# FISH LIPID COMPOSITION AND COOKING TECHNIQUES: A REVIEW

**Ogunbambo, M.M[1]*, Abubakar, F.B.[2] and Taiwo, M.A[3]**

[1]Department of Marine Sciences, University of Lagos, Akoka, Yaba, Nigeria

[2]Department of Fisheries and Aquaculture, Bayero University, Kano, Kano State, Nigeria

[3]Department of Food Science and Technology, Federal University Dutsin-Ma, Katsina State, Nigeria

***Correspondence:** *mutiat.ogunbambo@gmail.com*

## ABSTRACT

One of the chemical compounds which determine the nutritional quality of fish is lipid. Lipids are organic compounds that are found in many tissue cells, insoluble in water, soluble in non-polar solvents such as ether, chloroform, and benzene. Since fish lipids are high in eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), it is well recognized that they are good for human health. Species, season, and environmental factors all affect the fat and fatty acid composition of fish. Compared to other cooking methods, frying results in a higher loss of DHA and EPA. The amount of fish fat, the makeup of the frying oil, and the type of frying technique all affect how the fish changes throughout cooking. Some cooking methods or techniques may have an impact on this advantage. Different cooking methods have been shown to alter the lipid content and fatty acid composition of various fish species. This article evaluated the fish lipid properties and how they changed when subjected to various cooking techniques.

**Keywords***:* Cooking method, fish lipid, fatty acid, shellfish, omega-3.

## INTRODUCTION

All marine and freshwater creatures, including fish, shellfish, and mollusks, are referred to as "fish". Since fish lipids are high in essential n-3 polyunsaturated fatty acids (PUFA), mainly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), it is well recognized that they are good for human health. The effects of *n*-3 PUFA, which are said to have various positive impacts on human health, are primarily responsible for the nutritional advantages of fish consumption. The primary source of long chain PUFA *n*-3 with positive or even therapeutic effects on human health is fish tissue (Hixson *et al*., 2015). Only found in fish and other seafood, EPA and DHA are incredibly advantageous for preventing human coronary artery disease (Nieva-Echevarría *et al*., 2016). The American Heart Association advises eating at least two servings of fish each week to have cardio-protective effects.

Boiling, microwaving, grilling and frying are just a few of the cooking methods that can change the lipid content and nutritional value of cooked foods in comparison to raw samples (Roncero-Ramos *et al*., 2014). Rainbow trout fish is affected by boiling (100 °C, 5 min), microwave cooking (2450 MHz, 13 min), and frying (150 °C, 15 min), but only slightly by baking (180 °C, 30 min) (Karimian-Khosroshahi *et al*., 2016). Fish that has been fried have the most altered nutrient composition due to changes in fatty acid profiles, water loss, and fat absorption (Hosseini *et al*., 2014). Fried kutum roach was shown to have a higher concentration of linoleic acid due to the absorption of sunflower oil, a good source of this fatty acid, during cooking while due to fat uptake, confit cod cooked in olive oil (60 to 68 °C, 15-20 min) contained more oleic acid (C18:1, n-9) and linoleic acid (C18:2, n-6) (Sobral *et al*., 2018). According to Hosseini *et al*. (2014), the most significant factor affecting the overall concentration of *n*-3 fatty acids is fish's ability to absorb cooking oil. The present review reveals composition of fish lipid composition and impact of cooking process on fish lipid.

## LIPID CONTENT OF SHELL AND FIN FISH

The term "lipid" is sometimes used as a synonym for fats. Meanwhile, fats are a subgroup of lipids called triglycerides while lipid also encompasses molecules such as fatty acids and their derivatives (including tri-,di monoglycerides, and phospholipids), as well as other sterol-containing metabolites such as cholesterol (Moruf *et al*., 2021). Lipids or fats are organic compounds that are found in many tissue cells, insoluble in water, soluble in non-polar solvents such as (ether, chloroform, and benzene). Lipids are non polar or hydrophobic which include heterogeneous compounds present in plant and animal tissues, one of the groups that play an important role in nutrition is fats and oils (Junianto *et al*., 2022).

There are two kinds of lipid constituent fatty acids, namely saturated fatty (SFA) acids and unsaturated fatty acids (monounsaturated, MUFA and polyunsaturated, PUFA). They are the principal

classes of fatty acids in fish lipids (Taşbozan and Gökçe, 2017). The lipid SFAs are dominated by palmitic acid (C16:0), followed by myristic acid (C14:0), which are more abundant in the warmer water fish than the cold water fish. The MUFAs are dominated by oleic acid C18:1 (n-9), while PUFA composition is the most characteristic trait of fish lipids (Moruf *et al*., 2021).
There are two types of most important omega-3 fatty acids, namely; eicosypentanoic acid (C20:5) commonly known as EPA and docosahexanoic acid known as DHA (Figure 1). EPA is typically found in marine algae, while DHA is derived from zooplankton. The proportion between the two types of fatty acids depends largely on the type of food consumed by fish.

