

## THE EFFECT OF GELATIN EXTRACTED FROM DIFFERENT FISH SKINS ON THE GEL QUALITY OF TILAPIA (*OREOCHROMIS NILOTICUS*) CHIKUWA

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### ABSTRACT

Gelatin is a protein obtained from the hydrolysis of collagen derived from skin, bone, and connective tissue, commonly through acid hydrolysis followed by high-temperature extraction. Owing to its water-binding and gel-forming properties, gelatin can be used to improve the texture and gel quality of surimi-based products such as chikuwa. This study evaluated the effect of gelatin extracted from different fish skins, namely catfish, milkfish, and mackerel skins, on the gel quality of tilapia (*Oreochromis niloticus*) chikuwa. Chikuwa was formulated with 3% gelatin and analyzed for gel strength, texture profile, moisture content, water-holding capacity, and sensory properties. The study was conducted using a laboratory experimental method arranged in a completely randomized design. Parametric data were analyzed using analysis of variance followed by Tukey's honestly significant difference test, whereas non-parametric sensory data were analyzed using the Kruskal-Wallis and Mann-Whitney tests. The results showed that the type of fish-skin gelatin had a significant effect on all quality parameters of chikuwa ( $p < 0.05$ ). The best treatment was obtained from the addition of mackerel-skin gelatin, which produced gel strength of 1461.50 g.cm, hardness of 0.44 kgf, cohesiveness of 0.11, springiness of 4.27 mm, chewiness of 0.15 kgf.mm, moisture content of 53.45%, water-holding capacity of 33.33%, and sensory scores within a confidence interval of  $7.90 < \mu < 8.22$ , indicating that the product was favored by panelists.

**KEYWORDS:** gelatin; fish skin; chikuwa; tilapia; gel strength; surimi-based product.

## 1. INTRODUCTION

Gelatin is a protein extracted from collagen fibers present in bones, skin, and cartilage. It has several distinctive functional characteristics, including thermo-reversible sol-gel transformation, amphoteric behavior, and the ability to maintain colloidal properties. These characteristics make gelatin widely applicable in food, pharmaceutical, photographic, and cosmetic products. Fish gelatin is particularly relevant for fishery-product technology because it can be obtained from fish-processing by-products such as skin, scales, and bones, thereby increasing the value of underutilized raw materials [1]. Gelatin is produced through collagen denaturation, and in aqueous systems it can form gels when heated and subsequently cooled below approximately 35°C. In food systems, gelatin serves as a gelling agent, stabilizer, thickener, microencapsulating agent, and film-forming material [2,3].

The gel-forming functionality of gelatin is particularly useful in elastic fishery products, including chikuwa. Chikuwa is a traditional Japanese surimi-based product characterized by a tubular shape and a brownish grilled surface. It is commonly consumed as a grilled product or as an ingredient in steamboat-type dishes. In the present study, tilapia surimi was selected as the main raw material because tilapia is widely available and has white flesh, making it suitable for surimi-based processing. Surimi products such as kamaboko and chikuwa are traditional Japanese processed foods, and their production has increased alongside growing consumer attention to healthier fish-based food products [4,5].

The quality of chikuwa depends largely on the formation of a strong and elastic gel network. The addition of gelatin is expected to strengthen the gel matrix through protein-water interactions and cross-linking within the product structure. However, gelatin characteristics may differ depending on fish species, skin composition, habitat, and extraction conditions. Consequently, gelatin from different fish skins may produce different effects on the physicochemical and sensory quality of chikuwa. This study was designed to evaluate the effects of catfish-, milkfish-, and mackerel-skin gelatin on the gel strength, texture, moisture content, water-holding capacity, and sensory acceptability of tilapia chikuwa.

## 2. MATERIALS AND METHODS

### 2.1. Materials

The materials used for chikuwa preparation were tilapia surimi, potato starch, salt, sugar, ice water, and gelatin extracted from catfish, milkfish, and mackerel skins. The materials used for gelatin extraction included fish skin, 3% acetic acid, and distilled water.

