***Review Article***

**THE EFFECTS OF SMOKED FISH ON THE HEALTH STATUS OF ITS CONSUMERS**

**ABSTRACT**

Fish smoking is an ancient and popular way of fish preservation. Smoked fish are palatable with great flavor and longer shelf life. The purpose of this article is to describe the various smoking methods, nutritional composition of smoked fish and its effects to it consumers. There are two smoking methods; cold smoking/fumigation that uses heat between 30-40ºC and hot smoking which uses heat between 30-90⁰C. Smoked fish enhances growth and metabolism, foetal development and aid in the prevention of cardiovascular diseases. Prolong consumption of fish intoxicated with PAHs which occur as a result of incomplete combustion of wood or coal causes: cancer, retarded growth, low birth weight, small head circumference, low IQ, damaged DNA in unborn children among others.

*Keywords : Cold smoking, Hot smoking, Carcinogenic compounds, Cardiovascular diseases, Drying metabolism*

**INTRODUCTION**

Fish is a major source of food for humans providing a significant portion of the protein intake in the diets of a large proportion of the people, particularly in developing countries, where it represents about 14% of all animal protein on global basis (Abolagba and Melle, 2008; Afolabi *et al.,* 1984; Clucks and Ward, 1996; da Silva, 2002 and Eyo, 2001). In Nigeria, fish has an edge over meat because it is cheaper and relatively more abundant and constitutes about 40% of animal protein intake (Abolagba and Melle, 2008; Eyo, 2001). Fish is a cheap source of animal protein with little or no religious rejection of it, which gives it an advantage over pork or beef. Fish is highly perishable, therefore a considerable effort has been directed to extend the shelf life of fish using preservation and processing techniques, such as refrigeration, freezing, canning, smoking, salting, and drying.

In Nigeria, fish smoking is the most practiced preservation method. Practically all species of fish available in the country can be smoked, and it has been estimated that 70–80% of the domestic marine and freshwater catch is consumed in smoked form (Akinyemi, *et al.,* 2011). The drying effects during smoking, together with the antioxidant and bacteriostatic effects of the smoke, allow smoked products to have extended shelf life (Eyo, 2001). Smoking is commonly applied to fish and meat products (Cardinal *et al.,* 1997; Varlet *et al*., 2007) but also to other food categories, such as cheese and mushroom (Suchano *a et al*., 2008). da Silva *et al.*, (2008) examined the microbial safety and quality of smoked blue catfish (Ictalurus furcatus) steaks treated with antimicrobials and antioxidants during 6 weeks of ambient storage. Fafioye *et al.,* (2002) studied the fungal infestation of five traditionally smoked dried freshwater fish in Ago-Iwoye, Nigeria and isolated and identified 11 different fungal species, of which Aspergillus flavus was the most frequently encountered fungi on the fish species. Polycyclic aromatic hydrocarbons (PAHs) constitute a large class of organic compounds, containing two or more fused aromatic rings made up of carbon and hydrogen atoms. Food is one source of PAH (Guillen *et al.,* 1997).

**FISH SMOKING** Food has been preserved by smoke-curing before the dawn of recorded history. People in all cultures in the world have relied on the smoke curing of fish and meat products for long term storage. Smoking also impacts a desirable flavour, appearance and texture to the products. The process of smoking occur through the use of fire wood containing three major components that are broken down in the burning process known as pyrolysis which is a chemical decomposition by heat into cellulose, hermicellullose and lignin (Brownell, 1983). A preliminary drying period at 30 ⁰C during which the skin is toughened to prevent subsequent breakage, a smoking and partial cooking period at 50 ⁰C and final cooking period at 80 ⁰C. The total time and the proportion spent at each stage will depend on the species, its size, fat content and the kind of product required.

In developed countries where refrigeration and an integrated infrastructure for efficient transportation of perishables are in place, smoking is not a means of fish preservation but used to enhance the flavour of the fish through cold smoking. But in developing countries, hot smoking is still a very important method of fish preservation. In this process, drying is of paramount importance for preservation because it is the high moisture in the flesh of the fish that allows bacterial activity and spoilage (FDA, 1998). Smoking fish can be done by two methods of smoking, namely hot and cold smoking. Hot smoking uses temperatures above 90ºC.

