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DIVERSIFICATION OF TRASH FISH PROCESSING: THE IMPACT OF COMPOSITION ON THE CHARACTERISTICS OF FISH BALLS IN THE PASAR MANNA REGION, SOUTH BENGKULU

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ABSTRACT

The production of trash fish from capture fisheries in South Bengkulu Regency is remarkably high but remains underutilized by the local community. Predominant trash fish species include *peperek* (*Leiognathus bindus*), *senangin* (*Polynemus tetradactylum*), and *gulamah* (Johnius trachycephalus). This study aims to evaluate the organoleptic, physical, and chemical characteristics of fish balls derived from trash fish through compositional experimentation. The research employed a randomized complete design (RCD) with seven product formulations and three replications. The study was conducted and tested at the Faculty of Agriculture Laboratory, Universitas Sriwijaya, from March to May 2024. The results revealed significant effects of multi-species fish ball compositions on moisture content, ash content, protein content, fat content, and whiteness degree. The gel strength testing showed a maximum gel strength of 138.73 g/cm². Furthermore, this research highlights that factor influencing the success of diversification strategies, including climate, freshness, trash fish species, production processes, ice addition, and raw material availability, could contribute to increased value and community welfare.

Keywords: Diversification, Fish balls, Fish processing, Trash fish

INTRODUCTION

Statistical data from 2022 indicate that the capture fisheries production in South Bengkulu Regency reached 1,631.52 tons (Statistics, 2021). Among this production, three dominant trash fish species are identified: senangin (Polynemus tetradactylum) at 0.84%, gulamah (Johnius trachycephalus) at 0.88%, and peperek (Leiognathus bindus sp.) at 1.07% (Statistics, 2021). Observations reveal that these trash fish remain largely underutilized, primarily processed into salted fish or animal feed (Assadad et al., 2015). This underutilization is partly attributed to the small amount of edible flesh in trash fish (Alifah, 2022).

Trash fish typically measure around 10 cm in length and are generally less preferred by consumers (Alifah, 2022). They are often sold at relatively low prices, ungraded, and in bulk containers (Purnanila, 2010). Common uses

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include animal feed, fishmeal, or salted fish production (Alifah, 2022). However, the nutritional content of trash fish is comparable to that of more desirable species. Fresh trash fish contains approximately 58.97% protein (Minsas et al., 2022), 78.94% moisture, 14.00% protein, 0.48% carbohydrates (Kumar et al., 2014), 7.40% fat, and 4.15% calcium (Hanif, 2021). Given its nutritional similarity to other fish, trash fish can serve as a raw material for processed products, including fish balls.

Fish balls are processed food products shaped into spheres, made primarily from meat (with a minimum meat content of 50%), and combined with starch and other approved additives (SNI 3815-1995). As a diversification effort in seafood processing, fish balls are economically valuable products that are widely appreciated across different demographics (Nugroho et al., 2019). Fish balls can be made from various types of fish, and their texture can be adjusted by varying the type and amount of starch, such as tapioca (Widiati, 1998). Fish selection for fish ball production varies based on the desired taste profile, while the elasticity of the fish balls can be controlled through the amount and type of tapioca starch incorporated (Tritinaningsi, 2014).

Previous research on the physicochemical characteristics of fish balls (Nugroho et al., 2019) demonstrated that adding varying concentrations of transglutaminase to trash fish balls significantly affected moisture content, microstructure, and gel strength. This study aims to produce multi-species trash fish-based fish balls using various compositions, evaluate their organoleptic, physical, chemical, and gel characteristics, and analyze the best product composition in terms of trash fish species used. It also seeks to assess strategies for enhancing added value and improving the welfare of coastal communities through trash fish diversification in Pasar Manna, South Bengkulu.

