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Preliminary Studies on the effect of processing methods on the quality of three commonly consumed marine fishes in Nigeria

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Abstract

Three commonly available species of marine fishes in Nigeria, *Clupea harengus, Scomber scombrus* and *Trachurus trachurus* were subjected to boiling, frying and roasting and their effects on the fishes were observed. Frying reduced the protein content for all the fish types with the effect very pronounced on *Clupea harengus* and *Trachurus trachurus* but made fish less susceptible to spoilage. Fresh and fried *C. harengus* had 62.7 % and 10.6 % protein content respectively, while *T. trachurus* had 57.3 % and 9.18 %, respectively. The ash content reduced with all the treatment methods for all the fish species except for boiled *Scomber scombrus.* Boiling in water gave fish with the best nutritive value overall. *Scomber scombrus* was the most nutritious (in terms of protein and mineral content) of the three and the nutritive value did not diminish with the method of preparation. It is also the most palatable in terms of flavour and texture. *Trachurus trachurus* had the least protein value and the protein was very unstable to the treatment methods. The third species, *Clupea harengus* is also rich in protein but the protein content reduced with frying. Frying gave a better result when long-time preservation is of interest but boiling was the better processing method when preservation of nutrient is the focus. The results also showed that *Scomber scombrus* had the highest oil content (30.30%) followed by *Clupea harengus* (12.70%) while *Trachurus trachurus* has the lowest oil content (12.25) and irrespective of the processing method, the order remains unchanged. This work also shows that the effect of a treatment type on a fish sample is dependent on the fish species. The oils obtained from the fried fish samples had the least acid values in all cases, while the oils from the roasted samples had the highest saponification values

Keywords: Processing method, nutritive value, marine fishes

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INTRODUCTION

Fishes are a rich source of protein commonly consumed as an alternative source of protein due to the higher cost of meat and other sources of animal protein. Fish has lower cholesterol content when compared with meat[1] and thus often recommended for consumption especially among the adult population. The marine fish is generally cheaper and more abundant when compared with fresh water fishes, which are relatively more expensive in Nigeria.

The major constituents of fish are moisture, protein and fat with minerals occurring in trace amount[2]. Generally fish contains very little carbohydrate, while the moisture content is very high. In most fish species the moisture content is between 60 – 80%, protein between 15 – 26% and 2 – 13% for fat[3]. The fat content of fishes varies with species, age, size and also season.

Since fish is not normally consumed raw, various processing methods are employed in preparing them for consumption and some of these processes include boiling, frying, roasting, smoking, which could have varying effects on their nutrient contents, texture and flavour[4].

Previous workers had reported the effects of processing methods on different fish types. For example, Greenfield & Kosulwat said the type of food and cooking procedures influence the fat content and other nutrients[5]. The fat content of raw fishes can also influence fat exchanges and interactions between the culinary fat and that of the fish during processing[6]. Data on the macronutrient content of fish is only available for raw fish and there seems to be a scarcity of information on the processed ones.

The need to look at the effect of processing on the nutrient composition of fish is therefore high. This work is thus a preliminary investigation of the effect of some common processing methods – boiling, frying and roasting on the macronutrient content and oil qualities of some marine fishes that are commonly consumed in Nigeria as the major source of animal protein for the average individual and family.

MATERIALS AND METHODS

Materials and Preparation of Sample

The fish types used in this study were *Clupea harengus* (also known as herring or *shawa* in south western Nigeria), *Scomber scombrus* (also known as Atlantic mackerel or Titus) and *Trachurus trachurus* (also known as horse mackerel or *kote* in south western Nigeria). These fishes were chosen because they are readily available, cheap, affordable and within the reach of an average Nigerian. The fishes were purchased from two popular markets (Oja-Oba and Ipata) in Ilorin, Nigeria.

They were thoroughly washed, cut into about 75 g-pieces and washed again with tap and distilled water. The head region was discarded. The samples were then separated into four parts. One part was boiled in water; a second part was deep-fried with vegetable oil in a frying pan while the third part was roasted with heat from hot charcoal. The last part was analyzed raw. All processing methods followed the usual procedures used to prepare fish for table consumption in Nigeria.

The boiling was done in distilled water and the water was kept boiling for about 20 minutes until the pieces were well cooked and tender. The deep – frying was done in vegetable oil in a pot on hot flame with occasional turning in order to achieve even frying. Frying was achieved within 15 minutes and the temperature was about 240ºC. The roasting was done at 165ºC and it was completed within 15 minutes. All the processing methods were carried out without the addition of any ingredient. All samples were homogenized prior to analysis.

