

## Sensorial Evaluation of Fish Croquettes Produced from Different Seafood

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### ABSTRACT

This study evaluated the sensorial characteristics of fish croquettes produced from different seafood such as deep-water rose shrimp (*Parapenaeus longirostris*), sardine (*Sardina pilchardus*), and rainbow trout (*Oncorhynchus mykiss*). First, a sensorial appreciation test and a quantitative descriptive analysis (QDA) were conducted by 12 expert panelists. Then, a consumer appreciation test was carried out with 100 consumers aged between 20 and 55 years. The appreciation tests showed that all the croquettes were appreciated by both the panelists and the consumers. The shrimp croquette was found to be the overall favorite in terms of flavor, odor, and general appreciation parameters among the groups. The QDA results revealed that the shrimp and sardine croquettes maintained their characteristic flavor and odor, whereas those of the rainbow trout croquettes were preserved less compared with other croquettes. These results indicate that sardine croquettes can be recommended to consumers who enjoy consuming seafood with a strong fish aroma. Trout and shrimp croquettes can be recommended to some consumers who wish to consume seafood but do not necessarily like the taste of fish or shellfish.

**Keywords:** Deep-water rose shrimp, sardine, rainbow trout, quantitative descriptive analysis, croquette, deep-fried.

### INTRODUCTION

Fish and seafood are important sources of protein which provide 40% of the world's protein intake (Diaz and Hu, 2009) in addition to essential micronutrients which have various health benefits (Budtz-jorgensen et al., 2013). Moreover, they are rich in amino acids (Özden and Erkan, 2008) and unsaturated fatty acids especially docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) (Krzynowek and Murphy, 1987). Thus, the global fish supply obtained from both aquaculture (Kobayashi et al., 2015) and captured fish (Rickertsen et al., 2016) is increasing day by day. This increase of seafood consumption is likely to lead to improved health (Lund, 2013). Along with this trend, people want to consume new aquatic species or new seafood products (European Commission, 2017) which can be processed in various ways

such as fresh, frozen, dried, marinated and coated products (croquettes) (Tveteras et al., 2012). Among these processing technologies, the coating technique is one of the leading methods of producing new seafood products. Coating technology can be used to produce food products using non-economic fish or by-catch fish species (Yean, 1998) as well as aquatic species with a high economic value like shrimp and scallop (Çaklı, 2007). Fish croquettes are a type of small breaded food produced by mixing minced fish meat and various ingredients (Barros Fuchs et al., 2013) and are usually consumed after being deep-fried (Stastny et al., 2014). The deep-frying is one of the methods of frying most favored by consumers (Pokorny, 1987) and adds desirable flavor and textural properties to food (Holownia et al., 2000). Therefore, the evaluation of sensorial properties of fish croquettes is important.

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One of the most important aims of the food industry is understanding consumer's senses and acceptance of foods (Mani-Lopez et al., 2018). There is an increase in the number of consumers who will not compromise on flavor and appearance, in addition to food quality. In the competitive food production sector, not only is it imperative to ensure products pass the required food safety checks but it is also vital that products obtain the approval of consumers. In view of this, consumer attitudes are becoming increasingly important both in terms of nutritional and sensorial aspects. The aim of this study is to provide an insight into the preferences of consumers due to sensorial characteristics of croquettes produced from different seafood sources, each having a distinct and diverse aroma, which are easily accessible and address different budgets. Thus, the sensorial characteristics of fish croquettes obtained from deep-water rose shrimp (*Parapenaeus longirostris*), sardine (*Sardina pilchardus*) and rainbow trout (*Oncorhynchus mykiss*) were evaluated in this paper.

## MATERIAL AND METHOD

### Main materials

In this study, deep-water rose shrimp (*Parapenaeus longirostris*), sardine (*Sardina pilchardus*) and rainbow trout (*Oncorhynchus mykiss*) were used for croquette production. Deep-water rose shrimp and sardines caught in the Northern Aegean Sea were purchased from Çanakkale fish market. The length of all individuals were above the minimum legal size in compliance with Turkish fishing legislation. Rainbow trout were obtained from a freshwater aquaculture facility operated in Mount Ida Çanakkale, Turkey. In the production of the croquettes, 15 kg of each species were used.