MATERIAL AND METHOD

Materials

The primary raw materials used in this study were trash fish species, including peperek (Leiognathus bindus sp.), senangin (Polynemus tetradactylum), and gulamah (Johnius trachycephalus), sourced from fish auction markets in the Pasar Bawah area of South Bengkulu. Other ingredients included tapioca starch, cornstarch, garlic, shallots, pepper, ice cubes, sugar, and salt.

Research Design

This study employed a Completely Randomized Design (CRD) to ensure homogeneity within experimental units, as variability among units was minimal, and grouping did not provide additional benefits (Persulessy et al., 2016). The trash fish species used in this study comprised peperek, senangin, and gulamah.

The fish ball formulations were adapted from Mussayadah et al. (2020) with modifications to suit the objectives of this research. The specific compositions of the fish ball formulations are outlined in Table 1 below:

Table 1. Formulation of Multi-Species Fish Balls

Materials	Composition (g)						
	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
Peperek Fish (g)	200	0	0	100	100	0	66,66
Senangin Fish (g)	0	200	0	100	0	100	66,66
Gulamah Fish (g)	0	0	200	0	100	100	66,66
Gulamah Fish (g)	30	30	30	30	30	30	30
Garlic (g)	6	6	6	6	6	6	6
Shallots (g)	6	6	6	6	6	6	6
Pepper (g)	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Ice Cubes (g)	30	30	30	30	30	30	30
Sugar (g)	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Salt (g)	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Maizena (g)	3.5	3.5	3.5	3.5	3.5	3.5	3.5

Data Collection and Analysis

Data collection in this study involved laboratory tests and the use of surveys/questionnaires. The fish ball formulations were evaluated for freshness, sensory attributes, proximate composition, gel strength, and whiteness degree. Statistical analysis was conducted using analysis of variance (ANOVA) with SPSS version 29. Additionally, the Kruskal-Wallis test was employed, followed by De Garmo's method for determining the optimal formulation.

Freshness Testing

The freshness of fish was evaluated based on the Indonesian National Standard (SNI) 2729:2013. This included direct visual inspection and scoring on a 1–9 scale by panelists, covering parameters such as eye clarity, gill color, surface mucus, flesh texture, and odor.

Sensory Analysis

The sensory attributes of fish balls were evaluated following the SNI 7266:2014 guidelines, using a 1–9 scale for attributes like appearance, aroma, taste, and texture.

Proximate Analysis

Proximate analysis was conducted according to SNI 7266:2017, measuring moisture content, protein content, fat content, and ash content.

Gel Strength Testing

Gel strength was assessed according to SNI 2372.6:2009 using a plate probe instrument and analytical software for recording results.

Whiteness Degree Testing

The whiteness degree of the fish balls was measured using a CR-400 Chroma Meter. The device recorded L* (lightness), a* (redness/greenness), and b* (yellowness/blueness) values to evaluate product color quality.

Statistical Analysis

Data were analyzed statistically using analysis of variance (ANOVA) to evaluate the effects of treatments on response parameters. A 95% confidence level ($p < 0.05$) was used to determine statistical significance. Duncan's multiple range test (DMRT) was applied to identify significant differences between treatments. The Kruskal-Walli's test was employed for sensory data, while De Garmo's method was used for determining the optimal formulation across parameters.

RESULTS AND DISCUSSION

Fish Freshness Test

The freshness of fish was assessed based on parameters including the eyes, gills, surface mucus, flesh, odor, and texture.

