American Journal of Food Science and Technology, 2018, Vol. 6, No. 1, 26-32
Available online at http://pubs.sciepub.com/ajfst/6/1/5

DOI:10.12691/ajfst-6-1-5

Assessment of the Effect of Processing Methods on the Proximate Composition of *Trachurus trachurus* (Mackerel) Sold in Anyigba Market, Kogi State

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Abstract The effects of different preservation methods (fresh, boiled, fried and smoked) on the nutritional composition, mineral composition and vitamins in *Trachurus trachurus* were determined according to AOAC [1]. All processing methods revealed significant difference ($p<0.05$) in the various nutritional, mineral and vitamin composition. Boiling had the highest moisture content (60.01%), frying had the highest ash content (2.45%). Fresh fish had the highest level of fibre (0.07%), protein (3.86%) and carbohydrate (9.70%). Among the methods of preservation, boiled fish had the highest protein (22.71%), carbohydrate (8.20%) and smoked fish had the highest fat of 20.35%. Comparing all the methods of preservation, the fish samples had variable quantity of the various nutritional components measured. It is therefore recommended that consumers should check the appropriate diet need and go for the method of preservation that provides the best nutrient as all the methods are recommended.

Keywords: *preservation, trachurus, vitamins, nutrients*

Cite This Article: Okpanachi M.A., Yaro C.A., and Bello O.Z., "Assessment of the Effect of Processing Methods on the Proximate Composition of *Trachurus trachurus* (Mackerel) Sold in Anyigba Market, Kogi State." *American Journal of Food Science and Technology*, vol. 6, no. 1 (2017): 26-32. doi: 10.12691/ajfst-6-1-5.

1. 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 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, [2].

The major constituents of fish are moisture, protein and fat with minerals occurring in trace amount. 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% fat. 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 flavor.

Previous workers had reported the effects of processing methods on different fish types. For example, [3] said the type of food and cooking procedures influence the fat content and other nutrients. The fat content of raw fishes can also influence fat exchanges and interactions between the culinary fat and that of the fish during processing. 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.

Proximate composition generally comprises the estimation of moisture, protein, fat and ash contents of the fresh fish body. The percentage composition of these constituents amounts for about 96-98% of their total tissue constituents in fish. Biochemical composition of the whole body indicates the fish quality.

Therefore, it is important to study the effects of boiling, frying and smoking on the proximate composition of three commercial frozen fish species to determine the quality. However, reports on the quality of imported frozen fish marketed in Nigeria is limited.

2. Materials and Methods

2.1. Materials and Preparation of Sample

The fish used in this study was *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 markets within Anyigba, Dekina Local Government Area, Kogi State, Nigeria.

2.2. Fish Preparation for Proximate Analysis

The fishes were thoroughly washed, cut into about 75 g pieces and washed again with tap and distilled water. The head region was discarded. The samples was 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 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 240°C. The roasting was done at 165°C 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.

2.3. Analytical Procedures

The recommended methods of the Association of Official Analytical Chemists were adopted for the analyses of the samples [1].

2.4. Moisture Content

Whole fish samples, they were either blended in a food processor or blender or sliced open and then cut into pieces and weighed onto a pre-weighed dish. 2.0 g of sample when placed into a pre-weighed dish and dried in an oven at 110C for 24 hours, allowing a longer drying time and until constant weight was obtained. After removing the samples from the oven they were placed in a desiccator to cool and then reweighed.

The moisture content of the samples was calculate as:

$$\%\ \text{Moisture} = \frac{\text{Sample Weight}(\text{g}) - \text{Dried Sample Weight}(\text{g})\text{x}100}{\text{Sample Weight(g)}}$$

2.5. Crude Fat

Crude fat was obtained by exhaustively extracting 5.0 g of each sample in a soxhlet apparatus using petroleum ether (b.p. 40-60°C) as the extractant. Crude fat was determined by exhaustive soxhlet extraction using petroleum ether on a Soxtec System HT6 (Tecator application note 67/83). 5 g of the sample was put into a soxhlet extraction thimble. A soxhlet extraction cup, containing 5 glass balls, was weighed and 40 ml of petroleum ether (40-60°C, BP) were added. The thimble was moved to the Soxtec System and boiled in the solvent for 20 minutes and then rinsed for 2 hours. After the extraction, the solvent was evaporate off, the extraction cup was removed and placed into an oven at 110°C. After 1 hour, the extraction cup was removed from the oven and left to cool inside a desicator. Fat was quantified gravimetrically by reweighing the extraction cup and crude fat content was determined per weight of sample extracted. All samples were analysed in triplicate.

