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RESEARCH ARTICLE

# The chemical composition, sensory properties, and myofibrillar proteins of surimi produced from tilapia (*Oreochromis niloticus*) meat

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## ABSTRACT

Surimi, which is defined as the semi-processed minced meat of aquatic products that are discarded or have little fresh consumption, is usually offered for consumption by being made similar to valuable aquatic products such as shrimp, lobster tail, crab legs, and scallops. In this study, the chemical composition, myofibrillar proteins, and sensory properties of surimi manufactured from tilapia (*Oreochromis niloticus*) meat were investigated. Four study groups were created with different spice additives: red pepper, dill, thyme, and control (additive-free). Chemical composition analysis results of surimi were determined as total protein 12.85%, lipid 0.53%, ash 0.36%, moisture 86.59%, and myofibrillar protein 11.93%. Moreover, all groups were offered panelists to perform sensory analysis. At the end of the sensory evaluation, the groups received between 5.5 and 8.8 points on a 10-point scale from panelists regarding appearance, odor, chewiness, juiciness, taste and flavor, and overall acceptance. There were no differences between experimental groups in terms of appearance, odor, chewiness, and juiciness. However, statistical differences were observed between groups for taste and flavor as well as overall acceptance ($p<0.05$).

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## Introduction

Seafood has great importance in terms of nutritional value and especially protein content. It is also very rich in vitamins, amino acids, fatty acids, minerals, and other nutrients. There are different processing techniques for seafood, which have an important role in human nutrition. Among them, minced fish has a significant place (Hosomi et al., 2012; Durazzo et al., 2022).

Minced fish is a raw material for many new foods in aquaculture. One of the main products manufactured from minced fish is the product called "surimi". Surimi, which means minced meat in Japanese, is a kind of semi-manufactured fish protein extract prepared from deboned, minced, and washed fish. Surimi, typically produced and consumed fresh with conventional methods, has reached long-time preservation with the developments in protein denaturation prevention technology, and therefore its consumption has spread over a wider period (Matsumoto, 1978). Through repeated washing processes carried out in the surimi production, all substances other than protein in the fish are cleansed, and thus the fish becomes even healthier. In the manufacturing of surimi, which is a protein product with a neutral taste, unpopular and/or low economic value fish and seafood are utilized by processing directly or in combination with various other products (Frazier & Westhoff, 1978). The development of surimi technology has been achieved with factors such as the successful use of uneconomical and less economical species as raw materials in the Far East, America, and European countries, the long shelf life of frozen surimi and its very high functional protein content, and the manufacture of surimi and surimi-based products with the addition of various additives and with the use of various technological processes (Çaklı & Duyar, 2001; Duangmal & Taluengphol, 2010; Monto et al., 2022; Buamard et al., 2023). The steps of surimi production are shown in Figure 1.

Tilapia (*O. niloticus*), which is one of the fish species of low economic value in our country, occupies a very large place in terms of its aquaculture potential. It constitutes a natural potential, especially in the climatic conditions of the Mediterranean and Aegean regions, and its farming is performed with ease. In addition, tilapia is a very valuable fish species in terms of the nutritional quality of its meat. It may be beneficial for the economy to make this species, which is considered very useful in terms of both its high production capacity and nutritional quality, more palatable with various spices and flavors to increase its consumption by using modern processing technologies. Although there are many studies in the literature on surimi manufacture from different aquatic products (Alvarez et al., 1995; Gomez-Guillén & Montero, 1996; Gomez-Guillén et al., 1997; Yongsawatdigul et al., 1997; Lee & Park, 1998; Kong et al., 1999; Ramirez-Suarez et al., 2000; Nowsad et al., 2000; Kyaw et al., 2001; Huda et al., 2001a, 2001b; Choi & Park, 2002; Barrera et al., 2002; Luo et al., 2008; Panpipat et al., 2010; Oujifard et al., 2012; Singh et al., 2019; Chen et al., 2020; Yi et al., 2020; Fang et al., 2021; Pei et al., 2023), studies of surimi obtained from tilapia is very limited (Rohani et al., 1995; Klesk et al., 2000; Yongsawatdigul et al., 2000; Lou et al., 2005; Hleap & Velasco, 2010; Kobayashi & Park, 2017; Buamard et al., 2023). Therefore, in the present study, the sensory evaluation of the product was aimed by adding different spices to surimi prepared from tilapia. In addition, through chemical analysis, it is aimed to evaluate the nutritional value of surimi produced from tilapia, which is considered a valuable food source in terms of human nutrition.

