Changes in fish during cooking methods (frying and grilling): A review.

Adel A El-Lahamy[1*], Khalil I Khalil[2], Shaban A El-Sherif[1], Hassan R Ibrahim1 and Awad A Mahmud[2]

[1]National Institute of Oceanography and Fisheries, Fish Processing Technology Laboratory, Cairo, Egypt

[2]Food Science and Technology Department, Faculty of Agriculture, Fayoum University, Fayoum, Egypt

Abstract

Cooking methods of frying and grilling are the most common ways of cooking fish. In this article we highlight some changes that occur in fish during cooking with frying and grilling in both chemical composition chemical quality indices such as Total Volatile Basic Nitrogen (TVB-N), Thiobarbituric acid (TBA) and pH value. As well as the effect of cooking methods on the microbial safety Total Bacterial Count (TBC) and Yeast and Molds (Y&M)) nutritional value (amino acid composition) of cooked fish.

Keywords Cooking methods, Frying, Grilling, Chemical composition.

Accepted on May 03, 2019

Introduction

Fish is a suitable source of good quality protein which is essential for health [1]. Fish is usually cooked in different ways such as boiling, baked, frying and grilling. These cooking methods result in enhancing flavor, taste and improve the digestibility and inactivate the pathogenic microorganisms [2]. During cooking of fish, some chemical and physical reactions take place such as protein denaturation that increases its digestibility and improves the nutritional value. Meanwhile, the contents of thermolabile compounds, fat-soluble vitamins or polyunsaturated fatty acids are often reduced [3]. The grilling method has recently become more popular. Grilling is a mean of cooking by radiant heat from below and is different from broiling which means cooking by radiant heat from above. In the food service industry, grill has become synonymous with griddle. Both terms refer to the equipment that has a flat and solid heated surface to cook, such as hamburgers, steaks, chops, and cutlets. This equipment allows cooking with or without the addition of fat [4]. Deep Fat Frying (DFF) is a major cooking method and is considered to be one of the oldest methods of food preparation. It is a cooking method of immersing foods in hot oil at a temperature above the boiling point of water. The oil temperature usually varies from 130 to 200°C. During frying, there are many chemical reactions take place such as browning, gelatinization and denaturation due to the elevated temperature of the product [5].

Effect of Cooking (Frying and Grilling) Methods on Chemical Composition of Fish

Chemical composition

Chemical composition of fish varies widely depending on the fish species, age, size and sex, growth place, catching season, and the environmental conditions [6]. The chemical composition of Rainbow trout fish (*Oncorhynchus mykiss Walbaum*) cooked by frying and grilling. Chemical analysis (on wet weight basis) showed that fresh, fried and grilled samples, respectively contained 73.38, 62.69 and 65.83% of moisture; 19.80, 26.34 and 25.00% of protein; 3.44, 12.70 and 5.95 % of fat and 1.35, 1.66 and 1.54 % of ash, respectively [7]. The chemical compositions of fresh Sea bass (*Dicentrarchus labrax*) were 73.39, 17.07, 5.17 and 1.32, respectively for moisture, protein, fat and ash contents. Fried Sea bass contained 59.76, 23.65, 9.92 and 2.01 of moisture, protein, fat and ash, respectively, while grilled samples contained 68.33, 21.08, 5.18 and 1.58%, respectively [8]. The effects of cooking method on the proximate chemical composition of Snakehead fish were studied. The results showed that protein and fat contents of fried product were significantly higher ($P<0.05$) than the grilled samples. Protein and fat contents of fried samples were 17.3 and 16.1 ± 0.1, respectively, while their contents in grilled samples were 10.7 and 8.6, respectively [9]. There was no significant difference observed in fat content among boiled, baked, grilling and raw fish fillets ($P>0.05$) [9]. The increase in fat content of the fried fish fillets is related to oil absorption during the cooking process. Also, reported that the increase in dry matter content was observed in the fried and grilled fish fillets. The highest moisture content (77.2 %) was recorded in raw fillets and decreased moisture content was noticed in all the cooking method except for the boiled fillets. Increased ash content was noticed in all the cooked fillets when compared to raw fish fillets. Moisture loss was also recorded in baked fillets of Snakehead fish. The highest value of moisture loss was found in fried anchovy (49.55%). Protein and fat contents of cooked Anchovy by grilling and frying were 25.55%, 17.51% and 24.44%, 23.30%, respectively [2]. The highest protein, the lowest fat and energy contents were found in the grilled fish, therefore grilling can be recommended as the best cooking method for healthy diet [2]. The moisture, crude protein, crude fat and ash contents of fresh Sardines (*Clupea pilchardus*) fillets were 60.68%, 20.67%, 15.44% and 3.26%, respectively. While their values in grilled fillets were 50.81%, 29.96%, 16.40% and 4.31% respectively. Also the moisture, crude protein, crude fat and ash contents of refrigerator thawed