2.6. Crude Protein

Crude protein content was determined by Kjeldahl analysis (nitrogen x 6.25) using a Kjetec Autoanalyser (Tecator). Briefly, 200 mg of sample were weighed into a Kjeldahl digestion tube and 2 mercury Kjeltabs and 5 ml conc. Sulphuric acid were added. The tube was then placed into the digestion block. After 1 hour, the tubes were removed from the block and left to cool insde a fume cupboard for at least 15 minutes. Then, 20 ml de-ionised water and 5 ml sodium thiosulphate solution were added to the digestion tube and mixed thoroughly. The tubes were distilled using the Kjeltec auto analser and the titration values were recorded. All samples were analysed in triplicates.

Similarly, for each batch of samples, 3 urea standard tubes and 3 blank tubes were prepare and analysed.

The protein content of the samples was calculated as:

$$\%\ \text{Protein} = \frac{\left(\text{Sample Titre} - \text{Blank Titre}\right)\text{x}1750.875}{\text{Sample Weight(mg)}}$$

Where 1750.875 is a multiplication factor to convert titre vol. to % protein based on standardized protein factor.

2.7. Ash

Ash was determined by the incineration of 1.0 g samples placed in a muffle furnace maintained at 55°C for 5 hours. After ashing, the samples were removed from the furnace, cooled to room temperature in a desicator and then reweighed. The ash content was calculated as:

$$\%\ \text{Ash} = \frac{\text{Ash Weight}\left(\text{g}\right)\text{x}100}{\text{Sample Weight(g)}}$$

2.8. Crude Fibre

The method of AOAC [4] was adopted in the determination of the crude fibre content. Two grams (2 g) of the sample was put into a soxhlet apparatus and extracted with petroleum ether and diethyl ether. The extraction method was similar to that of the fat. The extracted sample was air dried and put to dry in 100 ml conical flask. 200 ml of boiled 0.25 N sulphuric acid was added. The content of the flask was boiled gently for 30 minutes. The flask was rotated so as to mix the contents and remove particles from sides.

A buckner fitted with a perforated plate covered with filter paper was preferred. The boiling water was then poured into the funnel, allowed to remain until the funnel was hot. The water was then removed by suction. The boiling period was 30 minutes after which the acid mixture was allowed to stand for 1 minute and then it was poured immediately into a shallow layer of hot water by

gentle suction in the preferred funnel. The suction was adjusted so that the quantity of the 200 ml would be collected in 10 minutes. Boiling water was used to wash the insoluble matter until it was acid free.

The insoluble matter was then washed back into the original flask by means of a washed bottle containing 200 ml of 0.313 N sodium hydroxide solution measured at ordinary temperature and brought to boiling point. The boiling continued for half an hour and then was allowed to stand for 1 minute and then filtered. All the insoluble materials were transferred to filter paper and washed first with the boiling water and then with 1% HCl. Lastly, it was washed with boiling water until it was acid free. The insoluble matter was then put into a dried weighed ash less filter paper and dried at 100°C until a constant weight was obtained. The content and the paper were incinerated to ash at a dull red heat. Because of the insoluble materials, the weight of the ash was subtracted from the increased weight of the paper. The difference was the fibre content weight.

$$\% \text{ Crude fibre} = \frac{(Y - X)x100}{Z}$$

Where X = Weight of the ash less filter paper
Y=Weight of the ash after incineration
Z=Weight of the sample

2.8.1. Determination of carbohydrate

The total carbohydrate was determined by difference. The sum of the percentage moisture, ash, crude lipid, crude protein and crude fibre was subtracted from 100.

2.9. Mineral Composition Analyses

the minerals in the ash (samples) powder were bought into solution by wet digestion concentrated nitric acid (63%) concentrated hydrochloric acid (60%) and concentrated sulphuric acid in the ratio 4:1:1 [5]. These were digested slowly at moderate heat in a fume cupboard, digestion continued for 15 minutes. After the appearance of white fumes, the solution was cooled and filtered with whatman filter paper No. 44 and further diluted with distilled water. Digestion was also carried out.

The minerals were determined by Perkin-Elmers Atomic absorption spectrophotometer (AAS) (Model 29 B Perkin-Ether Co. Ltd, USA) [4].

2.10. Vitamin C Determination

Pipette out 5 ml of the working standard solution into a 100 ml conical flask. Add 10 ml of 4% oxalic acid and titrate against the dye (V1 ml). End point is the appearance of pink colour which persists for a few minutes. The amount of the dye consumed is equivalent to the amount of ascorbic acid. Extract the sample (0.5-5g depending on the sample) in 4% oxalic acid and make up to known volume (100 mL) and centrifuge.

$$\text{Vitamin C}\left(\frac{\text{mg}}{100\text{g}}\right) = \frac{0.5\text{mg x V2x100mL x100}}{\text{V mL x5mL x Sample wt}}$$

Ascorbic acid can also be expressed in mg/100 ml sample weight will be substituted with sample volume.