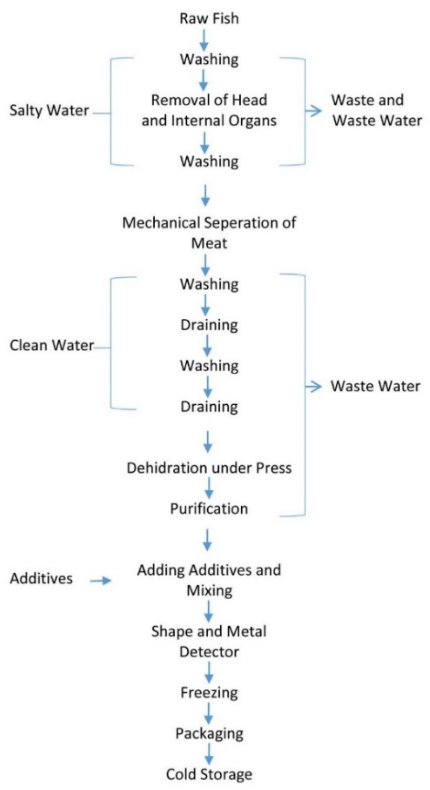


**Figure 1.** Flow diagram of surimi production (Lee, 1984)

## Material and Method

### *Material*

Tilapia (*O. niloticus*) was used as the material in the research. The mean weight of the fish was measured as 145 g and the mean length was measured to be 20 cm.

## *Method*

### *Surimi Preparation*

In the present study, skinless fillets of the fish were first obtained for the production of surimi from tilapia meat. The fillets were minced in a meat grinder of which the hole diameter is 1-5 mm. The finely minced fish meat was washed to eliminate undesired compounds. The washing process was repeated 3 times with clean water cooled in the refrigerator below 10°C, 0.3% salt was added to the final washing water, and the washing process was completed. The washed samples were passed through a fine mesh strainer and this process was repeated three times. Thusly, water-soluble proteins, proteolytic enzymes, pigments, blood, lipids, and all compounds that give the special taste and flavor were completely eliminated. At the end of the washing process, the minced fish was filtered for 3-4 hours under refrigerated conditions in cloth bags prepared earlier until the water content is 86% and the surimi was obtained.

### *Proximate Analysis*

The fish fillets were obtained after removing the head, skin, bones, and viscera. The fillets were thoroughly cleaned by washing and homogenized. The meat's moisture and ash content were determined with the methods according to the AOAC (1990). The nitrogen content was analyzed as per Kjeldahl's procedure (AOAC, 1990) and was converted to determine the crude protein content of the meat. The lipid content was determined according to Bligh & Dyer (1959). All procedures were performed in triplicate.

### *Myofibrillar Protein Analysis*

The extraction of myofibrillar proteins was carried out according to the method of Dyer et al. (1950). For extraction, firstly 5% NaCl and 0.02 M $NaHCO_3$ were added to 1 L of distilled water. The homogenized 50 g sample was extracted for 1 minute with the pre-cooled extraction solution in a Waring blender fitted with a defoamer to prevent foaming. Afterward, the obtained homogenate was centrifuged at 4°C, 4000 rpm for 30 minutes in a temperature-controlled centrifuge. One ml of the upper phase of the solution obtained as a result of the extraction was taken and placed in test tubes and the solution was completed to 5 ml with distilled water. This prepared solution was mixed thoroughly by adding a biuret solution and left to rest for the formation of violet color.

Bovine Serum Albumin was used as the standard for myofibrillar proteins (Snow, 1950). For the preparation of the Bovine Serum Albumin standard, 0.075 g BSA was completed to 25 ml. Blind and the samples were read in UV-Vis spectrophotometer at 540 nm wavelength and the absorbance values were recorded. The recorded values were calculated by placing them in the Equation (1):

$$B = \frac{1000 \times a \times b}{c} \tag{1}$$

In Equation (1);

*a*: BSA standard amount;

*b*: BSA added to the test tube;

*c*: The volume of the container in which the BSA standard was prepared.

This coefficient obtained from the standard was multiplied by the read spectrophotometer value to obtain the R value given in the equation below.