Sardines fillets were 61.55%, 18.18%, 18.01% and 2.55%, respectively. While their values in grilled fillets were 44.83%, 28.94%, 23.03% and 4.02%, respectively [10]. The proximate compositions of raw, grilled and fried anchovy (*Engraulis encrasicolus* (Linnaeus)) were determined. Moisture, fat, protein, ash and carbohydrate contents of raw fish were 62.85%, 10.64%, 22.71%, 1.48% and 2.31%, respectively, in grilled anchovy, these values were 62.86, 10.64, 22.71, 1.48 and 2.31, respectively. The fried anchovy showed values of 49.55, 23.30, 24.44, 2.02 and 0.68 for moisture, fat, protein, ash and carbohydrate contents, respectively [2]. The moisture, crude protein, crude fat and ash contents of raw Carp fish cutlets (*Cyprinus carpio*) were 65.70%, 17.06%, 3.14% and 2.20%, respectively. While their values in fried cutlets were 60.85%, 21.26%, 6.02% and 2.95%, respectively [11]. The gross chemical composition of fresh Mullet fish was affected by cooking method. The results showed that moisture, protein, fat, ash and carbohydrates contents of fried samples were 60.23 ± 1.28, 23.77 ± 0.444, 13.45 ± 0.259, 2.05 ± 0.288 and 0.50 ± 0.005, respectively while their contents in grilled samples were 64.72 ± 1.73, 22.65 ± 1.15, 10.2 ± 1.15, 1.98 ± 0.565 and 0.45 ± 0.017, respectively. These data could be due to the loss of water during cooking process; consequently dry matters were increased [12]. Also there was significant ($p<0.05$) loss in the moisture content of raw fish due to the cooking process by frying and grilling. It was observed that moisture content was decreased by 15.70 % in the fried steaks and 9.41 % in the grilled samples. That deep-fried fish had the highest protein value comparing other cooking methods. Water loss, occurring during cooking resulted in increasing protein content in the fried fish samples [7,8]. The higher lipid content of fried fish than grilled steaks is mainly due to the absorption of oil by the fish and losing moisture during frying process [13]. The apparent higher ash content of fried steaks is due to more loss of moisture took place during deep frying cooking comparing with grilling method [8].

Physiochemical Quality Parameters

Total volatile basic nitrogen (TVB-N)

Total volatile basic nitrogen (TVB-N) is a general term which includes the measurement of Trimethyl Amine (TMA), Dimethyl Amine (DMA), ammonia, and other volatile basic nitrogenous compounds associated with seafood spoilage [14]. The TVB-N of fresh Mullet was 12.90 mg/100 g and this value decreased to 12.05 and 12.35 mg /100 g for fried and grilled mullet, respectively. In tilapia fish, the TVB-N values were 14.31, 13.12 and 14.05 mg/100 g sample for raw, fried and grilled Tilapia, respectively [15]. The TVB-N value slightly decreased from 12.21 in raw to 11.75 mg/100 g sample in fried Carp Cutlets [11]. The total volatile basic nitrogen (TVB-N) values of raw Nile Tilapia was 12.60 mg/100 g and this value decreased to 11.30 and 10.40 mg/100 g sample for fried and grilled samples, respectively. Chemical analysis of Mullet fish indicated that TVB-N of raw, fried and grilled Mullet steaks were determined by 13.25 ± 0.144, 12.48 ± 0.277 and 12.96 ± 0.554 mg/100 g, respectively [16]. This decrease may be due to the effect of heat during frying and grilling that may be resulted in the volatilization and loss of some volatile nitrogen compounds during frying, and also in the grilling process some volatile nitrogen compounds may be dripped and lost in the dipping solution [15].

