Online https://www.asjp.cerist.dz/en/PresentationRevue/871
ISSN: 2800-101X, E-ISSN: 2992-0949
Volume 3, Number 1, December 2024
UMAB PoLSMER

RESEARCH ARTICLE

Effect of different types of cooking on biochemical compounds and lipooxidation in sardine fillets caught in the Algerian coast

Benguendouz Abdenour[1], Bouterfa Asma[1], Bouderoua Kaddour[2], Berrighi Nabila[2], Hammou Abdelillah[3], and Amrane Abdeltif[4]

[1]Applied Animal Physiology Laboratory, Department of Agricultural Sciences, Faculty of Natural and Life Sciences, Abdelhamid Ibn Badis University, Mostaganem 27000, Algeria. [2]Laboratory of Biotechnology Applied to Agriculture and Environmental Preservation, Higher School of Agronomy of Mostaganem, 27000. Algeria. [3]Laboratory of Beneficial Microorganisms, Functional Food and Health, Department of Food science, Faculty of natural and life sciences, University of Abdelhamid Ibn Badis, Mostaganem. 27000 Algeria. [4]Univ Rennes, École Nationale Supérieure de Chimie de Rennes, CNRS, ISCR (Institut des Sciences Chimiques de Rennes) -UMR 6226, F-35000 Rennes, France.

*Corresponding author: abdenour.benguendouz@univ-mosta.dz
Received: October 6, 2024/ **Accepted:** November 25, 2024/ **Published:** December 7, 2024

ABSTRACT

The aim of this study is to highlight the effects of different cooking methods (frying, baking, and grilling) on the main biochemical compounds of *Sardina pilchardus* fillets caught off the Algerian coast and to deduce their impact on the oxidation of lipids contained in this fish species. It was observed that the different cooking methods applied had a significant effect (P<0.05) on the variation in protein content (20.06 to 28.18g/100g), lipid content (7.68 to 13.31g/100g), ash content (3.08 to 4.77g/100g), and dry matter (40 to 50.1g/100g). The same applies to the malondialdehyde (MDA) level, which increased from 0.21 mg eq/kg in baked fillets to 1.35 mg eq/kg in fried sardine fillets.
Keywords: Cooking methods, *Sardina pilchardus*, Biochemical compounds, Lipid oxidation, Malondialdehyde

INTRODUCTION

The treatment of meat and fish through cooking improves their quality but can also lead to the oxidation of lipids and proteins, negatively impacting nutritional quality (Gatellier et al., 2009), sensory quality (Haak et al., 2006), and health value. The cooking method influences both the quantity and quality of organic matter. The fatty acid composition of the finished product is modified compared to that of raw material, as well as the ratio of fatty acids to each other (Bourre, 2003). According to Gandemer and Duchéne (2015), there are three main types of cooking that are widely used: dry cooking, which includes roasting, sautéing, or grilling, leading to a significant loss of water; moist cooking (in water, steam, en papillote, or with sauce); and finally frying, which generally requires the use of cooking oils. Moreover, cold preservation, which includes refrigeration and freezing, plays a crucial role in the preparation and storage of meat and fish (Balde, 2008). Refrigerated products constitute the vast majority of animal foodstuffs consumed worldwide (Balde, 2008). However, the different cold preservation techniques for meat and fish lead to physical, microbiological, and biochemical changes (Balde, 2008), mainly affecting fatty acids and proteins through several oxidative processes. These changes are mainly related to water activity, resulting in variations in the water content of muscle tissue (Monin, 2003). In this context, the objective of this research study is to examine the effects of certain thermal treatments (cooking) and preservation methods on the nutritional qualities of Sardina pilchardus fillets caught off the Algerian coast and to deduce their impact on the health value of this fish species.

MATERIALS AND METHODS

Sampling of Sardine Specimens

The samples of Sardina pilchardus were captured in the Mostaganem area by "Sardinier" type vessels during February 2014. From these sardine samples, 300 specimens of Sardina pilchardus, measuring 13 to 15 cm in length and weighing an average of 16 to 18 g, were selected. The heads, bones, viscera, and tails of the sardines were removed to obtain fillets. These fillets were then

randomly divided into 10 homogeneous groups of 30 fillets each. One group was kept fresh and raw to serve as a control (T). The remaining 9 groups (270 fillets) were equally divided into three distinct batches (each batch comprising 3 groups of 30 sardine fillets) to undergo different cooking methods.

