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Influence of Cooking Methods on Quality Characteristics of Oil Extracted From Atlantic Mackerel

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ABSTRACT

The quality characteristics of oil extracted from raw and cooked (boiled, smoked and fried) Atlantic mackerel (Scomber scombrus) were evaluated, in an effort to study the relationship between cooking method and wholesomeness of mackerel oil. Free fatty acid (FFA), a measure of hydrolytic breakdown, ranged from 2.5-2.7% for cooked mackerel versus 2.5% for the uncooked (control); Peroxide value (PV), a measure of oxidative breakdown was higher for the cooked samples particularly for the oil extracted from smoked (9.4 meq/kg) and fried (10.4 meq/kg) mackerel; while measurement of Iodine value (IV) indicate that all samples were highly unsaturated, with the oil from fried mackerel being the least unsaturated. IV of oil from cooked mackerel ranged from 162-188 g I2/100g versus 171 g I2/100g for the control. Findings from this work suggest that cooking led to increase in hydrolytic breakdown (as evidenced by FFA) as well as increase in oxidative breakdown (as evidenced by PV, IV and extinction coefficients K232 and K270). Smoking and frying of mackerel appeared to have the greatest impact on the quality of mackerel oil.

Keywords: Mackerel, Quality characteristics, Fish oil, Cooking method, Chemical analysis.

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1. INTRODUCTION

Fish consumption is gaining wide prominence particularly in developing countries where 40% or more of their protein are obtained from fish [6]. Apart from with protein, carbohydrate, vitamins and minerals, fat is also a major constituent of fish and is readily digested and utilized in the body. Nutritionists frequently emphasize the importance of fish in the diet due to their rich content of monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA), and easy digestibility of its fat [14]. These unsaturated fatty acids are widely distributed in various proportions in different fish species but are more concentrated in oily fishes such as mackerel, sardines, and salmon. The oil extracted from these fishes has been used either directly as human food or in the form of supplements due to their rich contents of omega-3 and omega-6 fatty acids which have been proven to have several dietary benefits such as alleviating, preventing or reducing cardiovascular

disease [5,12] high blood pressure [10] clotting [11] and cancer [16]. Although fish oils have been cited to have pharmacological and neutraceutical interventions, they are highly prone to oxidation due to their large number of double bonds and their position within fatty acid chain [15]. Oxidized fish oils may suffer reduced nutritional potency and consumption can pose danger to health.

Atlantic Mackerel (*Scomber scombrus*) commonly known as Titus is the most popular specie and abounds in Nigerian open markets. It is also one of the highly recommended oil fish for a healthy diet, hence its choice for this study. The fish is not usually consumed in its raw form but consumed after it has been subjected to various cooking methods (such as smoking, frying, and steaming) according to the consumer's desire and preference. Cooking of food is usually accompanied by inevitable risk of creating heat-induced damage. It has been reported that during cooking of fish products, chemical and physical reactions take place which improve or impair the nutritional value [1]. Hence, the necessity to assess the fate of major nutrients such as fat, after fish has been subjected to cooking methods commonly practiced in consumers' home. The present study therefore evaluates the influence of cooking methods (namely boiling, frying and smoking) on the quality characteristics of the oil extracted from Atlantic mackerel.

2. MATERIALS AND METHODS

2.1. Source and Preparation of Raw Material

The Atlantic mackerel was purchased from an open market in Abakaliki, Ebonyi State, and transferred in ice blocks to the Lab where the fish was allowed to thaw; then degutted, washed thoroughly and divided into four portions. The first, second and third portions were subjected to boiling, frying and smoking respectively, while the fourth portion (raw fish) did not undergo any thermal processing and served as the control. All 4 samples (boiled, fried, smoked and raw fish) were then subjected to cold extraction using n-hexane; and the oil extracted were analysed as described below.

2.2. Moisture Content

Moisture content which is a measure of shelf stability was determined by oven drying method at 105℃ described by AOAC [2]. The results obtained were calculated thus:

$$\text{Moisture content (\%)} = \frac{w_2 - w_3}{w_2 - w_1} \times \frac{100}{1}$$

Where w_1 = weight of empty dish, W_2 = weight of dish and sample before drying, W_3 = weight of dish and sample after drying.