## 2.2. Preparation of Fish-Skin Gelatin

Fish-skin gelatin was prepared by adapting the method of Trilaksani et al. [6]. Fish skins from catfish, milkfish, and mackerel were washed, soaked in 3% acetic acid at a skin-to-solution ratio of 1:4 for 18 hours, washed until neutral, and extracted with distilled water at a ratio of 1:3 for 3 hours. The extract was filtered and dried in an oven at 60°C to obtain gelatin.

## 2.3. Preparation of Tilapia Chikuwa

The preparation of chikuwa followed the procedure of Leviyani et al. [7] with modifications, particularly the addition of 3% gelatin. The dough was prepared by mixing tilapia surimi, salt, sugar, gelatin, and ice water until homogeneous. The dough was molded into a tubular form and baked in an oven at 80°C for 30 minutes. The experimental design consisted of four treatments, namely control without gelatin, catfish-skin gelatin, milkfish-skin gelatin, and mackerel-skin gelatin, each conducted in triplicate.

## 2.4. Gelatin Characterization

Gelatin yield was calculated according to the AOAC method [8] as the ratio between the weight of the resulting gelatin and the initial weight of fish skin. Yield was calculated using the following equation:  $\text{yield (\%)} = [\text{gelatin weight (g)} / \text{skin weight (g)}] \times 100$ .

Gel strength of gelatin was determined according to gelatin quality testing procedures [9]. A 6.67% gelatin solution was prepared by dissolving 7 g of gelatin in 105 mL of distilled water. The solution was homogenized using a magnetic stirrer, heated at 60°C for 15 minutes, poured into standard bloom jars, covered, and allowed to stand for 2 minutes. The solution was then cooled at 10°C for 16-18 hours until gel formation occurred. Gel strength was measured using a texture analyzer at a probe speed of 0.5 mm/s and a penetration depth of 4 mm, and expressed in bloom.

## 2.5. Chikuwa Characterization

Gel strength of chikuwa was measured using a TA\_TX2 texture analyzer. Samples were cut to a height of 2.5 cm and a diameter of 2.5 cm, placed on the testing plate, and positioned under the probe. The peak force generated during compression was recorded, and gel strength was calculated as the force-distance value from peak force to return point, expressed as g.cm [10].

Texture profile analysis was conducted using a texture analyzer based on the principles described for food texture measurement [11]. Samples with a thickness of 1.5 cm and diameter of 1.7 cm were compressed twice to 30% of their original height between flat plates using a texture analyzer connected to a computer. The probe speed was 0.5 mm/s. The

parameters recorded were hardness, cohesiveness, springiness, and chewiness. Hardness was defined as the peak force in the first compression cycle, cohesiveness as the ratio of the positive area in the second compression cycle to that in the first cycle, springiness as the recovery distance detected during the second compression relative to the first compression, and chewiness as hardness  $\times$  cohesiveness  $\times$  springiness.

Moisture content was determined according to the Indonesian National Standard method for fishery products [12]. Homogenized samples were weighed in pre-dried dishes, dried in an oven at 105°C for 16-24 hours, cooled in a desiccator, and reweighed. Moisture content was calculated as moisture (%) =  $[(B - C) / (B - A)] \times 100$ , where A is the weight of the empty dish, B is the weight of the dish and initial sample, and C is the weight of the dish and dried sample.

Water-holding capacity (WHC) was determined using the centrifugation method. A 5 g sample was placed in a 15 mL centrifuge tube, 5 mL of distilled water was added, and the tube was centrifuged at 3000 rpm. The separated liquid was measured as residual unabsorbed water. WHC was calculated as WHC (%) =  $[(\text{added water volume} - \text{residual water volume}) / \text{sample weight}] \times 100$ .

Sensory evaluation of chikuwa was conducted according to SNI 8643:2018 [13] using a scoring method with 5-, 7-, and 9-point scales. The sensory attributes evaluated were appearance, odor, taste, and texture.

