MedCrave
Step into the World of Research

MOJ Food Processing & Technology

Review Article

Open Access

CrossMark

Effect of processing methods on nutritional and physico-chemical composition of fish: a review

Abstract

Fish has been widely used as an excellent source of animal protein and other nutrients. It functions to prevent human beings from variety of diseases all over the world. Through different processing methods, it is possible to achieve the keeping of quality and securing fish availability round the year. This paper reviews up-to-date research on effect of processing methods on nutritional and physico- chemical composition of fish. Additionally, effects of different fish processing methods (such as drying, smoking, freezing, cooking and canning) on chemical, physical and nutritional composition are presented. The most compositional constituents of fish which can be affected through processing methods are proteins, fats, vitamins, minerals and the sensory attributes such as color, flavor, texture and general appearance. Changes of chemical composition resulted from processing methods can mainly be expressed as denaturation, coagulation, reduction of protein digestibility, oxidation and loss of vitamins. Heating protein fish can cause loss of nutritional value through amino acids destruction, protein denaturation and maillard reaction. Smoking is one of the processing methods which has an impact on fish protein denaturation that leads to changes in physical and chemical structure of protein and a reduction in the biological availability of protein. The major physical changes which occur on fish due to processing are changing texture (becomes hard and firm), change in color (the major first judgment detrimental factor) and yields. The extent of these changes depends on the temperature and time of treatment. All these changes (chemical, physical and nutritional) affect the final quality of fish and fishery products.

Keywords: fish, chemical composition, processing methods, effect of processing

Volume 6 Issue 4 - 2018

Bereket Abraha,[1,2] Habtamu Admassu,[1,3] Abdu Mahmud,[1,2] Negasi Tsighe,[1] Xia Wen Shui,[1] Yang Fang[1]

[1]State Key Laboratory of Food Science and Technology, Jiangnan University, China

[2]Department of Marine Biotechnology, Massawa College of Marine Science and Technology, Eritrea

[3]Department of Food Process Engineering, Science and technology University, Ethiopia

Correspondence: Bereket Abraha, School of Food Science and Technology, Jiangnan University, Wuxi 214122, PR China, Tel +86-186-1667226, Fax +86-510-85809610, Email bereketmft@yahoo.com

Received: July 04, 2018 | **Published:** August 03, 2018

Introduction

Fish and fish products are important commercial in Eritrea, with a catch volume (maximum sustainable yield) over 80,000 tons per year and small pelagic has been estimated around 50,000metric tons per year (Food and Agriculture Organization (FAO).[1] Fishes are well-known for their various nutritional compositions, approximately contains 70-84 % water, 15-24 % protein, 0.1-22% fat and 1-2%, minerals, 0.5% calcium, 0.25% phosphorus and 0.1% vitamins A, D, B and C. They have been widely used as one of the most important sources of animal protein and other nutrients for the human health all over the world.[2–6] Eating fish can help consumers to prevent from various diseases such as blood pressure, coronary heart disease, cancer, inflammatory disease and maintaining health, since fish can provide omega-3 highly unsaturated fatty acids (HUFA), eicosapentaenoic (EPA), docosahexaenoic (DHA) acids, and amino acids. Poly unsaturated fats are in a liquid form which flows freely in the blood vessel and this character makes it unique form than other types fat or oils.[6–8]

Fish can act not only as a source of protein to human being, but also provide foreign exchange earning to many people when the harvesting, handling and processing methods done in the right way and time.[4] In addition, preservation and processing can assure availability of fish in all year round.[9,10] The bio-chemical composition of fish is the vital aspect in fish processing, because which influences both the quality and technological characteristics of it.[5] Different processing methods of fish have different effect on their chemical, physical and nutritional compositions.[11] The effect could be either chemical or physical changes, which affects digestibility due to protein denaturation and reduction in the content of mobile compounds and polyunsaturated fatty acids. The quality and shelf life of fish differs using different methods and has different acceptability by consumers.[12] Freezing and thawing have profound effect on muscle physiochemical characteristics of frozen fish. Boonsumrej et al.,[13] found that freezing shrimp in cryogenic freezer at -120°C, which cause great effect on nutritional composition.

During fish processing several changes is occurred. Depending on the extent of heating and temperature protein denaturation may resulted. Heating also brings deconformation of natural features of the protein molecules or complexes, resulting in exposure of the reactive groups. Most proteins are compounds liable to quality and quantity changes during heat processing. The loss of solubility of temperature-sensitive proteins can be utilized as an indicator of the time and temperature that had been applied in heat processing of varieties of fish and fish products.[11,14–16] Sriket et al.,[16] and El & Kavas[17] reported that protein digestibility is reduced as a result of complex chemical (cross-linking) reactions, such as protein interactions or protein-fat interactions when fish is boiled at high temperatures. Pourshamsian et al.,[18] noted that frying has an effect on proximate composition and fatty acids of fish and fish products. Nevertheless, no basic information regarding the effect of processing methods on nutritional and physicochemical composition of fish processed in Eritrea fish processing plants (Eri-fish processing plant and Eritrea Marine Product Company) has been reported.