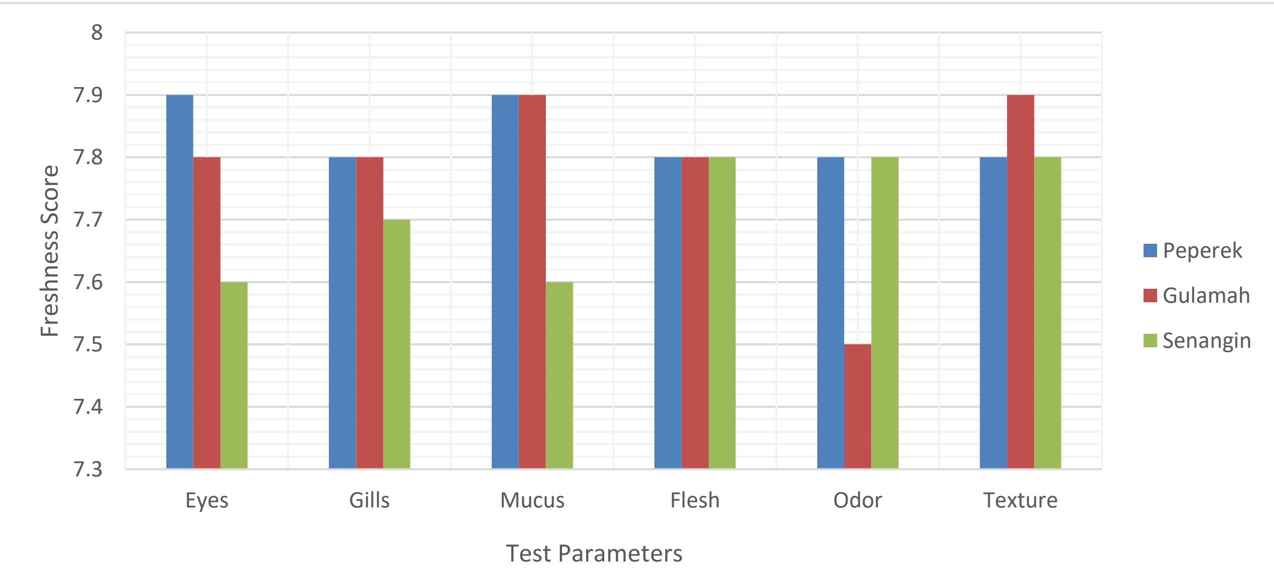

Figure 1. Results of Fish Freshness Testing

Eyes

The results of the eye component evaluation for peperek, gulamah, and senangin fish were 7.9, 7.8, and 7.6, respectively. These scores reflect the characteristics of flat eyeballs, clear and slightly glossy corneas, and pupils specific to each fish species. The appearance of fisheyes is a key parameter in determining fish freshness (Pariansyah, 2018). According to Widiastuti (2007), fresh fish exhibit bright eyes with prominent eyeballs and clear white corneas. Junianto (2003) further emphasized that fresh fish have convex and bright eyeballs, whereas spoiled fish exhibit sunken and cloudy eyes. Based on the SNI 2719:2013 standard, a minimum score of 7 is required to classify fish as fresh. One of the indicators of declining fish quality is the dull appearance of the eyes caused by bacterial activity (Pianusa et al., 2016).

Gills

The gill component assessment yielded scores of 7.8 for both peperek and gulamah fish, and 7.7 for senangin fish. These organoleptic test results confirm that the fish were still fresh, as indicated by the bright red color of the gills, their cleanliness, absence of bacterial mucus, and species-specific odor. According to Mailoa et al. (2020), fish quality deterioration can be observed from the condition of the gills, which function as oxygen filters during respiration and are thus prime sites for microbial accumulation. Berhimpon (1993) similarly noted that fish naturally harbor microbes, with the highest concentrations found on skin, gills, and gut. Based on the SNI 2719:2013 standard, which sets a minimum freshness score of 7 for gills, all three fish species used in this study met the freshness criteria.

Surface Mucus

Panelists' observations of fish mucus revealed scores of 7.9 for both peperek and gulamah fish, and 7.6 for senangin fish. The mucus was characterized as clear, transparent, and moderately bright. Sunarman (2000) stated that mucus secretion in fish is a natural response to distressful conditions, often observed when the fish is dying. According to SNI 27:2013, the scores obtained meet the standard for fish freshness, which requires a minimum mucus score of 7.

