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FULFILLMENT OF PROTEIN NEEDS FROM PROCESSED OYSTER MUSHROOM BALLS AND CELERY AS A SOURCE OF PLANT PROTEIN

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Abstract

The consumption of plant-based protein in Indonesia is comparatively higher than the consumption of animal-based protein, indicating a growing trend of substituting traditional meat-based ingredients with plant-based alternatives in dishes like meatballs. In order to address this shift and improve the nutritional value of the population's diet, researchers are exploring food diversification by incorporating oyster mushrooms and celery into meatball products. The objective of this study is to evaluate the impact of different ratios of oyster mushrooms (Pleurotus ostreatus) and celery (Apium graveolens) on the protein content and sensory qualities of plant-based meatballs. The research utilized a Randomized Complete Block Design (RCBD) with three different levels of celery addition in oyster mushroom meatballs: 0%, 10%, and 20%. Data analysis was conducted using SPSS software, employing the One-Way ANOVA test for normally distributed and homogenous data, and the Kruskal-Wallis test for non-normally distributed or heterogeneous data. The results indicated that the most favorable outcome was observed in formulation F2, which had a protein content of 9.700%, meeting the Indonesian National Standard for meatball products. Additionally, the addition of celery had a significant impact ($p < 0.05$) on the protein content.

Keywords: *Celery, Meatballs, Oyster Mushrooms, Plant-Based Protein, Protein*

1. INTRODUCTION

The role of food and nutrition in the development process is a multifaceted, integral element that underpins the success of development efforts across various sectors (Suryani, Maulidah, & Rahayu, 2014). Food and nutrition are not merely components of daily life but are pivotal determinants of public health, societal well-being, and economic prosperity. An effective strategy to advance development, particularly in the context of Indonesia, involves diversifying the food supply. Food diversification encompasses a spectrum of activities that encompass not only the exploration of novel food ingredients but also the development of innovative food processing methods. These endeavors contribute to a broader, more diverse spectrum of available food choices. The study by Suryani et al. (2014) highlights this critical concept, emphasizing how diversification can significantly enhance nutrition and subsequently improve the overall quality of life for communities.

According to Ardiani, Permatasari, & Sugiatmi (2021), dietary patterns have undergone significant transformations as the population increasingly turns to various plant-based protein sources. The preference for plant-based proteins over animal proteins has emerged as a notable trend. Several factors contribute to this shift, including the relatively high cost of animal protein. Economic factors, cultural considerations, and accessibility to different types of protein play a crucial role in shaping these dietary preferences. The 2014 Individual Food Consumption Survey (SKMI) provides empirical evidence supporting the prevalence of plant-based protein sources in the Indonesian diet. A majority of the population leans towards plant-based protein sources, thereby underscoring the dominance of plant-based proteins in their diets.

Meatballs, a traditional Indonesian dish, is renowned for its savory flavor and cultural significance. However, the conventional recipe for *meatballs* primarily relies on animal-based proteins, notably finely ground meat, which has raised concerns due to its association with various health issues, such as high blood pressure (Yusasrini & Ekawati, 2018). As dietary preferences evolve, a growing distinction emerges between non-vegetarians and vegetarians. The latter group deliberately abstains from consuming animal products. This evolving dietary landscape presents an exciting opportunity for culinary innovation, one that caters to the health-conscious vegetarian community and those who seek more sustainable food choices. This research aims to explore the potential for plant-based variations of *meatballs* that not only respect traditional flavors but also accommodate diverse dietary preferences, bridging the gap between meat-based and plant-based culinary traditions in Indonesia.

Among the promising avenues for incorporating plant-based proteins into food processing, oyster mushrooms, specifically *Pleurotus ostreatus*, stand out as a versatile and nutrient-rich option. Oyster mushrooms have garnered attention from researchers and health enthusiasts due to their impressive nutritional profile. With protein content ranging from 19% to 30%, carbohydrates, essential amino acids, and a host of vitamins and minerals, oyster mushrooms offer a unique blend of nutritional benefits (Suryani et al., 2014). Additionally, oyster mushrooms have been associated with a range of health-promoting properties, including anti-tumor effects, the ability to regulate cholesterol levels, and antioxidant qualities. With protein levels ranging from 19% to 35% when considering dry weight, oyster mushrooms represent an appealing plant-based protein source to enrich the nutritional value of a variety of dishes.