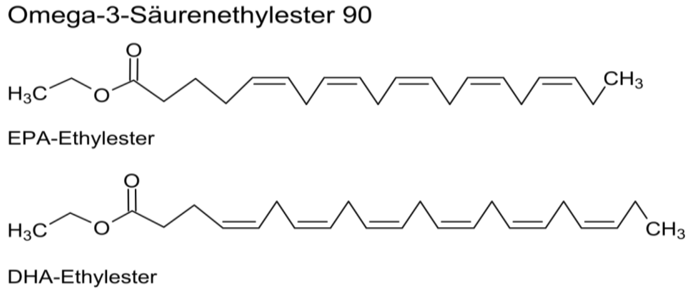


***Figure 1:** Chemical structure of Omega 3 found in Fish*

Marine shellfish are generally characterized by the predominance of essential *n*-3 PUFA, mainly EPA, DHA and DPA (Figure 2), which constitute usually almost half of the total fatty acids (Moruf *et al*., 2021). Researchers have shown that freshwater bivalves generally contain lower proportions of *n*-3 PUFA than marine bivalves; the lipid quality also differ in farmed and wild species while the lipid composition of marine bivalves is affected by the taxonomic relationship and environmental conditions (Prato *et al*., 2019; Moruf *et al*., 2020). In general, the lipid content of most marine bivalves ranged between 0.5 and 11.9% (Tan *et al*., 2019).

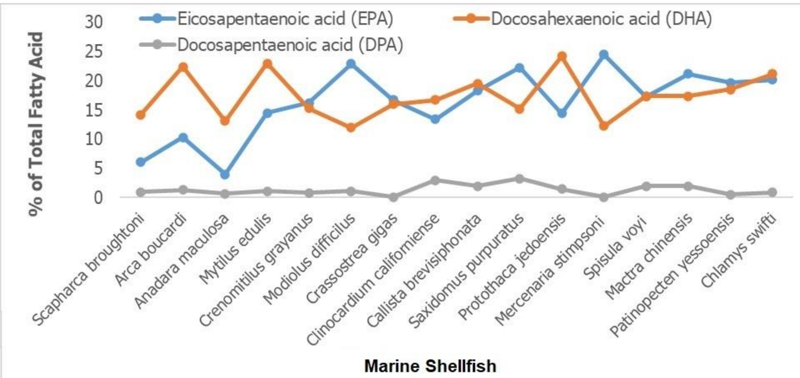


***Figure 2:** n-3 PUFA of Marine shellfish*

The lipid contents of fin fish depend on many factors and they are generally divided into three groups based on their composition: lean fish (less than 5% fat), mid-fat fish (5–10% fat), and fatty fish (10–25% fat) (Moruf *et al*., 2021).

**Table 1:** Fat and *n*-3 PUFA of marine finfish

| Fish species | Fat (g) | EPA (g) | DHA (g) |
|---|---|---|---|
| **Lean fish** | | | |
| Haddock | 1.0 | 0.07 | 0.27 |
| Cod | 0.6 | 0.07 | 0.16 |
| Saithe/coalfish | 0.3 | – | – |
| Tusk | 0.3 | – | – |
| European plaice | 1.5 | 0.24 | 0.26 |
| **Medium fat fish** | | | |
| Halibut | 3.9 | 0.28 | 0.41 |
| Atlantic wolffish | 2.7 | 0.40 | 0.20 |
| Rainbow trout | 6.7 | 0.32 | 1.16 |

| | | | |
|---|---|---|---|
| Spotted wolffish | 4.8 | 0.70 | 0.40 |
| **Fatty fish** | | | |
| Greenland Halibut | 15.6 | 1.00 | 0.90 |
| Salmon | 10.0 | 0.65 | 1.80 |
| Mackerel | 24.4 | 1.27 | 3.17 |
| Herring (summer) | 14.5 | 0.57 | 1.25 |
| Herring (winter) | 19.0 | 2.48 | 2.24 |
| Eel | 31.5 | 1.27 | 2.07 |

(Source: Taşbozan and Gökçe, 2017)

## COOKING TECHNIQUES FOR FISH

Cooking fish in modern times can be carried out by different methods, including boiling, poaching, steaming, roasting, baking, frying, microwaving, grilling, barbecuing and smoking. According to the work of Sobral *et al*. (2018), boiling, a simple cooking method widely used for fish, involves cooking fish in water at the boiling point of 100 °C; Poaching is a similar method, based on cooking food by submerging it in a liquid, such as water or milk, but at lower temperatures (70 to 80 °C). The fish is cooked gradually and softly, allowing it to become tender without losing its moisture content. This technique uses lower temperatures. Steaming relies on cooking with steam heat resulting from boiling water. Fish is maintained separate from the boiling water, having direct contact only with steam; this contributes to the moist texture of fish cooked with steam. Oven drying is a common cooking method used to enhance the flavor of fish via caramelization and Maillard browning occurring on the surface of the food; this is accomplished using dry heat, at temperatures above 200 °C, over variable cooking time. The cooking time, using this method, is generally more than 2 h in an open uncovered pan. Similarly, oven baking is a cooking method that uses dry heat at lower temperatures (170 °C) than those used for oven roasting and, usually, the food is covered while cooking (Sobral *et al*., 2018).

