Effect of Seafood Processing and Preservation Methods on Nutritional Aspects of Marine Food

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Introduction

Nutritionists all over the world are unanimous in their opinion that fishery resources can meet the protein requirements of the growing population. As an abundant and renewable source of cheap, high quality protein, fish is the ideal answer to the problem of protein malnutrition prevalent in developing countries. Fish have a high nutritional value having a valuable amount of protein, lipid, vitamins and essential micronutrients. Research is proving more and more that consumption of fish has positive health effects due to the presence of omega 3 fatty acid. Furthermore, fish also provide a significant quantity of fat-soluble vitamins, water soluble vitamins, taurine, choline and minerals calcium, phosphorus, iodine and selenium. It also provides the high proportions of iron and zinc to the population. European Food Safety Authority has also proposed fatty acid reference labelling intake values for the general population is 250 mg EPA (Eicosapentaenoic acid) with DHA (Docosahexaenoic acid), 2 g α linolenic acid and 10 g of Linoleic acid per day (EFSA, 2009). Furthermore, it was concluded, that a fish consumption of 1 to 2 servings per week could be protective against coronary hearth diseases and ischemic stroke (FAO and WHO, 2011). The few health benefits of fish are as follows:

- Help to maintain a healthy heart by lowering blood pressure and reducing the risk of sudden death, heart attack, abnormal heart rhythms, and strokes.
- Aid healthy brain function and infant development of vision and nerves during pregnancy.
- May decrease the risk of depression, Alzheimer's disease, dementia, and diabetes.
- May prevent inflammation and reduce the risk of arthritis.

But, being a perishable commodity, fish must be processed and preserved properly for its shelf life extension, maintain the quality and to meet the consumer satisfaction. Texture

and general appearance of fish have significant contribution in product acceptability by the consumers.

1. Effect of Processing in Fish Biochemical Composition

Being an extremely perishable commodity, without any processing or preservation measures, fish is highly susceptible to deterioration. 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, more over poor handling and preservation methods after capture increase its degree of spoilage. So, 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. Processing can be defined as a method applied to the fish from the time of harvest to the consumption period.

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, and prolonged storage life. These processing methods have different applications 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.

2. Effect of Cooking on the Nutritional Composition of Fish

Heating is used in the cooking method to enhance the taste, flavour & prolong shelf life of fish. The heating may be of boiling, baking, roasting, frying and grilling (Fig. 1). Time and temperature are the main factors which affects the protein quality during the heat processing. As the time and temperature increases the denaturation of protein increases, leading to loss of vitamins, minerals and essential amino acids.

Cooking via grilling, microwave, steaming and frying reduce moisture and increasing protein content of fish (Oduro *et al*., 2011). Though, the cooking improves the color and flavor of the fish, the texture gets harder leads to protein denaturation which affect the water

holding capacity. In the case of frozen fish, heating affects the water holding capacity of frozen fish resulting in protein denaturation at higher temperature leading to dehydration of muscle through disruption of cell structures and becomes very tough texture and difficult to eat (Smida *et al*., 2014).

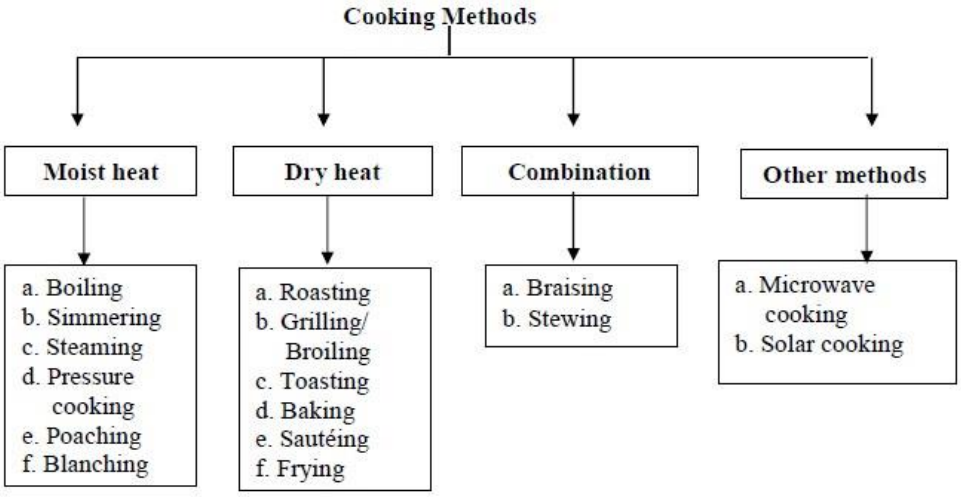

Fig. 1 Types of cooking method

Frying can alter the lipid composition of fried fish by decreasing the content of omega-fatty acid content due to the exchange of oils. Higher fat content was found in the grilled fish than oven baked and fresh fish (Garcıa-arias *et al*., 2003).

3. Effect of Freezing on Nutritional Composition of Fish

Freezing is one of the most employed methods used for preserving fresh fish and seafood products. It is one of the best ways to arrest all the biochemical changes and microbial growth by reducing the temperature of the fish. The faster the freezing process, the lesser the spoilage. In the year 2021-2022, Around 67 % of Indian seafoods has been exported in the form of frozen (MPEDA, 2022). Frozen storage can reduce the crude protein and fat content of fish fillet stored for 180 days (Foruzani *et al*., 2018). The most noticeable change in frozen stored fish is the development of tough texture. This is attributed to protein denaturation. Protein denaturation in frozen fish has 3 important aspects namely, i) effect on protein structure during processing ii) changes in the muscle protein during storage iii) the influence of other tissue constituents on the protein structure.