Flesh

Flesh is a crucial factor in determining the freshness and quality of fish. Based on the SNI 2719:2013 standard, the minimum freshness score for fish flesh is set at 7. Observations in this study showed that peperek, gulamah, and senangin fish each achieved a score of 7.8. This was attributed to their bright flesh cuts, species-specific characteristics, and firm muscle structure. Mailoa et al. (2020) emphasized that fish texture is classified as fresh when no changes have occurred in the flesh. This is evident in fish with dense, elastic flesh that remains firmly attached to the backbone and is difficult to tear apart.

Odor

The observed trash fish scored 7.8 for peperek, 7.4 for gulamah, and 7.8 for senangin, with all samples categorized as having a fresh odor. The odor scores met the requirements of SNI 2719:2013, which sets a minimum organoleptic score of 7 for fish freshness. Junianto (2003) noted in his research that one of the factors contributing to fish developing an unpleasant odor is a low glycogen content, which accelerates the onset of rigor mortis.

Texture

The trash fish samples showed texture scores of 7.8 for peperek, 7.9 for gulamah, and 7.8 for senangin. The texture was described as firm and elastic when pressed with a finger, with the flesh adhering tightly to the backbone. This indicates that the fish was still very fresh and meets the minimum standard set by SNI 2719:2013, which requires a minimum organoleptic texture score of 7 for fresh fish. According to Anindyajati et al. (2022), good food texture is characterized by freshness, firmness, and the absence of sliminess.

Table 2. Sensory Evaluation Res

Treatment	Mean Scores of Sensory Evaluation Parameters			
	Appearance	Odor	Taste	Texture
F1	5.40 ± 0.84[a]	7.20 ± 1.75[a]	7.20 ± 1.75[a]	5.40 ± 0.84[a]
F2	8.20 ± 1.03[a]	8.40 ± 0.96[a]	7.80 ± 1.03[a]	8.60 ± 0.84[a]
F3	7.60 ± 1.64[a]	6.20 ± 1.39[a]	6.80 ± 1.75[a]	7.80 ± 1.03[a]
F4	5.80 ± 1.03[a]	5.60 ± 0.96[a]	7.20 ± 1.47[a]	5.80 ± 1.03[a]
F5	6.00 ± 1.05[a]	5.80 ± 1.03[a]	6.40 ± 1.64[a]	5.60 ± 0.96[a]
F6	5.80 ± 1.03[a]	6.00 ± 1.70[a]	6.20 ± 1.03[a]	8.40 ± 1.35[a]
F7	5.60 ± 9.66[a]	6.60 ± 1.57[a]	5.40 ± 0.84[a]	8.00 ± 1.05[a]

Sensory Analysis of Fish Balls

Appearance

The highest score for appearance was observed in F2 (8.20), attributed to its visually appealing fish ball composition with senangin fish. In contrast, the lowest score was recorded in F1 (5.40), made from peperek fish. As Mussayadah et al. (2020) highlighted, appearance plays a vital role in consumer acceptance, with color being a key factor influencing purchase decisions.

Odor

The average organoleptic test results for the aroma parameter of multi-species fish balls showed the highest average score of 8.40 in F2, which used senangin fish as the primary ingredient. The high score for F2 can be attributed to the more complex aroma profile of senangin fish compared to other species. As noted by Soekarto (1985), aroma plays a significant role in determining the palatability of food. Aromas are more complex than taste, and the human sense of smell is more sensitive than the sense of taste. In contrast, the lowest average score of 5.60 was observed in F4, which used a combination of peperek and senangin fish. Statistical analysis using the Kruskal-Wallis test with SPSS version 29 yielded a p-value of 0.002. Since the p-value is less than 0.05, this indicates that the treatments had a significant effect on the aroma of the multi-species trash fish balls.

