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FORMULATION OF *HILSA KELEE* FISH MEATBALLS WITH VARIATIONS IN SEAWEED FLOUR CONCENTRATION: A STUDY OF QUALITY AND CONSUMER PREFERENCES

Formulasi Bakso *Hilsa kelee* dengan Variasi Konsentrasi Tepung Rumput Laut: Kajian Kualitas dan Preferensi Konsumen

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ABSTRACT

Hilsa kelee is an abundant fishery commodity in Balinese waters and has great potential as a raw material for functional food products due to its high protein content and omega-3 fatty acids. One popular form of processing is fish meatballs. However, challenges in improving sensory quality and nutritional value remain a concern. This study aims to investigate the effect of adding seaweed flour in various concentrations (0%, 1%, 2%, 3%, and 4%) on the quality and consumer preference of Mata Belo fish meatball products. Seaweed is known to contain fiber, minerals, and bioactive compounds that can improve the functional and organoleptic characteristics of food products. This study was conducted at the Teaching Factory of the Marine and Fisheries Polytechnic of Jembrana in February–March 2025, using experimental methods and sensory tests (SNI 7266:2017) and hedonic (SNI 2346:2015) with 30 panelists. Data analysis was carried out using the Kruskal-Wallis and Mann-Whitney tests. The results showed that the addition of seaweed flour significantly affected the odor and taste attributes ($p < 0.001$), but did not significantly affect the appearance and texture ($p > 0.05$). Meanwhile, the hedonic test showed that the concentration variation did not significantly affect the panelists' preference level for all attributes ($p > 0.05$). The addition of seaweed flour up to 4% can improve sensory quality without reducing consumer preference. This research contributes to the development of functional food products based on local fish and seaweed that are value-added and competitive.

Keywords: Seaweed Fortification, Belo Eye Fish, Innovative Fish Meatballs, Functional Food, Processed Products

ABSTRAK

Ikan Mata Belo (*Hilsa kelee*) merupakan komoditas perikanan yang melimpah di perairan Bali dan memiliki potensi besar sebagai bahan baku produk pangan fungsional karena kandungan

proteinnya yang tinggi dan asam lemak omega-3. Salah satu bentuk pengolahannya yang populer adalah bakso ikan. Namun, tantangan dalam peningkatan kualitas sensoris dan nilai gizi masih menjadi perhatian. Penelitian ini bertujuan untuk menanamkan pengaruh penambahan tepung rumput laut dalam berbagai konsentrasi (0%, 1%, 2%, 3%, dan 4%) terhadap kualitas dan preferensi konsumen pada produk bakso ikan Mata Belo. Rumput laut dikenal memiliki kandungan serat, mineral, serta senyawa bioaktif yang dapat meningkatkan karakteristik fungsional dan organoleptik produk pangan. Penelitian ini dilakukan di *Teaching Factory* Politeknik KP Jembrana pada Februari–Maret 2025, menggunakan metode eksperimen dan uji sensori (SNI 7266:2017) serta hedonik (SNI 2346:2015) dengan 30 panelis. Analisis data dilakukan dengan uji Kruskal-Wallis dan Mann-Whitney. Hasil menunjukkan bahwa penambahan tepung rumput laut secara signifikan mempengaruhi atribut bau dan rasa ($p < 0,001$), namun tidak berpengaruh signifikan terhadap penampakan dan tekstur ($p > 0,05$). Sementara itu, uji hedonik menunjukkan bahwa variasi konsentrasi tidak secara signifikan mempengaruhi tingkat kesukaan panelis pada semua atribut ($p > 0,05$). Penambahan tepung rumput laut hingga 4% dapat meningkatkan kualitas sensori tanpa menurunkan preferensi konsumen. Penelitian ini memberikan kontribusi dalam pengembangan produk pangan fungsional berbasis ikan lokal dan rumput laut yang bernilai tambah serta berdaya saing.