Analytical Procedures

The recommended methods of the Association of Official Analytical Chemists were adopted for the analyses of the samples[7]. Moisture content was determined by heating 2.0 g of each sample to a constant weight in a crucible placed in an oven maintained at 105ºC. Crude fat was obtained by exhaustively extracting 5.0 g of each sample in a Soxhlet apparatus using petroleum ether (b.p. 40-60ºC) as the extractant. Crude protein (% total nitrogen x 6.25) was determined by the Kjeldahl method, using 2.0 g samples. Ash was determined by the incineration[8] of 1.0 g samples placed in a muffle furnace maintained at 550ºC for 5 hours.

The oil extract from each fish sample was concentrated by rotary evaporator and all solvent completely expelled. The oil obtained was analyzed for the acid and saponification values. The acid and saponification values were determined by standard methods of the American Oil Chemists' Society, using 1 g sample of oil in each case[9].

Results are expressed as mean of triplicate trials. Data were analysed by one way analysis of variance. Test of means with $p<0.05$ was adjudge significant under student 't' test.

RESULTS

The results of the proximate compositions of the analyzed fishes are shown in Table 1. Subjection of fish to different preparation method resulted in samples with significantly different moisture content ($p=0.001$) though there was no significant difference ($p=0.58$) in the moisture content of the different fresh fishes. Table 2 shows the results of the acid and saponification values of oil extracted from the fish samples.

Table 1: Proximate composition (%) of fresh and processed fish samples

Fish Sample	**Moisture Content**	**Oil Content** (Moisture free)	**Crude Protein** (Moisture and Oil free)	**Ash Content** (Moisture and Oil free)
Scomber scombrus				
Fresh	58.24 ± 2.15	44.51	66.28 ± 0.00	7.83 ± 0.18
Boiled	57.81 ± 1.26	43.39	52.28 ± 0.44	9.43 ± 0.43
Fried	44.27 ± 1.48	44.37	65.41 ± 0.22	5.50 ± 0.00
Roasted	54.84 ± 2.80	30.30	59.28 ± 0.22	3.75 ± 0.25
Clupea harengus				
Fresh	66.12 ± 1.01	26.62	62.67 ± 0.33	8.50 ± 0.11
Boiled	57.68 ± 1.59	21.75	53.43 ± 0.00	7.01 ± 0.01
Fried	43.52 ± 2.55	31.19	50.61 ± 0.33	4.25 ± 0.25
Roasted	56.71 ± 1.83	12.70	57.27 ± 0.99	3.00 ± 0.00
Trachurus trachurus				
Fresh	72.54 ± 0.42	25.94	57.31 ± 0.22	7.89 ± 0.16
Boiled	72.78 ± 0.45	24.67	53.50 ± 0.87	6.25 ± 0.25
Fried	45.99 ± 1.95	27.39	49.18 ± 0.00	4.00 ± 0.50
Roasted	67.21 ± 0.98	12.25	48.45 ± 0.14	2.00 ± 0.50

Values are means ± standard deviations of triplicate determinations.

Table 2: Acid and saponification values of oil from fish samples

Fish Sample	Acid Value	Saponification Value
Scomber scombrus		
Fresh	12.78	129.29
Boiled	14.14	136.18
Fried	9.59	140.24
Roasted	13.61	196.62
Clupea harengus		
Fresh	19.53	127.18
Boiled	17.63	78.58
Fried	8.11	99.26
Roasted	12.13	134.31
Trachurus trachurus		
Fresh	34.18	121.58
Boiled	23.08	116.78
Fried	8.48	114.73
Roasted	10.17	170.97

Values are means of triplicate determinations.

