

## SHELF LIFE DURING STORAGE IN $4\pm 2^{\circ}\text{C}$ OF FISH CRACKERS MADE WITH *Oncorhynchus mykiss* AND *Cyprinus carpio*


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*In this study, changes in chemical, microbiological and sensory quality of fish crackers made from rainbow trout (*Oncorhynchus mykiss*) and carp (*Cyprinus carpio*) during storage at  $4\pm 2^{\circ}\text{C}$  was investigated. The fish cracker composed of fish meat, sugar, salt, egg, sunflower oil, vinegar, butter, flour, wheat starch and stirred until a homogenous mixture of crackers dough was achieved. The mixture was crushed in an extractor and baked in the oven. Chemical quality parameters (pH, Total Volatile Basic Nitrogen and Thiobarbituric Acid), microbiological parameters (Aerobe bacteria) and sensory quality (Flavor, Odor, and Texture) were determined during the storage period. The highest chemical changes and microbiological changes was determined in the crackers prepared by adding carp meat. The lowest sensory parameters was obtained for crackers groups by carp meat. The study results showed that crackers enriched with fish meat, mainly rainbow trout had an appropriate sensory, microbiological and chemical profile for consumption.*

*Key words: Fish cracker, *Oncorhynchus mykiss*, *Cyprinus carpio*, shelf life, microbiological quality.*

### 1. Introduction

Nutrition through ready-made, packaged, portable and ready-to-eat foods currently has an important share in Turkey, due to lifestyle changes such as the increase in the number of working women, university students and/or other individuals who live apart from their families for business purposes, intensive pace of life and the development of technology [1,2]. Consumption of such foods, called the snack foods (or appetizer food products) and that address different age groups, increases each day [3,4]. The content of a meal is highly significant for a proper and balanced diet. The energy and vitality in human body decreases due to the nutrition that is solely cereal based [5]. Several foods, such as crackers, onion rings, cookies and chips, are foods with low nutritional value, in other words, lack certain important nutrients, despite the high energy they provide. It is considered that enriching the nutritional value of such products, which are consumed in large quantities, through the use of fish meat could provide several benefits [6, 7], given the fact that fish meat is an excellent food in terms of its nutritional value, especially due to its contents with high quality protein, vitamin and minerals [8]. The objective is to develop an alternative product for individuals who tend to consume fish meat, which was recently acknowledged to have highly significant functions for proper and balanced nutrition. Thus, fish product consumption is expected to increase due to newly emerging flavors [4]. It is stated that various

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fish products created through altering the smell, taste and aroma of fish meat are highly recognized in numerous countries [9]. There exists plethora of studies in literature, conducted on fish crackers produced with different types of flour (potato flour, tapioca flour, starch) and fish meat [10-12]. Huda et al. [13] produced fish crackers using different amounts of surimi powder (10%, 20%, 30%) and examined the chemical composition of the obtained snack-like or cracker-like products with 10% surimi powder. King [14] examined the chemical composition of fried fish crackers produced by adding different amounts of fish meat. Nurul et al. [15] studied the chemical composition, oil absorption and sensory characteristics of the fish crackers they produced through mixing fish meat with different proportions of tapioca (a type of flour obtained from the roots of the *Manihot esculenta* plant). Huda et al. [16] examined the amino acid properties of the fish crackers they prepared. Saviklo et al. [17] examined corn snack fortified with 7% fish protein powder. Netto et al. [18] examined examined snacks containing different proportion minced fish of Nile tilapia. Broto et al. [19] examined of chemical changed by producing crackers from *Pila ampullaceal* waste as alternative food There exist few studies that investigated the parameters for the chemical quality of crackers enriched with fish meat.

The present study investigated the changes in the chemical quality, the microbiological quality and the sensory characteristics of crackers prepared with rainbow trout (*Oncorhynchus mykiss*) and carp fish (*Cyprinus carpio*) under refrigerated conditions.

## 2. Material and Method

### 2.1. Material

Rainbow trout (*Oncorhynchus mykiss*), with an average weight of  $310.90 \pm 10.90$  g and average length of  $26.55 \pm 4.67$  cm and carp fish (*Cyprinus carpio*), with an average weight of  $1439.65 \pm 80.65$  g and average length of  $39.67 \pm 5.67$  cm, both cultivated in Keban Dam Lake, Pertek region were used in the present study. The fish were obtained from the fishers in the region, brought to the Bioengineering Laboratory at Firat University in Styrofoam ice boxes, and the fillets of the fish were obtained using proper tools and were processed the same day.