The present work centers on reviewing current scientific literatures on effect of processing on nutritional and physico-chemical composition in fish. Thus, composition changes produced during

drying, cooking, freezing, smoking and canning has discussed. A special emphasis has given concerning effects resulted from the various processing methods on the quality of final fish products and the consumer's acceptability of these processed products.

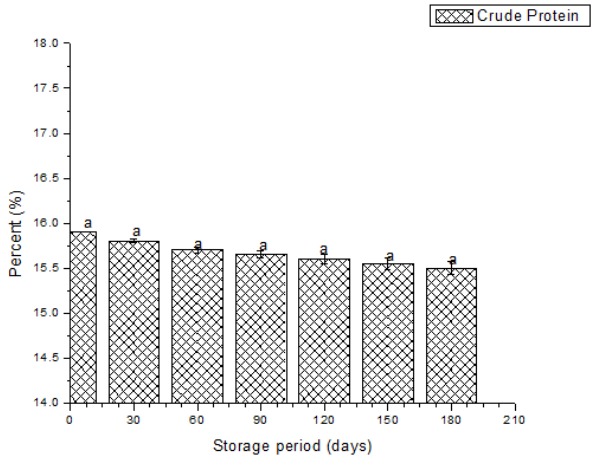

Figure 1A Effect of storage period on crude protein content of *Lutjanus johnii* during 180days of preservation in freezer.[47]

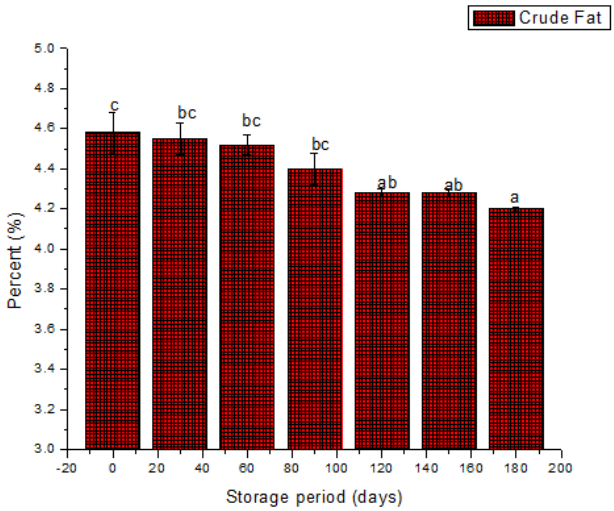

Figure 1B Effect of storage period on crude fat content of *Lutjanus johnii* during 180days of preservation in freezer.[47]

Fish as a food

Fish is a rich source of chemical composition such as proteins, fat (poly-unsaturated fatty acids), vitamin (including, vitamin A, vitamin B2, vitamin B6 and others), minerals (iron, calcium, iodine, potassium and other minerals), and carbohydrates.[2,9] In many part of the world people use fish as the main component in their diet, as a good source of nutrition.[5,11] Fish constitute more protein source than other animals protein source.[3,19] The higher crude protein content in fish is crucial from a dietary point of view, due to its very high quality and essential amino acid composition.[20] Further, reports also indicated that fish muscle is more digestible than other animal protein due to lower level of connective tissue.[21,22] It has health benefits, particularly to heart disease, blood pressures and a decreased risk of prostate cancer and Alzheimers's disease.[4,23]

Chemical composition

Generally fish is made up of 70-84 percent water, 15-24 percent protein, 0.1-22 percent fat and 1-2 percent minerals and 0.1-1 percent carbohydrate.[19,21,22] Fats from fatty fish species contain poly unsaturated fatty acids (PUFAs) namely, EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) (omega 3 fatty acids) which are essential for proper growth of children and prevent the cardiovascular diseases such as coronary heart disease.[6,20,21]

The nutritional value of fish used as a source of food is obtained from its chemical composition, which varies widely from species to species and within the same species.[24] The feeding habit, sex and seasonal variations are the main factors which can affect the chemical composition in fish.[11] Knowledge on chemical composition of fish is vital to develop processing technology for fish and fish products (both in commercial and industrial level), in order to compare its value with other foods as a source of protein, in fortification for product development and nutritional enrichment, to ensure that they are within the range of the dietary requirements, commercial specifications and maximum utilization; hence minimize loss of nutritional contents.[6]

Processing methods is not only be advantageous, however, they might also have some disadvantageous that could result large amount of wastes during processing, such as head, intestine, skin, bones and liver. These wastes have high content of nutritional components (protein, lipid, vitamins and minerals and essential fatty acids) and can offer a potential substrate of fish meal production. Therefore, there should be a possible mechanism in line with fish processing methods to recover and utilize all the possible biochemical components from waste products of processed fish to minimize losses and enjoy the benefit of processing methods.[9]

Effect of processing in fish biochemical composition

Processing can be defined as a method applied to the fish from the time of harvest to the consumption period.[25] Taking note the chemical composition, fish is extremely perishable. Without any processing or preservation measures, fish is highly susceptible to deterioration.[19,26] Enzymes, bacteria and oxygen are the main responsible factors for a number of physiological and microbial deterioration set in and thereby degrade and spoil the fish and fish products. Fish start to spoil as soon as caught from the sea,[5] more over poor handling and preservation methods after capture increase its degree of spoilage.[26] Holma et al.,[19] and[10] stated in their studies that, processing is essential to preserve fish both in quality and quantities in a good manner and helps to use in off seasons when it is done in the right time and right way, whereby availability of fish can be secured throughout the year.

