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Storage properties of refrigerated whiting mince after mincing by three different methods

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Abstract

Minced fish is commonly used for production of surimi-based or traditional, ready-to-eat, precooked products such as fish balls or burger patties. In this study, three types of fish mince from whiting (*Merlangius merlangus euxinus*, N. 1840) were investigated for quality changes during refrigerated storage. The first type of mince was plain mince. It is commonly used in Turkey for producing fish balls, and requires no washing steps. The second one was surimi. It is not commonly used in this country, although it is popular in other countries for making ready-made products. The third type of mince was the type produced from the boiled fish, which is used in household preparation of fish balls. All mince types were stored under refrigerated conditions (at 4 ± 1 °C) to analyze their shelf-life. Sensory and chemical analyses were used to test their quality changes during storage. The precooked samples showed the best quality and the longest shelf-life according to physical, sensory and chemical results. Plain mince showed the poorest quality in relation to sensory attributes. Surimi products had the best quality in terms of retaining their shape, but their whiteness was not as good as that of the pre-cooked ones.

Keywords: Fish mince; Whiting; Shelf-life; Surimi; Pre-cooking

1. Introduction

Whiting (*Merlangius merlangus*) has been reported to be a common fish in the North Sea and in parts of the Atlantic Ocean. Its size usually ranges between 30 and 40 cm. The smallest species is found in the Black Sea and is called *M. merlangus euxinus*, N. 1840. Such species have a maximum size of about 20 cm and are found on European shores from the Barents Sea and Iceland to Gibraltar and in the western parts of the Baltic, Black, and Mediterranean Seas (Bristow, 1992). This species was reported in 2000 to be the 4th most commonly caught and consumed type of fish in Turkey, with a production total of 18,000 Mt (DIE, 2001). However, whiting is not processed for domestic consumption in Turkey, as it is only consumed fresh throughout the year, mainly in coastal areas. This is because of the short shelf-life of whiting, which is 2 days under refrigerated conditions (Köse & Erdem, 2001).

Burgers and meatballs are very common and well-liked products in almost every country today. Chicken and fish burger patties or balls have also become widespread around the world, especially in Turkey. However, various methods are used to produce mince as well as ready-made products that are produced from mince, such as burger patties. One of the techniques that can be used for this purpose is surimi. Surimi originated in Japan, and is commonly produced from Alaskan pollack as well as from whiting (Sonu, 1986). Surimi is usually produced from white-muscled fish species, especially those of the Gadidae family, due to their white color and

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ability to produce a good gel. Although traditional surimi-based products are not well known in Turkey, they are consumed regularly in other parts of the world, including Japan and the USA. The traditional method for making fish mince in Turkey is either plain mincing or mince produced after recovery from boiled fish (Akkuş, Varlık, Erkan, & Mol, 2004; Metin, Erkan, & Varlık, 2002). Therefore, it is important to know the shelf life and quality changes of different types of mince during storage, in order to aid the seafood industry in selecting appropriate methods for the purpose of producing ready-made seafood.

Several studies have been carried out on the quality changes of ready-made seafood products. One of them was performed by Akkuş et al. (2004) on fish balls that were prepared using boiled and raw anchovy. These authors discovered that the shelf-life of the fish balls was 9 days at 4 ± 1 °C. Gökoğlu (1994) used sensory, physical, chemical, and microbiological analysis to study fish balls made from mackerel that were prepared using the boiling (pre-cooking) method and stored at a refrigerated temperature. In that study, a shelf life of up to 8 days and spoilage after 10 days were reported for fish balls stored under refrigerated conditions. Metin et al. (2002) found that trout burgers that were wrapped in gas barrier film had a shelf life of 21 days under cold storage. Baygar, Erkan, Metin, Özden, and Varlık (2002) carried out a study on stuffed trout under cold storage conditions and reported a shelf life of 5 days. However, storage trials for fish burgers or mince are generally performed on finished products to which other ingredients have already been added.

There is yet insufficient data on the processing methods and quality changes of fish mince stored under refrigerated conditions. Borderias, Moral, and Matamoros (1980) carried out research on the storage properties of blue whiting after mincing by different methods. They advised using the cutter method for those fish species that can be filleted industrially, and reported that this allowed the addition of chilled water and many additives during the preparation of the minced fish, resulting in a fine texture. In addition, their results demonstrated that the mincing method was also appropriate for such species and that extrusion was applicable to a great number of fish types and it can be used with any method of preparation of fish.

