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Organoleptic Characteristics of Catfish (*Clarias batrachus*) Sausages with the Addition of Chicken Eggshell (*Gallus gallus domesticus*) Powder

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ABSTRACT*: Catfish (Clarias batrachus) sausage is a fish-based processed product with potential to be developed as a value-added and calcium-fortified food. Chicken eggshell (Gallus gallus domesticus) powder is a poultry by-product with high calcium content that can be utilized as an alternative calcium source. However, its incorporation may affect the sensory quality of food products; therefore, organoleptic evaluation is required to determine consumer acceptance. This study aimed to evaluate the effect of eggshell powder addition on the organoleptic characteristics of catfish sausage and to determine the most acceptable formulation. A Completely Randomized Design (CRD) with a single factor, namely the level of eggshell powder addition, was applied with four formulations: F0 (0%), F1 (10%), F2 (20%), and F3 (30%). Organoleptic evaluation was conducted using hedonic and descriptive tests involving 30 untrained panelists. The parameters assessed included color, smell, texture, taste, aftertaste, and overall acceptability. Data were analyzed using one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test at a 95% confidence level. The results showed that increasing levels of eggshell powder significantly decreased sensory preference scores ($p < 0.05$), particularly for texture, taste, and aftertaste, due to the development of a gritty mouthfeel. Among the fortified formulations, F1 showed the most favorable balance between sensory acceptability and calcium enrichment with an overall hedonic score of 3.80 ± 0.76, while F0 had the highest overall sensory score (4.30 ± 0.59). In conclusion, the addition of 10% eggshell powder (F1) is recommended as the optimal formulation for producing calcium-fortified catfish sausage with acceptable sensory quality. The use of eggshell powder also offers a sustainable and cost-effective calcium source, supporting the valorization of poultry waste into functional food products.*
Keywords:*Catfish sausage, eggshell powder fortification, calcium enrichment, sensory evaluation, consumer preference*

1. INTRODUCTION

Catfish (Clarias batrachus) serves as an accessible animal protein source, easily cultured in freshwater with minimal maintenance, containing protein 18.93 mg/100 g, fat 1.97 mg/100 g, and zinc 1.856 mg/100 g (Kusumawardani et al., 2022). The superiority of catfish lies in its high lysine-leucine content plus abundant omega-3 and omega-6 fatty acids (Santoso et al., 2019). Lysine plays a crucial role in collagen synthesis and bone ossification, facilitating optimal calcium deposition in the bone

matrix (Rizkuna et al., 2014). Thus, catfish holds great potential when combined with high-calcium ingredients to create functional foods supporting essential mineral absorption for optimal body health

Calcium serves as a vital mineral essential for bone and tooth formation and maintenance, while also supporting various physiological processes in the body. Vulnerable groups such as children, adolescents, and the elderly require adequate calcium intake due to their high risk of deficiency. Calcium-rich foods or supplements effectively preserve bone density and reduce fracture risk (Yusmiati & Erni, 2017). Calcium deficiency poses serious health threats by triggering diseases like osteoporosis (Dewi, 2019). It also impairs immunity, disrupts nervous system function, and diminishes muscle contraction capacity (Sudiarmanto & Sumarni, 2020). According to Idris et al. (2016) low blood calcium levels stimulate PTH hormone secretion from the parathyroid gland, which extracts calcium reserves from bones, thereby accelerating bone degradation and elevating osteoporosis risk.

Calcium intake among Indonesians remains critically low. Hayati & Herwana (2018) revealed that most postmenopausal women suffer from hypocalcemia (<800 mg/day), far below the recommended 1000-1500 mg/day intake. Bening et al. (2016) reported that 98.6% of respondents in Java consumed less than 70% of the Recommended Dietary Allowance (RDA) for calcium. Growth stunting in children across regions stems from adaptive responses to calcium deficiency, with Ferilda (2023) documenting 50% prevalence among stunted children and 13.64% in non-stunted children in Sijunjung Regency. This indicates overall inadequate calcium consumption levels.

