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Utilizing edible mushrooms as natural flavor enhancers and nutrient sources in meatball products

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Abstract: Monosodium glutamate (MSG) is widely used as a flavor enhancer in Indonesia; however, excessive consumption has been associated with potential adverse effects on the metabolic, digestive, respiratory, circulatory, and nervous systems. This has prompted interest in developing natural alternatives with comparable flavor-enhancing properties. Edible mushrooms are promising candidates due to their inherent glutamate content and high nutritional value. This study aimed to formulate and evaluate mushroom-based flavorings as natural substitutes for MSG, utilizing three types of edible mushrooms: Pleurotus ostreatus (oyster mushroom), Lentinula edodes (shiitake mushroom), and Auricularia auricula (wood ear mushroom). The mushrooms were dried, ground into powder, and analyzed for their proximate nutritional composition. These powders were processed into flavoring agents and incorporated into beef meatball and sauce formulations. For comparison, three commercial flavorings—Totole (mushroom-based), Halawa (seasoning blend), and MSG—were also tested. A sensory evaluation was conducted using an organoleptic test with 30 panelists to assess attributes such as taste, aroma, and overall acceptability. Among the mushroom-based flavorings, shiitake mushroom performed best, with average scores of 2.90 for meatball sauce and 3.08 for meatballs. However, the commercial flavorings outperformed the natural ones: Totole achieved the highest score for meatball sauce (3.81), and Halawa was most preferred in meatballs (3.90). These results indicate that mushroom-based flavorings, particularly those derived from L. edodes, hold potential as natural flavor enhancers. Nevertheless, commercial products currently offer superior sensory appeal, suggesting a need for further optimization of natural formulations to improve consumer acceptance.

Keywords: *Alternatives, Flavoring, Meatballs, Mushrooms, Organoleptic.*

1. Introduction

MSG is a widely used flavoring agent derived from L-glutamic acid, a naturally occurring amino acid in various food products [1]. MSG production is mostly concentrated in Asia, as raw materials such as tapioca and sugar are abundant. MSG production in Asia accounts for about 94% of the world's MSG production capacity. China, Indonesia, Vietnam, Thailand, and Taiwan are the main producing countries in Asia [2].

Several studies prove that MSG can harm humans and experimental animals when used excessively [3]. Side effects reported by various studies can be summarized into the appearance of abnormalities in metabolism, digestion, respiration, circulatory, and nervous systems [4]. Exposure to MSG in mice at

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the neonatal stage can damage the hypothalamic nucleus of the rat (Arcuate nucleus and ventromedial nucleus), resulting in weight gain, fat deposition, decreased motor activity, and growth hormone secretion Nakagawa, et al. [5]. Tawfik and Al-Badr [3] also reported the same results with mice fed MSG (0.6 and 1.6 mg/g body weight) for two weeks. Therefore, it can be concluded that the use of MSG can interfere with liver and kidney function by increasing oxidative stress and altering the activity of antioxidant enzymes [6].

As a major source of natural umami components, mushrooms attract a lot of attention [7]. The natural glutamate content of mushrooms has the potential to be used as an ingredient in making flavoring spices [8]. In addition, mushrooms can also help reduce the risk of diseases, such as Parkinson's, Alzheimer's, hypertension, stroke, and cancer, as well as acting as antibacterial, immune system enhancers, and cholesterol-lowering agents [9]. There has been a lot of research on mushroom-based natural flavorings; generally, the mushrooms used are Oyster mushrooms [10-13]. There has also been research on flavoring a combination of Oyster mushrooms and Ears [14] and flavoring a combination of Oyster Mushrooms, Merang, and Shitake [15]. However, there has been no research on the flavor of mushrooms from the combination of Oysters, Ears, and Shitake in meatball products and the comparison of the level of preference between the three mushrooms.

One of the food products that is loved by various people in Indonesia is meatballs. But generally, these products use synthetic flavors such as MSG. The results of Mentari [16] stated that all samples of fried meatballs and soup meatballs taken at elementary schools in the Plaju area, Palembang, were proven to be positive for containing preservatives (benzoic acid, sodium benzoate) and MSG [16]. The results of the research of Astuti and Nina [17] show that the average use of MSG per serving of meatballs around the Tembalang Campus of UNDIP is 4.79 grams, with a maximum usage of 10.35 grams and a minimum consumption of 0.8 grams Astuti and Nina [17]. Additives, et al. [18] reassessed the safety of glutamate used as a food additive and resulted in an acceptable daily intake group (ADI) of 30 mg/kg body weight per day. With these problems, alternative flavorings are expected to be safer to consume.

The hypotheses tested in this study are: 1). There is a difference in the nutritional content of the mushroom samples used; 2). There was a difference in the level of preference of the panelists for the treatment of meatball samples and meatball sauce. Based on the description of the data and problems above, this study aims to conduct research on factors associated with the presence of parasites in rats caught around the homes of Pitue Village residents, Pangkep Regency.

2. Materials and Methods

The main ingredients used are Fruit bodies of Oyster mushrooms, Shitake mushrooms, and Ear mushrooms, white pepper powder, onion powder, garlic powder, salt, sugar, roasted tapioca flour, tapioca flour, beef, ice cubes, fried onions, pepper, mushroom flavoring treatment, and meatball chewy flour. The main tools used are mesh sieves, electric stoves, Teflon/pan, spatulas, scales and plastic containers, meat grinders, digital scales, basins, and spoons.

2.1. Proximate Analysis

Proximate analysis is carried out to assess the quality of food, especially on the standard of food substances contained in it. In the proximate analysis of mushroom flour, the proximate analysis tested is the content of water, ash, fat, and protein. The analysis was carried out in a duplex [18].

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Table 1.
The composition of the mushroom flour formulation.

Material	Grams
Oyster mushroom flour/Shitake/Ear	60.14
White pepper powder	6.18
Onion powder	1.11
Garlic powder	20.21
Salt	8.65
Yolk	1.24
Roasted tapioca powder	2.47
Total	**100**

Table 2.
Combination composition of 3 mushroom flours.