Cooking Methods Applied

Cooking is the final stage of food preparation before consumption. The cooking method, its duration, and intensity are adapted to the origin and quality of meat and fish. In our experiment, 3 cooking methods were selected for each batch: frying (F) for 4 minutes at 180 °C using sunflower oil (1st group of each batch); oven-cooked (OC) for 20 minutes at 200 °C (2nd group of each batch); and grilling (G) for 3 minutes on a stainless steel grill at a temperature of 350 °C (3rd group of each batch).

Analytical Techniques

Dry Matter

The dry matter content is conventionally determined by the weight of a test sample after drying at 105°C in an oven for 24 hours (AFNOR, 1985).

Ash

The ash content is conventionally the residue of the substance after the destruction of organic matter by incineration at 550°C in a muffle furnace for 6 hours (AFNOR, 1985).

Total Proteins

The determination of protein content in rib samples (raw/cooked) was performed using the Kjeldahl method (1883). This technique involves converting organic nitrogen into mineral nitrogen (mineralization), then displacing ammonia from the obtained ammonium salt (distillation) to neutralize it with a 0.1 N sulfuric acid solution (titration).

Total Lipids

Total lipids were extracted using the method of Folch et al. (1957). This technique is based on the principle of cold extraction of lipids contained in the rib using a chloroform-methanol solvent mixture (2V/1V). The addition of a 0.58% aqueous NaCl solution allows phase separation. The upper phase, consisting of methanol-water, contains hydrophilic compounds, whose dissolution is favored by the presence of salt, while lipids are dissolved in the chloroform-lipid organic phase.

Concentration of Thiobarbituric Acid Reactive Substances (TBA-RS)

Thiobarbituric acid reactive substances (TBA-RS) were determined by the method of Salih et al. (1987), modified by Genot (1996). Two grams of each previously minced sardine fillet are placed in a 25 ml tube containing 16 ml of 5% (w/v) trichloroacetic acid and 100 µl of vitamin E. The mixture is homogenized 3 times for 15 seconds using a homogenizer (Ultra-Turrax) at a speed of 20,000 rpm. The homogenate is passed through filter paper. From this filtrate, 2 ml is added to 2 ml of thiobarbituric acid (TBA). The thiobarbituric acid (TBA) reacts with malondialdehyde (MDA), formed after cooking, to produce a pink-colored complex with a maximum absorption rate at a wavelength of 532 nm.

Statistical Analysis

The results obtained were subjected to analysis of variance followed by a comparison of means using Duncan's test (IBM SPSS software® version 20).

RESULTS AND DISCUSSIONS

Effects of Cooking Methods on Biochemical Compounds and Lipid Oxidation in Sardina pilchardus

From a nutritional standpoint, cooking yields provide direct insight into the losses and gains of biochemical compounds in meat and fish on the one hand, and their modifications on the other. It is important to note that proteins and lipids are the most vulnerable to thermal treatments and preservation methods. The results recorded in this section are illustrated in Table 1.

Dry Matter Content

The results revealed that the cooking methods studied in our experiment led to a significant increase in dry matter content ($P<0.05$). Specifically, increases of 40%, 52%, and 46.7% were observed in fried, oven-cooked, and grilled sardines (F, OC, G), respectively (Table 1). According to Nikmaram et al. (2011), roasting applied to veal results in a significant increase in dry matter

content. Kocatepe (2011) reported that cooking anchovies results in water loss, a process that leads to an increase in dry matter after cooking.

Table 1. Effects of Different Cooking Methods on the Biochemical Composition (**mean ± SD),** and Lipid Peroxidation of Sardine Fillets (g/100g),

Group[2]	Dry matter	Proteins	Lipids	Ash	MDA[1]
Raw sardine fillet (T)	24,00±0,61[a]	20.31±0.33[a]	7,02±0,33[a]	2,17±0,23[a]	0,15±0,02[a]
Fried sardine fillet (F)	40,00±0.8[b]	28.18±0.24[b]	13.31±0.58[b]	4.77±0.09[b]	1.35±0.04[b]
Oven-cooked sardine Filtet (OC)	50.10±0.77[c]	20.60±0.42[a]	7.68±0.38[c]	3.08±0.13[c]	0.21±0.02[c]
Grilled sardine fillet (G)	45.10±0.55[d]	24.23±0.43[c]	9.60±0.40[d]	3.25±0.13[d]	0.33±0.04[d]

[1] in mg eq/Kg. [2]Sardine fillets subjected to different cooking methods are represented by the following labels: F (Fried), OC (Oven-cooked), and G (Grilled). Raw fillets are labeled as T. Different letters assigned [(a, b, c, d)] indicate significant differences. n=10.