Research on the shelf-life and quality changes of fish mince has mainly been performed on surimi under frozen storage conditions (Aguilera, Francke, Figueroa, Bornhardt, & Sifuentes, 1992; Köse & Uzuncan, 2000, 2001; Reppond, Babbit, Berntsen, & Tsuruata, 1995). Borderias et al. (1980) investigated the storage properties of frozen blue whiting produced by cutter, normal mincing, and extrusion mincing methods. They reported that during the storage period, the decrease of soluble proteins appeared to be less in minced fish obtained by the 'mincing method' than in minces obtained by the 'cutter' and 'extrusion' methods, up to the 10th month of storage. Evaluations by the taste panel showed that all were acceptable up until the 7th month of storage, but from this time onwards, that fish minced using the 'cutter' method became unacceptable, and the scores for the other two methods were far from optimal. However, since scarce literature exists on the quality changes of other types of mince stored at different temperatures, this study aims to investigate the effects of two other mincing techniques for whiting in comparison to surimi with respect to quality changes under refrigerated conditions.

2. Materials and methods

2.1. Materials

Whiting (*M. merlangus euxinus*, N. 1840) were caught using our research boat and gill net. They were brought to the laboratory within an hour. The fish sizes varied between 12.0 and 15.5 cm and average weight was 19.2 g. Approximately 2602 fish were used in the experiment and the total weight was around 50 kg.

2.2. Methods

Three types of fish mincing techniques were used and then compared with respect to quality and shelf-life under refrigerated conditions. One of the methods used to prepare the mince was the surimi technique, which is commonly used in USA and Japan. The second type of mince was plain whiting mince, prepared without washing steps. This method is currently used in Turkey for making and marketing fish balls. In both methods, mincing was carried out using a kitchen food processor with a pore size of 5 mm. The third method was adapted from a little-known Turkish fish dish recipe that is not marketed commercially. This technique involved precooking of the fish in boiling water for 1–5 min or more, depending on the fish size and the amount of fish placed in the water. After having their heads and guts removed and being boiled, the fish were taken out of the water and left to cool. At this point it was easy to separate the flesh from the bones manually, and in some fish this separation occurred on its own after cooking. The procedures of the three techniques are shown in Fig. 1.

After all three types of mince were produced; they were refrigerated at 4 ± 1 °C in straphor trays covered with aluminum foil for testing physical, sensory and chemical quality during the storage period.

Total volatile basic nitrogen (TVB-N) content was determined by the method of Lücke and Geidel as described in İnal (1992). Thiobarbituric acid (TBA) values, expressed in mg malonaldehyde/kg, were estimated

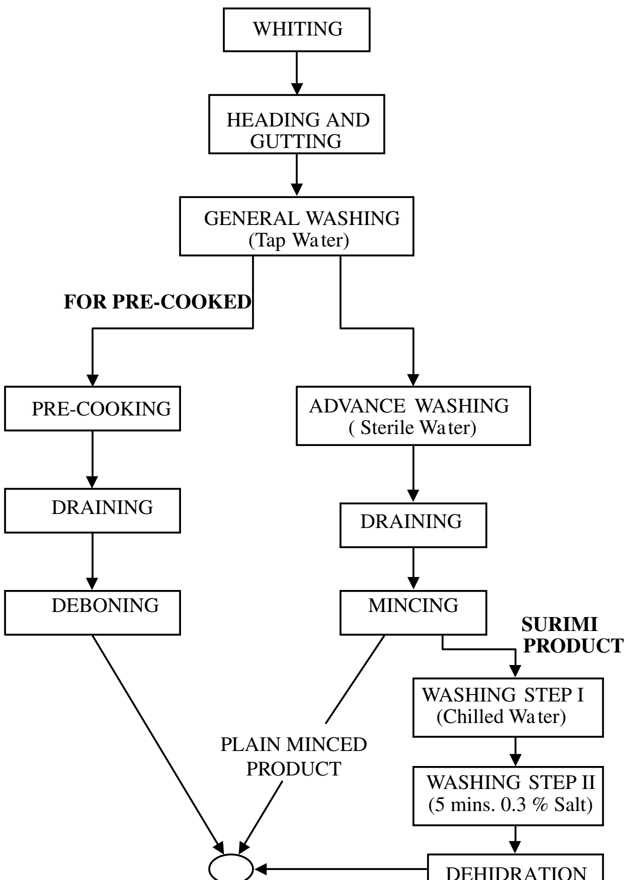

Fig. 1. Processing outline of the products.

