

# Mineral Composition and Fatty Acid Profile of Smoked Horse Mackerel *Trachurus Murphyi* Using an Improved Fish Smoking Kiln

Esan O. Moses

Department of Fish Technology and Product Development, NIOMR, Victoria Island, Lagos

## Abstract

The purpose of this research was to determine the quality of mineral and fatty acid profile of imported horse mackerel *Trachurus murphyi* using the improved NIOMR fish smoking kiln. 20kg of frozen imported horse mackerel were obtained from Ijora frozen food market Lagos state, Nigeria. Samples were transported to the NIOMR Pilot plant for processing and commencement of chemical analysis. Results show that, the most abundant saturated fatty acid in the fish was Palmitic acid, with a value of 19.404%, while the most abundant monounsaturated fatty acid was Elaidic acid with a value of 12.63%. However, low values of polyunsaturated fatty acid was recorded in the fish species, and the most abundant polyunsaturated fatty acid is the Docosahexaenoic acid with a value of 2.297%. The most abundant polyunsaturated fatty acid recorded is Linoleic acid (2.075 while the least abundant polyunsaturated fatty acid was eicosapentaenoic acid (EPA, C20:5n-3). There was significant variation ( $p < 0.05$ ) in the level of Docosahexaenoic acid and Eicosapentaenoic acid in the fish species. The monounsaturated fatty acids (MUFA) content of horse mackerel was mainly omega-9 fatty acids except Palmitoleic acid which is an omega-7 fatty acid. It can be concluded that the horse mackerel has a good mineral and fatty acid profiling.

**Keywords:** Smoking kiln; Fatty acid; Minerals composition.



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## 1. Introduction

Fish is a highly nutritious food and it is particularly valued for its protein which is of high quality compared to those of meat and egg [1]. It contains high quality protein, amino acids and absorbable dietary minerals [2]. Fish is currently being used as a good tool for food therapy and source of therapeutic substances for the treatment of coronary diseases, auto-immune diseases, anemia and protein energy malnutrition [3]. Sea foods play important roles in human nutrition as a source of digestible animal proteins, lipids, healthful polyunsaturated fatty acids (PUFAs), minerals and vitamins that support the biochemical processes of the human body [4]. Most of these constituents are economically important for human nutrition because of their high nutritional quality. The lipid fraction of fish are rich sources of long chain n-3PUFA especially,  $\alpha$ -linoleic acid (C18:3, ALA), Eicosapentaenoic (C20:5, EPA) and Docosahexanoic acid (C22:6w3, DHA) [5]. Kris-Etherton, *et al.* [6], revealed the effect of these fatty acids on blood pressure, arrhythmia (abnormal heartbeats) and hypertriglyceridemia. Arachidonic (C20:4n-6) acid and its parent fatty acid, linoleic acid (C18:2n-6) also drew consideration [7]. Due to inability of human body to synthesize EPA and DHA, its constant supply through food is a prerequisite [8].

Fish is also known to contain certain polyunsaturated fatty acids that can regulate prostaglandin synthesis and hence induce wound healing [9]. Polyunsaturated fatty acids (PUFA) have been shown to have positive effects on cardiovascular diseases and cancers [10]. PUFA composition may vary among species of fish, even among fresh water and marine fish [11]. Certain amino acids like aspartic acid, glycine and glutamic acid are also known to play a key role in the process of wound healing [12]. Nutritional and functional properties of fish are well-recognized [13, 14]. Their functional properties usually arise from their lipids [15, 16]. Besides affecting the palatability of seafood, fish lipids are gaining great attention due to their high levels of omega-3 fatty acids [17, 18]. Previous studies reported that an increase in dietary omega-3 fatty acids, particularly Eicosapentaenoic acid (EPA) and docosahexanoic acid (DHA), decreases the risk of cancer, heart disease, depression, asthma, obesity, autoimmune disease, diabetes, Alzheimer's, and osteoporosis [15, 16]. A major source of omega-3 fatty acids is marine fish such as Blue whiting and Horse mackerel [18].