In conjunction with oyster mushrooms, celery, often overlooked in terms of its nutritional significance, presents a valuable ingredient to enhance the flavor, texture, and nutritional content of various culinary creations. This unassuming vegetable, with its distinctive crunch and refreshing flavor, is well-regarded for its versatility (Suryani et al., 2014). Every 100 grams of fresh celery offers approximately 1.0 gram of protein, along with negligible fat content. Additionally, celery boasts an array of essential vitamins, most notably vitamin C, and essential minerals, such as calcium, phosphorus, and iron. These attributes make celery a compelling candidate for inclusion in plant-based recipes, contributing not only to the sensory appeal but also to the nutritional value of dishes.

Current research seeks to harness the synergistic potential of oyster mushrooms and celery in the development of *meatballs*, a beloved Indonesian dish. By integrating celery into the primary raw material of oyster mushroom-based *meatballs*, researchers aim to elevate the sensory qualities of the dish. This innovative culinary approach not only caters to the evolving dietary preferences of the population but also addresses pertinent nutritional concerns. It aligns with the broader imperative to transform favored traditional dishes into healthier and more nutritious options that accommodate various dietary patterns and contribute to the overall well-being of the Indonesian population.

Moreover, this research endeavors to explore the intersection of nutrition, culinary innovation, and evolving dietary preferences. The aim of the research is to evaluate the potential of oyster mushrooms (*Pleurotus ostreatus*) and celery (*Apium graveolens*) as alternative plant-based protein sources for *meatballs*, a cherished Indonesian dish. As health-conscious eating gains momentum, and concerns about the environmental impact of dietary choices grow, this research is not only poised to offer exciting culinary possibilities but also to contribute to the broader discourse on sustainable, nutritious, and delectable food options, aligning with the changing dietary landscape in Indonesia and beyond.

2. RESEARCH METHODS

This research employs three distinct research approaches, namely True Experimental Research, literature review, and observation. The experimental method involves creating variations in the preparation of oyster mushroom and celery meatballs with different proportions, followed by testing the protein content in these meatballs' products. The observational technique focuses on the organoleptic assessment of oyster mushroom meatballs by a panel of evaluators.

In this context, the research method to be employed is a Randomized Complete Block Design (RCBD), involving variations in the percentage of oyster mushrooms (*Pleurotus ostreatus*) and celery (*Apium graveolens*) used in *meatballs* preparation. The experimental design in the research can be outlined as follows:

- Dough for Oyster Mushroom *Meatballs* + Celery
- F0: 100% Oyster Mushroom *Meatballs* Dough + 0% Celery
- F1: 90% Oyster Mushroom *Meatballs* Dough + 10% Celery
- F2: 80% Oyster Mushroom *Meatballs* Dough + 20% Celery

In this research, non-probability sampling is utilized, implying that the samples are selected without giving equal opportunity or chance to the entire population. One sample is taken for each formulation, and then the protein content is tested. The organoleptic testing also involves the random selection of panelists from the community.

To test hypotheses based on the acquired data, the One-Way ANOVA test is employed. This choice is made because the data involve more than two samples that are related to each other. It's essential to note that One-Way ANOVA is a parametric test, and two conditions must be met: the data distribution should be normal, and the variances should be homogenous (Setiawan, 2019). If one of these conditions is not met, a non-parametric test will be used as an alternative. If the protein content test results indicate a significant difference ($P < 0.05$), further testing will be conducted using the Tukey method. For organoleptic test results, the analysis is performed using the Kruskal-Wallis test, and if there is a significant difference ($P < 0.05$), a hypothesis test summary will be conducted by examining pairwise comparisons of the mean values of the data to be analyzed.

3. RESULTS AND DISCUSSION

This research addresses the issue of diversification in food processing, particularly concerning the production of *meatballs*. In Indonesia, *meatballs* is typically made from meat and is a popular food or snack choice among the population. However, it is concerning that in Indonesia, degenerative diseases, especially hypertension or high blood pressure, have become one of the leading causes of death. The consumption of meat-based products can be a contributing factor to these health issues.

Through this research, oyster mushroom and celery *meatballs* are expected to serve as alternative food products that meet nutritional standards and can help address these health concerns. Additionally, the research evaluates the impact of adding celery on the protein content in *meatballs* and assesses its physical quality through organoleptic tests, measuring aspects such as color, taste, aroma, and texture in oyster mushroom *meatballs* products.

3.1. Protein Content Test Results

The results of the analysis of various formulations for the production of oyster mushroom meatballs with added celery were evaluated through laboratory testing at the Banjarbaru Medical Faculty. This testing was conducted with three repetitions for each sample, using the Kjeldahl test method to measure protein content. Thus, a total of nine samples were tested to determine the average protein content in oyster mushroom meatballs. The protein content test results can be seen in Table 1. as follows.