### 2.2. Method

#### 2.2.1. Obtaining of cracker samples

Two different fish species that the fillets were obtained from, were separately boiled in water ( $89 \pm 2^\circ\text{C}$ ) approximately for 10 minutes. The crackers were prepared based on the dough mixture ratios presented in Table 1 and were mixed in a mixer (Tefal) until a homogeneous mixture was obtained. Subsequently, the dough was transferred onto a baking sheet, compressed with an extractor (30 mm in diameter) and cut into lengths of 0.8x6 cm to form stick-shaped crackers. The shaped cracker dough was baked at  $180^\circ\text{C}$  for 35 minutes. The prepared cracker samples were kept in  $4 \pm 2^\circ\text{C}$  after packing in zip lock bags. C: Control group, CF: Carp fish meat added group, RT: Rainbow trout meat added group

**Table 1. Cracker mixture ratios**

Group	Fish Meat (%)	Salt (%)	Sugar (%)	Sunflower oil (%)	Egg (%)	Vinegar (%)	Butter (%)	Flour (Wheat) (%)	Starch (Wheat) (%)
C	-	1.00	1.90	13.50	1.62	0.88	13.50	48.50	19.10
CF	16.20	1.00	1.90	13.50	1.62	0.88	13.50	40.40	11.00
RT	16.20	1.00	1.90	13.50	1.62	0.88	13.50	40.40	11.00

As a result, three separate groups were obtained for cracker mixtures. Sensory, microbiological and chemical analyzes were conducted every three days during the preservation and the study was conducted through three repetitions, with the aim to determine cracker quality and the chemical properties of the crackers throughout the preservation.

#### 2.2.2. Chemical analysis

The pH values of the crackers were measured with a pH meter (Hanna, Romania). The measurement was completed by retrieving a 10g sample and disintegrating this sample with 90 mL of distilled water in a homogenizer for 1 minute [20]. Total volatile basic nitrogen (TVB-N) content (mg/100g) was measured based on the method developed by Conell and Shewan [21]. Subsequent to the MgO addition to the homogenized sample, volatile bases were kept in 3% H<sub>3</sub>BO<sub>3</sub> solution through water vapor distillation. Separated bases were titrated with 0.1 N HCl acid by Tashiro Indicator and TVB-N amount of the samples was calculated in units of mg/100g. The method developed by Tarladgis et al. [22] was used to determine thiobarbituric acid (TBA) value (mg MA/kg) in crackers. The absorbance of the red color, obtained from the malondialdehyde formed by oil oxidation and glacial acetic acid and 2-Thiobarbituric acid, at 538 nm was read on the spectrophotometer. The malondialdehyde value of the samples was calculated by multiplying the absorbance value by the factor of 7,8.

#### 2.2.3. Microbiological analysis

Cracker samples (10 g) were ground in a sterile pestle and mortar with 90 ml 0.1 percent peptone water. Appropriate dilutions of crackers samples were prepared in sterile 0.1 percent peptone water and plated, in duplicate, on the growth by using the pour plate method. Moreover, each dilution was pipetted onto the surface of plate count agar (LAB149, 125801/093) plates for determination of aerobic bacteria incubated at 30 ± 1 °C for 3 days. The microbial counts were expressed as log cfu/g [23, 24].

#### 2.2.4. Sensorial analysis

Sensorial characteristics of the cracker samples were evaluated by 5 panelists in terms of odor, texture and flavor. The panelists used a scoring scale between 1 and 9 to determine the quality characteristics of the samples (1: Inconsumable, 2: Highly bad, 3: Bad, 4: Slightly bad 5: Neither good nor bad, 6: Slightly good, 7: Moderately good, 8: Good, 9: Extremely excellent) [25].

#### 2.2.5. Statistical analysis

IBM SPSS<sup>®</sup>22 (SPSS Inc., Chicago, IL, USA) software was used to statistically analyze the obtained data in the present study. Analysis of variance (ANOVA) was used to investigate the statistical significance of the difference between groups and days during preservation in refrigerated conditions ( $p < 0.05$ ) [26].