Generally fish processing methods could be (high and low temperature treatments) including, chilling, freezing, canning, smoking, drying, salting, frying and fermenting, sun-drying, grilling and frying, and various combinations of these, to give the fish product a form which is attractive, fresh to the consumers and prolong storage life. These processing methods have different applications, techniques and significant influence and effect on the chemical, physical and nutritional composition of processed fish. This is because heating, freezing and exposure to high concentration of salt lead to chemical and physical changes. Ultimately different quality could be obtained via these methods, hence subsequent effect on processed fish's shelf life also varies.[27,28]

Dried-salted fish with salt content of 10–15%, can be effectively inhibits fish spoilage, but may be a limiting factor to consumer acceptance. Some vitamins are sensitive to heat and sunlight. According to Roos et al.,[29] almost all vitamin A in small sized fish is destroyed after sun-drying. Smoking of fish contributes in physical loss of lipids and micronutrients, due to dripping of fats and more water from the fish. Smoking of fish at high temperatures degrades protein, reduces functionality of essential amino acids and may lead to loss of vital nutrients such as antioxidants.[30]

Effect of drying and heating on nutritional and physio-chemical composition of fish

Effect of drying

Fish can be preserved using solar drying, which focused to reduce the water content; whereby activities of microorganisms will be reduced or stopped.[5] According to Smida et al.,[9] drying has a great negative effect on protein content at a lower drying speed of one meter per second. Solar drying also affects poly unsaturated fatty acids particularly omega-6 fatty acids. Natural drying can dry fish faster and flesh becomes hard even though some moisture are still inside, which slows down the drying process and promotes protein degradation. Exposure of fish for long period of time to sun light can oxidize the lipids, which can reduce nutritional quality and increase health risks of consumers.[9] The factors that influence quality of freeze dried fish during drying are chemical; browning reactions, lipid oxidation, color change, physical; rehydration, solubility, texture, aroma loss and Nutrition; vitamin loss, protein loss and microbial survival.

Influences of drying methods on nutritional properties of Tilapia fish (*Oreochromis nilotieus*) were studied by Chukwu.[31] He reported that, fat loss phenomenon is more intensive in fish dried using electric oven than in smoking, due to fat exude with the moisture evaporation during electric oven drying and enhance the phenomenon of lipids loss. Effect of drying on chemical composition of fish can be prevented using brine as a treatment before drying. Kituu et al.,[32] have done a research on influence of brining on the drying Parameters of Tilapia (*Oreochromis Niloticus*) in a glass-covered solar tunnel Dryer. It was suggested that brine should be used as pretreatment before drying which can reduce moisture content and play significant role in reducing drying rate and preserving fish nutrient. Other studies have also shown that application of drying to dehydrate fish does not only remove water but excess of such heat can affect the valuable nutritional content of the dried fish and its products. Drying temperature and time are the main factors which affect nutritional composition of fish. Taken this in to consideration, drying would be appropriate at 60°C for 15h or 70°C for 10h.[33] Katola and Kapute [34] highlighted that smoking is not advisable to use as a preservation method . It has been suggested that the smoke compounds like pyrene and benzo, as vapours, increased during the smoking process which dissolve in the liquid on the surface of the fish and have effects on fish nutrient like protein. However, other study has been noted that smoking causes some decrease in available lysine and that the loss of lysine is proportional to the temperature and duration of smoking.[33] Oparaku[10] where studied effect of processing on the nutritional qualities of three fish species (*Synodontis clarias, Trachurus trecae* and *Clarias gariepinus*). The result revealed that the fat loss phenomenon was intensive in the boiling and solar dried fish than in smoked samples. Fat may exude with the moisture evaporation through extended heat treatment (Table 1).

Table 1 Effect of different processing methods on proximate composition of the fish species (*Synodontis clarias, Trachurus trecae and Clarias gariepinus*)[10]

Fish species	Treatment	Moisture (%)	Crude protein (%)	Ash (%)	Carbohydrate (%)	Lipid (%)
Clarias gariepinus	Oven drying	18.92	31.4	13.15	25.81	1.71
	Boiling	61.85	22.33	4.3	9.252	2.27
	Solar drying	15.62	61.21	3.62	3.84	1.96
	Smoking	19.35	21.3	3.92	2.78	5.2
Synodontis clarias	Oven drying	15.6	56.915	6.55	8.34	8.34
	Boiling	58.5	28.89	8.3	1.705	2.6
	Solar drying	14.21	49.701	2.91	3.81	1.121
	Smoking	21.1	32.14	2.49	3.91	13.41
Trachurus trecae	Oven drying	33.5	45.71	8.83	6.413	2.023
	Boiling	51.6	37.403	3.95	1.547	1.671
	Solar drying	17.21	53.23	2.12	3.12	4.223
	Smoking	19.21	21.14	4.32	2.65	1.21

Citation: Abraha B, Admassu H, Mahmud A, et al. Effect of processing methods on nutritional and physico-chemical composition of fish: a review. *MOJ Food Process Technol.* 2018;6(4):376–382. DOI: 10.15406/mojfpt.2018.06.00191