### Supplemental Materials

The frying oil preferred was sunflower oil and main ingredients like wheat flour, corn flour, bread crumbs, wheat starch and ingredients such as dried coconut, dried onion, dried garlic, cilantro, black pepper, white pepper and salt that were used in the production of the croquettes were obtained from the local marketplace.

### Croquette Production

Croquettes were produced in previous studies carried out by Çankırılıgıl and Berik (2017a, 2017b, 2017c). According to these studies; croquette formulations consisted of 75.50% meat, 9.70% wheat flour, 1.31% corn flour, 9.70% breadcrumbs, 0.68% wheat starch, 1.78% dried coconut, 0.43% dried onion, 0.20% dried garlic, 0.13% cilantro, 0.28% black pepper, 0.23% white pepper and 1.00% salt. Initially, shrimp, pilchard and trout were eviscerated to remove internal organs and bones. Afterwards, the meat was pre-cooked at 150°C for 5 minutes in an oven and then minced with a grinder. The aforementioned ingredients were then added to the minced meat and mixed together until they become a homogeneous croquette paste. To form the croquette, this paste was shaped by hand, sliced evenly and coated with both a liquid soda-based material consist of 70% egg white, 12% carbonate, 8.50% breadcrumbs, 5.0% wheat starch, 1.20% salt and a dry coating material containing breadcrumbs, wheat flour and corn flour. The croquettes were deep-fried with sunflower oil at 180°C for 2 minutes which is the most preferred cooking method for

croquettes (Kilincceker and Hepsag, 2011). In the final stage of croquette production; 10.40, 10.51 and 10.94 g croquettes were produced from 15 kg of shrimp, sardine and trout, respectively. The loss in weight caused by the removal of undesirable parts such as the head, fins, bones, skin or shells from each species, was recovered in a ratio of 25% by adding the ingredients above.

### Sensorial Analyses

A sensorial analysis was carried out using the fried croquettes. In the analyses, 50 gram of fried croquettes from each group was evaluated by both panelists and consumers. The panelist group consists of expert panelists (6 men and 6 women) between the ages of 25 and 45. In order to determine the consumer group, volunteers from students and personnel of Çanakkale Onsekiz Mart University were listed with their name, age and gender. 100 consumers were selected from the list above to create an equally distributed and homogeneous group in terms of gender and age groups. Thus, the consumer group was formed with 50 men and 50 women between the ages of 18 and 55. Once the groups were selected, the sensory appreciation test, consumer sensory analysis and quantitative descriptive analysis were conducted on the fried croquettes.

### Sensory Appreciation Test

The Sensory appreciation test was modified from Mason and Nottingham (2002) and conducted on deep-fried croquettes by 12 expert panelists. The parameters of flavor odor, texture, appearance and general appreciation were evaluated by the panelists using a point scale ranging from 1 to 9. The descriptive terms and sensory appreciation test form are shown in Table 1 and Figure 1, respectively.

### Consumer Sensory Analysis

With the aim of assessing the market potential of the fish croquettes, a quantitative sensory test was carried out with the participation of 100 consumers (Mason and Nottingham, 2002). Flavor, odor and general appreciation parameters were evaluated by the consumer test group using a short and easy-to-understand form with five-point hedonic appreciation categories. The data obtained was expressed as mean values. The consumer sensory analysis test form is shown in the Figure 2.

### Quantitative Descriptive Analysis

In the quantitative descriptive analysis (QDA), the differences between the deep-fried croquettes were described by the same 12 expert panelists who carried out sensory appreciation test. The QDA was modified from Mason and Nottingham (2002) and the descriptive terms used for the fish croquettes were modified from Hayes (2011) and Shaviklo et al. (2010). The descriptive parameters of fish flavor, fish odor, saltiness, spiciness, color, hardness, oiliness and frying were evaluated by the panelists using a point scale ranging from 1 to 9. Results obtained were expressed in spider diagrams drawn in Excel (Office 2010; Microsoft, U.S.A.). The descriptive terms and QDA test form are shown in Table 1 and Figure 3, respectively.

### Statistical Analyses

Differences between the mean values were evaluated with data obtained from the 12 expert panelists who had participated in the sensory appreciation test and quantitative descriptive analysis.