Material	Gram
Oyster mushroom flour	20.04
Shitake mushroom flour	20.04
Ear mushroom flour	20.04
White pepper powder	6.18
Onion powder	1.12
Garlic powder	20.22
Salt	8.65
Yolk	1.24
Roasted tapioca powder	2.47
Total	100

2.2. Organoleptic Analysis

In the organoleptic analysis test, the flavoring used was flavoring from Oyster mushrooms, Shitake mushrooms, Ear mushrooms, and a combination of the three mushrooms. As a comparison of the mushroom flavoring that was studied, Totole mushroom flavoring, Halawa flavoring, and MSG flavoring were used.

This organoleptic analysis was carried out to determine the level of preference of the panelists for the aroma, color, and taste of the meatball sauce with additional mushroom flavoring and the aroma, color, taste, and texture of the meatball product with additional mushroom flavoring. The number of panelists used was 30 people. According to Mulyani [19] the minimum number of panelists for standard panelists in one test is 6 people, while for non-standard panelists is 30 people. Each panelist was given 7 samples that would be tested for their preference for several test criteria that had been set [19]. The test used in this organoleptic test is a hedonic test or a preference test. The hedonic scale used is 5 hedonic scales, which include: Dislike (1), Neutral (2), Somewhat like (3), Like (4), Strongly like (5). Each portion served per panelist is one meatball weighing ±15g and 50ml of meatball sauce. Hedonic scale data was collected using a Google form, and the data was processed using SPSS.

2.3. Data Analysis

The experimental design used to test the hypothesis in the organoleptic test of flavoring in meatballs and meatball sauce was a group randomized design (RAK) with a flavoring powder experimental unit consisting of seven treatments with 30 panelists. The 7 treatments carried out are as follows: Shitake mushroom flavoring (Kj 01), Oyster mushroom flavoring (Kj 02), Ear mushroom flavoring (Kj 03), Mushroom combination flavoring (Kj 04), Totole mushroom flavoring (Kj 05), Halawa flavoring (Kj 06), MSG flavoring (Kj 07). The equation of the RAK analysis model is.

$$Yij = \mu + \tau i + \beta j + \varepsilon ij$$

Information:

Yij = observation value in the treatment of the group to – j

μ = the general middle value

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τi = influence of treatment on – i
βj = influence of group on – j
εij = experimental error in the ith treatment and the jth group

If the results have a real effect between treatments, then it is further tested with the Duncan test. The value is considered to have a significant difference if the p-value is less than 0.05 (<0.05). Data analysis was carried out using the IBM SPSS Statistics 25.0 application.

This study was an analytic observational study with a cross-sectional approach. The research was conducted in April-May 2024 in Pitue Village, Pangkep Regency, South Sulawesi. Pitue Village consists of 4 hamlets, namely Gusunge Hamlet, Pitue Hamlet, Jenae Hamlet, and Sabange Hamlet, with a total household population of 543 as a population. Based on this study, the minimum sample size was 82 houses to anticipate the number of respondents who were not willing, so the researcher maximized it to 100 houses. A sample examination was carried out at the Community Health Laboratory Center.

Determination of the number of samples of each hamlet using the Proportional Stratified Random Sampling method is a sampling technique by dividing the population by certain characteristics (strata) and determines the sample size proportionally. Therefore, the number of Pitue Hamlet samples was 44 households, Sabange 13 households, Gusunge 22 households, and Jennae 21 households. Data collection was done by interview and observation using a questionnaire. The data were then processed using the Statistical Package for the Social Sciences (SPSS) with two types of analysis, namely univariate analysis and bivariate analysis using the chi square test, but in the chi square crosstabulation results there was an expected frequency value of less than five, so the fisher exact test was used.

Data collection was also carried out by setting 200 traps in 100 sampled houses. Each house was installed with 2 traps, each located inside and outside the house. Traps installed outside the house were installed by exploring locations such as the presence of holes in residential buildings, sewer conditions, the presence of garbage, puddles, piles of goods, and so on. The traps set inside the house are placed on the ceiling or in dark and humid places, such as the kitchen and underneath (beds, cupboards, shelves, etc.) at the edge of the rat runway.

3. Results

3.1. Nutritional Content in Mushroom Flour

The potential of mushroom flour can be seen from its nutritional content. The results of the proximate analysis include the content of water, ash, fat, and protein contained in the 3 types of mushroom flour used, namely Oyster mushrooms, Shitake mushrooms, and Ear mushrooms. Shown in Table 3.

Table 3.
Results of mushroom flour proximate analysis.

Test parameters	% Dry Weight		
	Oyster mushroom (*Pleurotus ostreatus*)	Shitake mushroom (*Lentinula edodes*)	Ear mushroom (*Auricularia auricula*)
Up to Air	9.16	4.07	5.30
Up to Ash	6.83	4.35	5.10
Fat content	3.33	2.33	2.33
Up to protein	22.85	16.42	8.44

From the results of the proximate analysis, it was shown that Oyster mushrooms had a higher moisture content (9.16%) compared to Shitake mushrooms (4.07%) and Ear mushrooms (5.30%). Likewise, with ash content, Oyster mushrooms have a higher ash content (6.83%) than Shitake mushrooms (4.35%) and Ear mushrooms (5.10%). The results of the proximate analysis showed that Oyster mushrooms had higher fat content (3.33%) compared to Shitake mushrooms (2.33%) and Ear mushrooms (2.33%), Oyster mushrooms also had higher protein levels (22.85%) compared to Shitake mushrooms (16.42%) and Ear mushrooms (8.44%).

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3.2. Consumer Preferences for Meatball Products with Mushroom Flavoring

After the proximate analysis test was carried out, an organoleptic test was carried out on meatballs with mushroom flavoring, which aimed to determine the degree of preference of panelists for meatball products with mushroom flavoring and compared with commercial flavoring. The panelists used in this test are 30 students, staff, and lecturers of the national university. The level of preference is divided into two, namely the level of preference for meatball sauce and the level of preference for meatballs. The parameters tested for the taste rate of meatball sauce are aroma, color, and taste. As for the level of liking of meatballs, the parameters tested were aroma, color, taste, and texture. The results of the organoleptic test can be seen in Figures 2 and 3.