## 2.6. Statistical Analysis

The study used a laboratory experimental method with a completely randomized design. Parametric data were analyzed using analysis of variance (ANOVA). When significant differences were detected, Tukey's honestly significant difference test was applied. Non-parametric sensory data were analyzed using the Kruskal-Wallis test followed by the Mann-Whitney test. Statistical significance was established at  $p < 0.05$ .

## 3. RESULTS AND DISCUSSION

### 3.1. Characteristics of Fish-Skin Gelatin

The yield and gel strength of gelatin extracted from different fish skins are presented in Table 1. Mackerel-skin gelatin produced the highest yield (14%) and gel strength (132.43 bloom), followed by milkfish-skin gelatin and catfish-skin gelatin.

**Table 1. Yield and gel strength of gelatin extracted from different fish skins.**

Parameter	Catfish skin	Milkfish skin	Mackerel skin
Yield (%)	8	13	14
Gel strength (bloom)	111.39	116.50	132.43

*Note: Values are presented descriptively based on gelatin extracted from each fish skin.*

The higher yield obtained from mackerel skin indicates that the collagen content and extraction response of marine fish skin may differ from those of freshwater and brackish-water fish skin. Differences in gelatin yield can also be influenced by washing, incomplete collagen hydrolysis, proximate composition of the skin, extraction method, species, and fish age. Gel strength also varied among gelatin types, suggesting that the molecular structure and amino acid composition of gelatin differed among fish species. Previous studies have shown that gelatin obtained from aquatic animals varies in physicochemical and functional properties depending on source material and extraction conditions [2,3,14,15].

### 3.2. Gel Strength of Chikuwa

Gel strength is an important parameter for determining the quality of surimi-based products. The gel strength of tilapia chikuwa increased after the addition of fish-skin gelatin compared with the control (Table 2).

**Table 2. Gel strength of tilapia chikuwa with different fish-skin gelatin treatments.**

Treatment	Gel strength (g.cm)
Control	317.91 ± 6.01 <sup>a</sup>
Catfish-skin gelatin	368.19 ± 9.68 <sup>b</sup>
Milkfish-skin gelatin	762.94 ± 6.68 <sup>c</sup>
Mackerel-skin gelatin	1461.50 ± 11.13 <sup>d</sup>

*Note: Values are means ± SD (n=3). Different superscript letters indicate significant differences (p < 0.05).*

The highest gel strength was obtained from chikuwa with mackerel-skin gelatin. This indicates that gelatin source strongly affected gel-network formation in chikuwa. Mackerel is a marine fish and may have different collagen composition, amino acid profile, and gel-forming properties compared with catfish and milkfish. The presence of gelatin can support a stronger three-dimensional gel network by binding water and interacting with myofibrillar proteins in surimi. A similar effect was reported by Irvan et al. [16], who observed that gelatin from different fish skins significantly affected the gel strength of chikuwa.

### 3.3. Texture Profile of Chikuwa

Texture profile analysis was conducted to determine the mechanical texture quality of chikuwa and to evaluate how different gelatin sources affected specific texture attributes. The results are presented in Table 3.

**Table 3. Texture profile of tilapia chikuwa with different fish-skin gelatin treatments.**

Treatment	Hardness (kgf)	Cohesiveness	Springiness (mm)	Chewiness (kgf.mm)
Control	0.19 ± 0.02 <sup>a</sup>	0.07 ± 0.00 <sup>a</sup>	2.66 ± 0.18 <sup>a</sup>	0.05 ± 0.01 <sup>a</sup>
Catfish-skin gelatin	0.27 ± 0.01 <sup>a</sup>	0.07 ± 0.01 <sup>a</sup>	1.94 ± 0.23 <sup>a</sup>	0.03 ± 0.01 <sup>a</sup>
Milkfish-skin gelatin	0.41 ± 0.05 <sup>b</sup>	0.13 ± 0.01 <sup>b</sup>	4.34 ± 0.13 <sup>b</sup>	0.26 ± 0.02 <sup>c</sup>
Mackerel-skin gelatin	0.44 ± 0.04 <sup>b</sup>	0.11 ± 0.00 <sup>b</sup>	4.27 ± 0.48 <sup>b</sup>	0.15 ± 0.03 <sup>b</sup>