An effective strategy to address this issue involves food fortification innovations that enrich ready-to-eat products with calcium, thereby reducing deficiency risks across the population. Calcium-rich foods with potential to boost consumption include dried anchovies (1200 mg/100 g), fresh anchovies (500 mg/100 g), dried shrimp (1209 mg/100 g), skim milk (1300 mg/100 g), and cheese (777 mg/100 g) (Afif, 2020). Additionally, chicken eggshell, an underutilized high-calcium food byproduct, offers significant value. Farmasetika et al. (2024) reported that analysis of 100 g eggshell powder using atomic absorption spectrophotometer (AAS) yielded 7200 mg calcium content. Its high calcium potential positions chicken eggshell as an ideal alternative for food fortification, particularly when combined with other ingredients.

Eggshells exhibit rough surfaces, fishy odors, and unappealing colors for food applications. Each chicken egg contains 7 g of shell weighing with 94% calcium carbonate composition (Qolis et al., 2020). Brun et al. (2013) reported calcium content reaching 381 mg Ca/g in eggshells, with 45.59% bioavailability in rats equivalent to CaCO3 supplements. Combining catfish with eggshell powder proves highly suitable as catfish lysine optimizes calcium carbonate absorption from the powder (Istikomah et al., 2023). Product develop ment from this combination yields calcium-fortified catfish sausage.

Sausage is a processed product from ground meat that is emulsified, seasoned, and encased in natural casings from animal intestines or synthetic materials (Fadhlurrohman et al., 2024). Currently, sausage innovations offer diverse flavors, including fish-based variants. Fish sausage provides simple processing, affordable pricing, no additional chemical preservatives, and ease of home-scale production (Chaerunnimah et al., 2021). Its high protein content enables nutrient fortification such as calcium to enhance nutritional value. Azizah (2023) demonstrated high consumer preference for sausages in Yogyakarta, with 100 respondents purchasing at least once weekly, positioning sausage as an ideal fortification medium.

Conventional meat products such as sausages generally contain low calcium levels. Therefore, fortification using calcium compounds has been explored to improve

their nutritional value while maintaining acceptable sensory properties (Irshad et al., 2016).

Sensory evaluation was conducted to determine panelists' acceptance of catfish sausage substituted with eggshell flour. Sensory acceptance of food products is commonly evaluated using hedonic tests covering color, aroma, flavor, texture, and overall acceptability (Kumalasari & Khairunnisa, 2024). Therefore, this study aims to evaluate the effect of chicken eggshell powder addition on the organoleptic characteristics of catfish (*Clarias batrachus*) sausage using hedonic and descriptive tests, to determine the optimal formulation that maintains sensory acceptability while enhancing calcium content.

2. MATERIALS AND METHODS

2.1. Materials and Tools

Fresh catfish (Clarias batrachus) from Pasar Giwangan Yogyakarta, chicken eggshells from Warmindo Pandeyan Yogyakarta, tapioca flour (Indonesia), egg white, pepper powder (Indonesia), garlic powder (Indonesia), ginger powder (Indonesia), baking powder, ice cubes, salt, sugar, mushroom seasoning (Indonesia), cooking oil (Indonesia), collagen casings, and acetic acid.

The equipment used in this study included a digital scale (SF-400, China), an analytical balance (Ohaus), a stove (Rinnai), a 100-mesh sieve (GB/T6003.1-2012, Indonesia), a chopper (Miyako HM-600, China), a cabinet dryer, a sausage filler, a steamer, plates, knives, bowls, needles, and cutting boards.

2.2. Eggshell Powder Production

Eggshell powder processing followed The production of chicken eggshell powder was conducted according to the methods described by Apsari Pebrianti et al. (2024) and Yonata et al. (2017) which included cleaning, size reduction, sterilization through boiling, drying, grinding, and sieving. The eggshells were cleaned to remove adhering impurities and the inner membrane, then reduced in size to facilitate subsequent processing. The eggshells were then soaked in an acetic acid solution at 60°C for 3 h as a sterilization treatment. Drying was carried out using a cabinet dryer at 60°C for 24 h. The dried eggshells were ground for 10 min and sieved using a 100-mesh sieve to obtain chicken eggshell powder. The flowchart of the eggshell powder production process can be seen in Figure 1.