Table 1. Protein Content Test Results in Oyster Mushroom *Meatballs*

Sample	Replication	Protein Content (%)	Average
F0	1	9,08	9,113
	2	9,11	
	3	9,15	
F1	1	9,40	9,377
	2	9,38	
	3	9,35	
F2	1	9,62	9,700
	2	9,81	
	3	9,67	

Source: Processed data (2023)

After conducting the initial test, which is the normality test, it was found that in sample F0, the significance level was 0.843, which is greater than the conventional significance level of 0.05. In sample F1, the significance level was 0.780, also greater than 0.05. Likewise, in sample F2, the significance level was 0.490, again greater than 0.05. These results indicate that the data in all three samples follow a normal distribution.

Furthermore, in the homogeneity test, the significance level for all three samples was 0.083, which is greater than the typical significance level of 0.05. This suggests that the data in all three samples exhibit homogeneity in their distribution. As a result, it can be concluded that this research meets the requirements for conducting a parametric test, specifically the One-Way ANOVA.

Subsequently, a post hoc test using the Tukey method will be performed if the ANOVA test results show a significance level less than 0.05 or if there are significant differences between the samples. The results of the ANOVA test for protein content in oyster mushroom *meatballs* can be seen in Table 2 below:

Table 2. Results of the ANOVA Test for Protein Content in Oyster Mushroom *Meatballs*

Testing	Average ± Std. deviation			Sig.	SNI
	F0	F1	F2		
Protein Content Test (Kjehdahl)	9,113 ±0,035	9,377±0,025	9,700±0,098	0,000*	Min. 9%

Note: The (*) symbol indicates the significance of data in the samples

Source: Processed data (2023)

Based on the data presented in Table 2, it can be concluded that there is a significant difference in the average levels at a significance level of 0.000, which is clearly less than the significance level of 0.05, in both the sample groups F0, F1, and F2. Therefore, the next step is to conduct a post hoc test, specifically the Tukey test. The purpose of this test is to assess whether there is a significant difference in the averages among the three plant-based *meatballs* formulations by comparing two sample groups sequentially. The results of the protein content data analysis using the Tukey test will be presented in the pairwise comparison table as provided below.

Table 3. Results of the Tukey Post Hoc Analysis

Comparison of Vegetable *Meatballs* Formulations		Sig.
F0	F1	0,005*
	F2	0,000*
F1	F0	0,005*
	F2	0,002*
F2	F0	0,000*
	F1	0,002*

Notes: Symbol (*) indicates significance of data between each sample

Source: Processed data (2023)

3.2. Organoleptic Test Results

From the data obtained in the organoleptic test, the researcher used SPSS software to analyze the relationship between the addition of celery and various aspects in the organoleptic test, such as color, taste, aroma, and texture. Similar to the protein content test, before conducting further analysis, the organoleptic test data also had to undergo the normality and homogeneity tests. The results of these tests indicate that in both sets of data, for both the normality and homogeneity tests, the significance level is 0.00. This indicates that the data is neither normally distributed nor homogeneous. Since the prerequisite for conducting parametric tests is that data must be normally distributed and homogeneous, the researcher cannot use parametric tests like One-Way ANOVA to test hypotheses based on the organoleptic test data.

Therefore, hypothesis testing will be conducted using non-parametric tests, specifically the Kruskal-Wallis test, as the basis for examining the relationship between the addition of celery and the organoleptic aspects. Below are the results of the data analysis using the Kruskal-Wallis test on the average values in the organoleptic test for oyster mushroom meatballs. These average values can be found in the table below.

Table 4. Average values of the Organoleptic Test for Oyster Mushroom *Meatballs*

Parameter	Average ± Std. deviation			Sig.
	F0	F1	F2	
Color	3,27 ± 0,084	2,40 ± 0,507	1,87 ± 0,915	0,000*
Flavor	2,73 ± 0,516	2,93 ± 0,594	2,93 ± 0,458	0,069
Scent	1,33 ± 0,258	2,93 ± 0,458	4,13 ± 0,516	0,000*
Texture	3,33 ± 0,976	3,07 ± 0,258	2,33 ± 0,724	0,002*

Notes: Data with symbols (*) indicate significance between data groups
Data without symbol (*) indicates no significance between data groups

Source: Processed data (2023)

From the analysis using the Kruskal-Wallis test on the average values of all aspects in the organoleptic test, a significant difference was found, indicated by a significance level of $p < 0.05$. Therefore, further testing, namely the hypothesis test summary, was conducted, examining pairwise comparisons of each oyster mushroom *meatballs* formulation. Below are the results of the pairwise comparisons of the average values for the color, taste, aroma, and texture parameters in each oyster mushroom *meatballs* formulation.