Dewi[35] has researched on anchovy to investigate effect of salting, drying and cooking on protein pattern changes by electrophoresis, reported that fish can undergoes undesirable changes in the functionality and nutritional quality of protein. Thermal denaturation has great influence to alter in physical properties which relate to molecular size and shape or conformation and these methods has positive effect to maintained color of fish by inactivating enzymes activities comparative to salting and drying methods.[36] High concentration of salt than inside the fish cause to loss the soluble proteins and loss water holding capacity, hence cause protein denaturation.[37] Drying of fish has the tendency to increase the protein solubility consequently degrade the myosin in to smaller units with smaller molecular weight. Dewi[35] also stated, lipid oxidation in fish resulted due to salting and drying by concentrating of unsaturated fatty acid and acting as pro-oxidant. Oxidation of fat leads to both physical and chemical changes such as amino acid destruction, decrease in protein solubility due to polymerization, formation of amino acid derivatives and reactive carbonyl, changes in protein digestibility.[23,37]

Effect of cooking

Heating in fish and food processing is applied in different ways, such as boiling, baking, roasting, frying and grilling.[14] In fish processing methods, heat is important to enhance taste and flavor as well as prolong shelf life of fish and fish products. During heat processing, time and temperature are the main factors which can affect protein quality, as time and temperature increases denaturation of proteins is affected in large amount as well as there is loss of vitamins, minerals, some other essential amino acids and other beneficial nutrients.[14,23] Oduro et al.,[23] investigated in their work that cooking fish via grilling, microwave, steaming and frying contributed in reducing of moisture and increasing protein content. From these heating conditions which caused fat extraction, hence decrease fat content is steaming, grilling and microwave. According to García-Arias et al.,[38] different cooking methods have also an effect on concentration of proximate composition of fresh and frozen fish (Table 2), such as losing water content of fresh, frozen fish and reduce fat content from fatty fish. Pourshamsian et al.,[18] conduct a research on fatty acid and proximate composition of farmed great sturgeon fish (*Huso huso*) affected by thawing. It was noted that frying had an effect to decrease the contents of EPA, DHA and omega-3 fatty acids. Due to the exchange of oils, frying can alter the lipid composition of fried fish.

Texture and general appearance of fish have significant contribution in product acceptability by the consumers. Eventhough cooking improves the color but also it has some impact towards texture and color during fish processing. Shrinkage of both filament lattice and collagen of proteins are resulted due to denaturation and aggregation during cooking, leads to loss in water holding capacity and consequently change texture of fish to became hard or firm. Another effect is the destruction of cell membrane and the aggregation of sarcoplasmic protein.[14] Smida et al.,[9] reported in their findings that, heating affects the liquid holding capacity of frozen fish, whereby resulted in protein deterioration at higher temperature, leading to dehydration of the muscle through disruption of cell structures and becomes very tough texture, difficult to eat.

Table 2 Effect of different cooking methods on proximate composition (g/100g wet matter and g/100dry matter) for raw, fried, oven baked, and grilled sardine fillets[38]

	Raw	Fried	Oven-baked	Grilled	ANOVA
Moisture g/100g wet matter	60.68a±0.28	43.12b±0.81	55.74c±0.44	50.81d±0.93	•••
Protein g/100g wet matter	20.7a±0.62	32.3b±0.54	26.0c±0.59	30.0d±0.08	•••
Fat g/100g wet matter	15.44a±0.12	21.23b±0.13	14.60c±0.25	16.40d±0.17	•••
Ash g/100g wet matter	3.26a±0.08	5.39b±0.09	4.22c±0.24	4.31c±0.17	•••
Protein g/100g dry matter	52.6a ±0.16	56.8b±0.95	58.7bc±1.34	59.5c±0.17	•••
Fat g/100g dry matter	39.25a±0.33	37.33b±0.22	32.99c±0.56	33.35c±0.34	•••
Ash g/100g dry matter	8.30a±0.17	9.48b±0.15	9.53b±0.53	8.76ab±0.35	••

Values are means±standard deviation of six samples. Values bearing different letters are significantly different (ANOVA one-way and Brown-Forsythe tests,••• $P < 0.001$. •• $P < 0.01$).

Effect of smoking

Smoking is also one type of preservation methods provide heat and antimicrobial smoke chemicals like formaldehydes and phenols which acts as anti microorganism and aids the fish product to have good attractive color and flavor.[2] Its heat effect resulting in reduced water activity of the fish allow better preservation causing microbial destruction and thus minimizes spoilage, increase storage shelf life and therefore increase fish availability to consumers. During the smoking protocol, if the time, temperature and type of wood is not controlled and selected as per the standards chemical, physical and nutritional contents of smoked fish products will be affected. Moreover, certain diseases might occur on consumers from carcinogenic effect of woods. The changes resulted due to smoking of fish are hard texture, color change from golden brown to black and loss of heat sensitive nutrients.[12]

Smoking of fish can be categorized in to hot and cold smoking, depend on the amount of temperature and preference of consumers. The denaturation of protein and amino acid of fish will be followed during smoking, depending on the intensity of heat generated and this leads to alteration in the physical and chemical properties of protein,[39] and causes a reduction in the biological availability of protein. Belitz et al.,[40] showed that overheating might occur in most traditional smoking methods of fish processing significantly reduces the availability of essential amino acids (methionine, tryptophan and lysine). According to Chavan et al.,[41] smoking also decreases the more soluble protein like myofibrillar and sarcoplasmic contents and increases the amount of insoluble protein.