Taste

The sensory evaluation of multi-species trash fish balls revealed that the highest average score for taste was 7.80, achieved by F2, which used senangin fish as the primary ingredient. This finding aligns with the study by Ardianti et al. (2014), which concluded that fish balls most preferred by panelists retained a distinct fish flavor. The taste of a product is heavily influenced by the ingredients and their composition. The more flavorful the ingredients used, the more pronounced the taste perceived by the palate. In contrast, the lowest average score was 5.40, observed in F7, which combined peperek, senangin, and gulamah fish. As stated by Furqon et al. (2022), taste is influenced by several factors, including chemical compounds, their concentration, and interactions with other components in the product. The Kruskal-Wallis test produced a p-value of 0.001, which is less than 0.05. This indicates that the treatments applied to the multi-species trash fish balls had a significant effect on their taste.

Texture

The texture evaluation of multi-species trash fish balls revealed that the highest average score of 8.60 was achieved by F2, which used senangin fish as the primary ingredient. Panelists favored the texture of F2 due to its greater elasticity, firmness when pressed, compact surface, and minimal cavities. These characteristics align with the SNI (2014) standard, which requires a minimum score of 7 for acceptable texture. Other formulations that met the SNI standard were F3, F6, and F7. According to Furqon et al. (2022), food texture can be evaluated using instruments or sensory analysis. Several factors influence the texture of fish balls, including the composition, manufacturing process, and cooking duration. During cooking, water absorption occurs, and hydrogen bonds between starch molecules are replaced by bonds between starch and water molecules. This process causes starch molecules to swell and dissolve, leading to a reduction in hardness.

Proximate Composition

Moisture Content

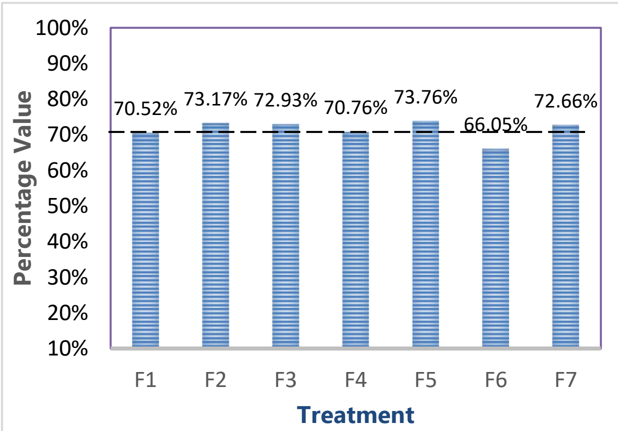

Figure 2. Results of Moisture Content Testing

The moisture content evaluation of multi-species trash fish balls showed that the highest average moisture content was found in F5, which consisted of fish balls made with a combination of peperek and gulamah fish, at 73.76%. In contrast, the lowest average moisture content was observed in F6, at 60.65%. Of the seven treatments, only F1, F4, and F6 met the maximum moisture content standard for fish balls of 70%, as specified in SNI 7266-2017. According to Astuti et al. (2022), moisture content refers to the percentage of water present in food materials. It significantly affects the shelf life of food products, as high moisture content makes them more susceptible to microbial growth. The high moisture content in F5 can be attributed to the naturally high-water content of peperek fish. Nugroho et al. (2019) reported that fresh peperek fish contains 77.07% moisture, 4.56% ash, 13.52% protein, and 3.96% fat. Statistical analysis using ANOVA produced a p-value of 0.001, which is less than 0.05, indicating significant differences among the treatments in terms of moisture content for multi-species trash fish balls.