2.3. Free Fatty Acid

Free fatty acid which is an important quality parameter for assessing the commercial value of fats and oils, was determined using the method of AOCS [3]. Results were obtained using the equation:

Free fatty acid (%) = Titre (ml) x 0.0282 / weight of sample

2.4. Extinction Coefficients K_{232}, K_{270}

UV absorption coefficient at wavelengths 232 and 270nm (K232 and K270) which is a measure of oxidation at advanced stage, was determined according to method described by Kamal-Eldin and Pokorny [8] using Genesys 10s UV-Vis spectrophotometer and iso-octane solution.

2.5. Peroxide Value

Peroxide value which is a measure of the oxidative status of oils was determined using the official method of AOCS [3]. Results obtained were computed using equation:

$$\text{Peroxide value (Meq/kg)} = \frac{1000 \text{ X } (b-a)N}{\text{weight of sample}}$$

Where a and b, titre values for sample and blank respectively; and N, Normality of titrant.

2.6. Iodine Value

Iodine value, a measure of the degree of unsaturation of oils was determined by the official method of AOCS [3] and results obtained were calculated using the equation:

$$\text{Iodine value} = \frac{12.69\times(b-a)N}{\text{weight of sample}}$$

Where 12.69 is constant for iodine value; a and b, titre values for sample and blank respectively; and N, Normality of titrant.

2.7. Smoke Point

Smoke point which is an indicator of the suitability of use of fats and oils for frying purposes was determined according to the method of AOCS [3] using the following materials: thermometer, evaporating dish and electric stove.

2.8. Saponification Value

Saponification value, which measures the mean molecular weight of fatty acids present in oil was determined using the method described by AOAC [2] and calculated using the equation:

$$\text{Saponification value (mgKOH/g)} = \frac{(b-a)\times 28.05}{\text{weight of sample}}$$

Where b and a are the titre values of sample and blank respectively

2.9. Statistical Analysis

Data collected from the study samples were analyzed using analysis of variance (ANOVA) method and difference separated using least square difference (LSD) test at 5% level of significance as described by Okporie [13].

3. RESULTS AND DISCUSSION

Moisture content (MC) of the extracted mackerel oil (Table 1) indicate that all cooking methods particularly boiling as evidenced by BFOE which recorded MC of 7.60%, led to substantial increase in moisture. The high levels of moisture observed for the BFOE, SFOE and FFOE are in line with literature report [9] that a number of chemical reactions that occur at elevated temperatures lead to water absorption and release of water. The low MC (0.20%) of RFOE is also in conformity with this report as the oil was extracted from fresh uncooked mackerel. Statistically, there was significant difference ($P<0.05$) between the moisture contents of the control (RFOE) and the other 3 samples.

Table-1. Quality attributes of oil extracted from raw and cooked Atlantic mackerel

Quality Attributes	Oil extract			
	RFOE	**BFOE**	**SFOE**	**FFOE**
Moisture content (%)	0.20 ± 0.03^{b}	7.60 ± 0.46^{a}	6.60 ± 0.81^{a}	6.40 ± 0.57^{a}
Free fatty acid (%)	2.50 ± 0.20^{a}	2.60 ± 0.51^{a}	2.70 ± 0.22^{a}	2.50 ± 0.47^{a}
Peroxide value (Meq/kg)	3.80 ± 0.30^{a}	5.20 ± 0.85^{b}	9.40 ± 0.58^{c}	10.40 ± 0.9^{c}
Iodine value (g I_2/100g oil)	171 ± 6.92^{b}	176 ± 4.62^{ab}	188 ± 3.46^{a}	162 ± 8.08^{bc}
K_{232}	0.84 ± 0.07^{a}	0.68 ± 0.01^{bc}	0.71 ± 0.01^{b}	0.77 ± 0.03^{ab}
K_{270}	0.38 ± 0.01^{a}	0.16 ± 0.02^{d}	0.26 ± 0.01^{b}	0.25 ± 0.03^{bc}
Saponification value (mgK0H/g)	197.75 ± 1.44^{a}	193.55 ± 1.42^{a}	148.67 ± 8.34^{c}	176.72 ± 5.74^{b}

Values are means ± standard deviations of triplicate determinations. Values with different superscript on the same row are significantly different ($p< 0.05$). Abbreviations: RFOE = Raw fish oil extract; BFOE = Boiled fish oil extract; SFOE = Smoked fish oil extract; and FFOE = Fried fish oil extract.