Friedman[42] showed that during the smoking process, fats and more water drips from the fish resulting in the physical loss of lipids, amino acids, and micronutrients. Hot smokings at high temperatures also degrade protein and reduce functionality of essential amino acids. In addition, smoke particles are likely to react with nutrients in the fish and may lead to loss of important nutrients and antioxidants.

Effect of freezing on nutritional and physio-chemical composition of fish

Effect of freezing

Freezing is one of the most employed methods used for preserving fresh fish and other seafood products. However, in the frozen state of fish, physical, chemical and enzymatic changes are still able to occur, eventually rendering the tissue to an undesirable state.[27]

Pourshamsian et al.,[18] reported that texture, flavor and color are some of the quality deterioration occurs in food during frozen storage. Freezing rate, thawing methods, and temperature fluctuations are some of the factors which affect the extent of quality loss.

Knowledge about effect of freezing and thawing to the muscle of frozen fish is necessary, in order to select conditions of preservation and keep texture properties of fish product; hence to be accepted by consumers.[28] Lourdes et al.,[28] indicated in his research work that fish muscle properties, like the edibility properties, can be affected by freezing and thawing process, as well as holding temperature. Fresh fish should be preserved by freezing or icing to maintain freshness. Freezing has the capacity to maintain the product fresh as it was kept initially and extend shelf life for long time, but depend on several factors, such as initial condition of fish, species and time elapsed between harvest and freezing, protein denaturation and texture defect can occur.[13,43] In freezing fish treatment process protein denaturation might occur. Once protein is denatured muscle texture, water holding capacity, color and flavor of frozen fish and fish products are affected, since muscle protein is the main contributor of textural characteristic properties. Toughening texture of fish muscle develops in edible muscle. As a result, proteins become more prone to damage and essential amino acids are more susceptible to loss.[16,41] It has been reported by Yerlikaya & Gokoglu[43] that, time of freezing affects the ultimate quality of frozen fish. Slow freezing time is not recommended, since it forms large ice crystals which damage cell wall of muscle, this may lead to denaturation of muscle protein as well as structural damage of membrane, which can result in increased drip loss, loss of water holding capacity and textural changes.[27,45] Lakshmanan et al.,[46] stated that, the texture changes and flavor deterioration of frozen fish can be resulted by indirect effects of free fatty acid which promoted due to protein denaturation and enhancement of lipid oxidation respectively.

The number of freeze- thawing process has direct relation on the nutritional losses of sea foods. Sriket et al.,[16] observed detrimental effects on shrimp muscle, due to repeated freeze-thawing process, which cause damage to cell membrane, protein (myosin) denaturation and oxidation and this was also shown to increase the cooking loss of fin fish and crustaceans. This implies that there is less acceptability of such products, due to loss of the significant chemical compositions with tasteful constituents.

Freezing also has an effect on chemical composition of frozen fish through the activity of enzymes. Enzymes can degrade trymethylamine oxide in to dimethylamine and formaldehyde. Color and flavor changes produced due to dimethylamine and cross-linking of proteins induced by formaldehyde, so that protein denaturation and toughening texture are produced.[43] These variations also cause odour changes and losses of tastes.

Quality deterioration of frozen seafood products can be caused by oxidation, denaturation of proteins, sublimation and re-crystallization of ice crystals. This observation has been reported by Boonsumrej et al.[13] Off-flavors, rancidity, dehydration, weight loss, loss of juiciness, drip loss and toughening, as well as microbial spoilage and autolysis are some of the consequence.[44] Foruzani et al.,[47] found that freezing have an effect on chemical composition of fish which can reduce crude protein and fat from fish stored for 180days (Figure 1A) (Figure 1B).

Effect of thawing

Time and temperature during thawing helps to obtain products similar to unfrozen one. Through the thawing operation, water may be reabsorbed by tissues and cells depending on ice crystal size and its localization in the tissue microstructure, thawing rate, biochemical and physiological state of the fish before freezing, and water-holding capacity (WHC) in muscle before freezing.[44] If the freeze–thaw procedure is ineffective, the final frozen product losses its nutritional composition and has great possibilities to loss taste, to the extent not to be accepted by consumers.

If a fish is not properly handled, freezing promotes protein aggregation and water loss after thawing, yielding a stiffer and harder product.[41] Water holding capacity in frozen fish can be also affected during protein denaturation. Water in protein can exist in bound form which is highly dependent on protein's physiochemical characteristics and in unbound form trapped within protein matrix. Sigurgisladottir[45] mentioned that high water holding capacity results in low aggregation of protein and lower drip loss during thawing. This shows texture of frozen muscle product does not cause gapping that cannot loss more juice solvent from muscle and finally similar texture with fresh product could be achieved which meets consumer preferences.[48]

Effect of canning on nutritional and physio-chemical composition of fish

Canning is one of the most important preservation methods that keep fish for long period of time. Canned fish and fish products supporting an important role in human nutrition. Since fish species have different nutritional compositions they have different stability towards the thermal processing of canning. According to the report of a study conducted by Aberoumand[25] lean fish are not recommended to canning process because their flesh disintegrate under the high temperature, hence their delicate flavor and texture would be lost.