**Table 1.** Descriptive terms used for fish croquettes modified from Hayes (2011) and Shaviklo et al. (2010)

Descriptor	Definition
<i>Sensory appreciation test</i>	
Flavor	General flavor of deep-fried croquettes
Odor	General odor of deep-fried croquettes
Texture	Structure of croquette felt with fingers or teeth
Appearance	Color and general look of deep-fried croquettes
General appreciation	General acceptance considering all parameters
<i>Quantitative descriptive analysis</i>	
Fish flavor	Flavor of selected species like shrimp, sardine or trout
Fish odor	Odor of selected species like shrimp, sardine or trout
Saltiness	Density of salt
Spiciness	Aromatics associated with spices or other ingredients
Color	Outside color of croquettes from light to dark
Hardness	Force required to compress the sample in first bite
Oiliness	Absorbed oil associated with frying oil
Frying	Frying rate of croquettes

	0	1	2	3	4	5	6	7	8	9	Point scale	
Flavor											Like extremely	9
Odor											Like very much	8
Texture											Like moderately	7
Appearance											Like slightly	6
General approval											Neither like nor dislike	5
Name: <input type="text"/> Date: <input type="text"/>											Dislike slightly	4
											Dislike moderately	3
											Dislike very much	2
											Dislike extremely	1

**Figure 1.** Evaluation form of sensory appreciation test

Parameters	1	2	3	4	5	6	7	8	9	Point scale		
Fish flavor											Extreme	9
Fish odor											Very strong	8
Saltiness											Strong	7
Spiciness											Above-moderate	6
Color											Moderate	5
Hardness											Below-moderate	4
Oiliness											Slightly	3
Frying											Very slightly	2
Name: <input type="text"/> Date: <input type="text"/>										Absent	1	

**Figure 3.** Evaluation form of quantitative descriptive analysis (QDA)

Name:	Date:	Flavor	Odor	General
Like very much				
Like moderately				
Neither like nor dislike				
Dislike moderately				
Dislike very much				

**Figure 2.** Evaluation form of consumer sensory analysis

However, the mean values of the consumer sensory analysis with a total of 100 participants were evaluated, separately according to age and gender groups, with the aim of evaluating possible differences between age or gender. Participants were divided into 7 categories representing the age ranges of 18-25, 25-30, 30-35, 35-40, 40-45, 45-50 and 50-55. SPSS Statistics package program version 21.0 (SPSS 21; IBM, U.S.A.) was used in all statistical analyses. The results were expressed as mean±standard

error. Differences between the mean values were evaluated with Tukey's multiple comparison test using a one-way variance analysis (ANOVA) after the normality and homogeneity of the data were tested with Anderson-Darling and Levene tests, respectively. The level of significance was set as 0.05.

## RESULT AND DISCUSSION

According to the results of the sensory appreciation test all deep-fried croquettes were liked by consumer groups. The shrimp croquettes were determined as the most preferred group with 8.44±0.30 points by the panelists. Moreover, the highest flavor and odor values were found to be 8.33±0.41 and 8.11±0.45, respectively in shrimp croquettes. The panelists stated that additions like onion, garlic and pepper into the croquette paste improved the flavor and odor of the products, particularly in shrimp croquettes. Thus, shrimp croquettes received the highest flavor and odor values. Several studies have shown that shrimp species are both nutritional and delicious (Nasiri et al., 2012) and they are

an aquatic food source in high demand by consumers (Fan et al., 2017; Khan et al., 2013). In addition, Yanar and Fenercioğlu (1999) stated that the addition of onion and garlic affected the flavor of coated products, positively. Texture is one of the most important attributes that indicates quality in fish and fish products (Cheng et al., 2014). Fried fish croquettes have a crisp texture on the outside and a soft texture on the inside, similar to other battered and fried foods. This characteristic texture is formed with a combination of high temperature, oil uptake and water loss due to deep-frying (Soto-Jover et al., 2016). In this research, the texture characteristics of all fish groups were liked by the panelists and the highest texture value was specified in sardine croquettes as  $8.33 \pm 0.41$ . The appearance value was detected as highest in trout croquettes as  $8.56 \pm 0.42$ . The color of trout meat was found to be lighter than other materials. Fish with white meat such as whiting, Alaskan Pollock etc. are preferred mostly in production of croquettes and surimi products (Boran and Köse, 2007). It is thought that trout croquettes have got the highest appearance points because of their similarity to fish croquettes sold commercially in the market. The results of the sensorial appreciation test are shown in Table 2.