Kata Kunci: Fortifikasi rumput laut, Ikan mata belo, Bakso ikan inovatif, Pangan fungsional, Produk olahan

INTRODUCTION

The Mata Belo fish (*Hilsa kelee*), abundant in Indonesian waters, particularly in Bali, is a marine fishery commodity with high nutritional value. This fish is rich in protein and omega-3 fatty acids, making it an ideal raw material for processed functional food products (Bhakta *et al*., 2022; Meepegamage *et al*., 2022). Fish balls, a popular processed product, are highly sought after by the public due to their chewy texture, savory flavor, and practicality. However, the development of fish balls still faces challenges in improving sensory quality, product stability, and diversification without sacrificing nutritional value (Lulu *et al*., 2022; Poluakan *et al*., 2015; Sen *et al*., 2022). As consumer awareness of the importance of health increases, food product innovation that integrates natural ingredients with functional benefits is highly relevant (Fadlan *et al*., 2022; Lesmana *et al*., 2022; Wally *et al*., 2022; You *et al*., 2024).

Seaweed, one of Indonesia's marine biodiversity, has long been recognized as a source of dietary fiber, minerals, vitamins, and bioactive compounds such as polysaccharides and antioxidants (Adhawati & Nuryanti, 2021; Erniati *et al*., 2023; Herawati *et al*., 2022; Laapo *et al*., 2022; Langford *et al*., 2023; Lestari *et al*., 2020; Raja *et al*., 2021; Rimmer *et al*., 2021; Rosmawaty *et al*., 2022; Saleh *et al*., 2023; Sinurat *et al*., 2022; Sumule *et al*., 2021; Sunadji & Lukas, 2023; Tabrani *et al*., 2022; Unsworth *et al*., 2018; Widyartini *et al*., 2023). Various studies have demonstrated the potential of seaweed to improve the functional properties of food products, including air-enveloping capacity, emulsifying properties, and even organoleptic profiles, which ultimately can enhance quality and nutritional value. For example, the addition of seaweed flour has been shown to affect the texture and shelf life of several processed meat products (Nugraha & Desnanjaya, 2021; Rizkaprilisa, 2023; Saraswati *et al*., 2022; Yudiastuti *et al*., 2022). However, the specific application of seaweed flour as a fortification or functional modification of Mata Belo fish (*Hilsa kelee*) meatballs remains limited and underexplored, particularly its impact on quality characteristics and consumer preferences.

Given the potential of *Hilsa kelee* fish and the functional benefits of seaweed, this research is crucial to fill this knowledge gap. This study focuses on the formulation of Mata Belo fish (*Hilsa kelee*) meatballs with varying seaweed flour concentrations: a quality assessment and consumer preference assessment. This study aims to scientifically examine

how the addition of various seaweed flour concentrations affects the quality characteristics of the fishballs, including physical, chemical, and especially organoleptic aspects. Furthermore, this study also examines the level of consumer acceptance or preference for this innovative product. The results of this study are expected to not only optimize the use of Mata Belo fish and local seaweed but also provide important information for the development of new functional food products that are healthy, value-added, and widely accepted by the market.

METHODS

This research was conducted from February to March 2025. All processing and some testing took place at the Marine Product Processing Teaching Factory of the Jembrana Marine and Fisheries Polytechnic, Bali. Data collection in this study utilized four main techniques: observation, experimentation, documentation, and literature review.

Direct observations were made throughout the entire Mata Belo (*Hilsa kelee*) fish meatball production process, including sensory testing (SNI 7266:2017) and hedonic testing (SNI 2346:2015). The testing involved 30 panelists, with three repetitions, to assess product preference using a scoresheet based on a 9-point scale, ranging from 1 (dislike extremely) to 9 (like extremely). Meanwhile, sensory testing was conducted to assess product quality attributes, such as color, aroma, texture, and taste, using a 5-, 7-, or 9-point scale depending on the attribute.

The experimental method used in producing Mata Belo fish meatballs used five seaweed flour concentration treatments: 0% (control), 1%, 2%, 3%, and 4% of the fish meat weight. These treatments were created by the researcher in accordance with several previous research studies that conducted similar activities in the process of making fish meatballs (Loso & Pascual, 2020; Mussayadah *et al*., 2020; Nugroho *et al*., 2020; Nurbety Tarigan, 2020; Sipahutar *et al*., 2021). Each treatment was tested to determine the effect of varying concentrations on consumer preference (hedonic test) and product sensory quality (sensory test). The treatments used are shown in Tables 1 and 2, and the meatball production process can be seen in Table 3.