COLD SMOKING

(Fumigation) Cold Smoking uses room temperature or temperatures between 30-40ºC (Nowsad, 2007). Smoke drying temperature, and time affect the nutritional, and physical quality of smoked fish (Idah and Nwankwo, 2013). Adawyah (2007) stated that cold smoking is a smoking process using a not too high temperature, around (15-50)°C. The use of low temperatures is intended so that the fish meat does not cook quickly or the protein in the fish meat is not lost (coagulated). According to Swastawati (2008), the cold smoking process takes a long time depending on the size of the fish, so cold smoking can result in smoked fish being stored longer. Drying that occurs in smoked fish meat causes the maximum moisture content of smoked fish to reach 60%. The cold smoking method according to Erkan et al. (2011) can be carried out using high pressure of 220-300 MPa at a temperature of 3-25ºC for 10 minutes.The cold smoking used in the developed countries only applies smoke to the product at temperature less than 90 ºF (32.5 ⁰C). The protein constituent in this fish will not coagulate at this condition (Clucas, 1982). Compounds in smoking raw materials such as wood and coconut shells have an effect on the quality of smoked fish such as taste, color, and anti-microbial (Lingbeck, 2014)

HOT SMOKING

The hot smoking which is common in developing countries cooks the fish product by the application of heat and smoke. The fish product is subjected to a temperature of 176 ºF (80 ⁰C) for a long period which will enable the protein to coagulate. Traditional hot smoking method. According to Iwegbue *et al*., (2015), traditional smoking with wood-burning processes will produce high levels of polycyclic aromatic hydrocarbons (PAHs), especially Benzoa pyrene (BP). These compounds are hazardous compounds that are toxic, mutagenic, and carcinogenic. According to Fecicilar and Genccelep (2013), hot smoking can be achieved in several phases. The

smoking temperature varies between 40-100oC and the fish core temperature will rise to 85oC. Fumigation with traditional methods has been replaced by the use of liquid smoke [17] [11]. The

liquid smoke does not contain the same compounds as natural smoke. The liquid smoke is safe to use because it has gone through a filtering process to remove toxins, impurities and other carcinogenic compounds. The liquid smoke is an alternative smoking process that is easy to produce, use and control. The smoking process requires five basic steps:

1. Preparation of the fish (small and medium fish may be smoked whole) while splitting, filleting, nobbing, or chunking are associated with large fish.b) Salting or brining c) Equilibration and drying d) Smoking and cooling (hot or cold smoking)e) Product packaging and storage.

**NUTRIENTS COMPOSITION OF SMOKED FISH**

Many authors have studied the influence of various methods of culinary processing, mainly boiling and baking, on the nutrient composition most frequently performing analyses of the content and quality of fish fat or protein. During the smoking process, fats and water drip from the fish, resulting in the physical loss of lipids, protein, and micronutrients. Smoking at high temperatures can also reduce the functionality of essential amino acids. Smoke particles can react with nutrients in fish meat and may lead to loss of important nutrients and antioxidants (Abraha *et al.*, 2018). Literature reports are typically focused on several most popular species of fish, e.g., salmon, mackerel, sardine, anchovy, tilapia, etc. (Garcia *et al*., 2003 and Abraha *et al.,* 2018). Cie´slik *et* *al., 2*018) observed that the process of smoking of freshwater fish: common carp, rainbow trout, and northern pike led to an increase in almost all amino acids, with the highest amount of EAA. However, Famurewa *et al* (2017) observed increasing content of protein at a level of 5.5% and crude ash—~14% as well as decreasing fat content—as high as 27% during fish smoking. In processed tilapia, significant changes in the ash content from 11.12% (fresh) to 14.72% (traditionally smoked) were observed as well. The mineral content did not show any significant differences (p > 0.05) (Katola *et al*., 2017). However, it is difficult to find a comprehensive study providing a comparison of the chemical composition and nutritional value of many freshwater and sea fish species as well as the content of micronutrients and analysis of the impact of culinary methods on changes in nutrient compounds.

**HEALTH BENEFITS OF SMOKED FISH**

Smoked fish is widely consumed not only for enjoyment but also for its nutritional values and health benefits. Fish itself is known for its richness in proteins, healthy fats, and minerals. These properties are also well preserved in dried fish products, furthering the benefits by prolonging the shelf-life of the fish by smoking. essential amino acids absent in either plant or meat proteins like cysteine (28 to 25 mg/g), methionine (0.18–2.66 g/100 g) and (0.89–9.864 g/ 100 g) lysine were found in smoked fish (Rasul *et al.,* 2021 and Siddanarth *et al.,* 2022). It is found out that cysteine and methionine are effective antioxidants in which cysteine prevents the build up of toxic metabolic wastes that accelerate ageing whereas methionine regulates nucleotide and redox statuses ( Piste, 2013). Additionally, it was stated that methionine metabolism could also be linked to tumour cell metabolism, making methionine possibly essential for cancer prevention. As for lysine, one study that claims that L-lysine could have preventative and therapeutic effects on osteoporosis as lysine aids in the uptake of calcium in the body (Civitelli *et al*., 1992). It mentioned that smoked fish proteins contain essential amino acids for body growth, repairing functions and metabolism (Rasul *et al.,* 2021). Hence, it can be concluded that the protein contents in dried fish aid in regulatory functions in the body and prevent various diseases.