### 3. Experimental Results and Discussion

The view of experimental groups of fish crackers samples are presented in Figure 1. The chemical (pH, TVB-N, TBA value), microbiological (Aerobe bacteria) and sensorial (flavor, odor, texture) changes for the cracker samples prepared in the present study and kept in refrigerated conditions were presented in Figure 2 – Figure 8.

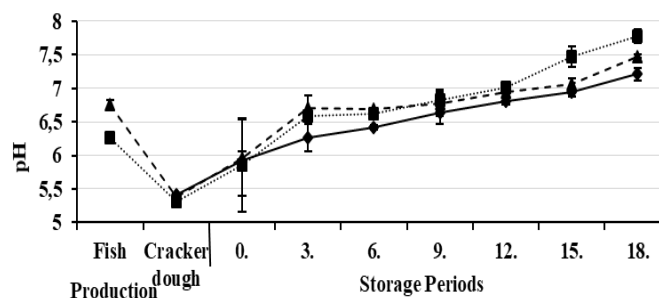


**Figure 1. The different groups of cracker samples**

### 3.1. Chemical changes

#### 3.1.1. pH changes

pH refers to the measurement of hydrogen ion concentration present in an environment. In fresh fish, pH ranges between 6.0 and 6.5. The pH reaches 7.0 or even higher in spoiled fish. Measurements are either conducted directly with a pH meter or after homogenizing the fish with distilled water. pH measurement in fish is not an exact criterion and should be supported by sensory and chemical tests [27]. The chemical changes observed during the production and preservation of the cracker samples, prepared with different fish species, in refrigerated conditions were presented in Figure 2. It was identified that the average pH of the crackers during the production process was  $6.26 \pm 0.04$  and  $6.75 \pm 0.08$  for carp fish and trout, respectively and the values decreased to  $5.42 \pm 0.02$ ,  $5.32 \pm 0.01$  and  $5.38 \pm 0.02$  in control, carp fish and trout groups, respectively, once the cracker doughs were formed. Such finding might be due to the dough contents and vinegar added in the dough. The statistical analysis of the cracker values in production process indicated significant differences ( $p < 0.05$ ). The lowest pH value,  $5.86 \pm 0.70$ , was determined at the first day of the preservation process of the cracker samples, in the carp fish added group, whereas the highest pH value was determined in the last day of preservation,  $7.77 \pm 0.11$ , in the carp fish added group. The change in pH values of cracker samples throughout the preservation process was statistically significant between the groups ( $p < 0.05$ ) on certain days of preservation (on 6th, 12th and 15th). Once the alteration of pH values between the preservation days of samples was examined, a close alteration was determined for the 3rd, 6th and 9th days ( $p > 0.05$ ), however, the alteration on the other days were significantly different ( $p < 0.05$ ). Neiva et al. [28] conducted a study on crackers, which were obtained through mixing minced fish and starch, and examined the pH values of the crackers. The findings of Neiva et al. [28] exhibit similarities with the findings of the present study.

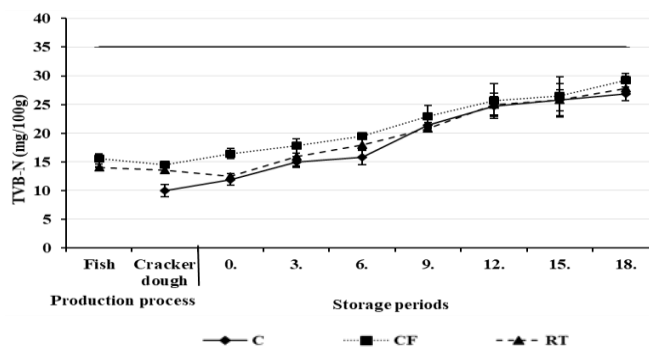


C: Control group, CF: Carp fish meat added group, RT: Rainbow trout meat added group