The absorbance values of the myofibrillar proteins obtained from the spectrophotometer were determined as percent protein by the Equation (2).

$$EP = \frac{(\frac{R}{V3} \times V4 + M \times W2/100) \times 100}{W2 \times 10} \tag{2}$$

In Equation (2);

*EP*: Amount of extracted (dissolved) protein (g/100 g meat);

*R*: Total mg of protein read in test tubes obtained from the protein standard plot;

*V3*: Amount of extract added to test tubes (ml);

*V4*: Amount of extracted solution put into the blender (ml);

*M*: Moisture content determined in the fish meat (ml);

*W2*: Weight of the fish used for the extraction (g);

### *Sensory Evaluation*

Manufactured surimi samples were divided into four equal portions. One group being plain (control); certain proportions of red pepper, dill, and thyme were added separately to each of the remaining 3 groups. The prepared mixtures were put into molds and cooked in a microwave oven at 450 W for 20 minutes and served to the panelists. For the sensory evaluation, the product's appearance, odor, chewiness, juiciness, taste and flavor, and overall acceptance criteria were used. Each criterion was evaluated on a 10-point scale (Gülyavuz & Tömek, 1991).

### *Statistical Analysis*

Statistical analysis was conducted by using the SPSS software for Windows (SPSS Inc., Chicago, IL, USA). Data were subjected to one-way analysis of variance (ANOVA). The differences between groups were revealed by Duncan's multiple range test at a significance level of 0.05.

## RESULTS AND DISCUSSION

### *Proximate Composition*

The proximate composition and myofibrillar protein content of surimi manufactured from tilapia (*O. niloticus*) meat are shown in Table 1.

According to the chemical analyses, the moisture content of the surimi manufactured was determined as 85.59%. The protein content after surimi manufacture was found to be 12.85%. Soluble proteins were eliminated after salt treatment, which is amongst the surimi production stages, and the remaining myofibrillar protein was determined as 11.39%. Moreover, the lipid content decreased considerably by the washing stage applied during the manufacturing process and was measured as 0.53%. As a result of the analysis conducted, the crude ash content was determined as 0.36%. According to a similar study, the proximate analysis results of surumin were determined as protein 10.77%, lipid 0.75%, moisture 78.23%, and collagen 1.15% (Zhou et al., 2017). Hosseini-Shekarabi et al. (2018) found the protein value of surumin produced as 17.77%, lipid value 0.94%, ash 0.58%, moisture 79.58%, and yield 36.56% in their study with blackmouth croaker fish. In another study, protein, lipid, ash, and moisture analyzes of surimi prepared from Talang quinfish fish obtained from the local market were performed, the results were determined as 16.97, 0.43, 2.77, and 67.09%, respectively (Moosavi-Nasab et al., 2019). In a similar study, Oh et al. (2019) reported the analysis results of basic nutritional components of surimi obtained from olive flounder fish as protein 18.93%, lipid 0.11%, ash 0.10, and moisture 73.18%. In another study, according to the physicochemical analysis results of surumin obtained from tilapia fish, protein was 11.1%, lipid 1.8%, ash 2.15%, and moisture 72.5% (Priyadarshini et al., 2021). The results obtained in the current study were compared with the results obtained by other researchers who worked with similar products. It is thought that the different results determined according to this comparison vary depending on the species, sex, production method and diet of the fish.

### *Sensory Evaluation*

Surimi manufactured from Tilapia (*O. niloticus*), one group being plain (control), was prepared by adding red pepper, dill, and thyme, and presented to the panelists according to the quality criteria of appearance, odor, chewiness, juiciness, taste and flavor, and overall acceptance. The mean values of sensory analysis performed based on the quality criteria and the Duncan multiple comparison test results of these data are shown in Table 2.

In terms of appearance, ranking from best to worst, the panelists evaluated group B (dill) with 8.6, group C (thyme) with 8.2, group A (red pepper) with 7.6, and group D (control) with 6.8 points. Based on the sensory analysis according to the odor criterion, two groups of values, i.e., 7.6 and 8.6, were recorded. Accordingly, in the order of preference, groups B and C were evaluated with 8.6 points, and groups A and D with 7.6 points. Chewiness was evaluated by the panelists with 7.8 points for group C, 7.6 points for group B, 7.2 points for group D, and 6.6 points for Group A. The juiciness values of the prepared surimi were evaluated by the panelists with 6.8 points for group C, 6.6 points for group B, 6.2 points for group D, and 5.8 points for group A. In the taste and flavor analysis, scores between 6.8 and 8.8 were recorded and in the order of preference, group B received 8.8 points, group C received 8.6 points, group A received 7.6 points, and group D received 6.8 points. According to the overall acceptance criterion, scores between 6.4 and 8.4 were recorded in the experimental groups, and the analysis data from best to worst were determined as 8.4 for group C, 8.0 for group B, 7.0 for group A, and 6.4 for group D. In a similar study conducted by adding camellia tea oil at different rates, the control group got the lowest sensory evaluation score, and the color, texture, taste-flavor and overall acceptability scores increased as the amount of added oil increased (Zhou et al., 2017). Similarly, in another study comparing minced fish and surimi, the sensory scores of surimi samples were found to be color 9.00, odor 8.86, texture 9.00, taste 8.57, and overall desirability 8.14 (Hosseini-Shekarabi et al., 2018).