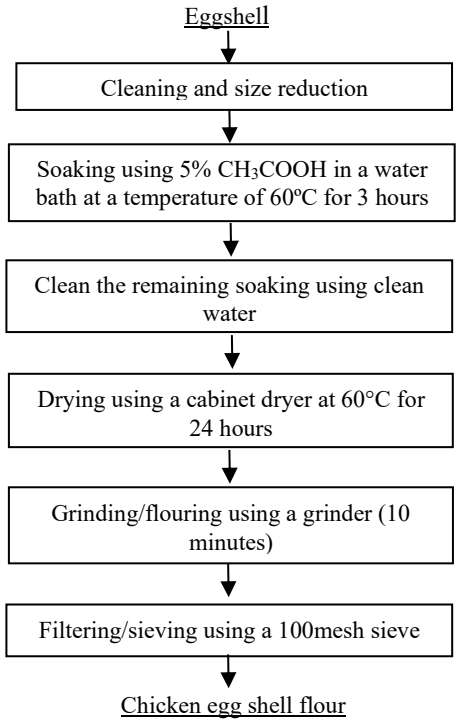

Figure 1. the eggshell powder production process

2.3. Sausage Production

The formulation of fish sausage in this study was based on Widiyanti & Kumalasari (2024) and Purba et al. (2022) with modifications involving the addition of chicken eggshell powder at different formulation levels. Fresh catfish were filleted, cleaned, and drained, then minced using a chopper with the addition of salt and ice cubes. The minced fish was mixed with tapioca flour and chicken eggshell powder at formulation ratios of F0 (60 g:0 g), F1 (60 g:6 g), F2 (60 g:12 g), and F3 (60 g:18 g), along with other ingredients as listed in Table 1, and homogenized until a uniform dough was obtained. The dough was stuffed into collagen casings using a sausage stuffer to form cylindrical sausages, then steamed until

firm, drained, and cooled to room temperature. The flow diagram of the catfish sausage production process can be seen in Figure 2.

Table 1. Sausage Formulation

No	Ingredients (gram)	Material weight (grams)			
		F_0	F_1	F_2	F_3
1	Catfish	60	54	48	42
2	Eggshell flour	0	6	12	18
3	Tapioca	15	15	15	15
4	Salt	1.2	1.2	1.2	1.2
5	Sugar	1.2	1.2	1.2	1.2
6	Flavoring	1.2	1.2	1.2	1.2
7	Garlic	0.72	0.72	0.72	0.72
8	Ginger	0.12	0.12	0.12	0.12
9	Pepper	0.5	0.5	0.5	0.5
10	Ice cube	3.6	3.6	3.6	3.6
11	Egg white	5.4	5.4	5.4	5.4
12	Baking powder	0.25	0.25	0.25	0.25
13	Oil	1.25	1.25	1.25	1.25
Total		90.47			

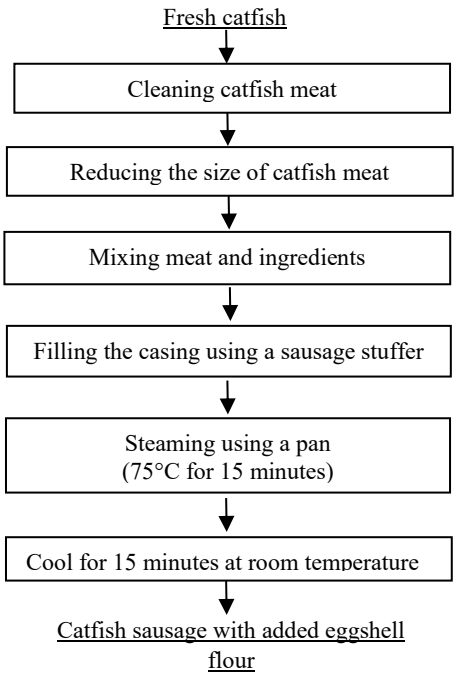

Figure 2. The catfish sausage production process

2.6. Organoleptic Test

This organoleptic evaluation involved 30 untrained panelists who voluntarily participated in the sensory evaluation. Prior to the evaluation, all panelists were informed about the research procedures and provided their consent to participate. The study ensured confidentiality and anonymity of the participants

The descriptive test was performed using a multiple-choice method, in which panelists selected sensory attributes that had been predetermined by the researcher. The sensory parameters evaluated included color, smell, texture, taste, *aftertaste*, and overall acceptability. The hedonic test was used to evaluate the level of panelists' preference using a 5-point hedonic scale (1 = extremely dislike, 5 = extremely) with a score sheet, in accordance with SNI 01-2346-2006 regarding procedures for organoleptic/ sensory evaluation.