Thiobarbituric acid (TBA)

TBA is one of the most widely used measurements of seafood quality. Studies on the effect of cooking method on the chemical quality parameters of fish products are scare. In an early study, the low TBA values during cooking process may be due to the formation of secondary products of lipids oxidation, which do not react with the TBA reagent or to the reaction of malondialdehyde with protein [17]. Similarly, the decrease of TBA values in fish cutlet as affected by cooking methods could be attributed to the interaction of the decomposition products from protein with malondialdehyde to give tertiary products [18]. The increment in malondialdehyde may be due to the oxidation of polyunsaturated fatty acids coming from the used oil [19]. The TBA values (determined as mg malondialdehyde/kg) of fresh Tilapia and Mullet fish samples were 0.55 and 0.95 and these values changed to 0.43 and 0.88 after frying process while in grilled fish TBA values were 0.28 and 0.70 mg malondialdehyde/kg, respectively [15]. The effect of frying method on the chemical quality parameters in Common Carp cutlets were studied and results showed that (TBA) value slight decrease from 1.20 in raw sample to 1.18 mg malondialdehyde/kg after frying [11]. More recently similar observations were found by El-Sherif et al. [20]. who reported that (TBA) content of Nile Tilapia from first lake of Wadi El-Rayan was decreased from 0.75 mg/kg in raw sample to 0.50 and 0.42 mg malondialdehyde/kg in fried and grilled samples, respectively, (on wet weight). TBA value of raw, fried and grilled Mullet samples were 0.88 ± 0.057, 0.75 ± 0.046 and 0.69 ± 0.034, respectively. TBA values decreased in the cooked samples [16].

pH value

The increase of pH values in processed fish may be due to the formation of some basic compounds as a result of amino acid degradation [21,22]. The pH values of fresh Tilapia and Mullet fish increased from 6.07 and 5.94, to 6.21, 6.12 and 6.16, 6.04 in fried and grilled fish products, respectively [15]. Also, they observed that at any time of storage period for 180 days at -18°C, the highest pH values were recorded for the fried samples followed by grilled and boiled samples. pH value of fish muscle is usually used as a good index for quality assessment. It is important determining factor of fish quality as texture of fish [23]. the pH value of fried Common in Carp Cutlets showed slightly increase after cooking from 6.15 and 6.23 in raw and fried Carp Cutlets, respectively [11]. The pH value of raw, fried and grilled Mullet samples recorded 6.2 ± 0.577, 6.32 ± 0.184 and 6.27 ± 0.155, respectively [16].

Microbiological Aspects of Cooked Fish products

It is well known that one of the most important benefits of cooking fish and fishery products with the different methods is improving the hygienic quality and safety by the inactivation of pathogenic microorganisms [10]. The effects of both frozen storage and different cooking methods (frying, grilling and boiling) on the Total Viable Count (TVC) of fish products were examined. The data showed that all cooking methods resulted in sharp reduction in the microbial load (TVC) and the highest reduction rate was found in the fried samples as compared with the raw frozen fish as well as the grilled and boiled samples. The low TVC may be due to the thermal destruction of microorganisms during the different cooking processes [15]. The Total Plate Count (TPC) value decreased from 3.20 log cfu/g in raw fish to 2.80 log cfu/g in fried sample [11]. The Total Bacterial Count (TBC) of raw, fried and grilled Nile Tilapia from first lake of Wadi El-Rayan were 3.39, 3.26 and 3.30 log10 cfu/g, respectively [20]. Also, TPC was sharply reduced in all the cooked fish samples and the highest reduction rate was observed in the fried samples followed by grilled sample. Microbiological examination showed that (TBC) of raw, fried, grilled samples of Mullet fish recorded 3.3 ± 0.144, 2.95 ± 0.040 and 3.04 ± 0.023 (log cfu/g), respectively. While yeast and mold counts were1.94 ± 0.034, 1.3 ± 0.046 and 1.69 ± 0.121 in raw, fried and grilled Mullet samples, respectively [23-29].