Table 5. Pairwise Comparison of Average Values in the Organoleptic Test Aspects

Parameter	Comparison of Plant-Based *Meatballs* Formulations	Sig.
Color	F2-F1	0,006*
	F2-F0	0,002*
	F1-F0	0,003*
Flavor	F0-F1	1,000
	F0-F2	0,050*
	F1-F2	0,028*
Scent	F0-F2	0,000*
	F0-F1	0,000*
	F2-F1	0,000*
Texture	F2-F1	0,001*
	F2-F0	0,026*
	F1-F0	0,364

Notes: Data with symbols (*) indicate significance between data groups
Data without symbol (*) indicates no significance between data groups

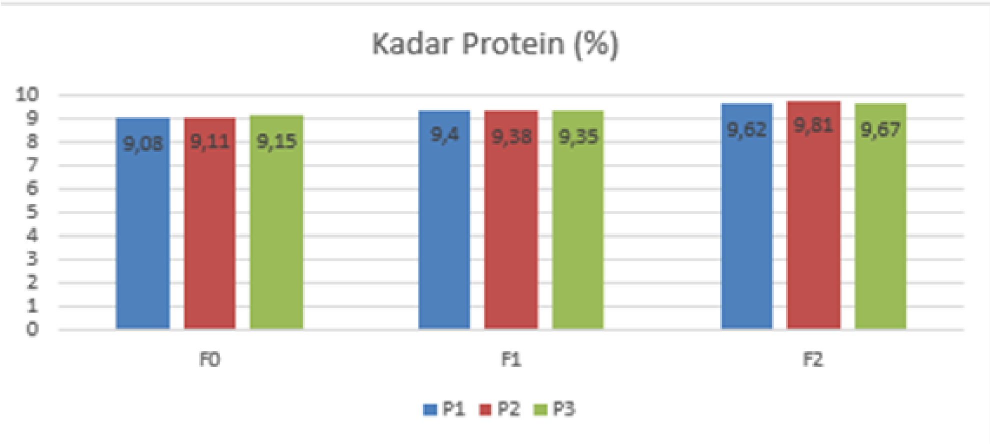
Source: Processed data (2023)

3.3. Discussion of Protein Test Results

Protein content in food materials is generally used as an indicator to measure the quality of food ingredients because protein is a vital substance for human life (S. Sudarmadji, 1997). Protein is a food component that contains nitrogen, which is an essential element for various bodily functions. In many body tissues, protein is the largest component after water.

Protein also plays a crucial role in human nutrition, serving as an essential element in tissue replacement, energy provision, and as a versatile macromolecule in the living system. Proteins have vital functions in various biological processes, such as acting as catalysts in chemical reactions, serving as transporters for various molecules, including oxygen, and participating in the immune system and nerve impulse transmission (S. Sudarmadji, 1997). Protein deficiency in the diet can lead to problems such as growth disorders, muscle mass reduction, edema, and fluid accumulation in the body, especially in children (Verma & Bashir, 2018).

Based on the results of the protein content test in Table 1, it is evident that the average protein content varies among the three samples. For a clearer understanding, refer to the following graph:



Source: Processed data (2023)

Figure 1. Protein Content Test Results in Oyster Mushroom Meatballs

All three formulations of oyster mushroom meatballs meet the standards set by the Indonesian National Standard (SNI), which require a minimum protein content of 9%. Therefore, the oyster mushroom meatballs with celery can be considered suitable for consumption. Furthermore, the laboratory test results indicate that formulation F2 has the highest average protein content compared to the other two formulations, making it the best among the three samples tested.

The differences in protein content among the three samples of oyster mushroom meatballs are attributed to variations in the formulations used. Another factor that can affect differences in protein content is the lack of homogeneity in the composition of the ingredients, which can result in poor protein binding. According to previous research reported by Riansyah (2013) in Yuarni et al. (2018), changes in the moisture content of ingredients can influence protein content, with reduced moisture content potentially increasing the percentage of protein. The use of heat in food processing can also reduce moisture content, subsequently increasing protein content. Additionally, the heating process during testing or cooking may also affect changes in protein content.