**Figure 2. Changes in pH values of fish crackers**

### 3.1.2. TVB-N changes

It was reported that TVB-N value in fish and other seafood products increased based on duration. For instance, Huss [29] reported the amount of TVB-N contained in freshly caught fish as 5–20 mg/100g, and the acceptable limit value for freshness as 30–40 mg/100g. The TVB-N values of crackers enriched via carp fish and rainbow trout meat were presented in Figure 3, both for the production and preservation processes. In the present study, the TVB-N values of cracker samples were determined as  $16.45 \pm 0.85$  mg/100g,  $12.05 \pm 0.05$  mg/100g, respectively, for the crackers enriched with carp fish and rainbow trout meat. It was also determined that crackers in all groups had TVB-N values between  $9.97 \pm 0.53$  -  $14.44 \pm 0.44$  mg/100g, during the cracker dough production process. The TVB-N values in cracker samples demonstrated regular increase from the beginning of the preservation process to the end of preservation. A statistically significant difference was identified between all fish meat added cracker groups on the 0<sup>th</sup> days of preservation ( $p < 0.05$ ). Furthermore, the statistical analysis of the TVB-N values indicated significant differences between all days of the preservation process ( $p < 0.05$ ). A study, which focused on the TVB-N values of fish crackers, presented lower values than the values obtained in the present study ( $18.16 \pm 1.57$ – $17.25 \pm 1.57$  mg/100g) [28]. A similar study conducted by Nor-khaizura et al. [30] obtained lower values for TVB-N when compared to the present study. It is possible to state that such difference stemmed from the differences of cracker mixtures.



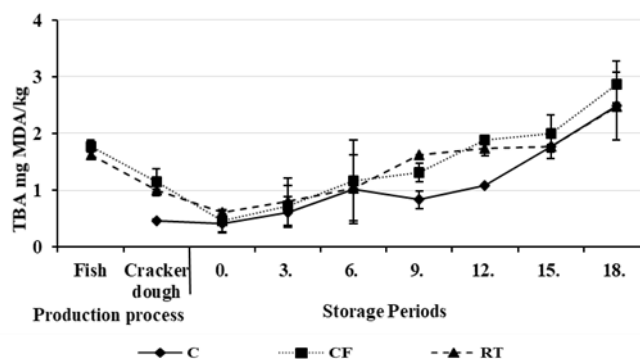
C: Control group, CF: Carp fish meat added group, RT: Rainbow trout meat added group

**Figure 3. Changes in TVB-N values of fish crackers**

### 3.1.3. TBA changes

Thiobarbituric acid (TBA) is one of the important criteria for the deterioration in fish and other seafood products. Such value is observed as a result of oil oxidation. A rancidified, bitter taste and yellow-brownish color occur in oxidized products. The TBA value, which is formed due to oil oxidation in seafood and is the index of rancidity, refers to “good quality” between 1–3 mg MA/kg, “medium quality” between 3–5 mg MA/kg, “low quality” between 5–8 mg MA/kg, and the products that exceed 8 mg MA/kg are classified as “inconsumable” [31–33]. The results of the TBA analysis, for crackers prepared with both fish meat, were presented in Figure 4. The TBA value of carp fish used in cracker production was determined as  $1.77 \pm 0.11$  mg MA/kg. Rainbow trout used in the other cracker group was determined to have an average TBA value of  $1.61 \pm 0.07$  mg MA/kg. It was determined that there were statistically significant differences between the values in the production process of the experimental samples ( $p < 0.05$ ). The storage/preservation process of the prepared products indicated increases in TBA values, and the statistical analysis of these values presented a statistically significant difference on the 12<sup>th</sup> day of preservation ( $p < 0.05$ ). Furthermore, the examination of the changes in

TBA values on all days of preservation yielded statistically significant differences ( $p < 0.05$ ). Such findings of the present study corresponded to the findings of similar studies [28].



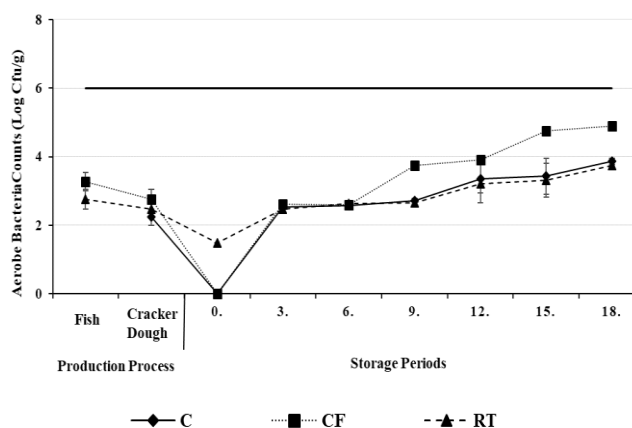
C: Control group, CF: Carp fish meat added group, RT: Rainbow trout meat added group