Ash Content

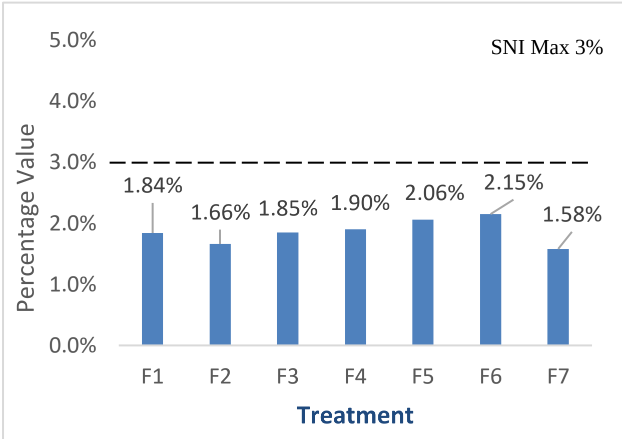

Figure 3. Results of Ash Content Testing

The evaluation of ash content in multi-species trash fish balls revealed that the highest average ash content was observed in F6, consisting of a mixture of senangin and gulamah fish, at 2.16%. Meanwhile, the lowest average ash content was recorded in F7, a formulation using a combination of peperek, senangin, and gulamah fish, at 1.58%. According to SNI 7266-2017, the maximum permissible ash content in fish balls is 3%. Based on this standard, all treatments met the ash content requirements. As noted by Astuti et al. (2022), ash content refers to the inorganic components of food materials, typically derived from the mineral content of the ingredients. Differences in ash content levels can be influenced by the raw materials used and the processing methods applied.

Statistical analysis using Duncan's test showed a p-value of 0.036, which is less than 0.05, indicating significant differences among the treatments in terms of ash content for multi-species trash fish balls.

Protein Content

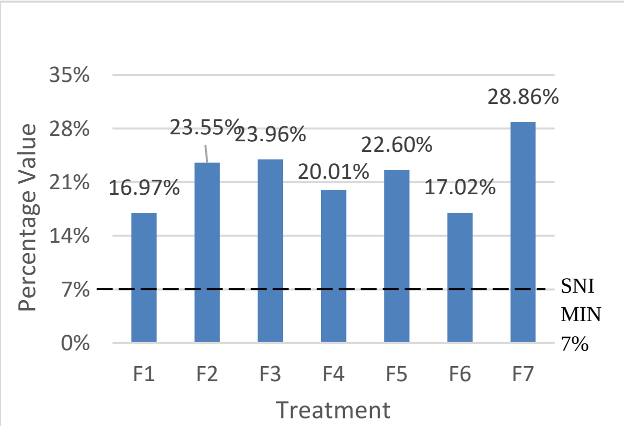

Figure 4. Results of Protein Content Testing

The protein content evaluation of multi-species trash fish balls revealed that the highest average protein content was found in F7, consisting of a combination of peperek, senangin, and gulamah fish, at 28.86%. Meanwhile, the lowest average protein content was observed in F1, which used only peperek fish, at 16.97%.

According to SNI 7266-2017, the minimum protein content requirement for fish balls is 7%. All treatments in this study met this standard. The variation in protein content among the formulations can be attributed to the differences in the types and proportions of fish used. This aligns with the findings of Pratama et al. (2014), who stated that higher protein levels are often associated with reduced moisture content due to dehydration during processing.

Statistical analysis using Duncan's test showed a p-value of less than 0.05, indicating significant differences in protein content among the treatments.

Fat Content

The fat content evaluation of multi-species trash fish balls revealed that the highest average fat content was observed in F7, which included a combination of peperek, senangin, and gulamah fish, at 5.36%. Meanwhile, the lowest fat content was found in F4, consisting of a combination of peperek and senangin fish, at 0.75%.

According to SNI 7266:2017, the minimum fat content for fish balls is 1%. Among the treatments, only F2 and F4 met this standard, while the other formulations (F1, F3, F5, F6, and F7) did not comply with the SNI requirement.

Statistical analysis using Duncan's test showed a p-value of < 0.05, indicating that the fat content significantly differed among the formulations of multi-species trash fish balls.