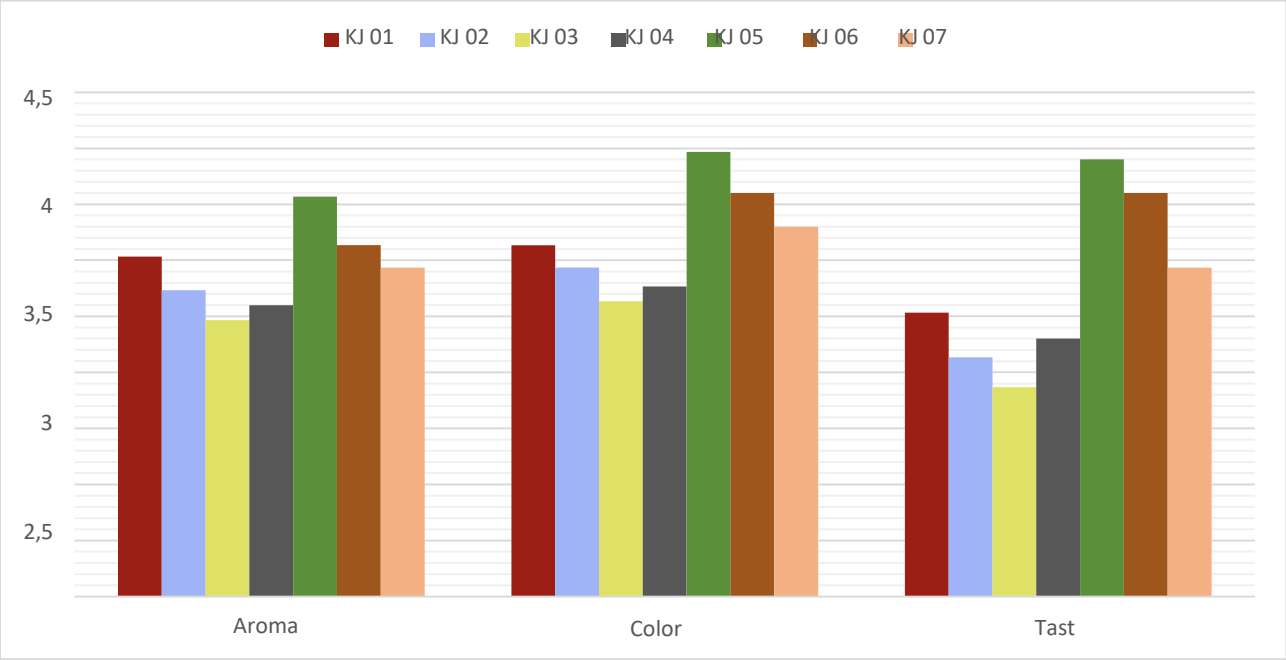

Figure 1.
Histogram of organoleptic results of the preference rate of meatball sauce. KJ 01= Shitake Mushroom flavoring, KJ 02= Oyster Mushroom flavoring, KJ 03= Ear Mushroom flavoring, KJ 04= Mushroom combination flavoring, KJ 05= Totole mushroom flavoring, KJ 06= Halawa flavoring, KJ 07= MSG flavoring.

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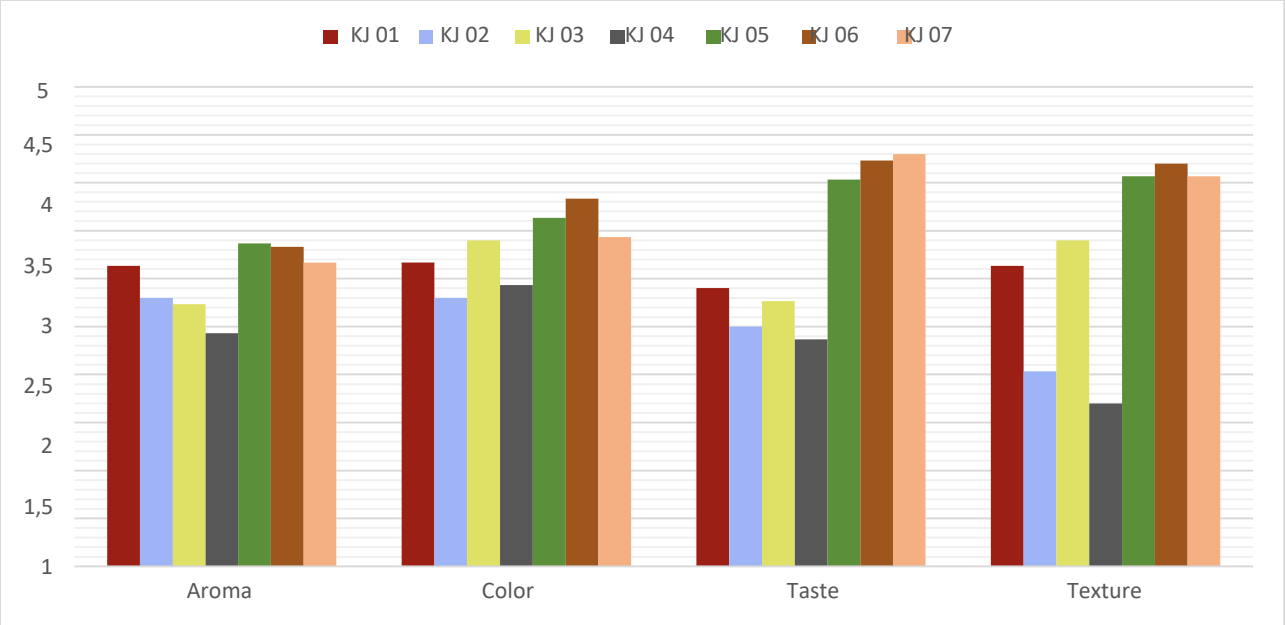

Figure 2.
Histogram of organoleptic results of meatball preference. KJ 01= Shitake Mushroom flavoring, KJ 02= Oyster Mushroom flavoring, KJ 03= Ear Mushroom flavoring, KJ 04= Mushroom combination flavoring, KJ 05= Totole mushroom flavoring, KJ 06= Halawa flavoring, KJ 07= MSG flavoring.

From the histogram of organoleptic results of the liking level of meatball sauce and the liking level of meatballs, it is known that:

3.2.1. Aroma

Based on figures 2 and 3 related to the aroma of flavoring treatment using mushrooms, KJ 01 (treatment with Shitake mushroom flavoring) is preferred for the aroma of meatball sauce and meatballs. However, when compared to commercial flavorings,KJ 05 (treatment with tootle mushroom flavoring) is preferred for the aroma of meatballsauce and meatballs.