**Figure 4. Changes in TBA values of fish crackers**

### 3.2. Microbiological changes

#### 3.2.1. Aerobe bacteria counts

Microbiological counts for aerobe bacteria counts, are shown in Figure 5. The aerobe bacteria counts of carp meat used in cracker production was determined as  $3.27 \pm 0.23$  log cfu/g. Rainbow trout meat used in the other cracker group was determined to have an average total aerobe bacteria counts of  $2.76 \pm 0.27$  Log cfu/g. The total viable counts in the production process were a big decline and determined as  $2.24 \pm 0.23$  log cfu/g,  $2.76 \pm 0.28$  log cfu/g and  $2.48 \pm 0.01$  log cfu/g for control cracks dough, carp cracks dough and rainbow trout cracks dough, respectively. The total aerobe bacteria count of crackers dough groups in the experimental study was a decline after cooking and, its was measurement as  $1.47 \pm 0.00$  log cfu/g in RT groups. But other groups (C, CF) wasn't detect in the total aerobe bacteria counts. This decline can be thought to be due to cooking. The population of aerobic bacteria in the all crackers samples used in the study was determined as  $3.86 \pm 0.08$  log cfu/g,  $4.89 \pm 0.01$  log cfu/g,  $3.75 \pm 0.07$  log cfu/g in storage end (C, CF, RT-respectively). In terms of total aerobe bacteria counts, significant differences were determined among the groups on the 9<sup>th</sup> and 18<sup>th</sup> days of storage ( $p < 0.05$ ). Our results were in agreement with the values reported by other researcher [28, 34].



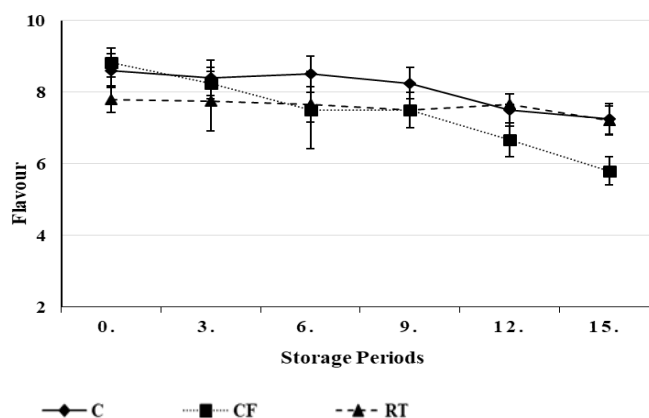
C: Control group, CF: Carp fish meat added group, RT: Rainbow trout meat added group

**Figure 5. Aerobe bacteria counts of fish crackers**

### 3.3. Sensory changes

#### 3.3.1. Flavor changes

Sensory characteristics are quality features evaluated by the senses of the consumers. Sensory characteristics, such as appearance, texture, flavor, and uniformity determine the consumer's impression of a food product [35]. The examination of the flavor of crackers yielded the highest score,  $8.83 \pm 0.37$ , on the first day of preservation for the RT group and the lowest score for flavors,  $7.80 \pm 0.40$ , was obtained by the CF group. On the last day of the preservation process, C group obtained the lowest score for flavor, with a value of  $3.62 \pm 1.11$ . The cracker samples were examined in terms of flavor scores and the difference between all groups was found to be statistically significant on the 1<sup>st</sup>, 6<sup>th</sup> and 15<sup>th</sup> days of preservation ( $p < 0.05$ ). Furthermore, it was observed that the scores were similar on days 0<sup>th</sup> and 3<sup>th</sup> ( $p < 0.05$ ), and there existed statistically significant differences on other days ( $p < 0.05$ ). Other studies indicate similar findings with the present study [6, 28, 36, 37].