Effect of Cooking Method on Amino Acids Composition of Fish

The protein quality depends on its content of amino acids, ratios of essential amino acids and the physiological utilization of amino acids after digestion, absorption and oxidation [24]. The nutritional quality of protein is connected to its content of the essential amino acids [25]. Fish contains high amounts of the essential amino acids, particularly lysine in which cereals are relatively poor and therefore fish protein can be used to a good complement of such essential amino acid [26]. The influence of the sequential freezing, thawing and grilling on the protein quality of Sardine fish fillets [10] and observed that after frozen storage followed by thawing, Sardine fillets showed significant decreases in several amino acids, with cyst (e) ine being the most affected. The difference in the percentages of loss of lysine and cyst (e) ine in grilled samples should be related to the kind of alteration compounds formed during grilling. The changes in amino acid profile of four marine fish species included Herring (*C. harengus*), Atlantic mackerel (*S. scombrus*), horse mackerel (*T. trachu-rus*) and white hake (*U. tenuis*) during processing methods (roasting, boiling and frying) were studied. In generall, raw fish samples of all the evaluated fish species had higher Total Essential Amino Acid (TEAA) as compared to the processed samples with different methods. The reduction of TEAA values was more pronounced in the fried samples comparing with the boiled and roasted samples. The investigators showed that TEAA of fresh of Herring (*C. harengus*) decreased from 40.73 g/100 g protein to 40.28, 40.17 and 33.38 g/100 g protein [27]. More recently, [28] studied the effect of the processing methods; boiling, roasting (over hot charcoal) and frying using different types of oils (using different types of oils) on the nutritional composition of Catfish (*Clarias gariepinus*) and Tilapia (*Oreochromis niloticus*). They observed that frying with palm oil appeared to have the worst effect on the amino acid contents of fish samples, resulting in the loss of essential amino acids for the two species. Several amino acids showed slight decreases due to frying and grilling processes while some others slightly increased either in the cooked samples from fresh fish steaks or from the frozen stored (for 6.0 months) steaks. Also the results indicated that the essential amino acids contents of fresh, fried and grilled Mullet fish steaks were 42.54, 36.74 and 39.62 g/100 g protein, respectively while their contents of the non- essential amino acids were 45.18, 43.53 and 45.25 g/100 g protein, respectively and the total amino acids contents were 86.72, 80.23 and 84.87 g/100 g protein, respectively. These data show that frying process resulted more loss in amino acids in comparison to the effect of grilling process [29].

Conflict of Interest

The author declares no competing interests.

References

Kim JD, Lall SP. Amino acid composition of whole body tissue of Atlantic halibut (Hippoglossus hippoglossus), yellowtail flounder (Pleuronectes ferruginea) and Japanese flounder (Paralichthys olivaceus). Aquaculture. 2000;187:367-73.

Kocatepe D, Turan H, Taşkaya G, et al. Effects of cooking methods on the proximate composition of black sea Anchovy (Engraulis encrasicolus, Linnaeus 1758). GIDA. 2011;36:71-5.

Alizade E, Chapleau N, Delamballerie M, et al. Effect of freezing and cooking processes on the texture of Atlantic salmon (Salmo salar) fillets. Proceedings of the 5th CIGR Section VI International Symposium on Food Processing, Monitoring Technology in Bioprocesses and Food Quality Management. Potsdam, Germany. 2009;262-69.

National Live Stock and Meat Board. Meat in the food service industry. 2nd ed. pp: 51-58. National Live Stock and Meat Board, Chicago, IL.1977.

Tangduangdee C, Sakarindr B, Suvit T. Heat and mass transfer during deep-fat frying of frozen composite foods with thermal protein denaturation as quality index. Science Asia. 2003; 29:355-64.

Gökçe MA, Taşbozan O, Çelik M, et al. Seasonal variations in proximate and fatty acid compositions of female common sole (Solea solea). Food Chem. 2004;88:419-23.

Gokoglu N, Yerlikaya P, Cengiz E. Effects of cooking methods on the proximate composition and mineral contents of rainbow trout (Oncorhynchus mykiss). Food Chem. 2004;84:19-22.

Kucukgulmez A, Celik M, Yanar Y, et al. Effects of different cooking methods on the proximate composition

and mineral contents of sea bass (Dicentrarchus labrax). Adv Food Sci. 2006;28:223-27.

Marimuthu K, Thilaga M, Kathiresan S, et al. Effect of different cooking methods on proximate and mineral composition of striped Snakehead fish (Channa striatus, Bloch) J Food Sci Technol. 2012;49:373-37.