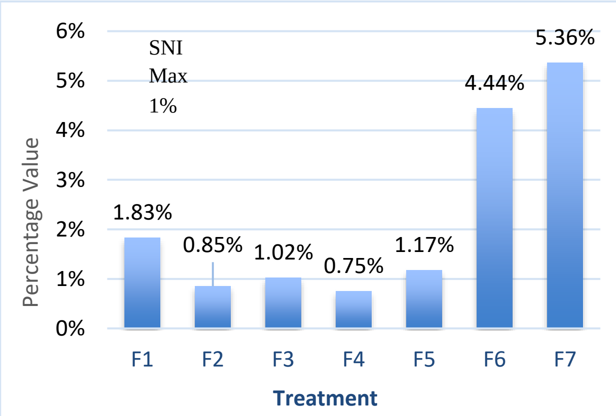

Figure 5. Results of Fat Content Testing

Variations in the fat content of fish balls can be attributed to differences in fish species and their habitats. Differences in fish species represent internal factors, while habitat differences are external factors (Furqon et al., 2022). Additionally, Dewita (2021) noted that moisture content significantly influences the fat content of a product. High moisture levels lead to lower fat content due to the inverse relationship between fat and water content.

Anindyajati et al. (2022) further emphasized that the fat level in the raw fish material directly impacts the fat content of fish balls. Fat content not only enhances the texture and flavor of fish balls but also contributes as an important energy source, improving their functional quality.

Gel Strength

The evaluation of gel strength in multi-species trash fish balls showed that the highest average gel strength was observed in F7, which included senangin and gulamah fish, at 138.73 g/cm^2. In contrast, the lowest gel strength was recorded in F1, which used only peperek fish, at 52.6 g/cm^2.

The variation in gel strength is likely influenced by the different fish species used in the formulations. Fish balls made with peperek fish tended to exhibit lower gel strength compared to those incorporating senangin and gulamah fish. Aristawati et al. (2013) noted that gel strength is significantly affected by the water content and the amount of starch added.

Additionally, higher water content and excessive starch addition can weaken gel formation by disrupting the bonds between starch granules and myofibrillar proteins, ultimately producing a softer texture (Richana & Sunarti, 2004)

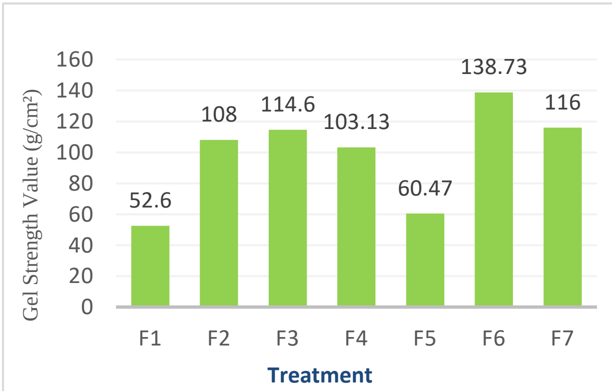

Figure 6. Results of Gel Strength Testing

Whiteness Degree

The whiteness degree evaluation was conducted using a CR-400 Chroma Meter Minolta, which measures the color reflected from the surface of the sample. Whiteness assessment in food products is essential for determining color quality.

Table 3. Results of Whiteness Degree Testing

Treatment	White Degrees
	L
F1	71.66 %± 0.50b
F2	71.25 %± 0.76b
F3	74.68 % ± 1.42c
F4	73.68 % ± 1.99c
F5	76.45 % ± 0.41d
F6	69.34 %± 0.98a
F7	72.72 %± 0.40bc

Among the multi-species trash fish ball formulations, the highest L* (lightness) value was recorded in F5, which contained a combination of peperek and gulamah fish, at 76.45. In contrast, the lowest value was observed in F6, which used senangin and gulamah fish, at 69.34. According to Soekarto (1985), a whiteness degree approaching 100 indicates a high-quality white color. This value is derived from the Hunter color system, which includes L* (lightness), a* (red-green spectrum), and b* (yellow-blue spectrum) components (Candara & Riyadi, 2014).