Protein structural changes, known as protein denaturation, are the primary cause of decreased solubility and dispersibility of powders obtained through high-temperature, short-time drying. Previous research conducted by Naozuka & Oliveirab (2012) has shown that the heating process can reduce the total protein concentration through changes in protein structure. However, the heating process can also enhance protein quality by inactivating or breaking down anti-nutrient components that can inhibit protein absorption and improve its biological availability. Furthermore, the heating process, which reduces moisture content, may have a more significant impact on increasing protein content in the ingredients.

3.4. Discussion of Organoleptic Test Results

Organoleptic tests, often referred to as sensory tests, are a method that employs the human senses as the primary tool to measure the perception of a product. In organoleptic testing, the senses used include sight (eyes), smell (nose), taste (tongue), and touch (hands). These sensory abilities influence the assessment of the tested product based on the stimuli or signals received by these senses. These abilities include the capacity to detect, recognize, differentiate, compare, and evaluate whether one likes or dislikes the tested product. Consumer acceptance is the level of satisfaction or preference of consumers for a product. Consumer acceptance encompasses aspects such as color, aroma, texture, and taste in a product (Gusnadi, Taufiq, & Baharta, 2021). It is essential to remember that the results of organoleptic tests are subjective because they depend on the circumstances, impressions, awareness, and personal behavior of the panelists or product assessors during evaluation (Merah, 2010).

The following is the discussion of the organoleptic (sensory) test results concerning the addition of celery to oyster mushroom meatballs.

a. Color

The organoleptic (sensory) test results regarding the addition of celery to oyster mushroom meatballs indicate that the visual appearance of the product plays a crucial role in consumer assessment and preference when selecting or consuming a product (Puni, Nur, & Asy'ari, 2020). Changes or differences in the color of food products reflect chemical alterations in the component materials resulting from specific treatments (Febriana, 2019).

The average scores given by the panelists for the color of oyster mushroom meatballs with celery are presented in Figure 2 below:

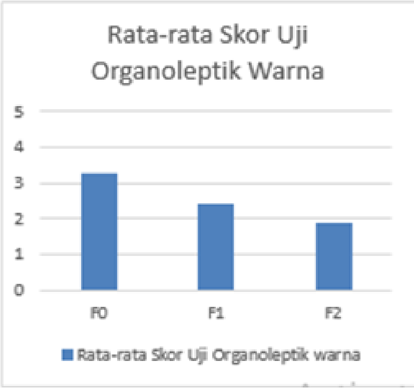


Figure 2. Diagram of the Average Color Test Score

Therefore, from the data obtained, it can be concluded that many panelists rated that an increased amount of celery led to a decrease in the brightness of the product in this case, oyster mushroom meatballs. This may be due to the presence of natural colorants in celery that affect the brightness of the product, as celery leaves contain chlorophyll, which imparts a green color. Chlorophyll can cause a change in the color of the product to be less bright or darker, which may not be preferred by the panelists. Additionally, degradation products of chlorophyll, such as pheophytin and pheophorbide, can darken the product.

b. Taste

Taste is one of the primary indicators in organoleptic testing, especially in the evaluation of food products because the taste evaluation of food is closely related to individual consumer preferences (Candra, Riyadi, & Wijayanti, 2014). Taste in food is influenced by various chemical components such as protein, fat, and carbohydrates, which provide characteristics like savoriness. There are four primary tastes known: sweet, sour, salty, and bitter. Flavor encompasses the stimuli perceived by the taste buds when tasting food, as well as the impressions left on the palate after swallowing (Trihaditia, 2016).

Data on the average ratings given by the panelists for the taste of oyster mushroom meatballs with the addition of celery are presented in Figure 3 below:

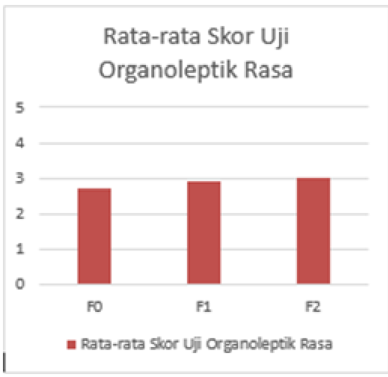


Figure 3. Diagram of the Average Taste Score

The average ratings for the taste aspect of the three formulations show that formulations F1 and F2 have the same highest average scores preferred by the panelists. This may be due to the fact that the addition of celery to the oyster mushroom meatball mixture in formulations F2 and F1 does not significantly differ. Additionally, the aroma of celery imparts a distinctive smell and texture when chewed, so these two formulations might have similarities in taste according to the panelists' evaluations. Statistical analysis also indicates that there are no significant differences in the average ratings between these two formulations.