Furthermore, the effects of the different cooking methods used in our research on dry matter also impacted moisture content, showing an inverse trend. A significant decrease ($P<0.05$) of about 21%, 35.3%, and 28% was recorded for fried, oven-cooked, and grilled sardines, respectively (F, OC, G). Our results are similar to those reported by Aberoumand (2014), who observed that different cooking methods (boiling, roasting, and frying) lead to significant water loss in the Carangoides malabaricus fish species caught in Iran.

Ash Content

The analysis of variance revealed that the applied cooking methods resulted in a significant increase ($P<0.05$) in ash content, with gains of 54%, 29.5%, and 33% in fried, oven-cooked, and grilled sardine fillets, respectively (4.77g vs. 3.08g vs. 3.25g/100g) compared to raw fillets (2.17g/100g) (Table 1). These increases in mineral content in the sardine fillets studied can be explained by the significant water loss during cooking. These results are consistent with those of Alipour et al. (2010), who found that grilling Iranian sturgeon fillets led to an increase in ash content. According to Hakimeh et al. (2010), frying silver carp results in an increase in ash content from 1.04g/100g before cooking to 1.72g/100g after cooking, while grilling had no observable effect on minerals.

Proteins Content

The protein content results of sardine fillets are illustrated in Table 1. The protein contents of the different studied samples show that fried sardine fillets surpass grilled (G) and oven-cooked (OC) fillets (28.18g vs. 24.23g vs. 20.60g). However, it is important to note that oven cooking does not show a significant effect on the protein rate of the studied fillets compared to the control (20.31g/100g) ($0.05 < P$) (Figure 33). According to Williams (2007), protein gains are mainly due to water losses in the sardine fillets following the application of different thermal treatments. Thus, according to the same author, these treatments have the effect of concentrating nutrients, especially proteins. On the nutritional level, cooking causes structural changes in myofibrillar proteins, particularly in collagen, leading to their denaturation, which significantly reduces their nutritional quality (Martens et al., 1982). Our results are in agreement with those of Gokoglu et al. (2004), who revealed that fried, oven-cooked, and microwave-cooked rainbow trout had higher protein levels compared to raw trout. A study conducted by Kocatepe (2011) on Turkish anchovies revealed that protein content varies according to the cooking method applied, with 22.71g/100g in raw anchovies versus 25.55g/100g in grilled anchovies, a difference estimated at 11%.

Total Lipid Content

Regarding the total lipid content, the obtained results show that the different cooking methods applied had a significant effect ($P < 0.05$) on the lipid proportions of the studied fillets. It should be noted that frying (F) enriched the sardine fillets the most in lipids compared to other thermal treatments; the difference is about 2 times (7.02g vs. 13.31g/100g) (Table 1). This outcome is related to water loss during cooking (Zotos et al., 2013). Furthermore, oven cooking (OC) did not have a marked effect on lipid gain compared to raw sardines (7.02g vs. 7.68g), whereas grilling (G) led to a greater fat gain estimated at 2.6g/100g (7.02g vs. 9.60g/100g). Similar results were reported by Nasopoulou et al. (2013), who found that total lipid content increased significantly in sardine fillets caught on the Greek coast after grilling (0.75g vs. 2.62g/100g), a gain of 71% (Table 1). According to Gokoglu (2004), frying rainbow trout promotes lipid concentration (3.44g raw vs. 12.7g/100g) by allowing oil to penetrate the structure of the cooked fillets through an absorption process. Furthermore, Puwastien et al. (1998) also noted that boiled Thai fish contained the same fat content as raw fish. According to Nielsen et al. (2005), lipid content in fish varies according to extrinsic factors related to the fish species (size, age, physiological state, and season). In fish, fat content is strongly dependent on the season of capture (Varela et al., 1990), trophic factors (diet) (Jobling and Bendiksen, 2003), environmental factors (temperature and salinity) (Eroldogan et al., 2004), and also on the cooking methods applied (Nasopoulou et al., 2013).

Concentration of Thiobarbituric Acid Reactive Substances (TBARS)