2.11. Vitamin A Determination

The antioxidant pyrogallol is added prior to saponification. Corrections for the presence of carotenoids are accomplished either by the removal of these compounds by column chromatography or in the case of low carotenoid concentration relative to the vitamin A content, by taking readings of a chloroform extract at 440 to 460 nm without prior chromatographic separation. These correction steps need not be taken in the absence carotenoids from the sample to be tested.

$$\textbf{Vitamin A } (\mu\textbf{g}) = \textbf{A}_{620}\textbf{x SL x } (\textbf{V}/\textbf{WT})$$

Where
A620 = Corrected absorbance at 620nm which equals A440-CF (correction factor of carotenoids)
SL = Slope of standard curve (vitamin A concentration)
V = final volume for calorimeter tube
WT = sample weight, g

2.12. Statistical Analyses

The data obtained was subjected to analysis of variance (ANOVA) and where there was significant difference at $P \leq 0.05$. The differences in the means were sorted out by the use of Duncan Multiple Range Test (DMRT).

3. Results

Analysis of fresh, boiled, smoked and fried fish samples for their moisture level, ash content, crude fibre and fat is presented in Table 1.

Percentage moisture revealed that boiled fish samples had the highest moisture level of 60.01%, followed by fresh fish samples with 55.46% then smoked fish (47.67%) while the fried fish samples had the least moisture level of 41.16%. Highly significant difference ($P<0.05$) was noted in moisture level among the fish samples.

For % ash content, it was observed that fried fish had the highest ash content of 2.45% which was not significant from fresh fish with 2.43%, and they were followed by smoked fish with ash content of 2.18% while boiled fish had the least ash content of 1.55%. Also, highly significant difference was observed in % ash content among the various preservation method.

Crude fibre level also revealed that fresh fish samples had the highest crude fibre of 0.07% and was significantly difference ($P<0.05$) from boiled fish (0.04%), smoked fish (0.03%) and fried fish (0.02%). Although fried fish had the least fibre content.

Fat level of the fish analysed was observed to be highest in fresh fish having 20.35% fat, followed by smoked fish with 20.35% while fresh fish and boiled fish had 8.20% and 7.50% respectively. The level of fat was highly significant among the methods of preservation.

Nitrogen level in fish determines the level of protein. In this study, the nitrogen level of the various fish samples was observed to be highest in fresh fish with 3.86%, followed by boiled fish with 3.63%, then smoked fish with 3.47% while the fried fish had the least nitrogen level of 3.35%. Highly significant difference ($p<0.05$) was observed among the methods of preservation (Table 2).

Percentage protein in the fish samples also revealed that the fresh fish had the highest protein level of 24.15%, followed by boiled fish (22.71%), then smoked fish (21.66%) while the fried fish (20.94%) had the least protein level.

The level of carbohydrate analysed from the various samples showed that the fresh fish had the highest level of carbohydrate with 9.70% carbohydrate, and it was followed by boiled and smoked fish with 8.20% and 8.08% respectively. Meanwhile, the fried fish has the least carbohydrate level of 0.92% which was far lower than the others. Highy significant difference was noted among the preservation methods. Although, boiled and smoked fish tends to have almost equal carbohydrate level.

The element composition of the fish were determined on the various samples (Table 3). Sodium, potassium, calcium and iron were highest in fresh fish while smoked fish had the highest magnesium and phosphorus level.

Sodium, Calcium and iron level was highest in fresh fish with 1233.00 ppm, 880.04 ppm and 41.01 ppm respectively which were significant from the other method of preservation, they were then followed by boiled fish with 979.56 ppm of Na, 800.59.

Plate I. *Trachurus trachurus* (a) Smoked (b) Boiled (c) Fresh (Raw) (d) Fried.