2.4. Experimental Design

This study employed a Completely Randomized Design (CRD) with one factor, namely the level of chicken eggshell powder addition in catfish sausage formulation, consisting of four treatment levels: F0 (100%:0%), F1 (90%:10%), F2 (80%:20%), and F3 (70%:30%). Organoleptic evaluation was conducted by involving 30 panelists as sensory evaluators, with each panelist assessing all treatment samples.

2.5. Data Analysis

The experimental data were analyzed using Microsoft Excel 2019 and SPSS version 21.0. Normality and homogeneity tests were conducted prior to statistical analysis. Data that met the assumptions were analyzed using one-way Analysis of Variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at a significance level of 0.05 to determine differences among treatments.

3. RESULTS AND DISCUSSION.

The production of catfish sausage was carried out with the addition of chicken eggshell powder at various ratios. Based on the research results, the ratios of chicken eggshell powder addition were determined as F0 (100%:0%), F1 (90%:10%), F2 (80%:20%), and F3 (70%:30%). The visual appearance of catfish sausage with the

addition of chicken eggshell powder is presented in Figure 3.

This study involved 30 untrained panelists who voluntarily participated in the sensory evaluation. Prior to the evaluation, all panelists were informed about the research procedures and provided their consent to participate. The study ensured confidentiality and anonymity of the participants

Figure 3. Catfish Sausage with Eggshell Flour

Formulation Description:
F0: 100% catfish meat and 0% eggshell powder
F1: 90% catfish meat and 10% eggshell powder
F2: 80% catfish meat and 20% eggshell powder
F3: 70% catfish meat and 30% eggshell powder

3.1. Organoleptic Results

In this study, sensory analysis was conducted by 30 untrained panelists who were students of Universitas Ahmad Dahlan. Organoleptic evaluation consisted of hedonic and descriptive tests. The sensory acceptance attributes evaluated in this study included color, smell, texture, taste, *aftertaste*, and overall acceptability. The hedonic assessment was expressed using a 5-point scale, ranging from 1 (very dislike), 2 (dislike), 3 (slightly like), 4 (like), to 5 (verry like). The results of the organoleptic evaluation of catfish sausage with the addition of chicken eggshell powder are presented in Table 2.

Table 2. Hedonic Scores of Catfish Sausage

Parameter	Sample				P- Value
	F0	F1	F2	F3	
Color	4.13 ± 0.62^{c}	3.87 ± 0.73^{b}	3.87 ± 0.57^{b}	3.70 ± 0.70^{a}	0.091
Smell	3.53 ± 0.81^{b}	3.53 ± 0.77^{b}	3.63 ± 0.76^{c}	3.47 ± 0.81^{a}	0.880
Texture	4.17 ± 0.69^{d}	3.70 ± 0.79^{c}	3.33 ± 0.84^{a}	3.37 ± 0.96^{b}	0.001
Taste	4.10 ± 0.80^{d}	3.73 ± 0.74^{c}	3.60 ± 0.77^{b}	3.33 ± 0.99^{a}	0.006
Aftertaste	4.00 ± 0.74^{d}	3.70 ± 0.83^{c}	3.60 ± 0.77^{b}	3.17 ± 0.87^{a}	0.001
Overall	4.30 ± 0.59^{d}	3.80 ± 0.76^{c}	3.73 ± 0.69^{b}	3.30 ± 0.95^{a}	0.001

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

a). Color

The average hedonic scores for the color acceptability of catfish sausage fortified with eggshell powder ranged from 3.70 to 4.13, corresponding to categories from "very dislike" to "very like." One Way ANOVA followed by Duncan's Multiple Range Test revealed a significant effect of eggshell powder addition on color preference ($p < 0.05$). Duncan's test indicated that formulations F1 and F2 were not significantly different from each other, but differed significantly from F0 and F3.