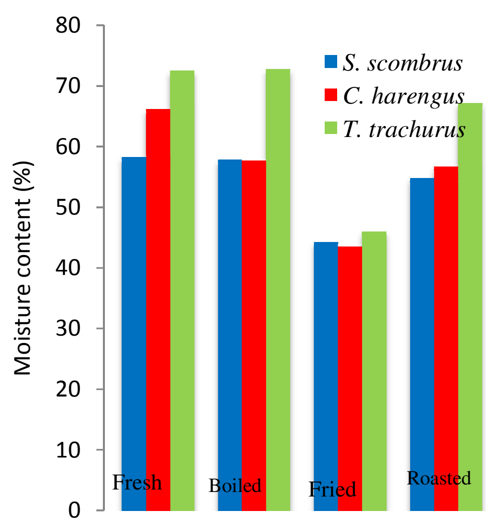

Fig 1: Moisture content of fish samples

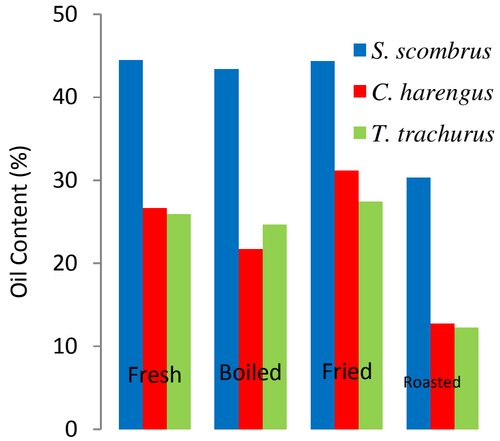

Fig 2: Oil content of fish samples

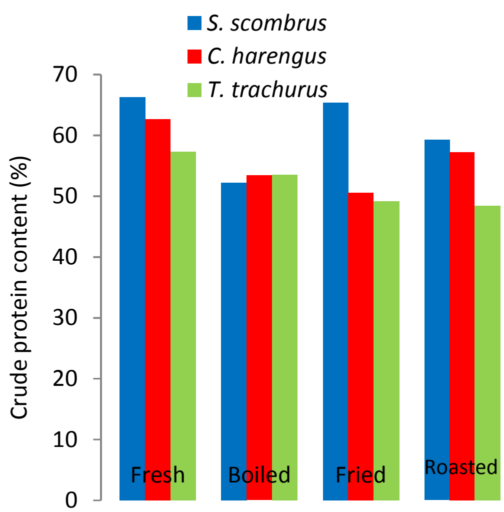

Fig 3: Crude protein content of fish samples

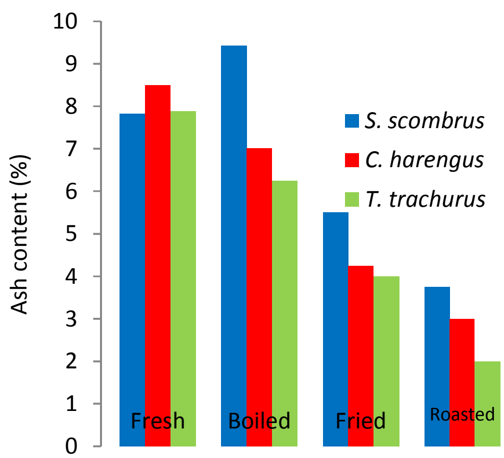

Fig 4: Ash content of fish samples

Figures 1-4 show in graphical form, the proximate composition of the various treated species of fish, while figures 5 and 6 display the comparison between the fishes in term of saponification and acid values.

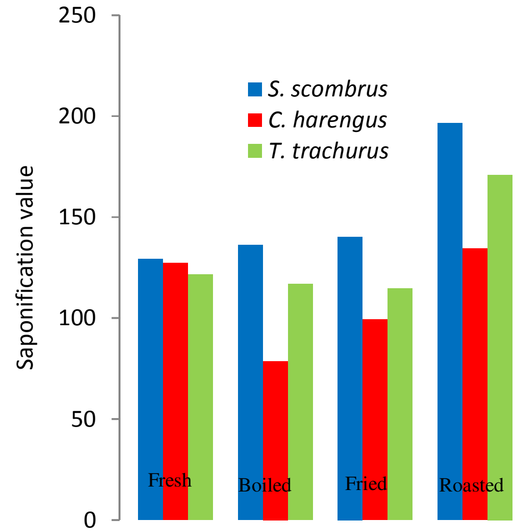

Fig 5: Saponification values of the fish oils

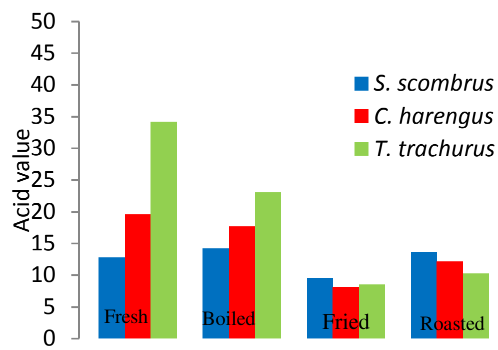

Fig 6: Acid values of the fish oils

DISCUSSION

Fried fish samples have the least moisture content (Fig. 1) and this is because the water in the fish forms aqueous/oil mixture during frying and the water is expelled before the frying is accomplished since the boiling point of the oil is far greater than that of water hence the reduction in the moisture content. The moisture contents of the fresh fish types were slightly, but not statistically different (p=0.58); *S. Scombrus* 58.24%, *C. Harengus* 66.12% and *T. trachurus* 72.54%. Subjection of fish to different preparation methods resulted in samples with significantly different moisture content (p=0.001. The reactions of water/oil with food items particularly at high temperature as obtained during frying and roasting have been shown to affect some nutrients in the food item as well as causing alteration of the structure of the oil and denaturing of the food nutrients[4,5,10]; hence the significant difference recorded in moisture content after the different processing methods.