Red meat contain higher portion of sarcoplasmic protein compared to white meat. The

sarcoplasmic proteins are not affected significantly during freezing and frozen storage. The most affected protein during frozen storage of fish is myofibrillar protein. During frozen storage, toughness in the texture leads to decrease in protein solubility. The loss of solubility is usually taken as a measure of protein denaturation. The toughness in the texture in frozen stored fish is mainly due to the formation of 3 types of bonds namely i) bonds formed by interaction of denatured protein ii) bonds between native protein molecules iii) cross link between protein molecules. Apart from these bonds, the concentration of tissue salts during freezing and lipid hydrolysis during frozen storage. The repeated freeze thawing process has also directly affected the nutritional composition of fish due to the damage in the cell membrane which causes myosin denaturation and oxidation of lipid (Sriket *et al*., 2007). Quick freezing, reducing the drip loss and good packaging may help to retain the nutrition value of frozen fish.

4. Effects of Thermal Processing on Nutritional 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. However, lean fish is not advisable for canning due to the disintegration of muscles during processing (Ryder, 2010). Since fish species have different nutritional compositions they have different stability towards the thermal processing of canning. As the thermal process involves high heat treatment during cooking and sterilization, it can affect the quality attributes of fish. Leaching of water-soluble vitamins and soluble proteins into cooking liquors is increasingly recognized as the major source of loss of nutrients during cooking. The nutritional and sensory values of canned fish could be reduced because of the production of undesirable and non-enzymatic browning compounds.

Changes in muscle proteins during heating can be studied in three stages.

- Temperature upto 55°C - The protein coagulation reactions dominate. This involves formation of unstable bonds between the free groups in the side chains.
- Above 55°C to 60°C - The polypeptide chains undergo uncoiling. The -SH groups get exposed from the protein helical structure. Another type of intermolecular cross links formed during heating are called isopeptide links. The formation of this bond results in the decreased digestibility of protein.

- Above 70°C - There is a reduction in the formation of -SH groups suggesting formation of S-S bonds. Also, oxidation of -SH groups results in the formation hydrogen sulphide.
- Above 120°C – The protein chains are likely to get fragmented

Influence of heat on meat proteins (Hofmann, 1977)

- Proteins of lower molecular weight are more resistant to thermal denaturation
- Presence of salts increase the reactivity of proteins and thereby leads to increased damage during heating
- During heating of muscle there is a loss of free -NH_2 and -COOH groups in the protein molecule due to the formation of isopeptide bonds.
- Isopeptide bonds being resistant to proteolytic enzymes, reduce the digestibility of the protein.

Thermal denaturation affects the connective tissue of muscle proteins. Fish muscle collagens get easily degraded to gelatin on heating. Sugars from muscle glycogen and amino acids react at above 80°C forming maillard type of products leading to non-enzymatic browning. This leads to loss of certain essential amino acids. 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.

5. Effect of Drying on the Nutritional Composition of Fish

Sun drying and salt curing are perhaps the oldest methods of fish preservation. Curing results in the loss of substantial amount of soluble proteins in the self-brine. But, qualitatively, salting or smoking do not have any pronounced adverse effect on the protein. 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*. (2003) almost all vitamin A in small sized fish is destroyed after sun-drying. 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. Fat loss phenomenon is more intensive in fish dried using electric oven than in smoking due to fat exudation with the moisture evaporation during electric oven drying. Effect of drying on chemical composition of fish can be prevented using brine as a treatment before drying.

6. Effect of Smoking on the Nutritional Composition of Fish

Smoking is the type of preservation methods providing heat and antimicrobial smoke chemicals like formaldehydes and phenols which acts as antimicrobial compounds. The smoke product has good attractive color and flavor. During the hot smoking, the kiln temperature may go as high as 80°C and the fish temperature upto 60°C. 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. However, in the case of cold smoking the kiln temperature should not rise over 30°C. Smoking of fish contributes in physical loss of lipids and micronutrients, due to dripping of fats and more water from the fish. Time, temperature and type of wood affects the nutritional contents of smoked fish products. Smoking decreases the availability of essential amino acids especially lysine, methionine and tryptophan. Smoking also decreases the soluble protein content in the fish. Effect of smoking on the nutritional composition of fish can be prevented by brining which reduced the protein denaturation.

7. Effect of Irradiation on the Nutritional Composition of Fish

Though not commercially applied so far in India, irradiation is another method to enhance shelf life of fishery product. Generally, ionizing radiations emitted by radioisotopes, Cobalt-60, and Cesium-137 are used for food preservation. It is generally assumed that the higher the amount of unsaturation in the fish lipids, the more will be its sensitivity to oxidation during irradiation process. Ozone, a strong oxidizer, is produced from oxygen during food irradiation and may oxidize lipids and also myoglobin. However, the gamma irradiation at 50 kGy of vacuum-packed herring fillets at 0°C did not affect the proportion of polyunsaturated fatty acids (Adam *et al*., 1982). Hau *et al*. (1992) examined the effect of irradiation at 10 kGy on the linoleic and linolenic acid contents of grass prawns. Irradiation caused a 16% decrease in linoleic acid content, whereas linolenic acid was not affected significantly.

Conclusion

Fish is the well-known nutritious aquatic animal. It constitutes reasonable percentage of the diet of human consumption when processed according to the protocol. Consumption of fish can help 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, fish processors and fishermen 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.

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