**Table 1.** Proximate composition and myofibrillar protein of surimi manufactured from tilapia meat (%)

| | Protein | Lipid | Ash | Moisture | Myofibrillar protein |
|---|---|---|---|---|---|
| **Surimi** | 12.85±0.21 | 0.53±0.02 | 0.36±0.00 | 86.59±0.47 | 11.93±0.7 |

***Note:*** Means (±sd) are based on triplicate analyses.

**Table 2.** The mean sensory evaluation values of surimi enriched with different additives

| | A (Red pepper) | B (Dill) | C (Thyme) | D (Control) |
|---|---|---|---|---|
| Appearance | $7.6\pm1.52^{a}$ | $8.6\pm0.54^{a}$ | $8.2\pm0.84^{a}$ | $6.8\pm2.49^{a}$ |
| Odor | $7.6\pm1.14^{a}$ | $8.6\pm0.55^{a}$ | $8.6\pm1.52^{a}$ | $7.6\pm1.67^{a}$ |
| Chewiness | $6.6\pm0.55^{a}$ | $7.6\pm1.34^{a}$ | $7.8\pm1.64^{a}$ | $7.2\pm0.84^{a}$ |
| Juiciness | $5.8\pm1.10^{a}$ | $6.6\pm1.95^{a}$ | $6.8\pm2.17^{a}$ | $6.2\pm1.48^{a}$ |
| Taste and flavor | $7.6\pm0.55^{ab}$ | $8.8\pm0.84^{b}$ | $8.6\pm0.55^{b}$ | $6.8\pm1.30^{a}$ |
| Overall acceptance | $7.0\pm0.00^{ab}$ | $8.0\pm0.71^{bc}$ | $8.4\pm0.89^{c}$ | $6.4\pm1.52^{a}$ |

***Note:*** In the statistical analysis, the findings expressed with different letters in the same row were found to be different at $p<0.05$ significance level (A: Red pepper, B: Dill, C: Thyme, D: Control).