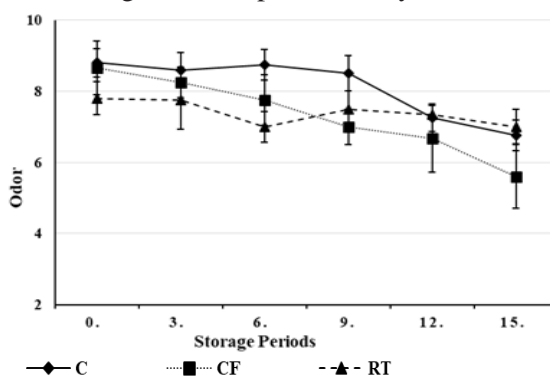


C: Control group, CF: Carp fish meat added group, RT: Rainbow trout meat added group

**Figure 6. Changes in the flavour characteristics of fish crackers**

#### 3.3.2. Odor changes

The prepared cracker samples were also evaluated by the panelists for odor scores and it was found that the C group had the highest score on the 0<sup>th</sup> day of preservation, with a value of  $8.88 \pm 0.40$  and CF group received the lowest score for odor, with a value of  $7.80 \pm 0.75$ . Once the changes in the odor values of the cracker samples throughout the preservation phase were statistically analyzed, the difference between the groups was determined to be significant on certain days of the preservation (1<sup>st</sup>, 6<sup>th</sup>, 9<sup>th</sup> and 15<sup>th</sup> days) ( $p < 0.05$ ). Furthermore, the cracker samples were examined in terms of odor indicated that there were statistically significant differences during the days of preservation ( $p < 0.05$ ). Other studies indicate similar findings with the present study [6, 28, 36, 37].

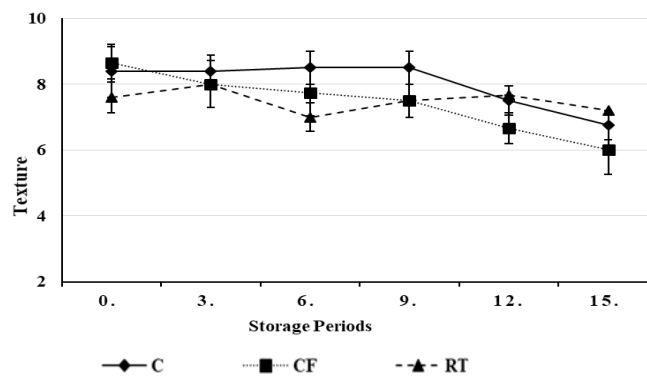


C: Control group, CF: Carp fish meat added group, RT: Rainbow trout meat added group

**Figure 7. Changes in the odor characteristics of fish crackers**

### 3.3.2. Texture changes

The prepared fish cracker samples were also evaluated for their texture and it was found that the highest score for texture was obtained for the RT group on the 0<sup>th</sup> day of preservation and the lowest score was for the CF group on the 15<sup>th</sup> day of preservation. It was determined that there was a decrease in the texture scores, and the statistical analysis of these values indicated statistically significant differences between groups on the 1<sup>st</sup>, 6<sup>th</sup>, 9<sup>th</sup> and 15<sup>th</sup> days of preservation ( $p < 0.05$ ). Furthermore, the evaluation of the cracker samples in terms of texture yielded significant differences for preservation days ( $p < 0.05$ ). An overall evaluation of all the sensory characteristics data indicated that rainbow trout group received the most appreciation and the carp fish group received less due to odor characteristics. Huda et al. [13] stated that fish cracker samples with 10% surimi powder were preferred more by the panelists when compared to the other ratios of surimi powder used in the cracker mixtures.



C: Control group, CF: Carp fish meat added group, RT: Rainbow trout meat added group

**Figure 8. Changes in the texture characteristics of fish crackers**

## 4. Conclusion

In conclusion, an overall evaluation in terms of sensory characteristics indicates that the crackers enriched with fish meat could be considered as a strategy to increase fish consumption and fish crackers have the potential to appeal consumers, especially children, since it combines the inclination towards snacks and the nutritious value of fish meat. The comparison between cracker groups indicated that the most preferred group was the group of crackers that were enriched with rainbow trout meat and the carp fish group demonstrated the fastest chemical and microbiological deterioration in refrigerated conditions. Products can be stored at  $4 \pm 1^\circ\text{C}$  for up to 15 days without marked loss in quality. Such findings, obtained through the evaluation of fish cracker samples obtained via two different fish species, present that the most suitable fish type for fish cracker products is rainbow trout.