The mean hedonic scores were 4.13 for F0, 3.87 for F1, 3.87 for F2, and 3.70 for F3. These results indicate that color acceptability decreased with increasing levels of eggshell powder. The most preferred color was observed in formulation F0, without eggshell powder addition, whereas the least preferred color was found in formulation F3, containing 30% eggshell powder.

The decline in color acceptability can be attributed to the effect of calcium carbonate on the visual characteristics of the sausage. Calcium carbonate, the main component of eggshell powder, can alter light reflection and absorption in food matrices, affecting perceived color (Amna et al., 2023). Fortification with high levels of eggshell

powder has been shown to change color parameters in baked goods and processed foods, thereby reducing consumer preference (Esmaeili et al., 2025). Additionally, excessive mineral addition may negatively affect visual appeal, which explains the lower hedonic scores in formulations with higher eggshell powder levels (Brun et al., 2013). A recent study also confirmed that calcium carbonate fortification can influence color perception in food matrices in a dose-dependent manner (Alvarez, 2024) The results of the descriptive color evaluation of catfish sausage are presented in Table 3.

Table 3. Descriptive Sensory Evaluation of Catfish Sausage Color

Attribute	Formulation (%)			
	F0	F1	F2	F3
White	10	3.3	10	20
Off-white	20	26.7	20	20
Brownish white	33.3	23.3	30	23.3
Grayish white	33.3	43.3	40	23.3
Dark gray	3.3	3.3	0	13.3

The descriptive test results for the color attributes of catfish sausage showed that in formulation F0, most panelists perceived the color as brownish white (33.3%) and grayish white (33.3%). In formulation F1, the majority of panelists selected grayish white (43.3%). Similarly, in formulation F2, most panelists also perceived the color as grayish white (40%). In formulation F3, panelists predominantly selected brownish white (23.3%) and grayish white (23.3%).

Based on the hedonic test results presented in Table 2. The most preferred color was observed in formulation F0 (100% catfish: 0% eggshell powder). Therefore, it can be concluded that the most acceptable color of catfish sausage was obtained in formulation F0, characterized by brownish white (33.3%) and grayish white (33.3%) color attributes.

b). Smell

The average hedonic scores for the smell acceptability of catfish sausage fortified with eggshell powder ranged from 3.47 to 3.63, corresponding to categories from “very dislike” to “very like.” The results of One Way ANOVA followed by Duncan’s Multiple Range Test indicated that the addition of eggshell powder significantly affected panelists’ preference for smell ($p < 0.05$). Duncan’s test revealed that formulations F0 and F1 were not significantly different from each other, but differed significantly from F2 and F3.

The mean hedonic scores for each formulation were 3.53 for F0, 3.53 for F1, 3.63 for F2, and 3.47 for F3. These results show that the most preferred smell was observed in formulation F2, containing 20% eggshell powder, whereas the least preferred smell was found in formulation F3, with 30% eggshell powder addition.

The differences in smell preference can be explained by general food aroma theory. Food aroma is determined by volatile compounds released during consumption, and the composition of the food matrix can influence how these compounds are perceived by panelists (Al-khalili et al., 2025). Moreover, literature reviews indicate that the addition of eggshell powder can affect organoleptic characteristics, including aroma, with panelists tending to dislike the aroma at higher concentrations, which negatively impacts overall product acceptability (Apsari et al., 2024). These findings are consistent with the current study, where moderate fortification (F2) maintained smell acceptability, while excessive addition (F3) decreased panelists’ preference. The results of the descriptive smell evaluation of catfish sausage are presented in Table 4.

Table 4. Descriptive Sensory Evaluation of Catfish Sausage Smell

Attribute	Formulation			
	F0	F1	F2	F3
Non-fishy, slightly spiced	40	33.3	33.3	40
Slightly fishy, slightly spiced	33.3	23.3	20	20
Non-fishy, not spiced	10	30	20	20
Slightly fishy, not spiced	16.7	6.7	23.3	13.3
Fishy	0	6.7	3.3	6.7

The descriptive test results for the Smell attributes of catfish sausage showed that in formulation F0, most panelists perceived the Smell as non-fishy and slightly spiced (40%). Similarly, in formulation F1, the majority of panelists selected non-fishy and slightly spiced Smell (33.3%). In formulation F2, most panelists also perceived the Smell as non-fishy and slightly spiced (33.3%), while in formulation F3, the predominant perception was likewise non-fishy and slightly spiced (40%).