The CR-400 Chroma Meter Minolta operates similarly to a digital camera, capturing L, a, and b values from the sample's surface. The device works based on the interaction of diffused light energy with atoms or molecules of the analyzed object. It uses a xenon lamp as a light source, which emits light onto the sample surface, and the reflected light is detected by a high-sensitivity silicon photodiode sensor with a dual-beam system to accurately measure the reflected color (Candara & Riyadi, 2014).

Statistical analysis using ANOVA and Duncan's multiple range test revealed a significant difference among the treatments, with a p-value of 0.001 ($p < 0.05$), indicating that the different formulations significantly affected the whiteness degree of the fish balls.

Strategies for Enhancing Added Value and Improving Coastal Community Welfare Through Trash Fish Diversification in Pasar Manna District

The assessment of strategies for increasing added value and improving the welfare of coastal communities through trash fish diversification was conducted using a questionnaire-based survey. The questionnaire consisted of 15 statements, evaluated using a Likert scale (1–5). A total of 35 respondents participated in this study, aligning with Sugiyono (2014), who stated that for measurement distribution to approximate normality, a minimum of 30 respondents is required for validity and reliability testing.

The questionnaire results indicate that several factors influence the strategy for increasing added value and improving the welfare of coastal communities. These factors include climate and weather conditions, as well as taste, which affects the flavor of diversified fish products. The type of trash fish used also plays a crucial role in determining the quality of diversified fish products. As explained by Wijayanti et al. (2015), all types of fish can be used in fish ball production; however, each species has different moisture, fat, and protein content, which directly impacts the final quality of the fish ball product.

Another factor influencing the increase in added value and the welfare of coastal communities is the addition of ice. As stated by Sembor (2018), one of the key characteristics of high-quality fish balls is their chewy texture, which requires the use of starch and ice. The addition of ice or cold water during fish ball production helps improve the stability of the formed emulsion.

Respondents also stated that the process of producing multi-species trash fish balls is more effective and efficient. They noted that the supporting ingredients are easily accessible, and the technology used in fish ball processing is relatively simple. Additionally, consumer interest in fish balls is quite high, considering their nutritional value and affordable price.

This aligns with the statement by Furqon et al. (2022), which emphasizes that the fish used as raw materials for fish ball production should be nutrient-rich, flavorful, non-fishy, and truly fresh. Fish meat contains high-quality animal protein and essential amino acids that are essential for human health.

To further improve community welfare, the government has implemented programs supporting fish processing diversification, such as the "*Gemar Makan Ikan*" (Encouraging Fish Consumption) program. This initiative aims to motivate the public to increase fish consumption. Through this campaign, it is expected that early malnutrition can be prevented, as fish is a widely available, affordable, and protein-rich food source.

CONCLUSION

Based on the test results, the composition of multi-species fish balls from proximate analysis showed that the lowest moisture content was 60.05%, the lowest ash content was 1.58%, the highest protein content was 28.86%, and the lowest fat content was 0.75%. In the gel strength test, the highest value was 138.73 g/cm^2 in F6, while in the whiteness degree test, the highest value was 76.45% in F5. In the sensory evaluation of multi-species trash fish balls, the highest scores were obtained for appearance at 8.20 in F2, odor at 8.40 in F2, taste at 7.80 in F2, and texture at 8.60 in F2. Based on the sensory evaluation, the best formulation for multi-species fish balls was F2, which contained senangin fish, with a moisture content of 70.46%, ash content of 1.66%, protein content of 23.55%, and fat content of 0.85%. The gel strength was 108 g/cm^2, and the whiteness degree was 73.13%. The sensory evaluation also showed that F2 had the highest average scores and was the most preferred, with appearance at 8.20%, odor at 8.40%, taste at 7.80%, and texture at 8.60%. The strategy for increasing added value and improving the welfare of coastal communities through the diversification of trash fish processing in Pasar Manna District, South Bengkulu, is influenced by several key factors. These factors include climate and weather conditions, fish freshness, the type of trash fish used, the production process and ice addition, production effectiveness and efficiency, supporting materials, the technology used, and marketing strategies.

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