Dried fish is a major component of harvested fisheries in many countries including Nigeria. About 25 to 30% of the world fish catch is consumed in the dried, salted, smoked form or combination of these processes [19]. Some of these processes, though important for preservation have various effects on the physical and nutritional quality of fish because it has been observed that different processing and drying methods have different effects on the nutritional compositions of fish [20]. The Mediterranean horse mackerel a semi-pelagic carnivore species, is a high-value marine fish distributed throughout the Mediterranean, Marmara, and Black Seas, and along the eastern Atlantic coast from Morocco to the English Channel [21, 22]. The species has a schooling habit, feeds on other fishes, (especially sardines, anchovies, and small crustaceans) (Fish base, URL-1), and is most commonly found at a depth of 20-200 meters [23, 24]. Boran and Karacam [25], found the fat content of horse mackerel to range between 8.4 and 13.3% with a seasonal variation. However, no study exists on seasonal changes of fatty acid profile of Mediterranean horse mackerel caught from Black Sea; although different studies reported different fatty acid values for single sampling times of different horse mackerel species caught from different regions.

Horse mackerel are known to be one of the richest sources of polyunsaturated fatty acids [26]. Many studies have shown that Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are present in significant amounts in the fish tissues [27]. These polyunsaturated fatty acids have been shown to play a vital role in human nutrition [28]. They also have curative and preventive effects on many human diseases such as cardiovascular diseases, cancers, rheumatoid arthritis, and inflammation [29]. Minerals play an important role in maintaining body functions because they maintain acid–base balance, and help bond formation (hemoglobin formation) [30]. They also control the water balance in the body, help bones formation and teeth structure, and catalyze many metabolic reactions [31]. The importance of minerals as food ingredients is not only their nutritional and physiological roles, but they also contribute to food flavor and also activate or inhibit enzyme-catalyzed and other metabolic reactions, and they affect the texture of food. Fish muscle and bones serve as good sources of essential minerals.

However, Horse mackerel (*Trachurus murphyi*) is a species of jack mackerel in the family Carangidae [32]. Its common name was derived from the legend that other smaller fish species could ride on its back over great distances. Other common names include European horse mackerel in the United State of America, Incascad, scad, and saurel [32]. Since the 1970's, it has become one of the world's more important commercial fish species. In the early 1970s, Chilean jack mackerels started flourishing along the west coast of South America, and became important as a commercial species. The mackerel then expanded in a westward movement out into and across the open ocean and they are a staple food in Africa. (*Digital Journal*, 8 February, 2012).

Furthermore, the application of heat to dehydrate fish does not only remove water but excess of such heat can affect the nutritional content of the dried fish. Studies have shown that smoking causes some decrease in available lysine and that the loss of lysine is proportional to the temperature and duration of smoking [33]. Clifford, *et al.* [34] reported a 25% loss of available lysine on the surface of hot smoked fish fillet and a 12% loss at the center. Other basic amino acids were reduced by 6.6% on the surface but remained unchanged at the center. It has also been reported that in the absence of millard reaction, heating alone was sufficient to render lysine unavailable [33]. It has been observed that the intensity of heat applied during processing greatly affects the fish protein concentration. It is therefore important to ascertain how the drying temperatures and time affect some of the nutritional properties of smoke-dried fish.

Therefore, it is very essential to carry out a study on the nutritional value of highly consumed fish species in Nigeria. The aim of this project is to examine the effect of different smoking method on nutritional changes of the fish species and to evaluate the mineral contents, amount of fatty acid profile present on freshly and smoked imported Horse Mackerel (*trachurus murphyi*) because the fish is the most consumable fishes in Nigeria due to their affordability, availability and serves as a good delicacy.

## 2. Materials and Methods

### 2.1. Sample Collection

20kg of frozen imported Horse Mackerel (*Trachurus murphyi*) were purchased from Ijora Frozen Food market (Latitude 6° 27' 59" North and Longitude 3° 22' 36" East) in Lagos State, Nigeria. The fish samples were transported to the chemistry laboratory of the Nigerian Institute for Oceanography and Marine Research (NIOMR) Lagos, where the chemical analysis was carried out.