3.2.2. Color

Based on figures 2 and 3 related to the color of the flavoring treatment using mushrooms, the KJ 01 treatment (Shitake mushroom flavoring treatment) has the color of the meatball sauce was the most in demand by the panelists, while for the color of the meatballs, the KJ 03 treatment (Ear mushroom flavoring treatment) was more in demand by the panelists. However, when compared to commercial flavorings, KJ 05 (tootle mushroom flavoring treatment) has the most favorite meatball sauce color among thepanelists, and KJ 06 (treatment with halawa flavoring) has the most preferred meatball color among the panelists.

3.2.3. Taste

Based on figures 2 and 3 related to the taste of mushroom treatment, KJ 01 (Shitake mushroom flavoring treatment) has a meatball sauce flavor and a meatball flavor that is preferred by the panelists. However, when compared to commercial flavorings, KJ 05 (tootle mushroom flavoring treatment) has the most favorite meatball sauce flavor among the panelists, and KJ 07 (MSG flavoring) has the most liked meatball flavor among the panelists.

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3.2.4. Texture

Based on Figure 3 related to the texture of meatballs in mushroom treatment, KJ 03 (Ear mushroom flavoring treatment) was more preferred by the panelists compared to other mushroom flavoring treatments. However, when compared to commercial flavorings, KJ 06(Halawa flavoring treatment) has a meatball texture that is more liked by the panelists.

3.3. Analysis of Meatball Sauce Preference

3.3.1. Aroma Test

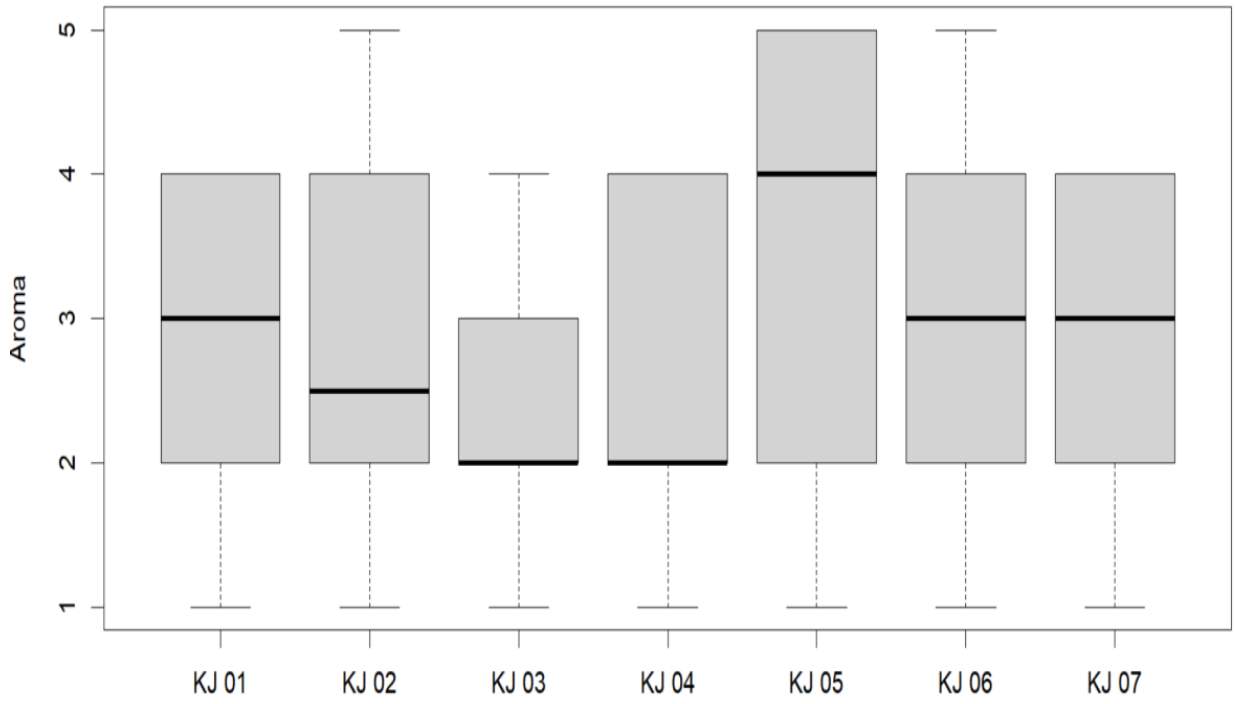

Figure 3.
Boxplot's favorite aroma of meatball sauce. KJ 01= Shitake mushroom flavoring, KJ 02= Oyster Mushroom flavoring, KJ 03= Ear Mushroom flavoring, KJ 04= Mushroom combination flavoring, KJ 05= Totole mushroom flavoring, KJ 06= Halawa flavoring, KJ 07= MSG flavoring.

Figure 3 shows the distribution of data from each type of meatball sauce content to the aroma preferences of the panelists. In the boxplot, the KJ05 meatball sauce content type is seen to have the highest box width compared to other types, this shows that the data distribution in the KJ05 type is the highest compared to other types. This shows that the aroma preferences of each panelist are quite diverse in the type of KJ05 meatball sauce. In addition, the center line of the KJ05 type is in the highest position, compared to other types. This shows that the KJ05 type has the highest median value compared to other types, so it can be interpreted that in the KJ05 type of meatball sauce most panelists tend to like the aroma of the KJ05 type of meatball sauce rather than the type that.