*Note: Values are means ± SD (n=3). Different superscript letters within the same column indicate significant differences ( $p < 0.05$ ).*

Hardness increased with the addition of milkfish- and mackerel-skin gelatin. This increase may be related to differences in gelatin composition and water content, as lower free-water content is generally associated with firmer texture. The hardness of gelled products is influenced by interactions among protein, starch, salt, and gelatin. Similar observations have been reported in gelatin-containing food systems, where gelatin, starch, and other components contribute to the formation of a protein-polysaccharide network and increase product firmness [17,18].

Cohesiveness represents the ability of the internal gel structure to maintain integrity when subjected to external force. Higher cohesiveness in chikuwa containing milkfish- and mackerel-skin gelatin indicates that the resulting gel network was more compact and resistant to deformation. Cohesiveness is closely associated with the internal strength of the gel matrix and the difficulty of breaking internal bonds under mechanical stress [19].

Springiness was higher in chikuwa containing milkfish- and mackerel-skin gelatin than in the control and catfish-skin gelatin treatments. This indicates that gelatin source affected the elasticity of chikuwa. Springiness describes the rate at which a deformed sample returns to its original condition after the deforming force is removed. The elasticity of fishery gels is influenced by myofibrillar proteins, stromal proteins, and non-meat components such as starch, fat, and gelatin [20].

Chewiness represents the energy required to chew a solid food product until it is ready to swallow. The addition of gelatin increased the chewiness of chikuwa, particularly in the milkfish- and mackerel-skin gelatin treatments. Higher hardness generally increases the energy required for mastication, and this relationship has been described in various gelled and processed meat systems [21-23].

### 3.4. Moisture Content

Moisture content is a critical quality parameter because it affects both gel strength and texture. The moisture content of tilapia chikuwa is presented in Table 4.

**Table 4. Moisture content of tilapia chikuwa with different fish-skin gelatin treatments**

Treatment	Moisture content (%)
Control	62.06 ± 1.53 <sup>c</sup>
Catfish-skin gelatin	57.58 ± 1.18 <sup>b</sup>
Milkfish-skin gelatin	57.16 ± 1.03 <sup>b</sup>
Mackerel-skin gelatin	53.45 ± 1.43 <sup>a</sup>

Note: Values are means ± SD (n=3). Different superscript letters indicate significant differences ( $p < 0.05$ ).

Moisture content decreased following gelatin addition, with the lowest value observed in chikuwa containing mackerel-skin gelatin. This trend is inversely related to gel strength: the treatment with the lowest moisture content produced the strongest gel. Gelatin can bind water through hydrogen bonding and immobilize water within the gel network. During heating, gelatin chains unfold, allowing water to become trapped in the three-dimensional gel structure upon cooling. As a result, free water decreases and the product structure becomes stronger and more rigid [24-27].

### 3.5. Water-Holding Capacity

Water-holding capacity (WHC) describes the ability of a product to retain water within its matrix. The WHC values of tilapia chikuwa are shown in Table 5.

**Table 5. Water-holding capacity of tilapia chikuwa with different fish-skin gelatin treatments.**

Treatment	Water-holding capacity (%)
Control	15.55 ± 1.92 <sup>a</sup>
Catfish-skin gelatin	26.67 ± 1.93 <sup>b</sup>
Milkfish-skin gelatin	31.11 ± 1.92 <sup>c</sup>
Mackerel-skin gelatin	33.33 ± 1.93 <sup>c</sup>

Note: Values are means  $\pm$  SD ( $n=3$ ). Different superscript letters indicate significant differences ( $p < 0.05$ ).