Roasting usually results in decrease in moisture content giving rise to desirable non-enzymatic browning reactions. Roasting of the fish samples were conducted at 165ºC and frying at 240ºC; and as should be expected, these processing methods resulted in the expulsion of water molecules from the fish samples since these temperatures were higher than the boiling point of water. The reduction in moisture content is an advantage in that it reduced the fishes' susceptibility to microbial spoilage, oxidative degradation of polyunsaturated fatty acids and consequently improved the quality of the fishes for longer preservation time[11,12]. Boiling did not impart any significant change on the moisture, oil and ash contents of the fish samples (Figs. 1, 2 & 4). In fact fresh and boiled samples had relatively similar moisture content. This might be because the temperature at which the boiling was done was not high enough to cause any morphological change in the fish samples. Roasting however drastically decreased the oil and ash contents of all fish species (Figs. 2 & 4) and it reduced the crude protein content of *T. trachurus* (Fig. 3). This suggests the possibility of some water soluble proteins being expelled during the high temperature of roasting. Also volatile oil materials in the fish were expelled at this high temperature.

The oil content of *T. Trachurus* was relatively low compared to the oil content of the other two fishes. *S. scombrus* had the highest oil content which remained fairly constant during boiling and frying but decreased during roasting. Frying increased the oil content of *C. harengus*. According to previous studies, frying does not always result in an increase in the fat content of food[13,14]. Also, Candela *et al* had reported that different fish species would have different behaviour during the frying process, which should be taken into consideration in determining the total fat intake of a fish meal[14]. This could therefore account for the seemingly different behaviours of the fishes to frying.

Since fishes are consumed as a major protein source in food, it is very important that the protein content should not be compromised during table preparation. It is significant to note therefore that all the table processing methods reduced the crude protein contents but the reduction did not follow a particular order or fish type. Fresh *S. Scombrus* had the highest crude protein content (66.28%) while *T. Trachurus* had the least (53.71%) (Fig 3). Disappearance of water soluble amino acids during high temperature of processing may be responsible for the reduction in amino acid content and consequently a reduction in the protein content. The crude protein content of the three fresh fishes are not significantly different (p=0.306) neither did the treatment methods significantly (p=0.405) affect the protein content.

Roasting and frying led to a great reduction in the ash contents of the fish samples with the highest reduction obtained with roasting, followed by frying, but boiling had no effect. This could be as a result of the volatility of the mineral elements at the high temperature involved in roasting and frying. This is reflected in the statistical analysis which showed that treatment methods significantly (p=0.00) affect the ash content of the fishes but had no significant difference (p=0.62) on the ash content of fresh fishes. The ash content of the three fresh fish species ranged between 7.83 and 8.50 which are within the range found in other fish types[16,17].

The saponification values of oils extracted from fresh fish samples are close (Table 2): *S. Scombus* 129.29, *C. Harengus* 127.18 and *T. Trachurus* 121.58 but a general increase of these values was observed following roasting of the samples. This may imply that the reduction in oil content of roasted samples (Table 1) was actually as a result of the loss of the volatile, low molecular weight fatty acids leaving behind oil with high molecular weight fatty acids. The high saponification values indicated the presence of high percentage of fatty acids in the oil. Statistical analysis revealed that the saponification values of oils from fresh fishes were not significantly different (p=0.239) and the treatment methods did not significantly (p=0.301) alter the saponification values.

Oil of fresh *Trachurus trachurus* had a very high acid value (34.2) relative to the other two (12.8 and 19.5) suggesting high content of fatty acids which comprise of essential fatty acids and other fatty acids necessary for human development. These fatty acids reduced drastically when fish samples are subjected to frying and roasting. The acid values of oils from fried fish samples were low and similar compared to highly different values obtained for oils from other treatment methods. The low acid values recorded for the fried and roasted samples can be because frying and roasting reduce hydrolysis but boiling does not. This hydrolysis resulted in the reactions of the hydroxyl and carbonyl groups of the acids in the oil[10,14] thereby reducing the fatty acid content of the oil. High moisture content (which was obtainable with the fresh and boiled samples) led to hydrolysis when temperature increased and this further led to the breakdown of essential fatty acids and reaction of the alkyl group of the fatty acids resulting in the production of undesirable, off-flavour hexanal and other rancidity products[4,18,19]. Low moisture content is in keeping with the preservation of the quality of the fish and prevention from spoilage. The lower the acid value, the higher the chances of keeping the quality of the oil, thereby giving oil with higher resistance to lipase action and rancidity, consequently better fish. Fried fish is the least susceptible to degradation due to less moisture content. The ANOVA showed that there are no significant differences (p=0.098 and 0.332) in the acid values of oils from both fresh and processed fishes (Fig. 1).

We conclude from the results of all the processing methods examined for preparation of fish for human consumption that frying is the best when preservation of the fish is of priority but when nutrient conservation is the focus, boiling is a better option.

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