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3.3.2. Color Test

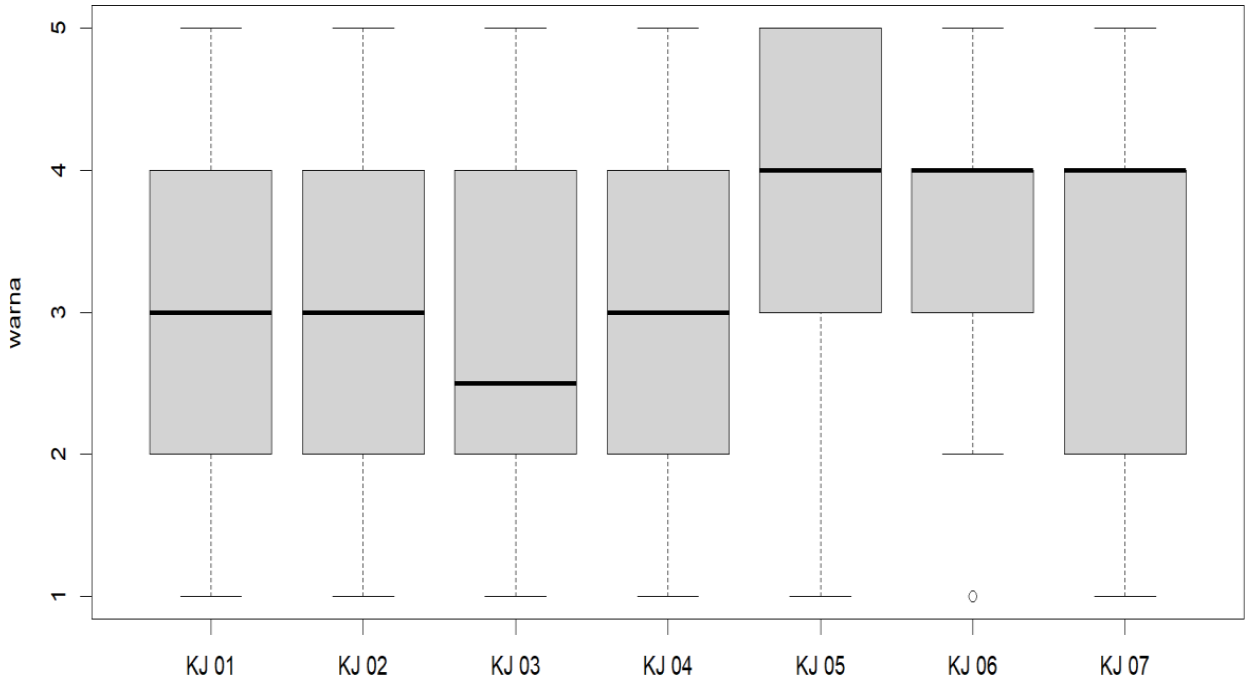

Figure 4.
Boxplot's favorite color of meatball sauce. KJ 01= Shitake mushroom flavoring, KJ 02= Oyster mushroom flavoring, KJ 03= Ear mushroom flavoring, KJ 04= mushroom combination flavoring, KJ 05= Totole mushroom flavoring, KJ 06= halawa flavoring, KJ 07= MSG flavoring.

Figure 4 shows the distribution of data from each type of meatball sauce level to the color preference of the panelists. In the boxplot, the KJ05 meatball sauce content type is seen to have the highest box position compared to other types. This shows that the data distribution on the KJ05 type has the highest color preference value compared to other types. This shows that the color preferences of some panelists are quite high for the type of KJ05 meatball sauce. In addition, the center line of the KJ05, KJ06, and KJ07 types is in the highest position compared to other types. This shows that this type has the highest median value compared to other types, so it can be interpreted that in the types of meatball sauce KJ05, KJ06, and KJ07, most panelists tend to like the color of the type of meatball sauce compared to other types.

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3.3.3. Taste Test

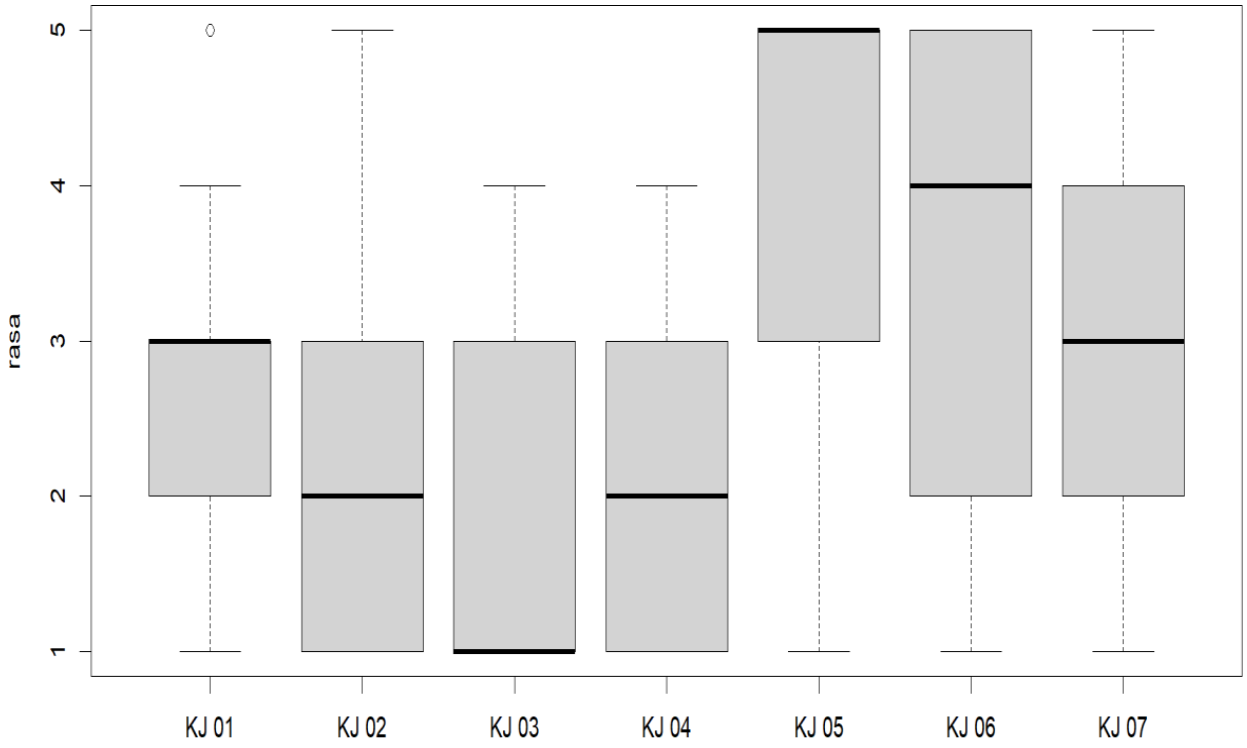

Figure 5.
Boxplot's favorite taste of meatball sauce. KJ 01= Shitake mushroom flavoring, KJ 02= Oyster mushroom flavoring, KJ 03= Ear mushroom flavoring, KJ 04= mushroom combination flavoring, KJ 05= Totole mushroom flavoring, KJ 06= Halawa flavoring, KJ 07= MSG flavoring.

