additives such as salt, tapioca flour and spices. This study was intended to investigate the dosage of white oyster mushroom supplementation on the quality characteristics of chicken meatballs. This study adopted a complete randomized design (CRD) with a dose of oyster mushroom supplementation which included 4 (four) treatments, namely A = 0%, B = 15%, C = 25% and D = 35% with 5 repetitions and 20 experimental units were obtained. The research variables included yield, ash content and sensory analysis (color, taste, aroma and texture). The results indicated that different levels of white oyster mushroom addition (0%, 15%, 25%, 35%) did not have a significant ($P > 0.05$) effect on the color, taste, and texture of the meatballs but had a significant impact ($P < 0.05$) on the yield and ash content as well as the sensory aroma of chicken meatballs. The best quality chicken meatballs were found in the 35% white oyster mushroom supplement with product characteristics: ash content 1.69%; yield 94.6%; aroma 3.58; color 3.54; taste 3.20; and texture 3.70.

Keywords: Chicken meatballs, ground meat, meat protein, ground beef, white oyster mushroom

INTRODUCTION

Oyster mushrooms are widely farmed economically, especially in developing countries, due to their ease of cultivation and high biological efficiency [1]. The use of plant-based waste

materials as functional food ingredients in meat products has increased in popularity because of their nutritional value, contributions to the circular economy, and environmental benefits. Consequently, mushrooms could serve as an ingredient in muscle-based products as a meat substitute because they have a similar texture to meat [2]. Eating habits have shifted, and people now prefer meat products more [3]. Compared to other selected animals (egg, mutton, hog, and beef), poultry meat is the most consumed. The manufacturer processed the chicken meat into various culinary products to meet the rising demand.

Meatballs are made from livestock meat, either chicken or beef, combined with starch or cereals, sometimes with food additives [4]. Originating in Indonesia, meatballs are popular among Indonesians. However, consuming excessive meatballs can adversely affect health. Processed foods often contain high levels of fat, sugar, and salt, which can lead to hypertension if consumed excessively and contribute to being overweight or obese. Therefore, manufacturers should be responsible for developing healthier options by incorporating non-meat ingredients, such as fruits and vegetables, into processed foods [5].

To address this, various food options, such as meatballs, should be developed as alternatives for those who cannot consume large amounts of meat or who adopt a health-conscious lifestyle by reducing meat intake, substituting oyster mushrooms for meatballs based on their chemical composition and quality attributes [6]. In particular, white oyster mushrooms have emerged as a promising plant-based raw material with potential as a meat substitute [7]. The mushrooms are rich in protein and carbohydrates, vitamins such as thiamin, riboflavin, and niacin, minerals like calcium, phosphorus, and iron, and trace amounts of fat [8].

The oyster mushroom is native to many regions worldwide and is well known for its distinctive umami flavor and texture, as well as its high content of vitamins and bioactive compounds [9]. The choice of white oyster mushroom (*Pleurotus ostreatus*) as a raw material for making vegetable meatballs is not only due to its effectiveness but also because of its nutritional value, which is comparable to that of meat in general. Oyster mushroom is one of the most nutritious mushrooms [10].

Notably, a study by Aviana and Heryani [7] showed that white oyster mushrooms have a higher protein content compared to other edible mushroom varieties. Additionally, these mushrooms naturally contain glutamic acid, which imparts a savory flavor to food. As a result, many researchers have investigated the use of oyster mushrooms to produce flavorful mushroom broths as a healthier alternative to monosodium glutamate (MSG) [11]. Meiliany [12] examined the effects of adding oyster mushrooms to chicken meatballs on water content and sensory properties. Specifically, the research demonstrated that incorporating oyster mushrooms significantly impacts both the water content and organoleptic qualities, with the water content meeting quality standards for the combined meatballs.

Using oyster mushrooms in meatball dough can enhance flavor diversity. Chicken meatballs, which contain most of the animal components, could be improved by incorporating vegetable components such as oyster mushrooms. Including 15% oyster mushrooms by weight of the meatball dough from discarded laying hens can improve its chemical and organoleptic qualities. The water and protein contents of broiler chicken meatballs with eggs, prepared with different thickening agents, meet the requirements of the Indonesian National Standard [13]. Therefore, our research aimed to investigate the dosage of white oyster mushroom supplementation on the quality characteristics of chicken meatballs.