### 2.2. Preparation of Fish Fillets and Smoking Process

Prior to the preparation of the fillets and smoking of fish, samples of the fish species were selected at random. 200g of the fish were filleted for the purpose of analysis. The remaining frozen blocks of fish were allowed to thaw at  $4 \pm 1^\circ\text{C}$ . After thawing, the fish were washed, cleaned, gutted and sprinkled with salt to be smoked, loaded into the smoking kiln and slowly cooked for about 5 hours with charcoal at  $160^\circ\text{C}$  chamber temperature. Smoking was done using NIOMR Improved Smoking Kiln (Plate 1). After smoking, the fire was extinguished and the fish left in the chamber overnight to avoid being burnt. The following morning, charcoal was added and smoking continued at a temperature of  $160^\circ\text{C}$  chamber temperature for 8 hours. After smoking and cooling, the smoked fish were packed in polythene bags, sealed and kept in paper boxes at ambient ( $30\text{--}33^\circ\text{C}$ ) temperature and transferred to NIOMR chemistry laboratory for further analysis.

**Plate-1.** Improved NIOMR Fish Smoking Kiln

### 2.3. Determination of Fatty Acid Profile

Fat and fatty acids were extracted from the fish using Bligh and dye method as described by AOAC [35], into ether, then methylated to fatty acid methyl esters (FAMES). FAMES were quantitatively measured by gas chromatography model 8700 (Perkin–Elmer Ltd., Buckinghamshire, England). Fitted with non-bonded biscynopropylsiloxane stationary phase, polar capillary column Rt-2560 (100m x 0.25mm) 0.2  $\mu$ m film thickness (Supelco, PA, USA) and an FID. Oxygen-free nitrogen was used as a carrier gas at a flow rate of 3.5 mL/min. The initial oven temperature was 150°C at rate of 4 min which was raised to 190°C at a rate of 2 C/min and further to 220°C held for 7 min. The injector and detector temperature were set at 260°C and 270°C, respectively. A sample volume of 1.0  $\mu$ L was injected. All of the quantification was done by a built-in data-handling program provided by the manufacturer of the gas chromatograph (Perkin–Elmer) as reported earlier by Talpur, *et al.* [36].

### 2.4. Determination of Minerals Content

Mineral composition after wet digestion with a mixture of sulphuric acid, nitric and perchloric acid was determined using the Atomic Absorption Spectrophotometer (AAS) (BuchScientific, USA) for calcium, magnesium, iron, sodium, potassium and phosphorus profiling as described by Njinkoue, *et al.* [37]. The concentration of mineral elements was determined using Flame Atomic Absorption Spectrophotometer (AAS) and calculated in ppm (ug/g dry weight).

### 2.5. Statistical Analysis

Data obtained were subjected to descriptive and inferential statistics (ANOVA) using SPSS (version 17 incorporation, Chicago, Illinois, USA). Means of samples were separated using Duncan Multiple range Test.

## 3. Results

### 3.1. Mineral Contents

The results of the mineral contents of the fish species are shown in Table 1.

**Table-1.** Mineral composition of Horse mackerel

Mineral parameters	Fresh sample	NIOMR Kiln smoked
Calcium (ppm)	2.10	292.10
Magnesium (ppm)	18.80	120.85
Potassium (ppm)	13.62	205.40
Iron (ppm)	3.40	21.81
Sodium (ppm)	113.42	310.11
Phosphorus (ppm)	6.36	501.52

### 3.2. Fatty Acid Profiled of Horse Mackerel

The fatty acid composition (% of total fatty acid) of the fish species is summarized in Table 2.

**Table-2.1.** Fatty Acid (SFA) Composition of Smoked Horse mackerel using the NIOMR improved Smoking Kiln

Fatty acid	Carbon atoms	Fatty acid class	% sample A
Caproic acid ME	8:0	SFA	ND
Capric acid ME	10:0	SFA	ND
Lauric acid ME	12:0	SFA	ND
Myristic acid ME	14:0	SFA	7.22
Pentadecanoic acid ME	15:0	SFA	0.55
Palmitic acid ME	16:0	SFA	19.40
Heptadecanoic acid ME	17:0	SFA	1.31
Stearic acid ME	18:0	SFA	5.45
Arachidic acid ME	20:0	SFA	1.13
Behenic acid ME	22:0	SFA	15.83
Lignoceric acid ME	24:0	SFA	ND
Total SFA			50.89