Figure 5 shows the distribution of data from each type of meatball sauce level to the taste preferences of the panelists. In the boxplot, the KJ06 meatball sauce content type is seen to have the highest box width compared to other types. This shows that the distribution of data on the KJ06 type has the most diverse flavor assessment distribution value compared to other types. In addition, the center line of the KJ05 type is in the highest position compared to other types. This shows that this type has the highest median value compared to other types, so it can be interpreted that in the KJ05 meatball sauce, the majority of panelists tend to like the taste of this type of meatball sauce compared to other types.

Table 4.
Results of the organoleptic test on meatball sauce.

Parameter	Treatment of seasoning for the meatball sauce						
	KJ 01	KJ 02	KJ 03	KJ 04	KJ 05	KJ 06	KJ 07
Aroma	3.03b	2.73bc	2.46c	2.60bc	3.56a	3.13 from	2.93bc
Color	3.13 bcd	2.93cd	2.63d	2.76cd	3.96a	3.60 from	3.30bc
Taste	2.53bc	2.13cd	1.86d	2.30cd	3.90a	3.60a	2.93b
Grade point average	2.89	2.59	2.32	2.55	3.81	3.44	3.05

The results of the organoleptic test analysis on the meatball sauce indicated that each sample treatment had an impact on the panelists' acceptance. As shown in Table 5, the treatment using KJ 05, which incorporates Totole mushroom flavoring, significantly influenced the panelists' preferences.

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According to the DMRT/Duncan further test, the KJ 05 treatment yielded a significantly different value compared to the other treatments, with a value of 3.5667. This indicates that consumers somewhat liked the aroma of the meatball sauce. Similarly, when assessing the color of the meatball sauce, the KJ 05 treatment also showed a significantly different value from the others, with a value of 3.9667, suggesting that consumers expressed a mild preference for the color of the sauce. In terms of taste, the KJ 05 treatment had a significantly different value compared to other treatments, with a score of 3.9000, which indicates that consumers somewhat liked the taste of the meatball sauce. Based on these findings, it is evident that the KJ 05 treatment achieved the highest acceptance levels across all attributes, aroma, color, and taste, making it the best treatment in the organoleptic test of meatball sauce.

3.4. Meatball Preference Rate Analysis

3.4.1. Aroma test

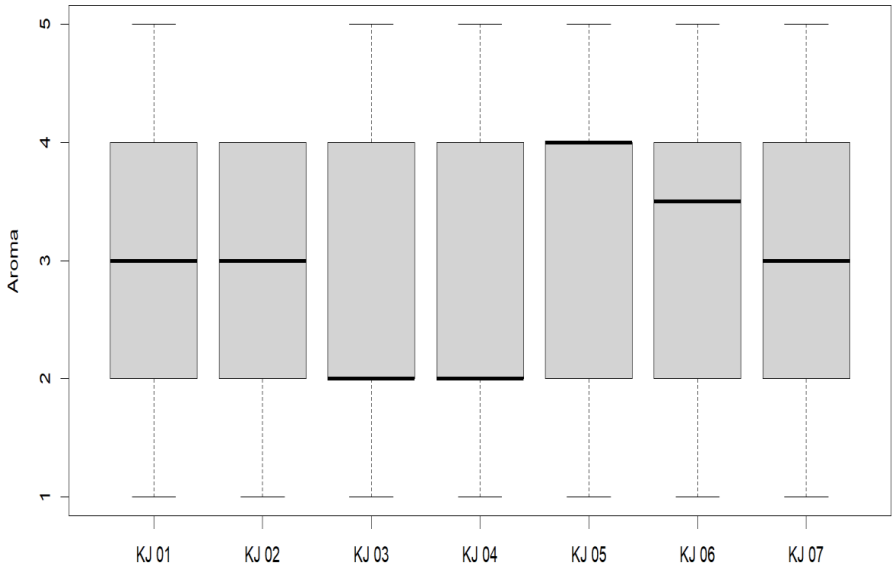

Figure 6.
Boxplot: Favorite smell of meatballs. KJ 01= Shitake mushroom flavoring, KJ 02= Oyster mushroom flavoring, KJ 03= Ear mushroom flavoring, KJ 04= mushroom combination flavoring, KJ 05= Totole mushroom flavoring, KJ 06= Halawa flavoring, KJ 07= MSG flavoring.

Figure 6 illustrates the distribution of data from each type of meatball content in relation to the aroma preferences of the panelists. In the boxplot, it is evident that each type of meatball content exhibits the same box width, indicating that the distribution of data for each type of meatball content follows a relatively uniform aroma assessment distribution value. Despite this uniformity, it is noteworthy that the center line of the KJ05 type is positioned higher compared to the other types. This suggests that the KJ05 meatball type has the highest median value among all the types represented, implying that, for this meatball type, the majority of panelists are inclined to prefer its aroma over those of the other types.

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3.4.2. Color Test

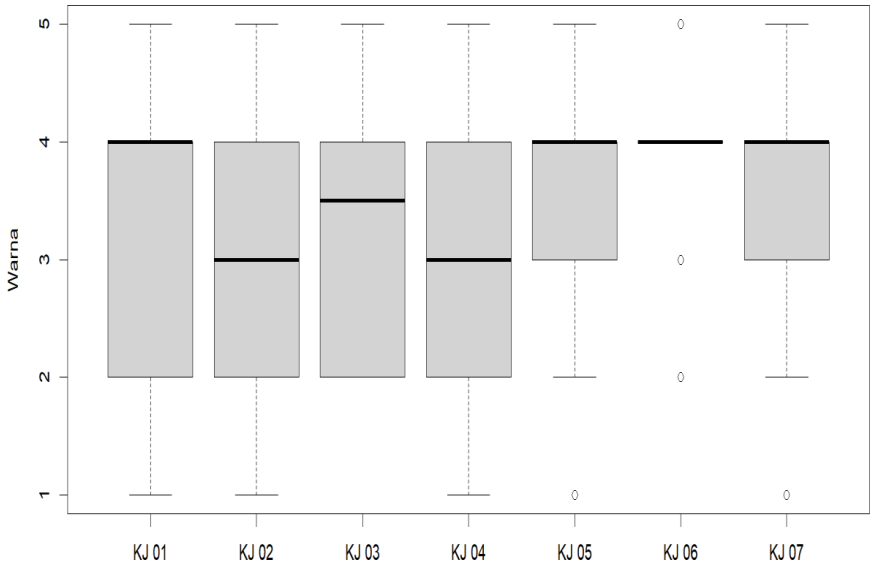

Figure 7.
Boxplot: Favorite meatball color. KJ 01= Shitake mushroom flavoring, KJ 02= Oyster mushroom flavoring, KJ 03= Ear mushroom flavoring, KJ 04= mushroom combination flavoring, KJ 05= Totole mushroom flavoring, KJ 06= Halawa flavoring, KJ 07= MSG flavoring.