FAO[49] reported that eventhough most canned fishery products support an excellent sources for human nutritional health, but some fish, such as lean fish, do not adapt to canning, due to the high thermal processing conditions carried out during canning their flesh (meat part) disintegrates. Compared to fatty fish, lean fish have delicate flavor and fragile structure, that are rendered virtually have low acceptability by consumers when processed by canning. As it is known, canning involves high heat treatment during cooking and sterilization which contributes changes on the raw flesh of lean fish, therefore, final product formed will be within effect of different quality attributes. During cooking, leaching of water soluble vitamins and soluble

proteins into cooking liquors is increasingly recognized as the major source of loss of nutrients.[50]

Fish can be directly processed or can be stored in chiller or freezers to be canned; for reducing moisture and inactivating endogenous enzymes activity is done through cooking. Canning is a thermal treatment undertaken to inactivate micro-organism that can be done at 121°C for 15minutes which is necessary to guarantee good palatability of the fish product.[51] As a result of high temperature, labile and essential nutrients (proteins, vitamins, lipids, minerals) present in the raw fish are exposed to different processing conditions. The nutritional and sensory values of these products could be reduced and unsuitable effects formed, such as formation of undesirable compounds and browning development that can influence shelf life of the final product.[20,25] Rodríguez et al.,[51] pointed out in their work that, during cooking treatment the nutritional and sensory qualities might be compromised, particularly if the fish is over processed. Heating has great possibility to degrade nutrients, oxidize vitamins and lipids, leaching of water soluble vitamins (Alpha-Tocopherol), minerals and proteins and hardening and drying of fragile protein of fish. Moreover, fish muscle can lose its nutritional composition such as proteins, minerals and vitamins if canning is carried out in oil, since proteins are denatured by the heat process to the point of releasing a considerable amount of water to the headspace of the can. Significance of fish canning is that bones become soft texture and thus edible, providing an important calcium source. On the other hand heat sensitive vitamins, like thiamine, riboflavin, niacin, are the nutrients damaged at the time of sterilization process.[36]

Conclusion

Fish is the well-known nutritious aquatic animal. It constitutes reasonable percentage of the dietary of human consumption when processed according to the protocol. Consumption of fish can helps to prevent various diseases such as blood pressure, coronary heart disease, cancer, inflammatory disease and maintaining health. The different processing methods of fish have different effect on chemical, physical and nutritional compositions of fish. These effects can influence the digestibility of protein due to its denaturation and reduction in the content of the mobile compounds and polyunsaturated fatty acids. Protein quality is one component which is severely affected by the heat applied during processing. Intensity of heat applied during processing greatly affects the fish nutrient concentration, whereby it is important to ascertain how the processing temperatures and time affect the nutritional properties as well as physico-chemical composition of processed fish and fish products. Therefore, one (particularly fish processing industries and fishermen) should must know the beneficial and optimal processing conditions that could result in the production of nutritionally superior products, beyond satisfying the consumer's organoleptic appetite. In order to prevent the effects of processing on nutritional and physico-chemical composition in fish, it is necessary to use and adopt appropriate as well as affordable processing techniques for processing fish and fish products.

Acknowledgements

The study was financially supported by the Natural Science Foundation of Jiangsu Province (BK20150152), the earmarked fund for China Agriculture Research System (CARS-45-26), and the program of "Collaborative innovation center of food safety and quality control in Jiangsu Province."

Conflicts of interest

The author declares that none of the conflicts.