using the method described by Smith, Hole, and Hanson (1992). The method of Boland and Paige (1971) was used for trimethylamine nitrogen (TMA) analysis. All chemical analyses were carried out in triplicate. Eight trained assessors judged the overall acceptability of the samples using a 5-point quality scale, according to a modified version of the technique used by Pedrosa-Menabrito and Regenstein (1990). About 25 g of sample were provided to each assessor. The scale points were; excellent, 5; good, 4; moderately good (acceptable), 3; poor, 2; very poor, 1 (Table 1). Quality attributes of each minced product were tested using ASHI, impurity and folding tests by the method described by Sonu (1986). The ASHI and impurity tests utilized a 10-point scale, while the folding test utilized a 5-point scale, with higher point values indicating higher quality. The data obtained were analyzed using analysis of variance (ANOVA) and when significant differences were found, comparisons among means were carried out by using Tukey test (Sokal & Rohlf, 1987).

3. Results and discussion

Table 2 shows the percentage yield after each processing step for each method. The highest yield was observed with plain minced products, the lowest with surimi products. The loss in the yield of surimi was attributable to washing steps. In comparison, the highest moisture content, up to 78%, was observed with plain minced products depending on the time that the products were left out to drain. Plain minced products required more flour compared to others, whereas surimi products required less due to their binding quality (good gel formation). Pre-cooked products required the addition of eggs for proper binding and shaping.

Table 3 shows the physical and sensory test analyses for all the products. According to the ASHI test, all products were weak. The folding test showed that surimi had a better binding force compared to others. Although purity was better for surimi products and poor for pre-cooked ones, the main impurity consisted of skin and tiny bones that were judged to be acceptable by the panellists. Color was whiter for precooked products and darker for plain minced products. Surimi showed medium color quality compared to the others. All the products had a shelf-life of 7 days, according to sensory attributes.

Several factors can affect the shelf-life of fish and fish products. These include differences between species, catching methods and season, fish handling methods,

Table 1
Sensory attributes for scores

Properties	Points
Original color (white-cream color for precooked products, brownish grey for plain mince and grey for surimi), no shiny or pale appearance. Fishy smell although not very strong, typical for each product (stronger for plain mince, follows by precooked and then surimi). Original taste when cooked. Firm texture although changes according to each type of product	5
Slight loss in original color and smell. Slight shiny appearance and slight paleness. No bitterness in taste. Firm texture	4
Paleness in appearance and shiny appearance causing slight loss in firmness. Beginning of slight bitterness in taste and off odor in its smell	3
High loss in original color. Liquidified shiny appearance. Loss in firmness and very bad smell and bitterness in taste	2
Off odors, bitterness in taste and heavy loss in firmness and sticky texture. High loss in original color and liquefied surface appearance.	1

Table 2
Percentage of yields after each processing steps of three types of whiting mince

Important processing steps	Surimi (%)	Plain minced (%)	Pre-cooked (%)
Whole fish (g)	100	100	100
Head and gutted (g)	55.5	55.5	55.5
Minced	48.9	48.9	–
Plain mince (excess water drained)	–	46.6	–
Surimi (washed and dehydrated)	25.1	–	–
Mince after boiling (for pre-cooked method)	–	–	41.6

Table 3
Some results for physical and sensory analyses

Test type	Surimi	Plain mince	Pre-cooked
ASHI test (10 points)	6	3	4
Impurity (10 points)	4	3	1
Folding test (5 points)	3	2	1
Shelf-life according to sensory scores (days)	7	7	7

and the physical condition of the fish when it is caught and while in storage (Huss, 1988). Several methods exist for assessing seafood quality and deterioration. However, there is great variation between species and different products in the chemical, bacteriological and sensory changes depending on the storage temperature and conditions, on whether the product is fresh or processed, and on the type of processing. Therefore, the acceptable limits for each quality criterion may vary for each type of product (Botta, 1995; Huss, 1988; Köse, Karaçam, Boran, & Kutlu, 2000).

The changes in TMA-N, TVB-N and TBA values for plain mince, surimi and precooked whiting mince that were stored at 4 ± 1 °C are given in Figs. 2–4. TMA-N, TVB-N and TBA levels of these products increased throughout the storage period of 15 days. TMA-N, TVB-N and TBA levels were low at the beginning of the period of storage since all products were fresh. During storage, all of these parameters increased significantly ($p < 0.001$) over time. Tables 4–6 represent the statistical analysis results for TMA, TVB-N and TBA values of the samples depending on storage time.