The control treatment showed the lowest WHC, whereas milkfish- and mackerel-skin gelatin produced the highest WHC values. This result confirms that gelatin improved the water retention ability of chikuwa. Gelatin contains hydrophilic amino acids capable of binding water within the food matrix, and an increase in gelatin concentration or gel-forming capacity can reduce the amount of free water in the system [23,28]. Differences among gelatin types may be associated with differences in amino acid composition, particularly hydrophilic amino acids and hydroxyproline, which influence the ability of protein to absorb and retain water against external forces [15,29].

### 3.6. Sensory Characteristics

Sensory evaluation was conducted to determine consumer-perceived quality using the attributes specified in SNI 8643:2018 for chikuwa. The results are presented in Table 6.

**Table 6. Sensory scores of tilapia chikuwa with different fish-skin gelatin treatments.**

Treatment	Appearance	Odor	Taste	Texture	Confidence interval
Control	8.33 $\pm$ 0.96 <sup>a</sup>	7.93 $\pm$ 1.26 <sup>a</sup>	8.07 $\pm$ 1.13 <sup>a</sup>	7.87 $\pm$ 1.14 <sup>a</sup>	7.81 < $\mu$ < 8.29
Catfish-skin gelatin	7.73 $\pm$ 1.33 <sup>a</sup>	7.67 $\pm$ 1.71 <sup>a</sup>	7.60 $\pm$ 1.30 <sup>a</sup>	7.53 $\pm$ 1.50 <sup>ab</sup>	7.35 < $\mu$ < 7.71
Milkfish-skin gelatin	8.33 $\pm$ 0.96 <sup>a</sup>	7.93 $\pm$ 1.00 <sup>a</sup>	8.20 $\pm$ 1.00 <sup>a</sup>	7.47 $\pm$ 1.13 <sup>ab</sup>	7.73 < $\mu$ < 8.23
Mackerel-skin gelatin	8.00 $\pm$ 1.46 <sup>a</sup>	8.07 $\pm$ 1.14 <sup>a</sup>	8.00 $\pm$ 1.01 <sup>a</sup>	8.20 $\pm$ 1.00 <sup>ac</sup>	7.90 < $\mu$ < 8.22

Note: Values are means  $\pm$  SD. Different superscript letters within the same column indicate significant differences ( $p < 0.05$ ).

Appearance scores did not differ significantly among treatments, indicating that 3% gelatin addition did not substantially alter visual acceptance. Chikuwa generally has a white base color with a brown grilled surface. Fish gelatin usually ranges from pale yellow to cream, and its color may vary depending on fish species, raw material, and extraction method [3]. At the concentration used in this study, the color contribution of gelatin remained acceptable to panelists.

Odor and taste were also not significantly affected by gelatin addition. This result is consistent with the relatively neutral odor and bland taste of gelatin. The aroma and taste of chikuwa are more strongly influenced by fish meat, potato starch, salt, sugar, and the grilling

process. Similar findings have been reported for gelatin-added meatball systems, in which gelatin did not markedly alter aroma or taste because it did not provide a strong characteristic odor or flavor [30,31].

Texture scores reflected the mechanical texture results. Chikuwa of good quality is expected to be dense, compact, and elastic. The addition of gelatin from different fish skins affected the texture perceived by panelists because each gelatin source produced different gel strength and texture profile values. Gelatin can increase the density of cross-links in the gel matrix and improve compactness, which supports the sensory perception of a firmer and more elastic product [19,32].

#### 4. CONCLUSIONS

The addition of gelatin extracted from catfish, milkfish, and mackerel skins significantly affected the gel strength, texture profile, moisture content, water-holding capacity, and sensory quality of tilapia chikuwa ( $p < 0.05$ ). Among the gelatin sources evaluated, mackerel-skin gelatin produced the most favorable overall quality. Chikuwa formulated with mackerel-skin gelatin showed the highest gel strength, low moisture content, high water-holding capacity, and sensory scores indicating panelist preference. These findings suggest that mackerel-skin gelatin is the most suitable gelatin source among the tested treatments for improving the gel quality of tilapia chikuwa.