Figure 7 provides a detailed representation of the distribution of data from each type of meatball content about the color preferences of the panelists. In the boxplot for the KJ06 meatball content type, the width of the box is the smallest compared to the other types, which indicates that the distribution of color preferences for this meatball is narrower and more concentrated. This suggests that the variation in color assessment for the KJ06 type is smaller, meaning the panelists' opinions about the color are more consistent compared to other meatball types. However, it is important to observe that the center line, which represents the median value, for the KJ05, KJ06, and KJ07 types is positioned higher than the other types. This positioning indicates that these types have the highest median values, signifying that most panelists have rated the color of these meatballs more positively compared to the other types. Therefore, it can be interpreted that, in general, the panelists tend to prefer the color of the KJ05, KJ06, and KJ07 meatball types over the others, with a stronger consensus in their color preferences for these types.

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3.4.3. Taste Test

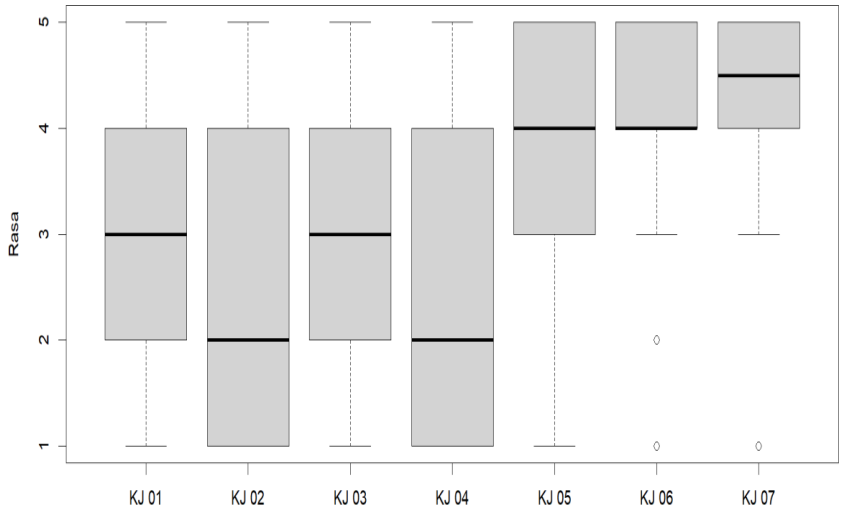

Figure 8.
Boxplot: Favorite meatball flavor. KJ 01= Shitake mushroom flavoring, KJ 02= Oyster mushroom flavoring, KJ 03= Ear mushroom flavoring, KJ 04= mushroom combination flavoring, KJ 05= Totole mushroom flavoring, KJ 06= Halawa flavoring, KJ 07= MSG flavoring.

Figure 8 shows the distribution of data from each type of meatball content to the taste preferences of the panelists. In the boxplot, the KJ02 and KJ04 meatball content types are seen to have the highest box width compared to other types. This shows that the distribution of data on these types has the most diverse flavor assessment distribution value compared to other types. However, the center line of the KJ07 type is in the highest position compared to other types. This shows that this type has the highest median value compared to other types, so it can be interpreted that in the KJ07 type of meatballs, the majority of panelists tend to like the taste of this type of meatball compared to other types.

3.4.4. Texture Test

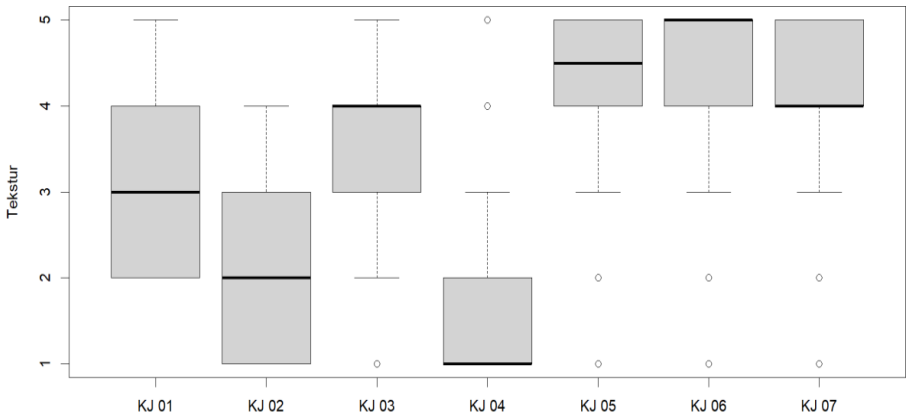

Figure 9.
Boxplot: Favorite meatball texture. KJ 01= Shitake mushroom flavoring, KJ 02= Oyster mushroom flavoring, KJ 03= Ear mushroom flavoring, KJ 04= mushroom combination flavoring, KJ 05= Totole mushroom flavoring, KJ 06= Halawa flavoring, KJ 07= MSG flavoring.

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Figure 9 shows the distribution of data from each type of meatball content to the texture preference of the panelists. In the boxplot, the KJ01 and KJ02 meatball content types are seen to have the highest box width compared to other types. This shows that the distribution of data on these types has the most diverse texture assessment distribution values compared to other types. However, the center line of the KJ06 type is in the highest position compared to other types. This shows that this type has the highest median value compared to other types, so it can be interpreted that in the KJ06 meatball texture type, most panelists tend to like the texture of this type of meatball compared to other types.