According to the consumer sensory analysis, shrimp croquettes were found to be the most popular in terms of both flavor and odor parameters, followed by trout and then sardine croquettes. When the irresolute consumers are not distributed, 70% of consumers liked shrimp croquettes, 62% of them liked sardine croquettes and 63% of them liked trout croquettes. Among consumers 19%, 23% and 19% of all did not like shrimp, sardine and trout croquettes, respectively. A significant difference was not detected for either sex or age groups statistically. The results of the consumer sensory analysis are shown in Table 3.

**Table 2.** Results of sensory appreciation test

Parameters	Shrimp	Sardine	Trout
Flavor	$8.33 \pm 0.41^a$	$7.56 \pm 0.42^c$	$8.00 \pm 0.41^b$
Odor	$8.11 \pm 0.45^a$	$7.22 \pm 0.56^b$	$8.00 \pm 0.29^a$
Texture	$7.89 \pm 0.45^b$	$8.33 \pm 0.41^a$	$7.44 \pm 0.51^c$
Appearance	$7.56 \pm 0.42^b$	$7.44 \pm 0.51^b$	$8.56 \pm 0.42^a$
General approval	$8.44 \pm 0.30^a$	$7.22 \pm 0.39^c$	$7.89 \pm 0.35^b$

Values are expressed as mean  $\pm$ SD, mean values in rows with different superscripts were significantly different ( $p \leq 0.05$ )

The aim of the quantitative descriptive analysis was to evaluate sensorial differences between products. Çaklı (2007) stated that fish and other seafood can reach out to larger masses by enhancing the flavor, odor and texture, as is done in croquette production technology. Therefore, the differences between croquettes in terms of sensorial quality owing to unique aromas of raw materials and the description of final products are important. In our research, the parameters of spiciness, saltiness and frying were found to be the same, statistically, in all croquettes because of the implementation of exact formulation to each group ( $p \geq 0.05$ ). The highest flavor and odor values of the species used in the croquette production were specified in sardine croquettes whereas the lowest values were determined in shrimp croquettes ( $p \leq 0.05$ ). Coated products have specific flavor components which come from the breading, frying oil and raw materials used in production (Albert et al., 2012). Deep-fat frying can produce desirable or undesirable flavor compounds that can affect final products (Choe and Min, 2007). It is clearly shown that deep-frying affects croquettes positively with medial frying rate as well as non-dominant aromas of spices or salt. The darker outer-color was specified in sardine croquettes due to the color of sardine meat and followed by shrimp and trout croquettes, respectively ( $p \leq 0.05$ ). The color parameter showed distinct differences between croquettes due to the specific meat color of each of the species used in the production of the croquettes. The inner color of sardine croquettes was found to be darker compared to that of shrimp and trout croquettes. In addition, the unique rosy color of shrimp meat was preserved in croquettes. Oiliness was found to be highest in sardine croquettes ( $P \leq 0.05$ ) whereas no differences were found statistically between the shrimp and trout croquettes ( $p \geq 0.05$ ). Several sardine species are rich in terms of crude fat and unsaturated fatty acids (Homayooni et al., 2014; Sánchez et al., 2013; Senapati et al., 2017). Thus, this can explain why the oiliness of sardine croquettes was deemed the highest. One of the results of deep-frying is gaining a distinctive structure of food (Stevenson et al., 1984). Even if just by a slight amount, hardness was found to be higher in sardine croquettes than the others statistically ( $p \leq 0.05$ ). As a result of deep-frying, food gains a crispy exterior crust and moist center by virtue of water evaporation and oil migration between the frying oil and the food (Nieto Salvador, 2014). According to Albert et al. (2012) this contrasting texture is an important and desirable feature for consumers. The results of the quantitative descriptive analysis are shown in Table 4 and Figure 4, respectively. According to the opinions of the panelists,

