***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 (CITE?).

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. I suggest to delete it and concentrate this section on smoked fish only.

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**

**Are here some studies about PAHs in smoked fish? If not, it is important to remark it. If exist papers about it, then make a review of it and discuss it.**

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. This sentence is ambiguous

 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 it is out of line….

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. In what paper, research or report based this affirmation? It is necessary to explain it.

REFERENCES

Abolagba, O. J., & Melle, O. O. (2008). Chemical composition and keeping qualities of a scaly fish tilapia (Oreochromis niloticus) smoked with two energy sources. African Journal General Agriculture KLOBEX, 4(2), 113–117.

Abraha, B.; Admassu, H.; Mahmud, A.; Tsighe, N.; Shui, X.W.; Fang, Y. Effect of processing methods on nutritional and physicochemical composition of fish: A review. MOJ Food Process Technol. 2018, 6, 376–382.

Adebayo-Tayo, B. C., Onilude, A. A., & Patrick, U. G. (2008). Mycofloral of Smoke-Dried Fishes Sold in Uyo, Eastern Nigeria. World Journal of Agricultural Sciences, 4(3), 346–350.

Afolabi, O. A., Arawomo, O. A., & Oke, L. O. (1984). Quality changes of Nigerian traditionally processed freshwater fish species. I. Nutritive and organoleptic changes. Journal of Food Technology, 19, 333–340. doi:10.1111/j.1365-2621.1984.tb 00356.

Akinyemi, A. A., Adejola, A. Q., Obasa, S. O., & Ezeri, G. N. O. (2011) Aflatoxins in smokeddried fish sold in Abeokuta, Ogun State, South-west Nigeria. Proceedings of the Environmental Management Conference, Federal University of Agriculture, Abeokuta, Nigeria, pp. 476–486.

Akpan V, Lodovici M, Dolora P (1994). Polycyclic aromatic hydrocarbons in fresh and smoked fish samples from three Nigerian cities. Bulletin of Environmental Contamination and Toxicology 53:246-253.

Belykh LI, Kireeva AN, Smagunova AN, Penzina EE, Pan‟kov SD, Protasova LE, (1999). Metrological investigations of procedures for determination benzo(a)pyrene in water using low-temperature luminescence. Zhurnal Analiticheskoi Khimii 54(7):678-684.

Brownell, B. 1983. A Practical Guide to Improved Fish Smoking In West Africa. UNICEF. 5-7.

Cardinal, M., Berdague, J.L., Dinel, V., Knockaert, C. & Vallet, J. J. (1997). Effect of various smoking techniques on the nature of volatile compounds and on the sensory characteristics of salmonmeat. Science des Aliments, 17, 679–696.

Chen J, Chen S (2005). Removal of polycyclic aromatic hydrocarbons by low density polyethylene from liquid model and roasted meat. Food Chem. 90: 461-469.

Cie´slik, I.; Migdał, W.; Topolska, K.; Mickowska, B.; Cie´slik, E. Changes of amino acid and fatty acid profile in freshwater fish after smoking. J. Food Process Preserv. 2018, 42, e13357.

Civitelli, R.; Villareal, D.T.; Agnusdei, D.; Nardi, P.; Avioli, L.V.; Gennari, C. (Dietary L-lysine and calcium metabolism in humans.Nutrition 1992, 8, 400–405.

Clucas, I. J. 1982. Fish Handling, Preservation and Processing in the Tropics. Part 2. Report of The Tropical Development and Research Institute (TDRI). 45-50.

Clucks, I. J., & Ward, A. R. (1996). Post harvest fisheries development: A guide to handling, preservation, processing and quality. Chamita Maritime, Kent, UK.

da Silva, L. V. A. 2002. Hazard analysis critical control point (HACCP), microbial safety, and shelf life of smoked blue catfish (Ictalurus furcatus). (Master’s Thesis) of Science in Food Science Thesis, the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College, Baton Rouge, LA, USA.

da Silva, L. V. A., Prinyawiwatkul, W., King, J. M., No, H. K., Bankston, J. D., Jr, & Ge, B. (2008, 2008 Dec). Effect of preservatives on microbial safety and quality of smoked blue catfish (Ictalurus furcatus) steaks during room-temperature storage. Food Microbiology, 25(8),958–963. doi:10.1016/j.fm.2008.07.001.

Dennis MJ, Massey RC, Gripps G, Venn J, Howarth N, Lee G (1991). Factors affecting the polycyclic aromatic hydrocarbon content of cereals, fats and other food products. Food Additives and Contaminants 8 (4):517-530.

Dennis MJ, Massey RC, McWeeny DJ, Knowles ME, Watson D (1983). Analysis of polycyclic aromatic hydrocarbons in UK total diets. Food and Chemical Toxicology 21(5):569-574.

Essumang DK, Dodoo DK, Adjei JK (2012). Polycyclic aromatic hydrocarbon (PAH) contamination in smoke-cured fish products. J.Food Composition and Analysis. 27:128-138.