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## References

- [1] Aksoylu Özbek, Z. Sağlıklı Bir Atıştırmalık, Kırmızı Pancarlı Çubuk Bisküvi. Conference: 2.Uluslararası Gıda Ar-Ge Proje Pazarı, İzmit, 2013.
- [2] Hendek Ertop, M., Kutluk, K., Coşkun, K., Canlı, S. A New Approach for Production of Chips with Food Industry Byproducts: Gluten Enriched Chips. Akademik Gıda, Volume 14, Issue 4, pp.398-406, 2016.



- [3] Şimşekli, N., Doğan, İ.S. Traditional and Functional Fermented Product: Maras Tarhana. *Iğdır University Journal of the Institute of Science and Technology*, Volume 5, Issue 4, pp. -40, 2015.
- [4] Büyüksaraç, F. The use of different compositions and production methods for production of fish chips. Master thesis, Pamukkale university institute of science food engineering. Denizli, Turkey, pp.78, 2018.
- [5] Tayar, M., Hecer, C. *Hazır yemek sistemleri*. Dora publishing, Bursa, 2016.
- [6] Karaton Kuzgun, N. Food composition and sensory quality of fish crackers made from *Luciobarbus esocinus*. *Journal of Scientific and Engineering Research*, Volume 4, Issue 9, pp. 392-396, 2017.
- [7] Karaton Kuzgun, N. Chemical composition and sensory quality of fish onion rings made from rainbow trout (*Oncorhynchus mykiss*). *International Journal of Nature and Life Science*, Volume 2, Issue 1, pp.34-41, 2018.
- [8] Varlık, C., Erkan, N. Özden, Ö., Mol, S., Baygar, T. *Su Ürünleri İşleme Teknolojisi*. İstanbul university, No:4465, İstanbul, 2004.
- [9] Yapar, A., Atay, S. Turna Balığı (*Esox lucius L.*, 1758) Effect of the different levels of salt and phosphate on some emulsion attributes of the northern pike fish (*Esox lucius L.*,1758) flesh. *Ege Journal of Fisheries and Aquatic Sciences*, Volume 22, Issue 3-4, pp.331-336, 2005.
- [10] Mohamed, S., Abdullah, N., Muthu. M.K. Physical properties of keropok (fried crisps) in relation to the amylopectin content of starch flour. *Journal of Agricultural and Food Chemistry*, Volume 49, , pp. 369-377, 1989.
- [11] Noorakmar, A.W., Cheow, C.S., Norizzah, A.R., Mohd-Zahid, A., Ruzaina, I. Effect of orange sweet potato (*Ipomoea batatas*) flour on the physical properties of fried extruded fish crackers. *International Food Research Journal*, Volume 19, pp., 657-664, 2012.
- [12] Kaewmanee, T., Karrila, T.T., Benjakul, S. Effects of fish species on the characteristics of fish cracker. *International Food Research Journal*, 2 Volume 2, Issue 5, pp. 2078-2087, 2015.
- [13] Huda, N., Abdullah, A., Babji, A.S. Functional Properties of Surimi Powder From Three Malaysian Marine Fish. *International Journal of Food Science and Technology*, Volume 36, pp. 401-406, 2001.
- [14] King, M.A. Development and Sensory Acceptability of Crackers Made From The Big-Eye Fish (*Brachydeuterus auritus*). *Food and Nutrition Bulletin*, Volume 23, Issue 3, pp. 317-320, 2002.
- [15] Nurul, H., Boni, I., Noryati, I. The effect of different ratios of Dory fish to tapioca flour on the linear expansion, oil absorption, colour and hardness of fish crackers. *International Food Research Journal*, Volume 16, pp.159-165, 2009.
- [16] Huda, N., Putra A.A., Ahmad R. Physicochemical and Nutritional Characteristics of Indonesian Buffalo Skin Crackers. *International Journal of Meat Science*, Volume 1, Issue 1, pp.36-51, 2011.
- [17] Shaviklo, G. R. Olafsdottir, A., Sveinsdottir, K., Thorkelsson G., and Rafipour, F., Quality characteristics and consumer acceptance of a high fish protein puffed corn-fish snack. *Journal of Food Science and Technology*, Volume 48, pp.668-676, 2011.
- [18] Netto, J.P.C. Filho, P.R.C.O., Guimarães J. and Viegas E.M. M., *Revista Ciência Agronômica*, Stability of snacks made with minced Nile tilapia stored at room temperature. *Revista Ciência Agronômica*, Volume 51, Issue 1, 2020.
- [19] Broto R.T.D.W., Arifan, F., Setyati, W.A, Eldiarosa, K. and Zein, A.R., Crackers from fresh water snail (*Pila ampullacea*) waste as alternative nutritious food. *Earth and Environmental Science*, Volume 448, 2020.
- [20] AOAC. *Official Methods of Analysis of the Association of Official Analytical Chemists (17 th ed.)* Gaithersburg, Maryland, 2002.
- [21] Conell, J.J., Shewan, J.M. Past, present and future fish science. In: *Advances in fish science and technology*. Fishing News Books Ltd., England, 1979.
- [22] Tarladgis, B.G., Watts, B.M., Younathan, M.T., Dugan, J.R. A distillation method for the quantitative determination of malonaldehyde in racid foods. *Journal of the American Oil Chemists' Society*, Volume 3, pp.44-48, 1960.
- [23] ICMSF (International Commission on Microbiological Specifications for Foods) *Microorganisms in foods 1. Their Significance and Methods of Enumeration*, 2nd ed., University of Toronto Press, Toronto, 1978.
- [24] Harrigan W.F. *Laboratory methods in food microbiology*, 3rd edn. Academic Press, London. 1998
- [25] Lawless, H.T., Heymann, H. *Sensory Evaluation of Food*. Springer, pp.596, 2010.
- [26] Özdamar, K. *SPSS ile Biyoistatistik*. No: 3-4. Baskı. Kaan Kitabevi. Eskişehir, 2001.