Documentation in this study serves as a complement to observational data, which was systematically conducted to record all stages of the meatball production process and testing. Documentation was conducted through photographic recordings, covering the process of ingredient preparation, dough mixing, meatball formation, boiling, and final presentation. Furthermore, documentation also included quality testing activities, such as organoleptic testing and observations of product texture or appearance, to provide visual evidence supporting the process description. Documentation was conducted not only to support the validity of the data but also to facilitate report preparation and presentation of information to readers. The resulting documentation, in the form of photographs, videos, and field notes, was archived in a structured manner and used as supporting appendices in the research report.

Meanwhile, a literature review was conducted to strengthen the theoretical foundation and support the analysis and discussion of the research results. The literature review involved searching for and gathering information from various scientific sources, such as textbooks, research journals, scientific articles, previous reports, and other academic sources relevant to the research topic. The information obtained was used to understand the characteristics of raw materials, fishball processing techniques, quality measurement principles, and sensory and nutritional standards for processed fish products. The literature review also assisted researchers in developing appropriate methods and comparing the results with those of previous studies. Thus, the literature review not only enriched theoretical insights but also strengthened the scientific arguments presented in the research discussion and conclusions.

The data obtained were processed and presented in a concise and structured format. Qualitative and descriptive data from observations and documentation were compiled in

narrative and visual forms. Quantitative data from sensory and hedonic tests were analyzed using Microsoft Excel and SPSS 29.0.2.0 software. Prior to statistical testing, the data were tested for normality to determine their distribution. The results of the normality test showed that the data were not normally distributed ($p < 0.05$), so statistical analysis was performed using the Kruskal-Wallis test, a non-parametric method to determine significant differences between treatments. If a significant difference was found based on the Kruskal-Wallis test results, a post hoc test using the Mann-Whitney test was conducted to determine which treatment group was significantly different.

Table 1. Treatments with Seaweed Addition in Mata Belo Fish Meatballs

Sample	Code	Treatment	Concentration
1	K	Control	0
2	P1	Treatment 1	1%
3	P2	Treatment 2	2%
4	P3	Treatment 3	3%
5	P4	Treatment 4	4%

Table 2. Composition of Mata Belo Fish Meatball Dough

Ingredients	A1	A2	A3	A4	A5
Mata belo fish meat	250 g	250 g	250 g	250 g	250 g
Tapioca flour	37.5 g	37.5 g	37.5 g	37.5 g	37.5 g
Garlic	20 g	20 g	20 g	20 g	20 g
Salt	6.25 g	6.25 g	6.25 g	6.25 g	6.25 g
Pepper	2.5 g	2.5 g	2.5 g	2.5 g	2.5 g
Lime juice	1.25 g	1.25 g	1.25 g	1.25 g	1.25 g
Ice cubes	6.25 g	6.25 g	6.25 g	6.25 g	6.25 g
STPP	8 g	8 g	8 g	8 g	8 g
Seaweed flour	0	2.5 g	5 g	7.5 g	10 g

Table 3. Processing of Mata Belo Fish Meatballs with Different Concentrations of Seaweed Flour

Activity Description	Documentation
Collection of mata belo fish	

Activity Description	Documentation
Collection of meatball ingredients	
Meatball-making equipment	
Mixing process of ingredients	
Meatball molding process	
Meatball boiling process	

Activity Description	Documentation
Mata belo fish meatballs with various concentrations of seaweed flour	
Hedonic and sensory testing	

RESULTS

Sensory analysis is a crucial step in evaluating food product quality, as it provides insight into the organoleptic characteristics and consumer acceptance levels. In this study, descriptive and hedonic sensory tests were conducted on mata belo fish meatballs supplemented with seaweed flour at various concentrations. The results of the statistical analysis using the Kruskal–Wallis test are presented in Tables 4 and 5, which demonstrate differences and similarities between treatments in several observed sensory attributes.

Based on the Kruskal–Wallis test results presented in Tables 4 and 5, it is known that in the descriptive sensory test (Table 4), the appearance and texture attributes showed no significant differences between treatments ($p > 0.05$), with a relatively high and consistent median score of 9. Conversely, significant differences were identified in the odor and taste attributes ($p < 0.001$). Samples 2 and 4 tended to achieve lower median scores than the other samples, indicating that the addition of seaweed flour at certain concentrations affected panelists' perceptions of the odor and taste of mata belo fish meatballs.