Table 5.
Results of organoleptic tests on meatballs

Parameter	Seasoning treatment of meatballs						
	KJ 01	KJ 02	KJ 03	KJ 04	KJ 05	KJ 06	KJ 07
Aroma	3.13 from	2.80bc	2.73bc	2.43c	3.36a	3.33a	3.16from
Color	3.16bc	2.80c	3.40 from	2.93c	3.63bc	3.83a	3.43from
Taste	2.90b	2.50b	2.76b	2.36b	4.03a	4.23a	4.30a
Texture	3.13b	2.03c	3.40b	1.70c	4.06a	4.20a	4.06a
Grade point average	3.08	2.53	3.07	2.35	3.77	3.89	3.74

The results of the analysis of organoleptic tests on meatballs showed that each sample treatment affected the acceptance of the panelists. As shown in Table 6, the treatment using KJ 05, which is based on Totole mushroom flavoring and subjected to the DMRT/Duncan follow-up test, has a significantly different value compared to other treatments, with a value of 3.3667. According to consumer feedback, they somewhat liked the aroma of the meatballs. Meanwhile, the treatment of KJ 06, which is a treatment using Halawa flavoring based on the Duncan test, has a significantly different value from other treatments, with a value of 3.8333, where consumers expressed a bit of preference for the color of meatballs. The treatment of KJ 07, which is a treatment using MSG flavoring based on the Duncan test, has a significantly different value compared to other treatments, with a value of 4.3000, where consumers express their liking for the taste of meatballs. The treatment of KJ 06 based on the Duncan test had a significantly different value compared to other treatments with a value of 4.2000, where consumers expressed their liking for the texture of the meatballs. Based on this, it is known that the best treatment in the organoleptic test of meatballs is the treatment of KJ 06.

4. Discussion

From the results obtained, it can be seen in Tables 5 and 6 that among the treatments using mushroom flavoring (KJ 01, KJ 02, KJ 03, and KJ 04), KJ 01, which uses Shitake mushroom flavoring, is the most in demand. Meatball sauce with KJ 01 flavoring treatment is superior in all three aspects, with a favorite value of the aroma of meatball sauce of 3.0333; The color of the meatball sauce is 3.1333; and the taste of meatball sauce is 2.5333. In the meatball preference test, KJ 01 has an aroma and taste that is more in demand among other mushroom flavoring treatments, namely with a meatball aroma preference value of 3.1333 and a meatball preference value of 2.9000. As for color and texture, KJ 03 which is a treatment using Ear mushroom flavoring is more in demand with a favorite value of meatball color of 3.4000 and a favorite value of meatball texture of 3.4000; followed by KJ 01 with a favorite value of meatball color of 3.1667 and a favorite value of meatball texture of 3.1333.

Shitake mushrooms are the preferred mushrooms because they contain a lot of amino acids that produce savory tastes, such as glutamate which is an umami amino acid, there are about 3.14mg in Shitake, and threonine which is a type of essential amino acid that gives a sweet taste, the level is relatively high in Shitake, which ranges from 7.40 mg to 8.89 mg. Levels of 5'-nucleotides, 5'-AMP, and 5'-GMP were also found to be abundant in Shitake mushrooms, amounting to 4.41mg, 2.40mg, and 2.32mg. EUC (equivalent umami concentration) levels are also found in Shitake, which is around 152.22 –153.98g MSG per 100g dry weight [20].

However, when compared to commercial flavorings, the average treatment of meatball sauce that is

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most in demand is the treatment of KJ 05, which is a treatment using Totole flavoring. This is because Totole flavoring contains MSG and disodium ribonucleotide. MSG contains glutamate, which can improve the taste of food by stimulating flavor receptors on the tongue. Adding MSG to food produces an umami flavor. The umami taste stimulates the secretion of saliva, increases appetite, and enhances the delicacy of food on the tongue [21, 22]. Meanwhile, the average meatball treatment that is most in demand is the KJ 06 treatment, which is a treatment with Halawa flavoring. Halawa flavoring is a flavoring that uses probiotics. Probiotics are beneficial bacteria and yeasts for the body, especially the digestive system [2].

From the overall results, mushroom flavoring cannot compete with commercial flavoring. Therefore, a follow-up test is needed to see the concentration of umami flavor compounds contained in mushrooms or commonly known as equivalent umami concentration (EUC). The EUC level [mg MSG per 100 g] represents a concentration of monosodium glutamate (MSG) equivalent to the umami intensity in mushrooms derived from a mixture of amino acids and 5′-nucleotides Yamaguchi, et al. [23] and Phat, et al. [24]. Phat, et al. [24] and Sun, et al. [25] stated that monosodium glutamate-like amino acids (MSG), especially Asp and Glu, and 5′-nucleotides such as 5′-guanosine monophosphate (5′-GMP), 5′-inosine monophosphate (5′-IMP), and 5′-xanthosine monophosphate (5′-XMP), contribute to the umami taste in mushrooms [25, 26]. According to Zhang, et al. [26] the umami taste in edible mushrooms can be affected by several factors, such as the type of mushroom, the quality level, the processing method, and the storage time [26].

5. Conclusions

Based on the results of the analysis, it can be concluded that the nutritional composition of various edible mushroom species differs significantly. Oyster mushrooms exhibited the highest protein content at 22.85%, along with a moisture content of 9.16%, ash content of 6.83%, and fat content of 3.33%. In contrast, shiitake mushrooms contained 16.42% protein, 4.07% moisture, 4.35% ash, and 2.33% fat. Meanwhile, ear fungus showed the lowest protein level at 8.44%, with a moisture content of 5.30%, ash content of 5.10%, and fat content of 2.33%. These variations highlight the importance of mushroom species selection in the development of functional food products. Specifically, incorporating mushrooms as natural flavoring agents in meatball formulations can not only enhance sensory appeal but also improve nutritional value, depending on the mushroom type used.

Organoleptic test results showed that among natural mushroom flavorings, shiitake mushrooms were the most preferred by panelists, with average scores of 2.90 for the sauce and 3.08 for the meatballs. However, commercial flavorings outperformed natural ones; Totole achieved the highest score for sauce (3.81), while Halawa scored highest for meatballs (3.90). These findings indicate that flavoring type significantly affects consumer acceptance of meatball products.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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