**Sample A:** Horse mackerel, ND=Not detected, SFA=Saturated fatty acid

**Table-2.2.** Fatty Acid (MUFA) Composition of Smoked Horse mackerel using the NIOMR improved Smoking Kiln

Fatty acid	Carbon atoms	Fatty acid class	% sample A
Myristoleic acid ME	14:1	MUFA	ND
Cis-10-pentadecanoic acid ME	15:1	MUFA	ND
Palmitoleic acid ME	16:1	MUFA	5.348
Cis-10-Heptadecanoic acid ME	17:1	MUFA	ND
Elaidic acid ME	18:1 Cis	MUFA	12.63
Cis-11-Eicosenoic acid ME	20: 1 n9	MUFA	2.55
Erucic acid ME	22:1	MUFA	5.85
Nervonic or Cis-15-tetracosenoic acid ME	24:1	MUFA	15.66
Total MUFA			42.04

**Sample A:** Horse mackerel, ND=Not detected, MUFA=Monounsaturated fatty acid.

**Table-2.3.** Fatty Acid (PUFA) Composition of Smoked Horse mackerel using the NIOMR improved Smoking Kiln

Fatty acid	Carbon atoms	Fatty acid class	% sample A
Linoleic acid ME	18:2 trans	PUFA	2.08
Linolelaidic acid ME	18:2 Cis	PUFA	1.72
Linolenic acid ME	18:3 n3	PUFA	0.69
Cis-11-14-Eicosenoic acid ME	20:2	PUFA	ND
Arachidonic acid ME	20:4 n6	PUFA	ND
Cis-5,8,11,14,17-Eicosapentaenoic acid ME	20:5	PUFA	ND
Cis-4,7,10,13,16,19-Docosa hexanoic acid ME	22:6	PUFA	2.29
Total PUFA			6.78

**Sample A:** Horse mackerel, ND=Not detected, PUFA=Polyunsaturated fatty acid.

## 4. Discussion

The mineral contents of horse mackerel significantly varied ( $p < 0.05$ ). The calcium content of NIOMR kiln smoked horse mackerel recorded the highest value of 292ppm, while the least value of calcium content was recorded in fresh horse mackerel with 2.10ppm. NIOMR kiln smoked horse mackerel recorded the highest value of magnesium with 120.85ppm. The least value of magnesium content was observed in fresh horse mackerel with 18.8ppm. The highest value of potassium was recorded in NIOMR kiln smoked horse mackerel with 205.4ppm, the least value of potassium content was observed in fresh horse mackerel (13.2ppm). However, highest value of sodium content was recorded in NIOMR kiln smoked horse mackerel with 310.11ppm, the least value of sodium content was observed in fresh horse mackerel (113.42ppm). Phosphorus content recorded the least value in fresh horse mackerel (6.36ppm). Iron content value was 21.81ppm in NIOMR kiln smoked horse mackerel while 3.40ppm was recorded for the fresh sample. The results of mineral content in this study is in line with the findings of [Adewoye, et al. \[38\]](#) who reported that variations exist in mineral composition of fish.

The fish species examined contained appreciable concentrations of calcium, sodium, magnesium, potassium, phosphorus and iron suggesting that these fishes could serve as good sources of minerals. Calcium helps for growth and maintenance of bones, teeth and muscles in human [39]. Normal extracellular calcium concentrations are necessary for blood coagulation and for the integrity, intracellular cement substances [40]. Sodium is an activator of transport ATP-ases in animals and also in plants possibly [41]. While, magnesium ions regulate over 300 biochemical reactions in the body through their role as enzyme co-factors [42, 43].

The saturated fatty acid (SFA) contents obtained from this study for NIOMR smoked horse mackerel, was 50.886%, while the monounsaturated fatty acid was 42.04%. The polyunsaturated fatty acid contents obtained from the NIOMR smoked horse mackerel was 6.779%. Results for fatty acid profile from this study was similar to that



reported by Kolade [44], who studied the fatty acid profile of Horse mackerel (*Trachurus murphyi*) from Agbalata market in Badagry, Lagos state Nigeria.