MDA levels appear in higher concentrations in fillets subjected to different cooking methods than in raw fillets (0.15 mg eq vs. 1.35 vs. 0.21 vs. 0.33 mg eq/kg); that is, differences estimated at 89%, 28.5%, and 54.5% for fried, oven-cooked, and grilled

sardine fillets, respectively ($P<0.05$) (Table 1). Indeed, frying causes the most lipid peroxidation compared to other thermal treatments; the difference is estimated at about 9 times (0.15 mg eq raw vs. 1.35 mg eq fried). According to Durand et al. (2006), lipid peroxidation is one of the major causes of elevated MDA levels. The high proportions of MDA in fried sardine fillets (1.35 mg eq) can be explained by their enrichment in fat from the oil used, which was absorbed by the fillets during cooking, subsequently promoting an increase in toxic compounds, particularly malondialdehyde (MDA) (Combes and Dalle Zotte, 2005). Our results are similar to those of Diana et al. (2010), who stated that frying salmon and cod in oil tends to increase the levels of thiobarbituric acid reactive substances (TBARS), including malondialdehyde (0.28 mg/kg vs. 0.73 mg/kg for salmon and 0.06 mg/kg vs. 0.53 mg/kg for cod), with differences of 61.6% and 88.6%, respectively. Furthermore, heating stimulates lipid peroxidation, thereby producing aldehydes that react with the amine groups of proteins to form "Schiff bases." According to Gladyshev et al. (2006), these lipoperoxidation phenomena can be slowed down by the natural antioxidants present in the flesh of some fish, thereby preventing the oxidation of polyunsaturated fatty acids during thermal treatments. Finally, Diana et al. (2010) concluded that vegetable oils used for frying can also limit lipid oxidation through their natural antioxidants.

CONCLUSION

At the end of this study, it was concluded that cooking has a significant impact on the biochemical compounds of sardine fillets, namely dry matter, proteins, lipids, and minerals. These thermal cooking treatments also have a significant effect on malondialdehyde (MDA) levels, allowing us to deduce that cooking is responsible for various lipoperoxidation phenomena, thus reducing the health value of meats in general.

REFERENCES

1. Aberoumand A, 2014. Nutrient composition analysis of gish fish fillets affected by different cooking methods. International Food Research Journal 21(5): 1989-1991.
2. AFNOR. 1985. Association Française de Normalisation. Aliments des animaux, méthodes d'analyses française et communautaire. 2eme édition, 200p.
3. Alipour .H .J, Bahareh .S, Ali .S , Alireza .S .M., 2010. Effects of cooking methods on physico-chemical and nutritional properties of Persian sturgeon *Acipenser persicus* fillet. Int AquatRes. 2010 2: 15-23 ISSN 2008-4935.
4. Balde Mamadou, 2008. L'efficacité du ressuage réfrigéré des viandes de bovins aux abattoirs de Dakar. Mémoire de diplôme d'études approfondies de productions animales. Université Cheikh Anta Diop de Dakar, Sénégal.
5. Bourre, J. M., 2003. Effect of animal feeding and nutritional value on derived products consumed by humans: are lipids concerned nearly exclusively?.OCL Oleagineux, Corps Gras, Lipides 10(5/6): 405-424.
6. Combes. S, Dalle Zotte .A, 2005. La viande de lapin : valeur nutritionnelle et particularités technologiques. 11èmes Journées de la Recherche Cunicole, 29-30 novembre 2005, Paris. P167-180.
7. Diana Ansorena ,AinhoaGuembe, Tatiana Mendizábal, Iciar Astiasarán., 2010. Effect of Fish and Oil Nature on Frying Process and Nutritional Product Quality. Journal of Food Science 75(2):H62-7.
8. Durand D., Gruffat D., Ortigues-Marty I., Savary-AuzelouX I., Thomas E., Peyron A., Bauchart D., 2006. Impact de différents modes de cuisson de la viande bovine sur les processus de peroxydations lipidiques. 11èmes JSMTV - Clermont Fd - 2006 - Page 104.
9. Eroldogan, O. T., Kumlu, M., Aktas, M., 2004. Optimum feeding rates for *European sea bass Dicentrarchus labrax L.* reared in seawater and freshwater. Aquaculture 231(1-4), 501- 515.
10. Folch, J., Lees, M. and Sloane Stanley, G.H., 1957. A simple method for isolation and purification of total lipids from animal tissues. The Journal of Biological Chemistry, 226, 497–509.
11. Gandemer G., Duchène C. 2015. Valeurs nutritionnelles des viandes cuites. Effets de la cuisson sur la composition des viandes. Paris. CIV, 93 pages.
12. Gatellier, Ph., Santé-Lhoutellier, V., Portanguen, S., & Kondjoyan, A., 2009. Use of meat fluorescence emission as a marker of oxidation promoted by cooking. Meat Science, 83,651–656.
13. Genot, C., 1996. Some factors influencing TBA test, Annual report of the Vth PCRD EU project: Dietary treatment and oxidative stability of muscle and meat products: nutritive value, sensory quality and safety (Diet-ox) Report of diet-ox project, AIRIII-CT- 92-1577.
14. Gladyshev MI, Sushchik NN, Gubanenko GA, Demirchieva SM, Kalachova GS., 2006. Effect of way of cooking on content of essential polyunsaturated fatty acids in muscle tissue of humpback salmon (*Oncorhynchus gorbuscha*). Food Chem 96(3):446-451.
15. Gokoglu N, Yerlikaya P, Cengiz E. 2004. Effects of Cooking Methods on the Proximate Composition and Mineral Contents of Rainbow trout (*Oncorhynchus mykiss).* Food Chem,84:19-22.