Table 1 also indicates that free fatty acid (FFA) values of oil from cooked mackerel ranged from 2.5-2.7% and were not statistically different ($p>0.05$) from that of the control (2.5%). During thermal processing, FFAs are formed by hydrolytic cleavage of triglycerides, promoted by the presence of food moisture [7]. Comparison of FFA values of the uncooked (RFOE) and cooked (BFOE, SFOE and FFOE) samples, suggest that hydrolysis occurred during smoking and boiling of mackerel. This is also supported by the relatively higher levels of moisture recorded by these two samples (Table 1); which may have necessitated hydrolytic breakdown, leading to higher FFA.

Peroxide values (PV) of cooked samples ranged from 5.2-10.4 meq/Kg versus 3.8 meq/kg for the control (Table 1). The high values of PV recorded for SFOE and FFOE, indicate that formation of hydroperoxides, the most important primary oxidation products, took place in both samples during the course of smoking (SFOE) and frying (FFOE). There was a significant difference ($P<0.05$) between the PV of the control and those of the other 3 samples. However PV of both the control and cooked samples were within the acceptable limit of 3-20 meq/kg reported for crude fish oil [4].

Iodine value (IV) which is a measure of the degree of unsaturation, ranged from 162-188 g 1_2 /100g for the cooked samples, versus 171 g I_2/100g for the control (RFOE) as shown in Table 1. The above IV were within the range (160-190 g I_2/100g) reported for crude mackerel oil [4] and further indicate that the oil extracted from raw and cooked mackerel were highly unsaturated. Statistically, there was no significant difference ($P>0.05$) between the IVs of RFOE, BFOE and FFOE; but significant difference ($P<0.05$) existed between the IV of

RFOE and SFOE (Table 1). The Saponification values of the fish oil samples ranged from 148.67- 197.75 mgKOH/g, with RFOE recording the highest value and SFOE, the lowest.

UV absorption coefficient at wavelengths of 232nm and 270nm determines the secondary oxidation products of oils based on the principle that conjugated double bonds are formed in oil during oxidation [8]. Table 1 shows that these coefficients differed with fish processing method, but generally did not follow a clear pattern. RFOE recorded the highest values of 0.838 and 0.379 for K_{232} and K_{270} respectively while BFOE recorded lowest values of 0.68 and 0.16 for K_{232} and K_{270}. Statistically, there was no significant difference ($P>0.05$) between the K_{232} values of RFOE and FFOE, but there was significant difference ($p<0.05$) between those of RFOE, SFOE and BFOE. On the other hand, significant difference ($P<0.05$) existed between K270 values of RFOE and the other 3 samples.

4. CONCLUSION

Findings from this study indicate that relationship exists between mackerel cooking method (boiling, smoking and frying) and quality of mackerel oil. Cooking led to increase in hydrolytic breakdown (expressed as FFA) as well as increase in oxidative breakdown (expressed as PV, IV, K_{232} and K_{270}). Smoking and frying appeared to have greater impact on oxidative degradation than boiling. The relatively low IV observed for FFOE suggests that there was greater formation of hyroperoxides in this sample; since during oxidation (and formation of hydroperoxides), unsaturated fatty acids react with oxygen and become less unsaturated, thus leading to decrease in IV. The overall quality characteristics of SFOE and FFOE suggest that these samples may have decreased nutritional potency. Further work on the fate of other nutrients during cooking of mackerel could be instrumental in encouraging or discouraging a particular cooking process as healthy or unhealthy.

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