Palmitic acid (C16:0) was the most abundant saturated fatty acid contents obtained from the NIOMR smoked horse mackerel with a value of 19.404%, followed by myristic acid (C14:0) with 7.216%. The least abundant saturated fatty acid recorded was Pentadecanoic acid and lignoceric acid in horse mackerel. Palmitic acid and myristic acid are healthy fat and have been reported to help in weight loss, reduce the risk of heart disease and decrease inflammation human [43, 45]. Other least occurring fatty acids amongst the saturated fatty acid (SFA) was found to be Pentadecanoic acid (0.55 %), this could be as a results of the fishes been grown in captivity as reported by Lenas, *et al.* [46], in his finding that fish grown under captivity usually have reduction in Pentadecanoic acid and Behenic acid due to land based oil used during culturing. Several authors have also reported palmitic acid (C16:0) as the most abundant saturated fatty acid in different fish species [47-52], which are similar to the findings of this study. Level of palmitic acid was found to be lower in horse mackerel (19.4%) presumably due to their physiology and environmental factors and this is in agreement with the report of Saglik and Imre [53], who studied N-3-Fatty acids in some fish species from Turkey.

Tetracosenoic acid (C24:1) was identified most abundant monounsaturated fatty acid (15.66%) in the smoked horse mackerel fish. This was followed by Nervonic acid (C22:1) with a value of 5.85%, Palmitoleic acid was (5.348%) while, eicosenoic acid value was 2.551. Monounsaturated fatty acid such as tetracosenoic acid, Nervonic acid Palmitoleic acid have been reported to play a vital role in human such as reduction of high blood pressure and anemia in women, prevention of certain birth defects, decrease risk of cardiovascular disease by decreasing homocysteine, decrease risk of cancer by improving DNA/RNA repair and gene expression [45] confirming the fish species studied to be a good source of fatty acid diet. The monounsaturated fatty acids (MUFA) content of horse mackerel was mainly omega-9 fatty acids except Palmitoleic acid which is an omega-7 fatty acid. The higher content of tetracosenoic acid could be directly related to fatty acid contents used in their feed formulation [46].

The most abundant polyunsaturated fatty acid recorded is Linoleic acid (2.075) in horse mackerel. While the least abundant polyunsaturated fatty acid was eicosapentaenoic acid (EPA, C20:5n-3). There was significant variation ( $p < 0.05$ ) in the level of Docosahexaenoic acid and Eicosapentaenoic acid in the smoked fish samples. Varying level of Eicosapentaenoic acid and Docosahexaenoic acid have been reported for different horse mackerel species caught in different seas [54-56].

Different health organizations recommend varying amounts of daily n-3 polyunsaturated fatty acid, Eicosapentaenoic acid and Docosahexaenoic acid intake in a range of 0.2g – 0.45g and 0.5g – 1.0g respectively, depending on the amount of some other fatty acids such as linoleic, linolenic and arachidonic acids [16, 57]. These values falls within the recommend values, affirming that the fish could serve as a good source of n-3 polyunsaturated fatty acid required for prevention of obesity, anti-inflammatory effects in cancer and metabolic disorders [45, 58]. It was also suggested that 4550mg EPA + DHA should satisfy the weekly requirement of an adult on a 200-kcal diet [15]. However, epidemiological/observational studies as well as past clinical trials have demonstrated that higher values of n-3 Polyunsaturated fatty acid, Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) are usually needed for the treatment and/or preventive effect of various illness such as cardiovascular and neurological disorders [57, 59]. Lee and Hiramatsu [60], summarized the recommended values set by various health organizations for health benefits include ing primary and secondary prevention of coronary heart diseases. According to the suggested values of EPA and DHA, healthy adults should eat 0.5g daily while patients with coronary heart disease should consume 1.0g. Therefore, from this study, eating the fish species could help to prevent coronary heart disease and neurological disorders.

## 5. Conclusion

The result obtained in this study has provided scientific information and detailed knowledge of the mineral and fatty acid profile of this commercial fish species. The results showed that the fish species had high quality levels of mineral and fatty acids. Overall, *Trachurus murphyi* smoked with NIOMR smoking kiln appears to be suitable as diet for humans due to its relatively high nutrient components and the ratio of polyunsaturated and saturated fatty acid. The fatty acid components of horse mackerel (*Trachurus murphyi*) used in this study suggest that it is a desirable item in the human diet, especially for the levels of DHA and EPA found are good for the maintenance of human health.

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