Meanwhile, the results of the hedonic test (Table 5), which assessed panelists' preference levels, showed that all observed attributes—including appearance, odor, taste, texture, chewiness, and color—did not differ significantly between treatments ($p > 0.05$). All samples achieved high median scores (the majority scored 9), indicating that panelists generally preferred all variations of the mata belo fish meatball formulations with the addition of seaweed flour at various concentrations.

Therefore, it can be concluded that although there were significant differences in odor and taste attributes in the descriptive sensory assessment, these did not impact overall consumer acceptance, as the hedonic test results indicated that all treatments remained well-received by panelists.

Table 4. Kruskal-Wallis Test Results of Sensory Evaluation

Variable	Sample	n	Brinkman Index	p-value
Appearance	1	90	9 (5–9)	p > 0.05
	2	90	7 (5–9)	
	3	90	9 (5–9)	
	4	90	9 (5–9)	
	5	90	9 (5–9)	
Odor	1	90	9 (5–9)	p < 0.001
	2	90	7 (5–9)	
	3	90	9 (7–9)	
	4	90	8 (5–9)	
	5	90	9 (5–9)	
Taste	1	90	9 (5–9)	p < 0.001
	2	90	7 (7–9)	
	3	90	9 (5–9)	
	4	90	7 (5–9)	
	5	90	9 (5–9)	
Texture	1	90	9 (5–9)	p > 0.05
	2	90	9 (7–9)	
	3	90	9 (5–9)	
	4	90	9 (5–9)	
	5	90	9 (5–9)	

Table 5. Kruskal-Wallis Test Results of Hedonic Evaluation

Variable	Sample	n	Brinkman Index	p-value
Appearance	1	90	9 (6–9)	p > 0.05
	2	90	9 (6–9)	
	3	90	9 (7–9)	
	4	90	9 (7–9)	
	5	90	9 (7–9)	
Odor	1	90	9 (6–9)	p > 0.05
	2	90	9 (6–9)	
	3	90	9 (6–9)	
	4	90	9 (6–9)	
	5	90	9 (5–9)	
Taste	1	90	9 (7–9)	p > 0.05
	2	90	9 (6–9)	
	3	90	9 (6–9)	
	4	90	9 (6–9)	
	5	90	9 (6–9)	
Texture	1	90	9 (6–9)	p > 0.05
	2	90	9 (6–9)	
	3	90	9 (6–9)	

	4	90	9 (5–9)	
	5	90	9 (6–9)	
Chewiness	1	90	9 (7–9)	p > 0.05
	2	90	9 (7–9)	
	3	90	9 (6–9)	
	4	90	9 (7–9)	
	5	90	9 (5–9)	
Color	1	90	9 (6–9)	p > 0.05
	2	90	9 (7–9)	
	3	90	9 (6–9)	
	4	90	9 (7–9)	
	5	90	9 (6–9)	

DISCUSSION

Hilsa kelee fish meatball making process

The Mata Belo fish meatball (*Hilsa kelee*) is made as an effort to diversify processed fishery products, offering high economic value and the potential to increase the competitiveness of local fish-based products. The production process begins with selecting high-quality fresh Mata Belo fish, followed by cleaning, washing, and separating the meat from bones, skin, and fine spines. The fish meat is then soaked in lime juice to reduce the fishy odor characteristic of sea fish. After soaking, the meat is thinned and weighed according to the formulation requirements.

The meatball dough formulation consists of Mata Belo fish meat, tapioca flour, additional spices, and seaweed flour in varying concentrations of 0%–4%. To maintain the dough's texture and elasticity, ice cubes are added during the mixing process. The resulting dough is then mashed again, shaped into balls using your hands or a spoon, and boiled in two stages: first boiling in hot (not boiling) water to solidify the meatball structure, and then boiling in boiling water until fully cooked. Afterward, the meatballs were immediately immersed in ice water to stop the cooking process and maintain product quality. The final stage of the production process was sensory and hedonic testing by panelists, with assessments covering color, aroma, texture, flavor, chewiness, and overall liking.