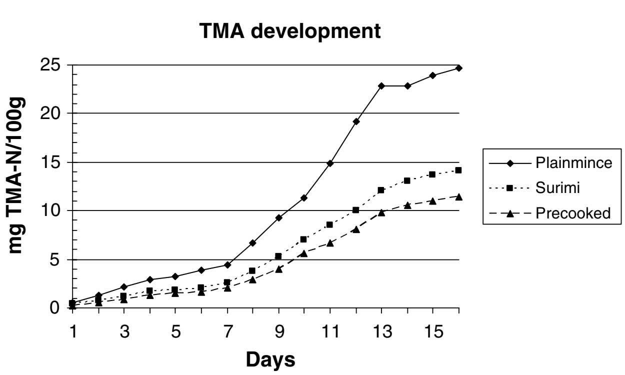

Fig. 2. Changes in TMA-N values for three types of whiting mince stored under refrigerated conditions.

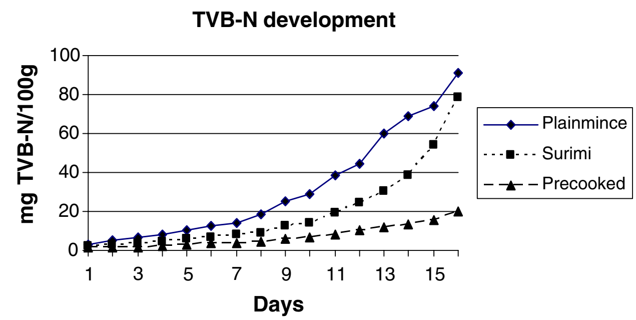

Fig. 3. Changes in TVB-N values for three types of whiting mince stored under refrigerated conditions.

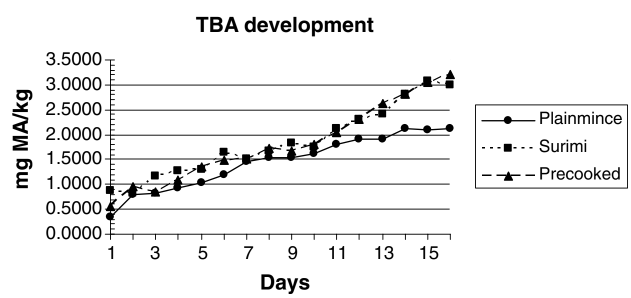

Fig. 4. Changes in TBA values for three types of whiting mince under refrigerated conditions.

TMA-N values of plain mince, surimi and precooked products varied from 0.545 to 24.7, 0.382 to 14.1, and 0.209 to 11.4 mg/100 g, respectively. TVB-N levels ranged from 2.82 to 91.1 for plain mince, 2.11 to 78.4 for surimi, and 1.40 to 20.3 mg/100 g for precooked samples. The TBA values varied between 0.338 and 2.11; 0.881 and 3.00; 0.561 and 3.22 mg malonalydehyde/kg for plain mince, surimi and precooked mince, respectively.

The processing method has also affected all parameters significantly ($p < 0.05$). Significant differences occurred ($p < 0.05$) between each product and others for TBA, TVB-N and TMA values. Table 7 shows the results of statistical analysis for each chemical parameter comparing three different methods.

TVB-N is well documented as an index of the quality of fresh fish because its increase corresponds to bacterial

Table 4
Statistical analysis results for TMA, TVB-N and TBA values of plain mince samples depending on storage time

Time (days)	Time (days)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	bc														
3	abc	ab													
4	abc	abc	c												
5	abc	abc	abc	bc											
6	abc	abc	abc	abc	bc										
7	abc	abc	abc	abc	abc	bc									
8	abc	abc	abc	abc	abc	abc	abc								
9	abc	abc	abc	abc	abc	abc	abc	ab							
10	abc	abc	abc	abc	abc	abc	abc	abc	abc						
11	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc					
12	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc				
13	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	ab			
14	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	bc		
15	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	
16	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	ab

Letters (abc) show the statistical significance ($p < 0.001$). 'a' represents TMA values, 'b' represents TVB-N values and 'c' represents TBA values. Day 1 represents the initial time before storage.