MATERIALS AND METHODS

The materials included meat grinders, scales, stoves, pots, various containers, spoons, knives, porcelain cups, electric kilns, desiccants, and analytical balances. The ingredients used included broiler meat, which was purchased at the Lambaro main market, and white oyster mushrooms (*Pleurotus ostreatus sp.*), obtained from the white mushroom breeding site in Gampong Lamceu, Lorong Lamguet, Lam Ateuk, Aceh Besar. Supporting ingredients comprised tapioca flour, garlic, sago flour, pepper, eggs, salt, and ice.

The study employed a complete randomization design, with white oyster mushroom supplementation at four treatment levels: A = 0%, B = 15%, C = 25%, D = 35%. Each treatment was performed five times, yielding 20 experimental samples.

Research Procedure

The procedure involved selecting fresh chicken meat that exhibited characteristics of freshness, such as a bright white color without unusual spots, a firm, chewy texture when pressed, a light aroma without a strong fishy odor, and a surface that was not slimy or watery. The chicken was defatted, deboned, and then cut into small pieces to facilitate processing. Ice cubes were added during grinding to maintain the meat's firmness. The ground meat was mixed with 15% tapioca flour, 2% salt, 2.5% garlic, 0.8% ground pepper, and 1% MSG. The meatball dough was placed in a container, and white oyster mushrooms were added at 0%, 15%, 25%, and 35% by weight.

The ground meat was mixed with tapioca flour, white oyster mushrooms, salt, garlic, ground pepper, ice, and MSG to create a smooth, uniform dough. The dough was then placed in a container and prepared for shaping into small balls. These balls could be formed by hand, either by clenching and pressing the dough into a circle or by using a small spoon. The formed meatballs were then boiled in a pot of boiling water until cooked, indicated by their floating to the surface. Once done, the meatballs were removed, drained, and ready for analysis.

Research Variables

The parameters analyzed in this study included yields as defined in [14]. Yield is calculated by weighing the meatball mixture and the cooked meatballs, then dividing the weight of the cooked meatballs by that of the mixture and multiplying by 100%. The determination of ash content followed the [4] method. Ash content is determined by weighing the ashed meatball mixture and the original meatball mixture, then multiplying the difference by 100%. The evaluation of organoleptic properties (color, taste, aroma, texture) [15]. Sensory analysis was performed as a hedonic test with 25 semi-trained panelists. Organoleptic assessment was conducted by panelists recruited and trained to perform specific evaluation tasks. The parameters measured were color, taste, aroma, and texture. A 5-point hedonic scale was used, where 1 = dislike very much; 2 = dislike; 3 = like slightly; 4 = like; and 5 = like very much.

Data Analysis

Data were analyzed using variance analysis (ANOVA) to determine the effect of the treatment on the observed outcomes. If the treatment has a significant impact, it is continued using the smallest real difference test at the 5% level [16].

RESULTS AND DISCUSSIONS

Ash Rate

The mineral content (ash) of food indicates the level of organic matter present and indicates which minerals are not burned off into volatile substances. Ash content reflects processing quality, can verify the authenticity of raw materials used, and affects the nutritional value of meatballs [4].

The ash content of chicken meatballs supplemented with white oyster mushrooms ranged from 1.26% to 2.23%, with an average of 1.71%. The least significant difference (LSD) test results indicated a significant effect ($P \leq 0.01$) on the ash content due to increased white oyster mushroom concentration. Figure 1 displays the results of the LSD 0.05 test for different levels of white oyster mushroom concentrations.

Adding white oyster mushrooms (0%) results in the highest ash content of 2.08%, while adding 15% oyster mushrooms leads to the lowest ash content of 1.51%. Ash levels decrease as the concentration of white oyster mushrooms increases. *Pleurotus ostreatus* contains high levels of K, Mg, Fe, Zn, and Na, but low levels of Ca. The heavy metal content (Pb, Ni, Cd, and Cr) was very low [17].