- [27] Varlık, C., Uğur, M., Gökoğlu, N., Gün, H. Su ürünlerinde kalite kontrol ilke ve yöntemleri. Gıda teknolojisi derneği, no:17, Ankara, 1993.
- [28] Neiva, C.R.P., Machado, T.M., Tomita, R.Y., Furlan, É.F., Lemos Neto, M.J., Bastos, D.H.M. Fish crackers development from minced fish and starch: an innovative approach to a traditional product. Food Science and Technology, Volume 31, Issue 4, pp. 973-979, 2011.
- [29] Huss, H.H. Quality and Quality Changes in Fresh Fish. Technical paper:348, Rome: Food and Agriculture Organization (FAO) of the United Nations, pp.132, 1995.
- [30] Nor-khaizura, M.A.R., Zaiton, H., Jamilah, B., Rusul, R.A.G., Fitry, M.R.İ. Histamine and Histamine-Forming Bacteria in Keropok lekor (Malaysian Fish Sausage) during Processing. Food Science and Technology Research, Volume 15, Issue 4, pp. 395–402, 2009.
- [31] Sinnhuber R.O., Yu, T.C. 2- Thiobarbituric acid metod fort he measurement of rancidity in fishery products II. The quantitative determination of malonaldehyde. Food Technology, Volume 1, pp., 9-12, 1958.
- [32] Varlık, C., Mol, S., Baygar, T., Tosun, Ş.Y. Su Ürünleri İşleme Teknolojisinin Temelleri. İstanbul university, No:4661, İstanbul, 2007.
- [33] Karaton Kuzgun, N. Farklı esansiyel yağlar ve kitosan ile hazırlanan filmlerle ambalajlanmış *Luciobarbus esocinus* filetolarının 2±1 C'de raf ömrünün araştırılması. Doktora tezi, Fırat Üniversitesi, Su Ürünleri Fakültesi, Elazığ, Turkey, pp.116, 2014.
- [34] Gürel İnanlı, A., Karaton, N., Çoban O.E. Sensorial, chemical and microbiological quality of anchovy cake. African Journal of Biotechnology, Volume 10, Issue 48, pp. 9870-9874, 2011.
- [35] Altuğ Onoğur, T., Elmacı, Y. (2015). Gıdalarda duyuşal deęerlendirme. Sidas Media, İzmir.
- [36] Oduor-Odote, P.M., Kazungu, J.M. The Body Composition of Low Value Fish and Their Preparation into a Higher Value Snack Food. Wes. Indian Ocean Journal of Marine Science, Volume 7, Issue 1, pp.111-117, 2008.
- [37] Karaton Kuzgun, N., Physicochemical and sensory evaluation of fish chips made from *Luciobarbus esocinus* (Heckel,1843). The Journal of Animal&Plant Sciences, Volume 29, Issue 3, pp.842-847, 2019.