16. Gokoglu N, Yerlikaya P, Cengiz E. 2004. Effects of Cooking Methods on the Proximate Composition and Mineral Contents of Rainbow trout (*Oncorhynchus mykiss*). Food Chem,84:19-22.
17. Haak, L., Raes, K., Smet, K., Claeys, E., Paelinck, H., & De Smet, S. 2006. Effect of dietary antioxidant and fatty acid supply on the oxidative stability of fresh and cooked pork.Meat Science, 74, 476–486.
18. Hakimeh. J. A, Akram.A.A, Bahareh.S et Alireza.S.M. 2010. Physicochemical and sensory properties of silver carp (*Hypophthalmichthys molitrix*) fillets as affected by cooking methods. International Food Research Journal 17: 921-926.
19. Jobling, M. & Bendiksen, E.Å. 2003. Dietary lipids and temperature interact to influence tissue fatty acid compositions of Atlantic salmon, Salmo salar L. Parr. Aquac. Res.34: 1423-1441.
20. Kjeldahl J. 1883. Neue Methode zur Bestimmung des Stickstoffs in organischen Körpern. *Fresenius, Zeitschrift f. anal. Chemie* 22, 366–382 (1883). https://doi.org/10.1007/BF01338151
21. Kocatepe Demet, Hülya Turan, Gökay Taşkaya, Yalçın Kaya, Rabiya Erden, FulyaErdoğdu, 2011. Effects of cooking methods on the proximate composition of black sea anchovy (Engraulisencrasicolus, Linnaeus 1758). GIDA (2011) 36 (2): 71-75.
22. Martens, H., Stabursvik, E. & Martens, M., 1982. Texture and colour changes in meat during cooking related to thermal denaturation of muscle proteins. Journal of Texture Studies 13, 291-309.
23. Monin G., 2003. Abattage des porcs et qualités des carcasses et des viandes. INRA Prod.Anim., 16,251-262.
24. Nasopoulou, C., Evangelia.P, Eleni. S., Constantinos, A. D. and Ioannis, Z., 2013. Evaluation of sensory and in vitro Cardio Protective Properties of Sardine (Sardina pilchardus): the effect of Grilling and Brining. Food and Nutrition Sciences, (4), 940-949.
25. Nielsen, D., Hyldig, G., Nielsen, J., Nielsen, H. H., 2005. Lipid content in herring(Clupea harengus L.)- Influence of biological factors and comparison of different methods ofanalyses: solvent extraction, Fatmeter, NIR and NMR. Lebensmittel-WissenschaftundTechnologie38(1-2) 537-548.
26. Nikmaram P., Yarmand M. S. and Emamjomeh Z. 2011. Effect of cooking methods on chemical composition, quality and cook loss of camel muscle (*Longissimus dorsi*) in comparison with veal. African Journal of Biotechnology Vol.10(51), pp. 10478-10483.
27. Puwastien, P., Judprasong, K., Kettwan, E., Vasanachitt, K., Nakngamanong, Y., & Bhattacharjee, L. 1998. Proximate composition of raw and cooked Thai freshwater and marine fish. Journal of Food Composition and Analysis, 12, 9–16.
28. Salih, A.M., Smith, D.M., Price, J.F. & Dawson, L.E., 1987. Modified extraction 2-thiobarbituric acid method for measuring lipid oxidation in poultry. Poult. Sci. 66, 1483-1488.
29. Varela, G., Perez, M., & Ruiz-Roso, B. 1990. Changes in the quantitative andqualitative composition of fat from fish, due to seasonality and industrial and culinary processing. Bibliotheca Nutritio and Dieta, Karger, Basel, 46, 104–109.
30. Williams, P.G, 2007. Nutritional composition of red meat, Nutrition & Dietetics, 64 (Suppl 4), .S113-S119.
31. Zotos, A. Kotaras, A. and Mikras, E., 2013. Effect of Baking of Sardine (*Sardina pilchardus*) and Frying of Anchovy (Engraulis *encrasicholus*) in Olive Oil and Sunflower Oil on Their Quality," Food Science and Technology International, Vol. 19, No. 1, pp. 11-23.