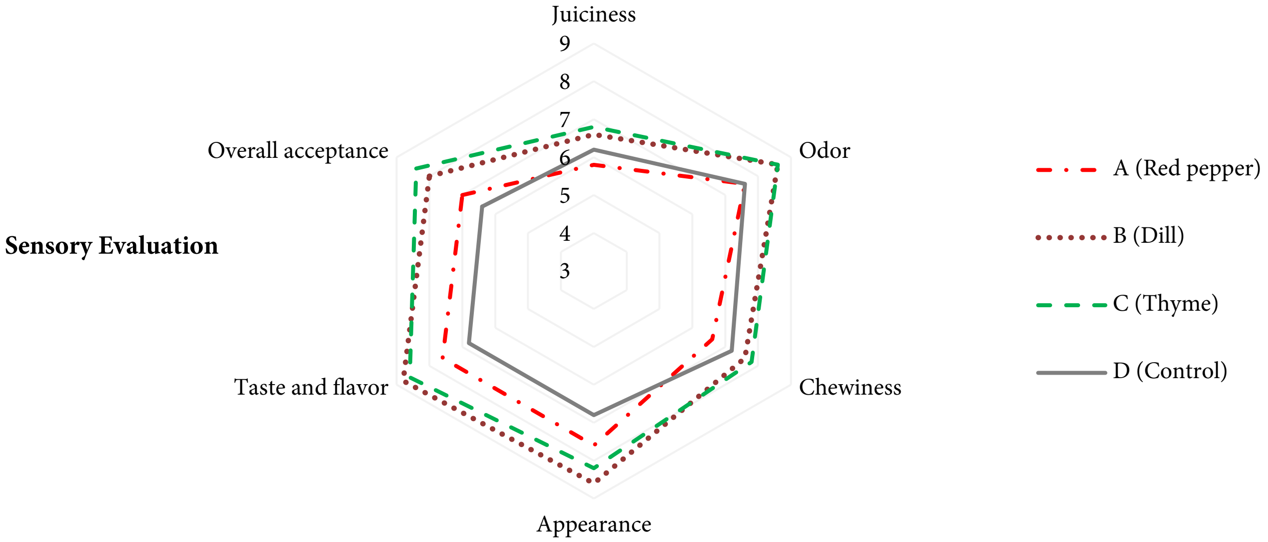


**Figure 2.** Sensory evaluation values of surimi enriched with different additives

In order for the fish introduced to the market for consumption to possess a high market share, it should have a long shelf life and a marketing potential with diversifiable sensory characteristics such as taste, odor, and aroma. For this purpose, in addition to methods such as smoking, freezing, canning, drying, and salting applied to fresh fish, surimi is a product that can also increase the consumption rate of seafood products. Moreover, considering the consumption possibilities by adding spices and similar seasonings according to the regional taste demands, surimi was attempted to be determined as a result of the sensory analysis conducted in this study whether it is a suitable product. The surimi was diversified by manufacturing with additives such as dill, thyme, and red pepper in accordance with the taste preference of the local people of our country. As a result of the sensory analysis, the most preferred products were determined to be the ones enriched with thyme and dill (Figure 2). Furthermore, the appearance, odor, juiciness, and chewiness of the product were also included in the sensory analysis criteria. In terms of these criteria, the products received scores between 5.8 and 8.8 out of 10 in the sensory evaluation. In addition to the sensory evaluation, chemical analyses were made in the manufactured surimi, and according to the results obtained as a result of these analyses, it was determined that surimi is a low-fat and high-protein source. This shows that it is a highly beneficial food in terms of human nutrition (Jaziri et al., 2021).

It is known that fish and seafood products, which are not preferred to be consumed fresh or less preferred in some parts of the world, especially in Southwest Asia and Far East countries, are transformed into new products by employing various processing techniques and thereby their market share is increased. Increasing consumption by offering species with these characteristics to people in different forms is possible through creating new products using the state-of-the-art technologies. It is inaccurate to state that tilapia, which is considered to possess high aquaculture potential in the south and west regions of our country, is highly preferred for fresh consumption. Despite its high potential for aquaculture, the farming of this fish has not been developed in our country due to the low habit of eating freshwater fish. The results obtained in this study show that tilapia, which is typically disliked because it is usually consumed fresh, can be preferred by the consumer if it is offered to the market in the form of surimi. This can lead to extremely positive results for a less preferred fish species such as tilapia. Manufacturing surimi from tilapia under suitable conditions and presenting it to the consumer by providing different tastes and flavors in line with the taste and eating habits means creating a new market for this fish species. When people find the taste and flavor they desire, from which fish the product is manufactured will take second place in their ranking of priorities. Thus, the breeders will be able to offer this fish species to the public in different areas and have the chance to give a new impetus to tilapia farming. This can both create a new market in our country, which is extremely rich in terms of inland waters, and increase our societal fish consumption.

## Conclusion

The dissemination of surimi technology, which has limited use in Türkiye, may provide a number of advantages. These are;

- Processing a portion of the product, offered to the market as fresh, with surimi technology may encourage the consumption to be spread over a year on a regular basis.
- The possibility of utilization of wastes resulting from the surimi processing may emerge by processing them into fish meal and similar products,
- It may provide the opportunity to increase the consumption of fish, which have low economic value, are not consumed with pleasure, and have limited fresh consumption in the market, such as tilapia,
- An opportunity to offer an alternative product can be provided to people who tend toward preferring seafood against the problem of excessive weight gain caused by overeating,
- Since it provides a new taste and flavor, it may increase the variety of processed fish products and therefore can function as a consumption enhancer,
- With the dissemination of surimi technology, it may create the opportunity to start new businesses and therefore generate employment,
- When the resulting products are used as additives, it may enable lowering of the food prices and increase their nutritional values,
- In addition to its direct contribution to the economy, it may also indirectly be impactful on the formation of a stable market structure in the production and consumption of seafood products.

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## Compliance With Ethical Standards

### *Authors' Contributions*

GB: Investigation, Laboratory experiments, Methodology, Writing.
MC: Supervision, Data curation, Reading, Review & Editing.
AK: Laboratory experiments, Manuscript design, Draft checking.
AEK: Visualisation, Writing, Draft checking, Reading, Editing.
All authors read and approved the final manuscript.

### *Conflict of Interest*

The authors declare that there is no conflict of interest.

### *Ethical Approval*

For this type of study, formal consent is not required.

### *Data Availability Statement*

The data that support the findings of this study are available from the corresponding author, [AEK], upon reasonable request.

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