**Table 3.** Results of consumer sensory analysis

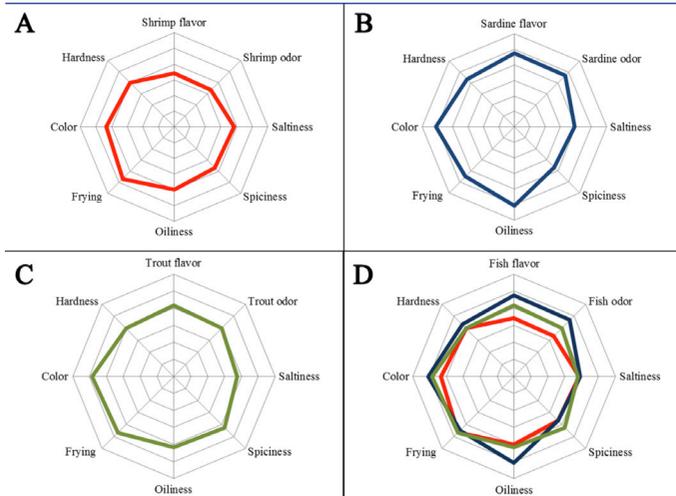
Parameters	Shrimp			Sardine			Trout		
	F	O	G	F	O	G	F	O	G
Like very much	41%	35%	39%	27%	19%	23%	32%	24%	29%
Like moderately	24%	28%	31%	35%	28%	32%	33%	36%	34%
Neither like nor dislike	16%	19%	17%	16%	28%	22%	14%	27%	18%
Dislike moderately	11%	10%	9%	12%	16%	14%	9%	7%	8%
Dislike very much	8%	7%	4%	10%	9%	9%	12%	6%	11%

\*F: flavor, O: odor, G: general

**Table 4.** Results of quantitative descriptive analysis (QDA)

Parameters	Shrimp	Sardine	Rainbow trout
Fish flavor	4.41±0.21 <sup>c</sup>	5.75±0.42 <sup>a</sup>	5.17±0.33 <sup>b</sup>
Fish odor	4.33±0.42 <sup>c</sup>	5.67±0.28 <sup>a</sup>	5.00±0.58 <sup>b</sup>
Saltiness	4.83±0.17 <sup>a</sup>	4.91±0.20 <sup>a</sup>	4.83±0.23 <sup>a</sup>
Spiciness	4.66±0.21 <sup>a</sup>	4.67±0.31 <sup>a</sup>	5.25±0.42 <sup>a</sup>
Color	5.33±0.27 <sup>c</sup>	6.08±0.54 <sup>a</sup>	5.83±0.45 <sup>b</sup>
Hardness	5.00±0.16 <sup>b</sup>	5.33±0.24 <sup>a</sup>	5.00±0.31 <sup>b</sup>
Oiliness	5.00±0.17 <sup>b</sup>	6.08±0.23 <sup>a</sup>	5.17±0.33 <sup>b</sup>
Frying	5.66±0.42 <sup>a</sup>	5.50±0.56 <sup>a</sup>	5.67±0.25 <sup>a</sup>

Values are expressed as mean ±SD, mean values in rows with different superscripts were significantly different (p<0.05)



**Figure 4. a-d.** Quantitative Sensory Analysis (QAD) results of croquettes; (a) shrimp croquettes, (b) sardine croquettes, (c) trout croquettes, (d) combined results of all croquettes

sardine croquettes preserved the characteristics of the raw material such as fish flavor, odor, color and oiliness used in croquette production more than others. Shrimp and trout croquettes can be recommended to consumers who need to consume seafood but do not particularly like the taste of fish or shellfish. However, sardine croquettes, which have dominant fish aroma, can be recommended as a new fishery products to consumers who enjoy eating seafood. Moreover, according to the European Commission (2017), 65% of European consumers want to try new fish and fishery products.

## CONCLUSION

In conclusion, fish croquettes produced from different aquatic species such as deep-water rose shrimp, sardine and rainbow trout were evaluated in terms of their sensorial quality. According to the results, all products were evaluated by both panelists and consumers. Shrimp croquettes received the highest approval by both consumers and panelists with their exquisite flavor. A number of different seafood products have been cho-

sen as raw material. It is necessary to use sustainable and easily accessible food sources such as fish species from healthy stocks, aquaculture species, discard species of commercial fishing operations or edible waste of seafood processing facilities for substantial croquette production. The results of the present comparative study would be beneficial for the seafood production sector.

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