Garcia-Arias MT, Ai lvarez Pontes E, Garcia-Linares MC, et al. (Grilling of sardine fillets. Effects of frozen and thawed modality on their protein quality. J Lebensm-Wiss u Technol 2003;36: 763-69.

Talab SA. Effect of cooking methods and freezing storage on the quality characteristics of fish cutlets. J Food Sci Technol. 2014;6:468-79.

El-lahamy AA. Effect of some processing methods on quality of some fishes of wady El-rayan, Fayoum Governorate. PhD Thesis, Faculty of Agriculture Fayoum University Egypt. 2018.

Saguy IS, Dana D. Integrated approach to deep fat frying: Engineering, nutrition, health and consumer aspects. J Food Eng. 2003;56:143-52.

Sallam KI, Ahmed AM, Elgazzar MM, et al. Chemical quality and sensory attributes of marinated Pacific saury (Cololabis saira) during vacuum-packaged storage at 4C. Food Chem. 2007;102: 1061-70.

El-Sherif SA, Ibrahim SM, Abou-Taleb M. Relationship between frozen pre-storage period on raw Tilapia and Mullet fish and quality criteria of its cooked products. Egyptian J Aquatic Res. 2011;37:183-89.

El-Lahamy AA, Khalil KI, El-Sherif SA, et al. Impact of cooking methods and frozen storage on quality parameters of mullet fish (Mugil cephalous) steaks. J Food Technol Pres. 2018;2:7-13.

Gokalp HA, Ockerman HW, Plimpton RF, et al. Fatty acids of natural and phospholipids rancidity scores and TBA values as influenced by packaging and storage. J Sci Food Agri 1983;44:335.

Hernandez-Herrero MM, Roig-Sagues AX, Lopez-Sabater EI, et al. Total volatile basic nitrogen and other physicochemical and microbiological characteristics as related to ripening of salted anchovies. J Food Sci. 1999;64:344-47.

Serrano M, Martinez-Romero D, Guillen F, et al. Maintenance of broccoli quality and functional properties during cold storage as affected by modified atmosphere packaging. J Postharvest Biol Technol. 2006;39:61-8.

El-Sherif SA, Ibrahim SM, Abd El-Gahfour SA. The validity of some dominant fish obtained from wadi el-rayan Lake for human consumption. Int J Adv Res. 2016;4:1278-85.

Hafez NE. Chemical and physical studies on the fish flesh Dolphin, PhD thesis Faculty of Agriculture, Ain Shams University, Egypt.1982

Ruiz-Capillas C, Moral A. Correlation between biochemical and sensory quality indices in Hake stored in ice. Food Res Inter. 2001;34:441-47.

Rathod N, Pagarkar A. Biochemical and sensory quality changes of fish cutlets, made from pangasius fish (pangasianodon hypophthalmus), during storage in refrigerated display unit at -15 to -18°C. Int J Food Agri Vet Sci. 2013;3:1-8.

Friedman M. Nutritional value of proteins from different food sources. J Agri Food Chem. 1996;44:6-29.

Acton JC, Rudd CL. Protein quality methods for sea foods in seafood quality determination. Proceedings of an International Symposium Coordinated by the University of Alaska Sea Grant College Program. Kramer DE Liston J Eds. 1986:453-72.

FAO. Nutritional Elements of Fish. Fisheries and Aquaculture Department, food and agriculture organization of the United Nations. 2013.

Oluwaniyi O, Dosumu O, Awolola G. Effect of local processing methods (boiling, frying and roasting) on the amino acid composition of four marine fishes commonly consumed in Nigeria. Food Chem. 2010;123:1000-06.

Oluwaniyi O, Dosumu O, Awolola G. Effect of cooking method on the proximate, amino acid, and fatty acid compositions of Clarias gariepinus and Oreochromis niloticus. J Turk Chem Soc. 2017; 4:115–32.

El-Lahamy A A, Khalil IK, El-Sherif SA, et al. Effect of frozen storage and cooking method on amino acid composition of mullet fish (Mugil cephalus). MOJ Food Process Technol. 2018;6:458-63.

***Correspondence to:**

Adel A El-Lahamy

National Institute of Oceanography and Fisheries

Fish Processing Technology Laboratory

Cairo

Egypt

Tel: +201100425093

E-mail: adelammar11@yahoo.com