Based on the hedonic Smell test results presented in Table 2, the most preferred Smell was observed in formulation F2, with a score of 3.63. Therefore, it can be concluded that the most acceptable Smell of catfish sausage was obtained in formulation F2, characterized by a non-fishy and slightly spiced Smell. The absence of a fishy odor in the catfish sausage may be attributed to the use of fresh fish meat, which minimizes lipid oxidation that commonly causes off-odors in fish products (Bernadeta et al., 2022). In addition, the use of seasoning ingredients such as garlic powder, ginger powder, and white pepper powder may naturally contribute to masking fishy odors and enhancing the overall Smell.

c). Texture

The average hedonic scores for the texture of catfish sausage fortified with eggshell powder ranged from 3.33 to 4.17. The results of One Way ANOVA followed by Duncan's Multiple Range Test revealed that the addition of eggshell powder significantly affected the panelists' preference for texture ($p < 0.001$). Formulation F0 obtained the highest texture score (4.17), while the lowest score was recorded in F2 (3.33). These findings indicate that increasing the proportion of eggshell powder tended to reduce panelists' acceptance of the sausage texture.

The decline in texture preference may be associated with the physical properties of eggshell powder incorporated in the formulation. Eggshell is widely recognized as a rich source of calcium carbonate and has been explored as an alternative calcium source for food fortification (Brun et al., 2013). The shell structure is mainly composed of calcium carbonate crystals forming a compact and rigid matrix (King'ori, 2011). When eggshell powder is added to food products, the presence of mineral particles can influence the physical characteristics of the product, including its texture.

A comparable trend was reported in a study investigating the application of eggshell powder in brownies, where increasing levels of eggshell powder led to changes in textural properties and decreased sensory acceptance at higher concentrations (Esmaeili et al., 2025). This suggests that excessive incorporation of eggshell powder may negatively affect the sensory attributes of fortified food products. The results of the descriptive texture evaluation of catfish sausage are presented in Table 5.

Table 5. Descriptive Sensory Evaluation of Catfish Sausage Texture

Attribute	Formulation			
	F0	F1	F2	F3
Not chewy	0	0	23.3	13.3
Slightly chewy	10	36.7	20	36.7
Chewy	70	46.7	43.3	36.7
Very chewy	20	1.6	13.3	13.3

The descriptive test results for the texture attributes of catfish sausage indicated that in formulation F0, most panelists perceived the texture as chewy (70%). In formulation F1, the majority of panelists also selected a chewy texture (46.7%), while in formulation

F2, most panelists described the texture as chewy (43.3%). In formulation F3, panelists predominantly selected slightly chewy (36.7%) and chewy (36.7%) textures.

Based on the hedonic texture test results presented in Table 2, the highest texture preference was observed in formulation F0, with a score of 4.17. Therefore, it can be concluded that the most acceptable texture of catfish sausage was obtained in formulation F0, characterized by a chewy texture.

Texture characteristics of sausage products are strongly influenced by their moisture content and water distribution within the protein matrix. Previous studies reported that moisture content plays an important role in determining the softness and elasticity of sausage texture, as water contributes to the formation and stability of the protein gel structure during processing (Kim et al., 2022).

In this study, the proximate analysis showed that formulation F0 had the highest moisture content (62.37%) compared to the other formulations. This condition likely contributed to the formation of a more elastic and desirable texture, which explains why formulation F0 received the highest preference score from the panelists.

d). Flavor

The mean hedonic scores for the flavor acceptability of catfish sausage substituted with eggshell powder ranged from 3.33 to 4.10, corresponding to categories from dislike to like. Statistical analysis using One Way ANOVA followed by Duncan's Multiple Range Test showed significant differences among the formulations ($p < 0.01$). The mean hedonic flavor scores were 4.10 for F0, 3.73 for F1, 3.60 for F2, and 3.33 for F3. These results indicate that flavor acceptability decreased as the level of eggshell powder increased.