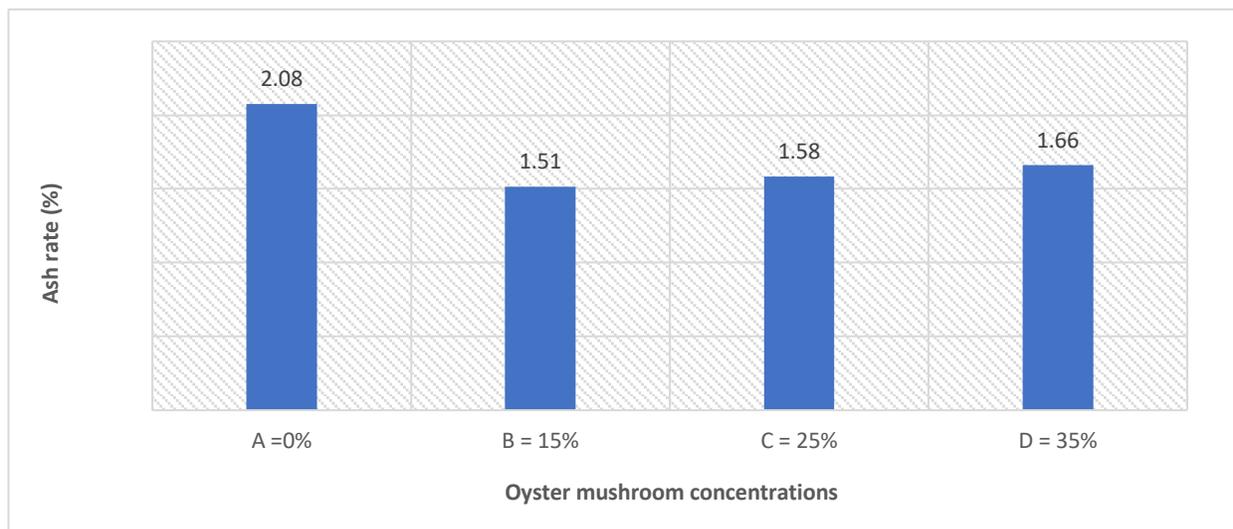


Figure 1. Effect of White Oyster Mushroom Concentration on Meatball Ash Content

The maximum allowable ash content of meatballs is 3%. The ash content observed in this study ranged from 1.48% to 2.32%. It was noted that the meat ash content in this study aligned with the INS [4] criteria for meatball quality. The ash content reflects the mineral composition of the food sample.

In addition, the decrease in ash content was also caused by heating/cooking, which made a decrease in the mineral content of white oyster mushrooms, so that it affected the ash content of the meatballs produced in our research. Sundari et al. [18] reported that food processing, including cooking, generally reduces the chemical composition and nutrient content of food, such as moisture, ash, protein, and fat.

Yield

Yield measures the results obtained relative to the raw materials. The yield of chicken meatballs varied from 16% to 98%, with an overall average of 52.15%. The least significant difference test results showed that adding white oyster mushrooms at various concentrations (0%, 15%, 25%, and 35%) significantly affected ($P \leq 0.05$) the yield of chicken meatballs. Further LSD 0.05 test results are shown in Figure 2.