References

1. FAO. FAO Fishery and Aquaculture Development. Eritrea. 2015.
2. Longwe P, Fannuel K. Nutritional Composition of Smoked and Sun dried Pond raised Oreochromis karongae (Trewavas, 1941) and Tilapia rendalli (Boulenger, 1896). *American Journal of Food and Nutrition*. 2016;4(6):157–160.
3. Reza SA, Karmaker S, Hasan M, et al. Effect of Traditional Fish Processing Methods on the Proximate and Microbiological Characteristics of Laubuka dadiburjori During Storage at Room Temperature. *Journal of Fisheries and Aquatic Science*. 2015;10(4):232–243.
4. Mazrouh MM. Effects of freezing storage on the biochemical composition in muscles of Saurida undosquamis (Richardson,1848) comparing with imported frozen. *International Journal of Fisheries and aquactic Science*. 2015;3(2):295–299.
5. Farid FB, Latifa GA, Nahid MN, et al. Effect of Sun–drying on proximate composition and pH of Shoal fish (C. striatus; Bloch, 1801) treated with Salt and Salt–turmeric storage at Room Temperature (27°C–30°C). *IOSR Journal of Agriculture and Veterinary Science (IOSR–JAVS)*. 2014;7(9):1–8.
6. Hantoush AA, Al–hamadany QH, Al–hassoon AS, et al. Nutritional value of important commercial fish from Iraqi waters. *Mesopot J Mar Sci*. 2014;29(1):13–22.
7. Morales M, Holgado F, Sevenich R, et al. Fatty acids profile in canned tuna and sardine after retortsterilization and high pressure thermal sterilization treatment. *Journal of Food and Nutrition Research*. 2015;54(2):171–178.
8. Yetunde KO. Biochemical composition of Micromesistus poutassou from agbalata market, Badagry Lagos West, Nigeria. *Food and Applied Bioscience Journal*. 2016;4(1):12–14.
9. Smida MAB, Bolje A, Ouerhani A, et al. Effects of Drying on the Biochemical Composition of Atherina boyeri from the Tunisian Coast. *Food and Nutrition Sciences*. 2014;5(14):1399–1407.
10. Oparaku, Nkiruka Francisca, Nwaka FC. Effect of processing on the nutritional qualities of three fish species (*Synodontis clarias*, *Trachurus trecae* and *Clarias gariepinus*). *International Journal Of Biology and Biological Sciences*. 2013;2:143–149.
11. Akinneye JO, Amoo IA, Bakare OO. Effect of drying methods on the chemical composition of three species of fish (*Bonga* spp., *Sardinella* spp. and *Heterotis niloticus*). *African Journal of Biotechnology*. 2010;9(28):4369–4373.
12. Mojisola O. The Effect of Different Processing Methods on the Nutritional Quality and Microbiological Status of Cat Fish (Clarias lezera). *Journal of Food Processing & Technology*. 2014;5(6).
13. Boonsumrej S, Chaiwanichsiri S, Tantratian S, et al. Effects of freezing and thawing on the quality changes of tiger shrimp (*Penaeus monodon*) frozen by air–blast and cryogenic freezing. *Journal of Food Engineering*. 2007;80(1):292–299.
14. Alipour HJ, Shabanpoor B, Ali Shabani, et al. Effects of cooking methods on physico–chemical and nutritional properties of Persian sturgeon Acipenser persicus fillet. *Internaional Aquatic Resource*. 2010;2:15–23.
15. Sarker ZI, Elgadir MA, Ferdosh S, et al. Effect of some biopolymers on the rheological behavior of surimi gel. *Molecules*. 2012;17(5):5733–5744.
16. Sriket P, Benjakul S, Visessanguan W, et al Comparative studies on the effect of the freeze–thawing process on the physicochemical properties and

microstructures of black tiger shrimp (*Penaeus monodon*) and white shrimp (*Penaeus vannamei*) muscle. *Food Chemistry*. 2007;104(1):113–121.