The decrease in flavor preference may be related to the mineral composition of eggshell powder, which is primarily composed of calcium carbonate (CaCO3). The addition of mineral-rich ingredients into food products may alter the natural flavor profile and produce a slightly chalky or mineral-like taste when used in high concentrations.

Previous studies have reported similar findings in fortified food products. Sana et al. (2022) observed that the incorporation of eggshell powder in biscuit formulations affected sensory properties, including flavor and overall acceptability, particularly at higher concentrations. Therefore, the higher concentration of eggshell powder in formulations F2 and F3 likely contributed to the lower flavor preference scores observed in this study. The results of the descriptive flavor evaluation of catfish sausage are presented in Table 6.

Table 6. Descriptive Sensory Evaluation of Catfish Sausage Flavor

Attribute	Formulation			
	F0	F1	F2	F3
Fish flavor not detectable	3.3	6.7	10	20
Fish flavor slightly detectable	30	46.7	40	36.7
Fish flavor detectable	46.7	40	43.3	33.3
Fish flavor strongly detectable	20	6.7	6.7	10

The descriptive test results for the flavor attributes of catfish sausage showed that in formulation F0, most panelists perceived the fish flavor as distinct (46.7%). In formulation F1, the majority of panelists perceived the fish flavor as slightly noticeable (46.7%). In formulation F2, most panelists perceived the fish flavor as distinct (43.3%), whereas in formulation F3, panelists predominantly perceived the fish flavor as slightly noticeable (36.7%). Based on the hedonic flavor test results presented in Table 2, the most preferred flavor was observed in formulation F0, with a score of 4.10. Therefore, it can be concluded that the most acceptable flavor of catfish sausage was obtained in formulation F0, characterized by a distinct fish flavor.

Furthermore, the highest flavor acceptability was observed in formulation F0 (without eggshell powder addition), with a score of 4.17, while the lowest flavor acceptability was found in formulation F2 (with 20% eggshell powder addition), with a score of 3.33. Similar findings were reported by Olomia et al. (2024) who observed significant changes in the flavor of sorghum cookies fortified with chicken eggshell powder. Increasing concentrations of eggshell powder resulted in decreased panelist preference for the flavor of sorghum cookies.

e). Aftertaste

The average hedonic scores for the aftertaste acceptability of catfish sausage fortified with eggshell powder ranged from 3.17 to 4.00. One Way ANOVA followed by Duncan's Multiple Range Test indicated that the addition of eggshell powder significantly affected the panelists' aftertaste preference ($p = 0.001$). Formulation F0 received the highest score (4.00), while the lowest score was recorded for F3 (3.17). These results indicate that aftertaste acceptability tended to decrease with increasing levels of eggshell powder.

In the study by Esmaeili et al. (2025) panelists evaluated the mouthfeel and aftertaste of brownies fortified with eggshell powder and reported lower acceptability at higher addition levels. The decrease in aftertaste preference is likely related to the physical effects of mineral particles from eggshell powder on mouth sensation. Calcium carbonate, the main component of eggshell powder, is known to affect sensory attributes and texture in food products at high concentrations (Alvarez, 2024). Furthermore, literature reviews indicate that product acceptability generally decreases with higher eggshell powder concentration, particularly regarding aftertaste and gritty mouthfeel in various food products (Apsari Pebrianti et al., 2024).

Based on the hedonic evaluation, it can be concluded that the most acceptable aftertaste of catfish sausage was obtained in formulation F0, whereas formulations with higher proportions of eggshell powder tended to produce a sandy or gritty aftertaste that was less preferred. These findings emphasize the importance of optimizing the proportion and particle size of eggshell powder in calcium fortification to maintain desirable sensory attributes. The results of the descriptive aftertaste evaluation of catfish sausage are presented in Table 7.