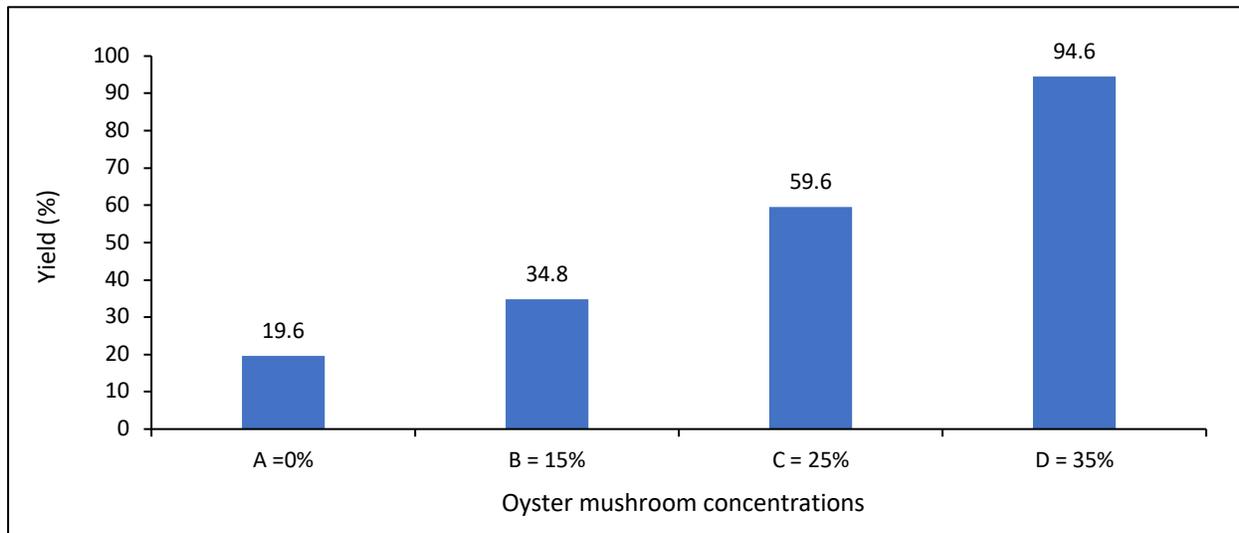


Figure 2. Effect of White Oyster Mushroom Concentration on Meatball Yield

Figure 2 shows that the highest yield was achieved at an oyster mushroom concentration of 35% (94.6%), which is significantly higher than those at 0%, 15%, and 25%. The lowest yield was observed in the 0% oyster mushroom concentration treatment (19.6%), which differed significantly from the 15%, 25%, and 35% treatments.

The higher the percentage of white oyster mushrooms added, the greater the yield of meatballs. It is believed that adding white oyster mushrooms can yield more meatballs. Additionally, the fiber content of white oyster mushrooms increases yield. According to Sekan et al. [19], white oyster mushrooms (*Pleurotus ostreatus*), also known as hiratake and a traditional edible, are the most popular among *Pleurotus* species. These mushrooms are highly nutritious. Depending on the mushroom species, the proximate composition and nutritional properties can include 84.1-61.3% carbs [20].

Organoleptic Test

Hedonic parameters are used to determine customer preferences. These tests include evaluating color, taste, aroma, and texture. Hedonic testing is an organoleptic test that assesses the reactions of both untrained and experienced consumers to a product, typically conducted during new product development. This test asks panelists to share their likes and dislikes. Organoleptic tests, which relate to sensory perception—such as hedonic tests—are used in research to measure deliciousness. The organoleptic test regarding the impact of adding white oyster mushrooms includes a preference (hedonic) test for color, taste, aroma, and texture.

Color

Consumers first perceive the color of food products. Therefore, color plays an important role in determining how customers receive products. Color plays an important role in food perception and can indicate chemical changes in food. Boiling oyster mushrooms yielded the highest panelists' liking scores [21]. The organoleptic results of the color of chicken meatballs obtained ranged from 3.13 (somewhat liked) to 3.83 (liked). The sensory average of the color of chicken meatballs was 3.55 (somewhat liked). The results of the least significant difference showed that the addition of white oyster mushrooms with different concentrations (0%, 15%, 25%, and 35%) did not have a significant impact ($P > 0.05$) on the color of chicken meatballs.

Table 1. The Color of the Meatballs Added with White Oyster Mushrooms

White oyster mushroom concentration	Color
A = 0%	3.54±0.25
B = 15%	3.46±0.15
C = 25%	3.64±0.17
D = 35%	3.54±0.14

Table 1 defines the panelists' preference for the color of chicken meatballs. The highest color organoleptic value was observed at an average white oyster mushroom concentration of 25% (3.64), whereas the lowest was at 15% (3.46). The variance analysis showed that adding white oyster mushrooms at 0%, 15%, 25%, and 35% did not significantly affect the organoleptic color of chicken meatballs ($P > 0.05$). This indicates that panelists' acceptance does not affect the organoleptic color of meatballs, as white oyster mushrooms are used. This may also be because chicken meatball products subjected to various treatments with white oyster mushroom concentrations produce colors that are not substantially different from those of the panelists. The white color of the chicken meatballs is influenced by the basic color of the white oyster mushroom, so that the color produced is not significantly different between treatments.

The color of the meatballs, according to the research results, appears brighter and more yellowish-white. The normal color of the produced meatballs aligns with the Indonesian National Standard, which states that meatballs made from a mixture of meats should have a normal color [4].

Novita and Pangesthi [22] stated that the color of meatballs can be changed by adding white oyster mushrooms. The natural anthoxanthin pigment is found in oyster mushrooms, so

adding mushrooms can make winged flour meatballs brighter than control meatballs. This makes the oyster mushrooms appear white. The acidic environment of the meatballs can cause the mushrooms' white color to turn yellowish. The presence of the enzyme polyphenol oxidase, which triggers an oxidation reaction, also affects the color of oyster mushrooms [23].

Taste

Taste is the second factor influencing the flavor of food, after its appearance, and the response to chemical stimuli that reach the tongue's taste buds. Taste plays a vital role in the acceptance of meatballs; even if other parameters are good, if the meatballs are not flavorful, they will be rejected [24]. Hedonic attributes were used to evaluate the organoleptic properties of oyster mushroom meatballs, with a focus on flavor. The results of the taste organoleptic test were used to assess the panelists' preferences for the oyster mushroom meatballs.