Sensory test results for *Hilsa kelee* fish balls

Sensory tests were conducted to assess the organoleptic characteristics of Mata Belo fish balls with the addition of seaweed flour at various concentrations (0%, 1%, 2%, 3%, and 4%). The assessment data were analyzed using the non-parametric Kruskal–Wallis statistical test, as the data were not normally distributed. The analysis results showed a significance value of 0.084 for appearance, $p < 0.001$ for odor, $p < 0.001$ for taste, and 0.293 for texture. Based on these values, it can be concluded that only odor and taste attributes differed significantly between treatments ($p < 0.05$), while appearance and texture did not show significant differences ($p > 0.05$). This indicates that the concentration of seaweed flour primarily affected panelists' perceptions of odor and taste, but did not significantly affect the product's appearance and texture.

To further identify differences between treatments, a Mann–Whitney test was performed as a follow-up analysis. The analysis results showed that when comparing the control sample (0%) and the sample with 1% seaweed flour, there were significant differences in appearance and odor, but not in taste and texture. Between the control and the sample with 2% flour, only odor showed a significant difference, while other attributes were consistent. Between the

control and the 3% sample, a significant difference only appeared in taste. Meanwhile, between the control and the 4% sample, there were no significant differences in any attributes.

Furthermore, comparisons between other treatments also showed variation in results. The most significant differences were found between samples 2 (1%) and 3 (2%), namely in appearance, odor, and taste. However, in other combinations, such as samples 3 and 5, and 4 and 5, almost all attributes were not significantly different, except for taste in the comparison of samples 4 and 5. In general, sensory differences were more frequent at low to medium concentrations (1%–3%), while at high concentrations (4%) the differences were less pronounced compared to the control. These findings confirm that seaweed flour plays a role in influencing the sensory quality of meatballs, particularly in odor and flavor attributes, which are important for consumer preference.

Hedonic test results for *Hilsa kelee* fish balls

The hedonic test aims to assess the panelists' overall level of preference for the product, thus determining consumer acceptance. The Kruskal–Wallis test analysis of hedonic attributes showed a significance value of 0.328 for appearance, 0.662 for odor, 0.937 for taste, 0.237 for texture, 0.739 for chewiness, and 0.577 for color. All p-values were > 0.05, indicating no significant differences between treatments in panelists' preference for any attribute.

Further analysis using the Mann–Whitney test on paired sample combinations (1 with 2, 1 with 3, 1 with 4, 1 with 5, 2 with 3, 2 with 4, 2 with 5, 3 with 4, 3 with 5, and 4 with 5) also showed similar results, with no significant differences across all tested attributes. This indicates that although variations in seaweed flour affected some descriptive sensory attributes (odor and taste), they did not affect the overall level of panelist acceptance.

Therefore, it can be concluded that the addition of seaweed flour up to a concentration of 4% in the mata belo fish meatball formulation did not reduce panelist preference. All treatments still achieved high median scores, particularly around 9, indicating that the product was well-received by consumers. This finding is crucial in the context of developing processed fish products, as seaweed flour can serve as a functional additive without compromising the product's organoleptic quality in the eyes of consumers.

CONCLUSION

Research on the production and quality evaluation of *Hilsa kelee* fish meatballs with the addition of seaweed flour showed that the entire production process, from selecting fresh fish, processing the meat, adding formulation ingredients, to forming and boiling, ran according to established procedures. The variation in seaweed flour concentration used ranged from 0% to 4% of the weight of the fish meat, with the aim of improving texture and adding nutritional value, as well as diversifying processed fish products. The results of sensory tests revealed that odor and taste attributes experienced significant differences between treatments, as indicated by the Kruskal-Wallis test with a p value < 0.001, while appearance and texture attributes showed no significant differences (p > 0.05). Further tests using the Mann-Whitney method also confirmed significant differences in odor and taste between several pairs of samples, although not consistent across attributes. Meanwhile, the results of the hedonic test showed that consumer preferences were not significantly affected by variations in seaweed concentration, as assessments of appearance, odor, taste, texture, chewiness, and color showed p values > 0.05 in both the Kruskal-Wallis and Mann-Whitney tests. Overall, this study concluded that the addition of seaweed flour up to 4% did not reduce consumer preference levels, and in some attributes, especially odor and taste, it could even provide significant sensory quality improvements. These findings provide a strong basis for developing Mata Belo fish ball products with the addition of seaweed flour as a functional alternative ingredient that can improve the quality and competitiveness of fishery products.

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