Frying is a cooking method in which food is submerged in hot fat, most commonly in cooking oil. Typically, it is a rapid preparation technique that promotes physical and chemical changes in the products and leads to unique sensory properties like colour, flavour, texture, and palatability (Sobral *et al*., 2018). There are different types of frying, the most common being pan- and deep-frying. The first consists of cooking the food in a hot pan containing a scanty amount of cooking oil; in the second one, the pan contains enough cooking oil to allow the food to float in the cooking oil. Microwaving is a more recent cooking method, widely applied to cook and reheat food. Microwave ovens work by producing electromagnetic waves via a magnetron contained inside the oven. These waves cause the vibration of water molecules in the food, producing heat that is then transferred throughout the product by thermal conduction. One of the major problems associated with microwave heating is non-uniform temperature distribution. This can result in cold spots, which may pose serious health concerns with respect to meat products, because of the survival of bacteria in the cold spot of the fish (Sobral *et al*., 2018).

Grilling allows consumers to prepare a quick meal by using a direct heat source; the heat source, such as thermal radiation or direct conduction and may differ according to the type of grill. Direct grilling can expose food to a temperature up to 260 °C, resulting in grilled fish with aroma and flavor characteristics similar to those achieved by roasting; this is due to Maillard reactions. Contrary to grilling, barbecuing is a slow cooking process, using the smoke produced by burning wood or charcoal as indirect heat source, resulting in smoking-flavoured, tender, and juicy fleshy fish (Sobral *et al*., 2018). Smoking is an ancestral flavouring and preserving method commonly used with fish.

## IMPACT OF COOKING TECHNIQUES ON FISH LIPID

The temperature and time of cooking play an important role in the characteristics of cooked fish. Meanwhile, cooking processes, such as boiling, microwaving, grilling and frying, can affect the lipid composition and nutritional value of cooked products compared with those in the raw samples (Dom´ınguez *et al.*, 2014). Boiling (100 °C, 5 min), microwaving (2450 MHz, 13 min), and frying (150 °C, 15 min) change the composition of fatty acids in kutum roach and rainbow trout fish, while baking (180 °C, 30 min) has only minor effects (Hosseini *et al*., 2014; Karimian-Khosroshahi *et al.*, 2015).

Frying has the greatest effect on nutrient composition in fish because of water loss, fat uptake, and changes in the profile of fatty acids (P´erez-Palacios *et al.*, 2017). Oil absorption occurs during frying, while water is partially driven out by evaporation. An increased content of linoleic acid was observed in fried kutum roach, which resulted from sunflower oil absorption during cooking, which is a good source of this fatty acid (Hosseini *et al.,* 2014). Hosseini *et al.* (2014) stated that the absorption of cooking oil by fish is the most important factor reducing the total contents of *n*-3 fatty acids.

All cooking methods decreased SFA contents of fish, and in the case of frying, the SFA contents were replaced by MUFAs derived from oil used during cooking. The aroma and flavor development in fried foods is a complex process mainly derived from lipid oxidation and Maillard reactions (P´erez-Palacios *et al.,* 2014). The presence of PUFAs renders the product more susceptible to oxidation during heating. The content of arachidonic acid (20:4, n-6), an essential PUFA, reduced to 21.7%, 30.4%, and 47.8%, respectively by boiling, frying and microwaving in cooked kutum roach fish (Hosseini *et al.*, 2014). Lipid oxidation reactions are more prone to happen in fish samples because of its high content in PUFAs. Hydroperoxides and other primary products of oxidation are formed mainly from PUFAs (P´erez Palacios *et al.*, 2017). Time of cooking seems to contribute more to lipid oxidation than temperature (P´erez Palacios *et al.,* 2017).

Roasting and microwaving contributed the highest increase, 92.8% and 91.6%, respectively, followed by grilling and frying with 90.8% and 79.4% increase of lipid oxidation (Dom´ınguez *et al.,* 2014). The lowest lipid oxidation observed in fried samples ~~may~~ results from the combined reactions of products derived from oxidation processes (Dom´ınguez *et al.,* 2014). Boiling and baking silver catfish (*Rhamdia quelen*) increased lipid oxidation (TBARs values), whereas grilling and frying seem not to influence those values, as well as confit cod that did not change in lipid oxidation after cooking (P´erez Palacios *et al.,* 2017).

The nutritional value of fat for human consumption is widely evaluated by the ratio of PUFA/SFA that must be higher than 0.45, and, within PUFAs content, the n-6/n-3 PUFAs ratio that must not exceed 4 (Sobral *et al*., 2018). In the case of fish, boiling (1.77), oven baking (1.56), microwaving (1.81), grilling (1.91), frying (1.42 to 5.39), and confit (0.61 to 0.91), all exhibited PUFA/SFA ratios higher than 0.45 while confit cod increased *n*-6/*n*-3 ratio from 0.14 (raw) to 0.36 to 0.68, while for silver catfish (*Rhamdia quelen*), only frying increased this ratio to 7.18, which is higher than recommended (P´erez Palacios *et al*., 2017). Thus, for fish, frying is not recommended, being preferable to use other cooking methods as boiling, baking, and microwaving.

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