Table 5
Statistical analysis results for TMA, TVB-N and TBA values of surimi samples depending on storage time

Time (days)	Time (days)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	a														
3	abc	ac													
4	abc	abc	ac												
5	abc	abc	abc	bc											
6	abc	abc	abc	abc	bc										
7	abc	abc	abc	abc	abc	abc									
8	abc	abc	abc	abc	abc	abc	abc								
9	abc	abc	abc	abc	abc	abc	abc	abc							
10	abc	abc	abc	abc	abc	abc	abc	abc	ab						
11	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc					
12	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc				
13	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc			
14	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc		
15	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	
16	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	ab

Letters (abc) show the statistical significance ($p < 0.001$). 'a' represents TMA values, 'b' represents TVB-N values and 'c' represents TBA values. Day 1 represents the initial time before storage.

spoilage. The concentration of TVB in freshly caught fish is typically between 5 and 20 mg TVB-N/100 g, whereas levels of 30–35 mg/100 g flesh are generally regarded as the limit of acceptability for cold water fish stored on ice (Kyrana, Lougovois, & Valsamis, 1997). Trimethylamine-oxide (TMAO) is generally present in sea water fish and product of decomposition of TMAO used for assessment of fish quality, commonly used as an indicator for fish quality. It is reported that 10–15 mg TMA-N/100 g is usually regarded as the upper limit of acceptability for human consumption (Huss, 1988). TBA values represent the degree of the rancidity in the products, and the values above 3–4 mg malonalydehyde/kg indicate quality loss in the product (Scott, Fletcher, Charles, & Wong, 1992).

Although sensory values showed 7 days of storage life, according to chemical results, plain mince lost its consumable properties after 11 days when the TMA-N value reached 19.2 mg/100 g. Taking consideration of TVB-N values, plain mince was not consumable after 13 days of storage. TMA and TBA levels for surimi were found to be acceptable up to the 15th day of storage, whereas TVB-N concentration reached 38.2 mg/100 g on the 13th day, which exceeded the limit of acceptability. The TBA levels of plain mince and surimi remained under the limit for edibility up to the end of the storage period. These results indicate that oxidative rancidity remained relatively low in plain mince and surimi throughout the entire period of refrigeration. Another possible reason for this result

Table 6
Statistical analysis results for TMA, TVB-N and TBA values of pre-cooked samples depending on storage time

Time (days)	Time (days)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	c														
3	c	c													
4	abc	abc	c												
5	abc	abc	abc	bc											
6	abc	abc	abc	abc	bc										
7	abc	abc	abc	abc	abc	b									
8	abc	abc	abc	abc	abc	abc	abc								
9	abc	abc	abc	abc	abc	abc	abc	ab							
10	abc	abc	abc	abc	abc	abc	abc	abc	abc						
11	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc					
12	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc				
13	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc			
14	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc		
15	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	bc	
16	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	bc

Letters (abc) show the statistical significance ($p < 0.001$). 'a' represents TMA values, 'b' represents TVB-N values and 'c' represents TBA values. Day 1 represents the initial time before storage.

Table 7
Statistical analysis showing significant differences ($p < 0.05$) between three different methods for each chemical parameter in relation to time

Days	TBA	TVB-N	TMA
1	abc	abc	abc
2	–bc	abc	abc
3	a–c	abc	abc
4	–	abc	abc
5	ab–	abc	abc
6	abc	abc	abc
7	–	abc	abc
8	ab–	abc	abc
9	abc	abc	abc
10	ab–	abc	abc
11	–	abc	abc
12	ab–	abc	abc
13	abc	abc	abc
14	ab–	abc	abc
15	ab–	abc	abc
16	abc	abc	abc

a, Significant difference between plain mince and surimi.
b, Significant difference between plain minced and pre-cooked.
c, Significant difference between surimi and pre-cooked.
–, Not significant.
Day 1 represents the initial time before storage.

could be the low oil content of whiting. As expected, precooked products had low levels of TMA, TVB-N and TBA, although the results also showed that there was an increase in TMA, TVB-N and TBA by the end of the 15 days of storage.

Akkuş et al. (2004) found that the shelf-life of fish balls was 9 days at 4 °C according to the results of the sensory, physical and chemical analyses. In another study conducted by Chytiri, Chouliara, Savvaidis, and Kontominas (2004), TMA, TVB-N and TBA values were measured in whole and filleted rainbow trout stored in ice for 18 days. The results of their study indicated that the shelf-life of whole ungutted and filleted trout stored on ice were 1–16 and 10–12 days, respectively.

4. Conclusion

Different types of mince from whiting were monitored over 15 days during refrigerated storage. Increasing amounts of TVB-N, TMA-N and TBA were found in all types of mince with increasing storage time. According to the results of measured chemical parameters, plain mince retained its consumable properties up to 11 days of storage, surimi was acceptable for consuming up to 13 days of storage. Pre-cooked product was still consumable up to the end of storage time. However, sensory attributes showed only 7 days of storage life for all types of products.

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