#### 5. REFERENCES

1. Agustin, A. T. (2013). Fish gelatin: sources, chemical composition, and potential utilization. *Media Teknologi Hasil Perikanan*, 1(2), 44-46.
2. Lin, L., Regenstein, J. M., Lv, S., Lu, J., & Jiang, S. (2017). An overview of gelatin derived from aquatic animals: properties and modification. *Trends in Food Science & Technology*, 68, 102-112.
3. Alfaro, D. T., Balbinot, A. E., Weber, C. I., Tonial, I. B., & Machado-Lunkes, A. (2015). Fish gelatin: characteristics, functional properties, applications and future potentials. *Food Engineering Reviews*, 7(1), 33-44.
4. Yamada, K., Fuchimoto, H., Konishi, A., Takahashi, R., Fukushima, H., & Matsumiya, M. (2017). Quality evaluation method for frozen surimi by suwari speed and activation energy. *Symposium Proceedings*, 10005, 1-2.

5. Lestari, N., & Purwanti, T. (2018). Application of surimi from threadfin bream (*Nemipterus* sp.) for the preparation of various processed fish products. *Warta Industri Hasil Pertanian*, 33(01), 9-16.
6. Trilaksani, W., Nurilmala, M., & Setiawati, I. H. (2012). Extraction of gelatin from red snapper (*Lutjanus* sp.) skin using an acid-treatment process. *Jurnal Pengolahan Hasil Perikanan Indonesia*, 15(3), 240-251.
7. Leviyani, R. A., Kurniasih, R. A., & Swastawati, F. (2019). Application of liquid smoke for chikuwa tilapia. *IOP Conference Series: Earth and Environmental Science*, 246(1), 1-9.
8. AOAC. (1995). *Official Methods of Analysis of the Association of Official Analytical Chemists*. AOAC International, Washington, DC.
9. Badan Standardisasi Nasional. (1995). *Gelatin quality and testing methods*. Standar Nasional Indonesia 06-3735-1995. Jakarta, Indonesia.
10. Badan Standardisasi Nasional. (2009). *Physical test method for determining paste quality in fishery products*. Standar Nasional Indonesia 2372.6:2009. Jakarta, Indonesia.
11. Bourne, M. C. (2002). *Food Texture and Viscosity* (2nd ed.). Academic Press, New York.
12. Badan Standardisasi Nasional. (2006). *Determination of moisture content in fishery products*. Standar Nasional Indonesia 01-2354.2-2006. Jakarta, Indonesia.
13. Badan Standardisasi Nasional. (2018). *Chikuwa*. Standar Nasional Indonesia 8643:2018. Jakarta, Indonesia.
14. Chandra, M. V., & Shamasundar, B. A. (2015). Texture profile analysis and functional properties of gelatin from the skin of three species of freshwater fish. *International Journal of Food Properties*, 18(3), 572-584.
15. Rawdkuen, S., Thitipramote, N., & Benjakul, S. (2013). Preparation and functional characterisation of fish skin gelatin and comparison with commercial gelatin. *International Journal of Food Science & Technology*, 48(5), 1093-1102.
16. Irvan, M., Darmanto, Y. S., & Purnamayati. (2019). Effect of gelatin addition from different fish skins on chikuwa characteristics. *Jurnal Ilmu Pangan dan Hasil Pertanian*, 3(1), 78-93.
17. Souissi, N., Jridi, M., Nasri, R., Slama, R. B., Njeh, M., & Nasri, M. (2016). Effects of the edible cuttlefish gelatin on textural, sensorial and physicochemical quality of octopus sausage. *Food Science and Technology*, 65, 18-24.