17. EL SN, Kavas A. Determination of protein quality of rainbow trout (*Salmo irideus*) by *in vitro* protein digestibility–corrected amino acid score (PDCAAS). *Food Chemistry*. 1996;55(3):221–223.
18. Pourshamsian K, Ghomi MR, Nikoo M. Fatty Acid and Proximate Composition of Farmed Great Sturgeon (*Huso huso*) Affected by Thawing Methods, Frying Oils and Chill Storage. *Advanced Studies in Biology*. 2012;4(2):67–76.
19. Holma K, Ayinsa, Maalekuu BK. Effect of traditional fish processing methods on the proximate composition of red fish stored under ambient room conditions. *American Journal of Food and Nutrition*. 2013;3:73–82.
20. Marta M, Francisca H, Robert S. Fatty acids profile in canned tuna and sardine after retort sterilization and high pressure thermal sterilization treatment. *Journal of Food and Nutrition Research*. 2015;54:171–178.
21. Suganthi Venkatraman, Chezhian. Proximate composition of different fish species collected from Muthupet mangroves. *International Journal of Fisheries and Aquatic Studies.* 2015;2(6):420–423.
22. Tidwell JH, Geoff L Allan. Fish as food: aquaculture's contribution (Report no. 11). Ecological and economic impacts and contributions of fish farming and capture fisheries. *European Molecular Biology Organization*. 2001;2(11): 958–963.
23. Oduro FA, Choi ND, Ryu HS. Effects of Cooking Conditions on the Protein Quality of Chub Mackerel Scomber japonicus. *Fisheries and aquatic sciences*. 2011;14(4):257–265.
24. Mohamed EHA. Proximate and Mineral Composition in Muscle and Head Tissue of Seven Commercial Species of the Nile Fish from Sudan. *Asian Journal of Science and Technology*. 2013;4:62–65.
25. Aberoumand A. Studies on the effects of processing on food quantity of two selected consumed marine fishes in Iran. *International Food Research Journal*. 2014;21(4):1429–1432.
26. Omodara MA, Olanyan AM. Effects of Pre–Treatments and Drying Temperatures on Drying Rate and Quality of African Catfish (*Clarias gariepinus*). *Journal of Biology, Agriculture and Healthcare*. 2012;2(4):2224–3208.
27. Magnussen OM, Hemmingsen, Vidar Hardarsson. Frozen Food Science and Technology. In. Judith A Evans, editors. *Freezing of Fish (151–164)*. Australia, Blackwell Publishing; 2008. 365 p.
28. Lourdes Tenorio D, Fernaldo L, Carrenol G, et al.. Comparison of Freezing and Thawing Treatments on Muscle Proporties of White Leg Shrimp (*Litopenaeus Vannaamei*). *Journal of Food Biochemistry*. 2007;31(5):563–576.
29. Roos N, Mohammed Islamy, Thilsted S H. Small Indigenous Fish Species in Bangladesh: Contribution to Vitamin A, Calcium and Iron Intakes. *Journal of Nutrition*. 2003;133(11 Suppl 2):4021S–4026S.
30. Kabahenda MK, Omony P, Husken SMC. Post–harvest handling of low–value fish products and threats to nutritional quality: a review of practices in the Lake Victoria region. *Fisheries and HIV/AIDS in Africa: Investing in Sustainable Solutions*. 2009;1–15.
31. Chukwu O. Influences of Drying Methods on Nutritional Properties of Tilapia Fish (*Oreochromis nilotieus*). *World Journal of Agricultural Sciences*. 2009;5:256–258.
32. Kituu GM, Shitanda D, Kanali CL, et al. Influence of Brining on the Drying Parameters of Tilapia (*Oreochromis Niloticus*) in a Glass–Covered Solar Tunnel Dryer. *Agricultural Engineering International*. 2007;11:1–10.
33. Idah PA, Nwankwo I. Effects of smoke–drying temperatures and time on physical and nutritional quality parameters of Tilapia (*Oreochromis niloticus*). *African Journal of Agricultural Economics and Rural Development*. 2013;5(3): 29–34.
34. Katola A, Kapute F. Nutrient composition of solar dried and traditionally smoked *Oreochromis mossambicus* (Peters, 1852). *International Food Research Journal*. 2017;24(5):1986–1990.
35. Dewi EN. Chemical Analysis During The Processing Of Dried Salted Anchovy. *Journal of coastal management*. 2002;5(2):55–65.
36. Roe M, Churchs S, Pinchen H, et al. Nutrient analysis of fish and fish products. UK: Analytical Report. Survey; 2013:17–59.
37. Kong F, Oliveira A, Tang J, et al. Salt effect on heat–induced physical and chemical changes of salmon fillet (*O. gorbuscha*). *Food Chemistry*. 2008;106(3):957–966.
38. García–Arias MT, Álvarez Pontes E, García–Linares MC, et al. Cooking–freezing–reheating (CFR) of sardine (*Sardina pilchardus*) fillets. Effect of different cooking and reheating procedures on the proximate and fatty acid compositions. *Food Chemistry*. 2003;83(3):349–356.
39. Ihekoronye AI, Ngoddy PO. *Integrated food science and technology for the tropics.* London; 1985.
40. Belitz HD, Gorsch W, Schieberle P. Food Chemistry. 4th ed. Springerverlag Berlin Heidelberg; 2009:617–639.
41. Chavan BR, Basu S, Kovale. Development of Edible Texturized Dried Fish Granules From Low–Value Fish Croaker (*Otolithus argenteus*) and its Storage Characterisitcs. *Chiang Mai University Journal of Natural Sciences*. 2008;7:173–182.
42. Friedman M. Nutritional Value of Proteins from Different Food Sources. A Review. *Journal of Agricultural and Food Chemistry*. 1996;44(1):6–29.
43. Yerlikaya P, Gokoglu N. Effect of Previous Plant Extract Treatment on sensory and Physical Properties of Frozen Bonito (*Sarda darda*) Fillets. *Turkish Journal of Fisheries and Aquatic Sciences.* 2010;10(3).
44. Makri M. The biochemical textural and sensory properties of frozen stored (–22°C) king scallop (*Pecten maxinus*) meats. *African Journal of Biotechnology*. 2009;8(16):3893–3903.
45. Sigurgisladottir S, Ingvarsdottir H, Torrissen O, et al. Effects of freezing/thawing on the microstructure and the texture of smoked Atlantic salmon (*Salmo salar*). *Food Research International*. 2000;33(10):857–865.
46. Lakshmanan R., Piggott JR, Paterson A. Potential applications of high pressure for improvement in salmon quality. *Trends in Food Science & Technology*. 2003;14(9):354–363.
47. Foruzani S, Maghsoudloo T, Noorbakhsh H. The effect of freezing at the temperature of –18°C on chemical compositions of the body of Lutjanus johnii. Aquaculture, Aquarium, Conservation & Legislation. *International Journal of the Bioflux Society.* 2015;8(3):431–437.
48. Rastogi NK. Recent Developments in High Pressure Processing of Foods. 2013;73.
49. FAO. Second International Congress on Seafood Technology on Sustainable, Innovative and Healthy Seafood. FAO Fisheries and Aquaculture Processing; 2010.
50. Bell JW, Farkas BE, Hale SA, et al. Effects of Retorting and Storage on Liquid Mass Transfer in Canned Skipjack (*Katsuwonas pelamis*). *Journal of Food Processing and Preservation*. 2002;26(4):267–278.
51. Rodríguez A, Carriles N, Cruz J, et al. Changes in the flesh of cooked farmed salmon (*Oncorhynchus kisutch*) with previous storage in slurry ice (–1.5ºC). *LWT–Food Science and Technology*. 2008;41(9):1726–1732.