Essumang DK, Kowalski K, Sogaard, EG (2011). Levels, distribution and source characterization of polycyclic aromatic hydrocarbons (PAHs) in topsoils and roadside soils in Esbjerg, Denmark. Bulletin of Environmental Contamination and Toxicology, 86(4):438-43.

Eyo, A. A. (2001). Fish processing technology in the tropics. Nigeria: University of Ilorin press. 403 p.

Fafioye, O. O., Efuntoye, M. O., & Osho, A. (2002). Studies on the infestation of five traditionally smoked-dried fresh-water fish in Ago-Iwoye, Nigeria. Mycopathologia, 154,177–179. Direct Link doi:10.1023/A:1016331418893.

Famurewa, J.A.V.; Akise, O.G.; Ogunbodede, T. (2017). Effect of storage methods on the nutritional qualities of African Catfish Clarias gariepinus (Burchell, 1822). Afr. J. Food Sci. 2017, 11, 223–233.

FDA. 1998. Pathogen growth and Toxin formation as a result of inadequate drying ch. 14.In Fish and Fishery Products hazard and Controls Guide 2nd Ed. PP 175-182. Department of Health and Human service, Public Health service, Food and Drug Administration center for food Safety and Applied Office of Seafood, Washington D.C.140 -167.

Gao, X.A.-O.; Dai, Z.A.-O.X.; Locasale, J.A.-O. Methionine metabolism in health and cancer: A nexus of diet and precision medicine. Nat. Rev. Cancer 2019, 19, 625–637.

García-Arias, M.T.; Alvarez-Pontes, E.; García-Linares, M.C.; García-Fernández, M.C.; Sánchez-Muniz, F.J.Cooking–freezing–reheating (CFR) of sardine (Sardina pilchardus) fillets. Effect of different cooking and reheating procedures on the proximate and fatty acid compositions. Food Chem. 2003, 83, 349–356. [CrossRef]

Guillen MD (1994). Polycyclic aromatic compounds: extraction and determination in food. Food Additives and Contaminants 11(6):669-684.

Guillen MD, Sopelana P (2003). Polycyclic aromatic hydrocarbons in diverse food. In: D‟Mello JPF (Ed.), Food Safety: Contaminants and Toxins. CABI, UK.

Guillen, M. D., Sopelana, P., & Partearroyo, M. A. (1997). Food as a source of polycyclic aromatic carcinogens. Reviews on Environmental Health,12,133–146.http://dx.doi.org/10.1515/REVEH. 1997.12.3.133.

Haratake, M.; Takahashi, J.; Ono, M.; Nakayama, M.(2007).6 An Assessment of Niboshi (a Processed Japanese Anchovy) as an Effective Food Source of Selenium. J. Health Sci. 2007, 53, 457–463.

Hussain, B.; Sultana, T.; Sultana, S.; Mahboob, S.; Farooq, M.; Al-Ghanim, K.; Nadeem, S. First report on fish cysteine as a biomarker of contamination in the River Chenab, Pakistan. Env. Sci Pollut. Res. Int. 2016, 23, 15495–15503.

International Agency for Research on Cancer IARC (1999). Metabolic polymorphisms and susceptibility to cancer. In: Vineis P, Malats N, Lang M, d‟Ericco A, Capaaso N, Cuzick J, Boffetta P (Eds.), IARC Scientific Publications No. 148. International Agency for Research on Cancer, World Health Organization, Lyon, p. 505.

Katola, A.; Kapute, F. (2017). Nutrient composition of solar dried and traditionally smoked Oreochromis mossambicus (Peters, 1852). Int. Food Res. J. 2017, 24, 1986–1990.

Larsson BK, Sahlberg GP, Erikson AT, Busk LA (1983). Polycyclic aromatic hydrocarbons in grilled food. J. Agric. and Food Chemistry 31:867-873.

Lightfoot TJ, Coxhead JM, Cupid BC, Nicholson S, Garner RC (2000). Analysis of DNA adducts by accelerator mass spectrometry in human breast tissue after administration of 2-amino-1-methyl-6-phenylimidazo[4,5-b]pyridine and benzo[a]pyrene. Mutation Research, 472(1-2):119-127.

Lodovici M, Dolara P, Casalini C, Clappellano S, Testolin G (1995). Polycyclic aromatic hydrocarbon contamination in the Italian diet. Food Additives and Contaminants 12(5):703-713.

Moret S, Conte L, Dean D (1999). Assessment of polycyclic aromatic hydrocarbon content of smoked fish by means of a fast HPLC/HPLC method. J. Agric. and Food Chemistry, 47(4):1367-1371.

Moret S, Dudine A, Conte LS (2000). Processing effects on the polyaromatic hydrocarbon content of grapeseed oil. J. Am. Oil Chemists Society, 77(12) 1289-1292.

Moret S, Piani B, Bortolomeazzi R, Conte, L.S., 1997. HPLC determination of polyaromatic hydroc arbons in olive oils. Zeitschrift fu¨r Lebensmittel-Untersuchung und -Forshung A 205, 116-120.

Nordvi, B.; Langsrud, O.; Egelandsdal, B.; Slinde, E.; Vogt, G.; Gutierrez, M.; Olsen, E. (2007). 7Characterization of volatile compounds in a fermented and dried fish product during cold storage. J. Food Sci. 2007, 72, S373–S380.