The fat contents in smoked ﬁsh are claimed to be healthy, especially when smoked ﬁsh have lipid oxidation properties by omega-3 polyunsaturated fats (PUFA) (Nordvi *et al.,* 2007). For instance, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)are long-chained omega-3fatty acids that help in foetal development and the prevention of cardiovascular diseases (Swanson, 2003). Smoked ﬁsh has been declared to be rich in calcium, phosphorus, and βvitamins, which aid in bone development and maintenance. Another notable mineral present in smoked ﬁsh is seem substances in the immune system by being the cofactor of glutathioneperoxidase ( Haratake *et al*, 2007 and Rocourt *et al*., 2013).

**NEGATIVE EFFECT OF SMOKED FISH ON CONSUMERS HEALTH STATUS**

PAHs are formed by incomplete combustion processes which occur whenever wood, coal or oil are burnt. The possible sources of PAHs in food are environmental contamination, as well as thermal treatment of varying severity which is used in the preparation and manufacturing of foods (Guillen, 1994),the absorption and deposition of particulates during food processing such as smoking, grilling, boiling and toasting, the pyrolysis of fats and the incomplete combustion of charcoal (Larsson *et al*., 1983; Guillen, 1994; Moret *et al.,* 1997). Regarding food of animal origin, one hypothesis suggests that the lipophilic character of PAHs is responsible for the accumulation in the fat of animals which eat contaminated plants (Guillen *et al.,* 1997). PAHs occur as contaminants in different food categories and beverages including water (Belykh *et al.,* 1999), fruit, cereals, oils (Dennis *et al.,* 1983, 1991; Moret *et al.,* 2000), smoked meat (Potthast, 1977; Simko, 2002) and smoked fish (Simko, 1991; Akpan *et al*., 1994; Lodovici *et al.,* 1995; Moret *et al.,* 1999). Non-processed fish contains low PAHs concentration even when it comes from contaminated water because fishes rapidly metabolize PAHs, resulting in low steady-state level in the tissue (Moret *et al.*, 2000; Chen and Chen, 2005; Wretling *et al.,* 2010; Essumang *et al*., 2011). The health effects resulting from PAH exposure have recently been discussed extensively in the literature (Shen *et al.,* 2008). These include growth retardation, low birth weight, small head circumference, low IQ, damaged DNA in unborn children and the disruption of endocrine systems, such as estrogens, thyroid and steroids (Essumang *et al.,* 2012). Skin changes (thickening, darkening and pimples) and reproductive-related effects such as early menopause due to destruction of ova have also been identified with PAHs (Essumang *et al.,* 2011, 2012). It is known that in mammalian cells, PAHs undergo metabolic activation to diol, and epoxides that bind covalently to cellular macro molecules, including DNA, thereby causing errors in DNA replication and mutations that initiate the carcinogenic process (Rodriguez *et al.,* 1997; Schoket, 1999; Lightfoot *et al.,* 2000; Essumang *et* *al.,* 2012). Polymorphisms causing glutathione transferase deficiencies (GSTM1) may result in elevated breast cancer, lung cancer and other forms of human cancer risk from PAHs (IARC, 1999; Van der Hel *et al.,* 2003).

**CONCLUSIONS**

Smoked fish can have both positive and negative effects on health depending on various factors such as the type of fish, the smoking process, and the frequency of consumption. The positivity of smoked fish consumption is that smoked fish is an excellent source of protein and omega-3 fatty acids, which have been associated with numerous health benefits, including improved heart health, brain function, and reduced inflammation. However, smoked fish can also contain high levels of salt, which can lead to high blood pressure in some individuals. Additionally, smoked fish may contain carcinogenic compounds called polycyclic aromatic hydrocarbons (PAHs) and heterocyclic amines (HCAs), which can increase the risk of certain cancers when consumed in large amounts over a long period. Health status of smoked fish consumers can also depend on other factors such as their overall diet and lifestyle

RECOMMENDATION.

Therefore, it is recommended that liquid smoke should be used in fish smoking since it passes through a filter thereby being free from impurities and other carcinogenic compounds and and alsobalanced diet should be maintained with plenty of fruits and vegetables to mitigate any potential negative effects of smoked fish consumption.

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