c. Aroma

Aroma is one of the crucial parameters in sensory organoleptic testing, involving the sense of smell. Aroma is the smell produced by chemical stimuli that can be detected by olfactory nerves in the nasal cavity. Aroma plays a significant role in determining the palatability of food and greatly influences how food is perceived by consumers. Food without an appropriate aroma can reduce acceptance and preference for that food (Winarno, 2004). Food aroma can be sensed when the food ingredients produce specific scents. Spices used in food can impart a characteristic aroma to the product. The more spices used in food, the stronger the aroma of the product (Febriana, 2019).

Data on the average ratings given by the panelists for the aroma of oyster mushroom meatballs with the addition of celery are presented in Figure 4 below:

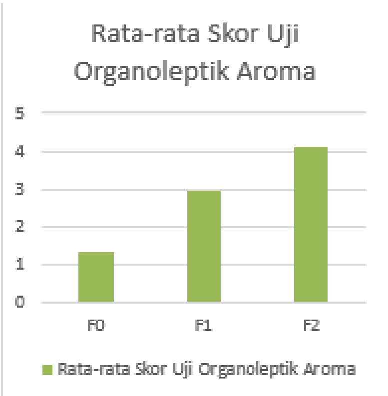


Figure 4. Diagram of the Average Results of the Aroma Test Score

Celery leaves used have a distinctive aroma that is expected to stimulate the appetite, especially due to oyster mushrooms, as the main ingredient for vegetarian meatballs. It does not have a strong aroma compared to meat-based meatball products. The unique aroma of celery is also one of the factors that lead to higher panelist ratings as celery is added to the meatball dough. This indicates that the use of celery in oyster mushroom meatballs is well-received by the panelists and can enhance the aroma character of the product.

d. Texture

Texture is one of the sensory aspects related to the sense of touch or feel. Sometimes, texture is considered equally important as taste and aroma in food evaluation because it can influence the overall impression of the food. Texture is particularly significant in foods with soft and crispy characteristics (Lamusu, 2018). The evaluation of food texture can involve the sense of touch and the sense of smell. Some aspects related to the assessment of food texture include hardness, elasticity, tenderness, elasticity, density, stickiness, and resilience (Sipahutar et al., 2021).

Average panelist ratings for the texture of oyster mushroom meatballs with the addition of celery are presented in Figure 5 below:

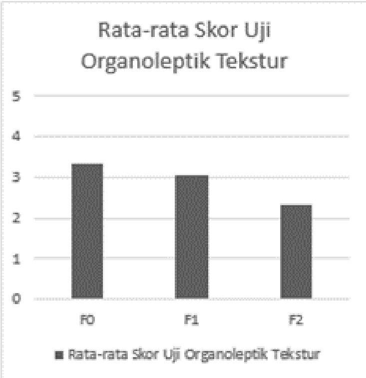


Figure 5. Diagram of Average Texture Test Scores

Based on this data, it can be concluded that sample formulation F0 has the highest average ratings, while formulation F2 has the lowest average ratings among the three samples, with F1 falling in between the two. Therefore, the addition of celery to the formulation makes the texture of oyster mushroom meatballs less dense. This is likely due to the high-water content in celery, which makes the dough less dense and compact, causing panelists to perceive the texture of the formulation with 20% celery as softer and more porous. Additionally, the process of blending oyster mushrooms with celery using a machine like a blender when mixed can also make the dough softer.

4. CONCLUSION

Based on the research and analysis conducted, it can be concluded that the addition of celery to the oyster mushroom meatball dough has a significant and positive impact on the nutritional composition of the product. Proximate analysis results indicate that sample formulation F2 exhibited the highest average protein content at 9.700%. Statistical analysis using a One-Way ANOVA further supports this finding, with an Asymp. Sig. value of 0.00 for the proximate analysis of protein content, indicating a strong statistical significance in the increase in nutritional value, particularly in terms of protein content, due to the addition of celery.

Additionally, in the organoleptic evaluation, with the inclusion of celery in oyster mushroom meatballs, there were significant differences in sensory assessments across various aspects. However, in pairwise comparisons, there were no significant differences in terms of taste and texture, especially for sample formulations F1 and F2 regarding taste, as well as F0 and F1 regarding texture, as per the panelists' evaluations.

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