Analysis of sensory taste data for chicken meatballs showed that panelists' preference ratings ranged from 2.93 (somewhat liked) to 3.70 (liked). The overall sensory average for chicken meatball taste was 3.37 (somewhat liked). The results of the least significant difference test indicated that adding white oyster mushrooms at different concentrations (0%, 15%, 25%, and 35%) had no significant effect ($P>0.05$) on the taste of chicken meatballs.

Table 2. The Flavor of Meatballs Added with White Oyster Mushrooms

White oyster mushroom concentration	Taste
A = 0%	3.45±0.16 nd
B = 15%	3.48±0.09 nd
C = 25%	3.38±0.27 nd
D = 35%	3.16±0.18 nd

The most preferred taste of chicken meatballs by the panelists came from the average concentration of white oyster mushrooms of 15% (3.48) and the concentration of white oyster mushrooms of 35% (3.16). The sensory variation of chicken meatball tastes showed that the addition of different concentrations of white oyster mushrooms did not affect on panelist's acceptable effect towards the sensory taste of chicken meatballs. Panelists seem to select the same taste in the meatballs produced. It is suspected that white oyster mushrooms impart a soft taste and reduce saltiness in meatballs. The amount of white oyster mushrooms added is not much different, so it produces the same product taste for the panelists.

Due to their unique taste and aroma, as well as high nutritional content, mushrooms are increasingly popular as future culinary ingredients. Free amino acids, particularly L-glutamic acid and L-aspartic acid, along with 5'-nucleotides found in mushrooms, meat, fish, seafood, and vegetables, contribute to mushrooms' distinctive umami flavor, which is meaty, brothy, or savory [25].

Aroma

The themeaty flavor arises from hundreds of volatile compounds, with only a small subset responsible for the distinctive odor. Alcohols, aldehydes, and aromatic hydrocarbons were the

most common volatiles found in all types of meatballs, while carboxylic acids, esters, ethers, and nitrogen- and sulfur-containing compounds were present in lower concentrations. Cooked beef contains hundreds of volatile chemicals, including lipid and fatty acid oxidation products such as aliphatic hydrocarbons, aldehydes, ketones, alcohols, carboxylic acids, and esters [26].

The panelists' acceptance of the aroma of chicken meatballs ranged from 3.16 to 3.73. The average acceptance rating for the aroma among panelists was 3.46 (somewhat liked). The results of the last significant difference test showed that adding white oyster mushrooms at different concentrations (0%, 15%, 25%, and 35%) had a significant effect ($P \leq 0.05$) on the organoleptic aroma of the chicken meatballs. The results of the LSD 0.05 further test are presented in Figure 3.