18. Garrido, J. I., Lozano, J. E., & Genovese, D. B. (2015). Effect of formulation variables on rheology, texture, colour, and acceptability of apple jelly: modelling and optimization. *Food Science and Technology*, 62(1), 325-332.
19. Atma, Y., Ramdhani, H., Mustopa, A. Z., Pertiwi, M., & Maisarah, R. (2018). Physicochemical characteristics of catfish bone gelatin (*Pangasius sutchi*) extracted using pineapple (*Ananas comosus*) waste. *Agritech*, 38(1), 56-63.
20. Yusof, N., Jaswir, I., Jamal, P., & Jami, M. S. (2019). Texture profile analysis (TPA) of jelly dessert prepared from halal gelatin extracted using high pressure processing (HPP). *Malaysian Journal of Fundamental and Applied Sciences*, 15, 604-608.
21. Yasin, H., Babji, A. S., & Ismail, H. (2016). Optimization and rheological properties of chicken ball as affected by  $\kappa$ -carrageenan, fish gelatin and chicken meat. *Food Science and Technology*, 66, 79-85.
22. Calvarro, J., Perez-Palacios, T., & Ruiz, J. (2016). Modification of gelatin functionality for culinary applications by using transglutaminase. *International Journal of Gastronomy and Food Science*, 5(6), 27-32.
23. Mutlu, C., Tontul, S. A., & Erbas, M. (2018). Production of a minimally processed jelly candy for children using honey instead of sugar. *Food Science and Technology*, 93, 499-505.
24. Jridi, M., Abdelhedi, O., Souissi, N., Kammoun, M., Nasri, M., & Ayadi, M. A. (2015). Improvement of the physicochemical, textural and sensory properties of meat sausage by edible cuttlefish gelatin addition. *Food Bioscience*, 12, 67-72.
25. Shalahuddin, D. S., Darmanto, Y. S., & Fahmi, A. S. (2019). Effect of gelatin addition from scales of different fish species on the characteristics of analog rice based on canna flour and *Caulerpa racemosa* flour. *Jurnal Ilmu dan Teknologi Perikanan*, 1(2), 56-66.
26. Lawrie, R. A. (2003). *Ilmu Daging* (5th ed.). Universitas Indonesia Press, Jakarta.
27. Halim, M., Julianti, E., & Rusmarilin, H. (2014). Preparation of carrot ciam noodles from wheat flour, sweet potato starch, and germinated soybean flour with carrot juice and thickening agents. *Jurnal Rekayasa Pangan dan Pertanian*, 2(2), 10-18.
28. Rismandari, M., Agustini, T. W., & Amalia, U. (2017). Characteristics of jelly candy with the addition of iota carrageenan from *Euचेuma spinosum* seaweed. *Jurnal Saintek Perikanan*, 12(2), 103-108.
29. Efendi, A., Napirah, A., & Hafid, H. (2020). Yield, water-holding capacity, and elasticity of chicken meatballs with gelatin as an elasticizing agent. *Jurnal Ilmiah Peternakan Halu Oleo*, 2(3), 333-337.

30. Koli, J. M., Basu, S., Nayak, B. B., Patange, S. B., Pagarkar, A. U., & Gudipati, V. (2012). Functional characteristics of gelatin extracted from skin and bone of tiger-toothed croaker (*Otolithes ruber*) and pink perch (*Nemipterus japonicus*). *Food and Bioproducts Processing*, 90(3), 555-562.
31. Hafid, H., Napirah, A., & Efendi, A. (2020). Organoleptic characteristics of chicken meatballs using gelatin as a gelling agent. *IOP Conference Series: Earth and Environmental Science*, 465, 1-6.
32. Midayanto, D., & Yuwono, S. (2014). Determination of tofu texture quality attributes recommended as additional requirements in the Indonesian National Standard. *Jurnal Pangan dan Agroindustri*, 2(4), 259-267.
33. Pradnyasari, I. A. P. R., Setijawati, E., Ristiarini, S., Suseno, T. I. P., & Jati, I. R. A. (2019). Effect of gelatin concentration on the physicochemical and organoleptic properties of red rice snackbar with preliminary soaking in eggshell  $\text{CaCl}_2$  solution. *Jurnal Teknologi Pangan dan Gizi*, 18(1), 58-63.