***Review Article***

**A REVIEW OF THE EFFECTS OF SMOKED FISH ON THE HEALTH 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. Smoked fish enhances growth and metabolism, foetal development and aid in the prevention of cardiovascular diseases. However, prolonged consumption of fish intoxicated with PAHs could 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, Liquid smoking, Electrostatic smoking, Carcinogenic compounds, Cardiovascular diseases*

**1.0 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 [1]. In Nigeria, fish has an edge over meat because it is cheaper and relatively more abundant and constitutes about 40% of animal protein intake [1]. 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 [2]. When fish are smoke dried, the antioxidant and bacteriostatic effects of the smoke, allow smoked products to have an increased shelf life. Smoking is commonly applied to fish and meat products [3] but also to other food categories, such as cheese and mushroom[4]. [5] examined the microbial safety and quality of smoked blue catfish (*Ictalurus furcatus*) steaks treated with antimicrobials and antioxidants during 6 weeks of ambient storage. [6] 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 [7].

**2.0 FISH SMOKING**

Smoking is an ancient method of food preservation, which is also known as smoke curing, produces products with very high salt content (>10%) and low water activity (~0.85). Smoking is a process of treating fish by exposing it to smoke from smouldering wood or plant materials to introduce flavour, taste, and preservative ingredients into the fish. This process is usually characterised by an integrated combination of salting, drying, heating and smoking steps in a smoking chamber. The drying effects during smoking, together with the antioxidant and bacteriostatic effects of the smoke, allow smoked products to have extended shelf-life. Smoked seafood includes different varieties like, smoked finfish and smoked bivalves. Many of the smoked products are in the form of readyto-eat [8].

Over time, food has been preserved by smoking. People in all cultures in the world have relied on the smoking of f ish and meat products for long term storage. Smoking also impacts a desirable flavor, appearance and texture to the products. Most times in Africa, the process of smoking occurs through the use of fire wood. Heat from smoke contains three major components that are broken down in the burning process known as pyrolysis (a chemical decomposition by heat into cellulose, hermicellullose and lignin).

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 [9].

Developments of modern food preservation technology, such as pasteurization, cooling/refrigeration, deep-freezing, and vacuum packaging, have eclipsed the preserving functions of many traditional methods including smoking. Nowadays, the main purpose of smoking has been shifted for sensory quality rather than for its preservative effect [8]. Depending upon how the smoke is delivered into the food and smoking temperature, four basic types of smoking can be defined: hot smoking, cold smoking, liquid smoking, and electrostatic smoking. Hot smoking is the traditional smoking method using both heat and smoke, which usually occurs at temperatures above 70 °C. For smoked fish and fishery products, a minimum thermal process of 30 min at or above 145°F (62.8 °C) is required by [9].

**2.1 Hot smoking**

The Torry smoking kiln is considered as a model for the modern smokers/smokehouses by enabling the precise controls of the heating temperature, air ventilation, and smoke density. Some recently designed smoke house may also be equipped with more precise time and temperature controls, humidity control, and product internal temperature monitor probes. Thus, the products produced by the modern smokehouses are much more uniform than those produced with traditional smokers. Hot smoking is typically not a single process. Several other steps such as brining, drying and smoking are also involved to produce a product of good quality.

**2.2 Cold smoking**

Fish can also be subjected to cold smoking. Temperatures of cold smoking typically do not exceed 30 °C. Thus, cold smoked products are not cooked and typically heavily salted. Compared to the traditional hot smoking, cold smoking runs longer, has a higher yield and retains the original textural properties much better than the hot-smoked ones. Cold smoking of varied fish species has been reported, including rainbow trout.

**2.3 Liquid smoking**

Liquid smoke can be used directly on products by dipping or spraying. It is rapid and much easier to achieve a uniform smoke flavor than traditional cold and hot smoking processes, although the flavour and colour from the traditional smoking cannot be exactly duplicated [3]. Some potential harmful ingredients (e.g. polycyclic aromatic hydrocarbons, PAHs) in the nature smoke can be separated out and excluded from the liquid smoke [10].

Other advantages of liquid smoke include easy modification, application to food items that traditionally are not smoked, lower operation cost, and less environmental pollution [11]. However, the application of liquid smoking may be expensive compared to other methods. Liquid smoking of fish species had been reported on swordfish, salmon and rainbow trout.

**2.4 Electrostatic smoking**

Electrostatic smoking is another rapid way to smoke. In the electrostatic smoking, fish are sent into a tunnel where an electrostatic field is created. Smoke particles are given a positive charge and deposit onto the surface of the fish which are negative charged. Although this procedure will change the composition of the smoke, the efficiency of smoking is still higher than that of the traditional smoking. It can also be operated continuously. The smoke compound ratio in the vapour phase may be modified by the electrostatic field, which results in increased level of carbonyl compounds. Factors that may influence the electrostatic smoking operation include the skin thickness, presence of scales, and subcutaneous fat amount [12]. This operation may present safety problems to employees. Applications of electrostatic smoking have been reported mainly in salmon and herring.

**3.0 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 [14]. Literature reports are typically focused on several most popular species of fish, e.g., salmon, mackerel, sardine, anchovy, tilapia, etc. [15][14][16] 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, [17] 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)[18] . 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.

4.0 **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 [19] [20]. 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 [21] 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 [22] It mentioned that smoked fish proteins contain essential amino acids for body growth, repairing functions and metabolism, [19]. 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) [23] .For instance, Eicosa Pentaenoic Acid (EPA) and Docosa Hexaenoic Acid (DHA) are long-chained omega-3 fatty acids that help in foetal development and the prevention of cardiovascular diseases [24]. 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 glutathione peroxidase [25][26].

**5.0 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 [27],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 [28][27][29]. 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 [7]. PAHs occur as contaminants in different food categories and beverages including water [30] fruit, cereals, oils [31][32], smoked meat [33][34] and smoked fish [35][36][37][38]. 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 [32][10][39][40]. The health effects resulting from PAH exposure have recently been discussed extensively in the literature [41]. 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 [42]. 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 [40][42]. 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 [43][44][45][42]. Polymorphisms causing glutathione transferase deficiencies (GSTM1) may result in elevated breast cancer, lung cancer and other forms of human cancer risk from PAHs [46][47].

**6.0 OTHER POTENTIAL HAZARDS ASSOCIATED WITH SMOKING OF FISH**

If wood or plant material is using for smoking of fish, there is a chance of presence of natural toxins, chemicals, paint, or impregnating material in plant or wood used which may result in imparting undesirable odour in processed products. This can be prevented by using sufficiently dried wood or plant material for smoke generation, judicious selection of the species of wood or plant and not using woods having mould or fungus growth for smoking process. Moreover, the material for smoking should be

kept in a clean dry place during storage to prevent any kind of contamination, till the usage.

**7.0 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

**8.0 RECOMMENDATION**

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 andandalsobalanced diet should be maintained with plenty of fruits and vegetables to mitigate any potential negative effects of smoked fish consumption.

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