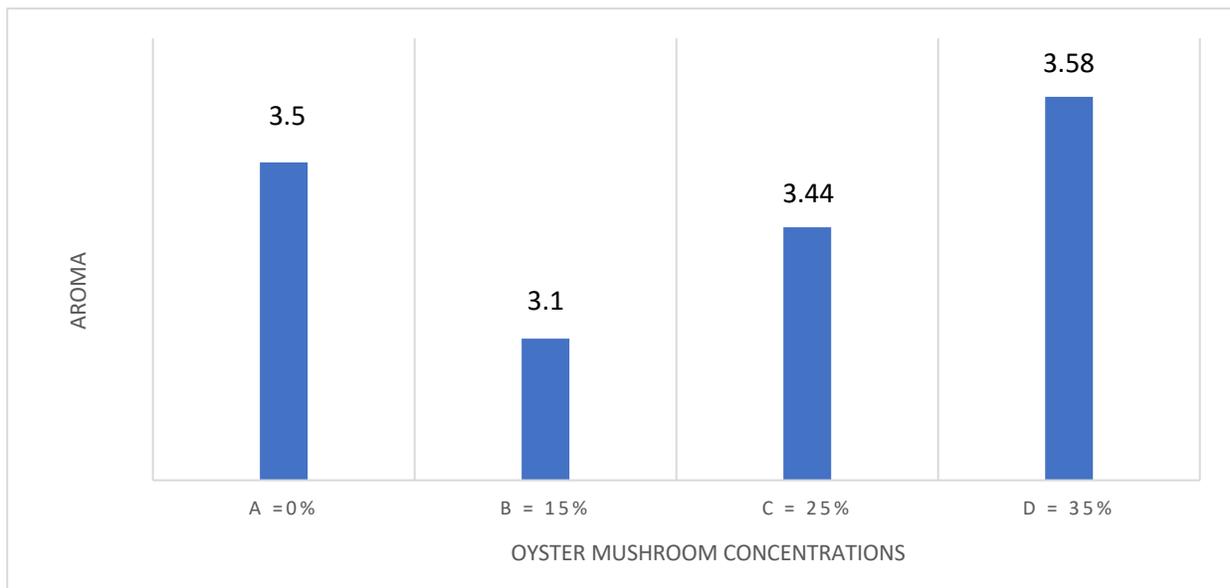


Figure 3. Effect of White Oyster Mushroom Concentration on the Aroma of Meatballs

Figure 3 shows that the highest aroma of chicken meatballs perceived by the panelists was at a concentration of 35% (3.58) white oyster mushrooms, which differs from the concentration of 15% (3.31) but is not different from the treatments with 0% (3.51) and 25% (3.43) oyster mushrooms.

Research shows that the more ingredients, such as white oyster mushrooms, are added, the more panelists like them. This may be because panelists prefer the smell of meatballs with mushrooms. It has been reported that mushrooms can replace meat in certain meat-based recipes without affecting the dishes' flavor. This is because mushrooms contain special, so-called "umami" flavor-enhancing chemicals [27].

Texture

Meat, an important food source in human diets, provides a wealth of nutrients. The physical characteristics of meat are closely connected to its sensory attributes, such as elasticity, viscosity, and hardness [28]. The organoleptic texture of chicken meatballs ranges from 3.06 (somewhat liked) to 4.00 (liked). The average preference of the panelists for the texture of

chicken meatballs was 3.54 (likes). The results of the least significant difference showed that adding white oyster mushrooms at different concentrations (0%, 15%, 25%, and 35%) did not significantly affect ($P>0.05$) the texture of the chicken meatballs.

Table 3. The Organoleptic Texture of the Meatballs to Which White Oyster Mushrooms

White oyster mushroom concentration	Texture (%)
A = 0%	3.43±0.22
B = 15%	3.63±0.17
C = 25%	3.38±0.23
D = 35%	3.70±0.25

The highest preference score for the texture of chicken meatballs was obtained at a concentration of 35% (3.70), and the lowest was obtained at a concentration of 25% (3.38) of white oyster mushrooms. The results of the various fingerprints showed that the addition of different concentrations of white oyster mushrooms (0%, 15%, 25% and 35%) did not have a significant impact ($P>0.05$) on the sensory texture of chicken meatballs. Meatballs processed with white oyster mushrooms will have a softer, chewier texture because the layered bottom surface of white oyster mushrooms (*Lamellae*) imparts this effect. This is important information that white oyster mushrooms (*Pleurotus ostreatus*) are a promising choice, because they are rich in dietary fiber, contain essential amino acids, are low in fat and calories, and contain bioactive compounds [29] that are beneficial for digestion and immunity, so they are very good to be added to meatball production. The chemical composition of white mushrooms includes various bioactive substances, such as polysaccharides, biologically active proteins such as enzymes and lectins, ergothionein (amino acids), terpenoids, sterols, antioxidants, and vitamins such as thiamine, riboflavin, ascorbic acid, niacin, and tocopherol [30], which are the most important reasons that make white mushroom meatballs an innovation that makes them functional.

CONCLUSIONS

The results showed that the color, taste, and texture of chicken meatballs were not significantly affected by the addition of different percentages of white oyster mushrooms (0%, 15%, 25%, and 35%). Conversely, increasing the percentage of white oyster mushrooms enhances the yield, ash content, and aroma of the chicken meatballs produced. Adding 35% white oyster mushrooms yields the highest-quality chicken meatballs. The product's characteristics include an ash content of 1.69%, a yield of 94.6%, an aroma score of 3.58, a color score of 3.54, a taste score of 3.20, and a texture score of 3.70.

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AUTHORS' CONTRIBUTIONS

Conceptualized the study and drafted and revised the manuscript. All Author: Conducted experiments and analyzed data. All authors have read and approved the final manuscript.

COMPETING INTERESTS

The authors have to declare that they have no competing interests.

ETHICAL CLEARANCE

This research does not require ethical clearance because it does not involve livestock directly.

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