Table 7. Descriptive Sensory Evaluation of Catfish Sausage Aftertaste

Attribute	Formulation			
	F0	F1	F2	F3
Not gritty	66.7	26.7	16.7	10
Slightly gritty	23.3	53.3	40	10
Gritty	10	13.3	36.7	33.3
Very gritty	0	6.7	6.7	46.7

The descriptive test results for the aftertaste attributes of catfish sausage showed that in formulation F0, most panelists perceived the aftertaste as not gritty (66.7%). In formulation F1, the majority of panelists selected a slightly gritty aftertaste (53.3%). Similarly, in formulation F2, most panelists perceived the aftertaste as slightly gritty (40%), whereas in formulation F3, panelists predominantly perceived the aftertaste as very gritty (46.7%).

Based on the hedonic aftertaste test results presented in Table 2. The most preferred aftertaste was observed in formulation F0, with a score of 4.00. Therefore, it can be concluded that the most acceptable aftertaste of catfish sausage was obtained in formulation F0, characterized by a not gritty aftertaste. Similar findings were reported by Ayu et al. (2015) who observed a significant change in the sensory quality of cookies fortified with chicken eggshell powder. Increasing concentrations of eggshell powder resulted in decreased panelist preference for cookie aftertaste. Most panelists in the present study also perceived samples from formulations F1 to F3 as having a sandy or gritty aftertaste, which may be attributed to the increasing levels of eggshell powder addition.

e). Overall

`Table 2 shows that the mean hedonic scores for the overall acceptability of catfish sausage substituted with eggshell powder ranged from 3.30 to 4.30, corresponding to categories from very dislike to very like. The results of the One Way ANOVA followed by Duncan's Multiple Range Test indicated significant differences among formulations at a significance level of $p < 0.001$, showing that formulations F0, F1, F2, and F3 differed significantly from each other. The mean hedonic overall scores were 4.30 for F0, 3.80 for F1, 3.73 for F2, and 3.30 for F3. These results indicate that overall acceptability decreased with increasing levels of eggshell powder addition. The most preferred overall acceptability was observed in formulation F0 (without eggshell powder addition), with a score of 4.30, while the least preferred was found in formulation F3 (with 30% eggshell powder addition), with a score of 3.30.

The decrease in overall acceptability was consistent with the decline in flavor and aftertaste, which are key determinants of consumer acceptance. Changes in sensory characteristics due to the addition of functional ingredients may influence the overall product evaluation by panelists (Silsia et al., 2025). Similar findings were reported by Kurniawan et al. (2024) who observed significant changes in the overall acceptability of sorghum cookies fortified with chicken eggshell powder, where increasing concentrations of eggshell powder resulted in decreased panelist preference.

Based on the overall hedonic test results, formulation F0 was the most preferred by panelists. However, to support nutritional fortification for consumers at risk of calcium deficiency, formulation F1 was selected due to its higher calcium content. The selection of formulation F1 represents a balance between sensory preference and functional nutritional benefits.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusion

The incorporation of chicken eggshell (*Gallus gallus domesticus*) powder significantly influenced the sensory attributes of catfish (*Clarias batrachus*) sausage. The mean hedonic scores for each attribute were as follows: color ranged from 3.70 to 4.13, with the highest score observed in F0; aroma ranged from 3.47 to 3.63, with F2 being most preferred; texture ranged from 3.33 to 4.17, with F0 receiving the highest score; flavor ranged from 3.33 to 4.10, with F0 as the most favored; aftertaste ranged from 3.17 to 4.00, with F0 achieving the highest acceptance. Overall acceptability followed a similar trend, with F0 scoring the highest.

Although higher levels of eggshell powder tended to reduce panelists' preference, particularly in texture, flavor, and aftertaste due to a gritty sensation, the formulation containing 10% eggshell powder (F1) maintained acceptable sensory quality while providing additional nutritional benefits through calcium enrichment. Therefore, F1 was identified as the most suitable formulation, offering an optimal balance between sensory quality and functional value.

4.2. Recommendations

Further research is recommended to assess the physicochemical properties, calcium concentration, and calcium bioavailability of catfish sausage fortified with chicken eggshell powder to support its application as a functional food product. Additionally, improving the processing of eggshell powder, such as reducing particle size or applying appropriate pre-treatment techniques, is suggested to minimize gritty texture and enhance sensory acceptance at higher fortification levels. Future studies involving a larger and more diverse group of panelists, as well as shelf-life and consumer preference evaluations, are also recommended to facilitate the development of this product for commercial purposes.

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