Piste, P. (2013). International journal of pharmaceutical, chemical and biological sciences cysteine–master antioxidant. Int. J. Pharm.Chem. Biol. Sci. 2013, 2013, 143–149.Sanderson, S.M.;

Potthast K (1977). Polycyclic aromatic hydrocarbons in smoked meat products. An application of a new method. ActaAlimentaria Polonica 3:195-201.

Rasul, M.G.; Yuan, C.H.; Azad Shah, A.K.M. (2021). Chemical composition and nutritional value of dried fish in Bangladesh. Egypt. J.Aquat. Biol. Fish. 2021, 25, 379–399.

Rocourt, C.R.; Cheng, W.H. (2013). 7Selenium supranutrition: Are the potential benefits of chemoprevention outweighed by the promotion of diabetes and insulin resistance? Nutrients 2013, 5, 1349–1365.

Rodriguez LV, Dunsford HA, Steinberg M, Chaloupka KK, Zhu LJ, Safe S, Womack JE, Goldstein LS (1997). Carcinogenicity of benzo[a]pyrene and manufactured gas plant residues in infant mice.Carcinogenesis, 18 (1), 127-135.

Schoket B (1999). DNA damage in humans exposed to environmental and dietary polycyclic aromatic hydrocarbons. Mutation Res. 424(1-2):143-153.

Shen M, Chapman RS, Xingzhou H, Lai LZLH, Chen H, Lan Q (2008). Dietary

Siddhnath; Ranjan, A.; Mohanty, B.P.; Saklani, P.; Dora, K.C.; Chowdhury, S. (2022). Dry Fish and Its Contribution Towards Food andNutritional Security. Food Rev. Int. 2022, 38, 508–536.

Simko P (1991). Changes of benzo(a) pyrene in smoked fish during storage. Food Chemistry 40:293-300.

Simko P (2002). Determination of polycyclic aromatic hydrocarbons in smoked meat products and smoke flavouring food additives. Journal of Chromatography, B770(1-2):3-18.

Suchanová, M., Jana Haj, L., Tomaniová, M., Kocourek, V., & Babika, L. (2008). Polycyclic aromatic hydrocarbons in smoked cheese. Journal of Science of Food and Agriculture, 88(8),1307–1317.

Swanson, D.; Block, R.; Mousa, S.A. Omega-3 fatty acids EPA and DHA: Health benefits throughout life. Adv. Nutr. 2012, 3, 1–7.

Van der Hel OL, Peeters PH, Hein DW, Doll MA, Grobbee DE(2003). NAT2 slow acetylation and GSTM1 null genotypes may increase postmenopausal breast cancer risk in long-term smoking women. Pharmacogenetics, 13(7):399-407.

Varlet, V., Serot, T., & Knockaert, C. (2007). Organolepticcharacterization and PAH content of salmon (Salmosalar) filletssmoked according to four industrial smoking techniques. Journal of Food Science and Agriculture, 87, 847–854.

Wretling S, Eriksson A, Eskhult GA, Larsson, B. (2010). Polycyclic aromatic hydrocarbons (PAHs) in Swedish smoked meat and fish. J. Food Composition and Analysis 22:264-272.

Nowsad AKMA. A new approach applied in

the fish processing. Bangladesh Fisheries

Research Forum; 2007.

Idah PA, Nwankwo I. Effect od smokedrying temperatures and time on physical and nutritional quality parameters of Tilapia (Oreochromis niloyicus). International Journal of Fisheries and Aquaculture. 2013;5(3):29-34.

Adawyah. “Pengolahan Dan Pengawetan Ikan”. 2007. Jakarta: Bumi Aksara. ID

 Swastawati F. “Pengasapan menggunakan liquid smoke. Universitas Diponegoro, Semarang; 2008. ISBN: 979-704-473-3. ID

Erkan N, Uretener G, Alpas H, Selcuk A, Ozden O, Buzrul S. The effect of different high pressure condition on the quality and shelflife of cold smoked fish. Innovation Food Science and Emerging Technologies. 2011;12(2):104-110

Iwegbue CMA, Tesi GO, Overah LC, Bassey FI, Nwadukwe FO, and Martincigh BC. Concentration and profiles of PAH in some popular fish species in Nigeria. Journal of Food Protection. 2015;75(9): 1619-1626

Lingbeck JM, Cordero P, Bryan P, Johnson MG. Fuctionality of liquid smoke as an all-natural antimicrobial in food preservation. Meat Science. 2014;97(2): 197-206.

Oyeleye OJ. Proximate compotition of some common hot smoked freshwater fish species using different packaging materials. International Journal of Fisheries and Aquaculture Research. 2020;6(2):29-39.

Martinez CC, Machado TJ. Consumer evaluation of cold smoked fat in beef sausages. International Food Research Journal. 2016;23(4):1782-1786.

Ficicilar BB, Genccelep HA characterization study of hot smoked Rainbow Trout for Each Production Stages. International Journal of Agriculture Innovations and Research. 2017;6(2): 2319-1473.