Table 1. Percentage Moisture, Ash Content, Crude Fibre and Fat in Fresh, Boiled, Smoked and Fried *Trachurus trachurus*

Fish Preservation Type	% Moisture	% Ash	% Crude Fibre	% Fat
Fresh Fish	55.46±0.14b	2.43±0.03ba	0.07±0.01a	8.20±0.10c
Boiled Fish	60.01±0.13a	1.55±0.05c	0.04±0.00b	7.50±0.00d
Smoked Fish	47.67±0.17c	2.18±0.03b	0.03±0.01b	20.35±0.05b
Fried Fish	41.16±0.04d	2.45±0.05a	0.02±0.00b	34.52±0.08a
Total	51.08±2.73	2.15±0.14	0.04±0.01	17.64±4.16
P value	0.000*	0.000*	0.028*	0.000*

Key: *-significant at P<0.05

Table 2. Percentage Nitrogen, Protein and Carbohydrate in Fresh, Boiled, Smoked and Fried *Trachurus trachurus*

Fish Preservation Type	% Nitrogen	% Protein	% Carbohydrate
Fresh Fish	3.86±0.01a	24.15±0.09a	9.70±0.37a
Boiled Fish	3.63±0.01b	22.71±0.04b	8.20±0.13b
Smoked Fish	3.47±0.01c	21.66±0.08c	8.08±0.17b
Fried Fish	3.35±0.01d	20.94±0.06d	0.92±0.08c
Total	3.58±0.07	22.36±0.46	6.72±1.29
P value	0.000*	0.000*	0.000*

Key: *-significant at P<0.05

Table 3. Comparison of Na, K, Ca, Mg, Fe, P in Fresh, Boiled, Smoked and Fried *Trachurus trachurus*

Fish Preservation Type	Sodium (Na) (ppm)	Potassium (K) (ppm)	Calcium (Ca) (ppm)	Magnesium (Mg) (ppm)	Iron (Fe) (ppm)	Phosphorus (P) (ppm)
Fresh Fish	1233.00±3.00a	161.36±0.66a	880.04±0.04a	90.60±0.20c	41.01±1.01a	70.70±0.10c
Boiled Fish	979.56±0.56b	153.75±0.33d	800.59±0.19b	86.50±0.00d	38.26±0.15b	68.46±0.04d
Smoked Fish	201.60±1.20c	158.31±0.11b	208.52±0.39c	100.27±0.14a	20.57±0.33c	400.52±0.49a
Fried Fish	194.60±0.28d	155.71±0.29c	198.57±0.44d	96.20±0.20b	18.47±0.03d	388.47±0.13b
Total	652.19±174.94	157.28±1.09	521.93±120.81	93.39±1.99	29.58±3.83	232.04±61.43
P value	0.000**	0.001**	0.000**	0.000**	0.000**	0.000**

Ppm of Ca and 38.26 ppm of Fe and smoked fish with 201.60 ppm of Na, 208.52 ppm of Ca and 20.57 ppm of Fe. Meanwhile the fried fish had the least with 194.60 ppm of Na, 198.57 ppm of Ca and 18.47 ppm of Fe (Table 3).

Potassium level also was highest in fresh fish (161.36 ppm), followed by smoked fish (158.31 ppm) and fried fish (155.71 ppm) while boiled fish (153.75 ppm) had least potassium level (Table 3).

Magnesium and phosphorus followed the same trend, smoked fish had the highest level for both, followed by fried fish, fresh fish and boiled fish had the least level of them. In smoked fish, 100.27 ppm Mg and 400.52 ppm of P; in fried fish, 96.20 ppm of Mg and 388.47 ppm of P, in fresh fish, 90.60 ppm of Mg and 70.70 ppm of P while the least which is boiled fish had 86.50 ppm of Mg and 68.46 ppm of P (Table 3).

Vitamins are essential for living a healthy life. The vitamin C and A level was determined for the various fish samples as presented in Table 4.

Table 4. Comparison of Na, K, Ca, Mg, Fe, P in Fresh, Boiled, Smoked and Fried *Trachurus trachurus*

Fish Preservation Type	Vitamin C (µg/g)	Vitamin A (µg/g)
Fresh Fish	46.04±1.59a	4.43±0.04a
Boiled Fish	32.55±0.80b	1.06±0.07d
Smoked Fish	24.61±0.80c	1.84±0.07b
Fried Fish	15.88±0.00d	1.53±0.04c
Total	29.77±4.21	2.21±0.49
P value	0.000**	0.000**

The fresh fish samples showed highest level of vitamin C with 46.04 µg/g, followed by boiled fish with 32.55 µg/g and then smoked fish with 24.61 µg/g while the fried fish had the least vitamin C level of 15.88 µg/g. Highly significant difference (p<0.05) was observed among the fish samples.

Also, vitamin A level was highest in fresh fish with 4.43 µg/g, followed by smoked fish with 1.84 µg/g, then fried fish 1.53 µg/g while boiled fish had the least vitamin A level of 1.06 µg/g.

4. Discussion

Moisture, Proteins and lipids contents were the major constituents, which had been considered in evaluating the nutritional value of the fishes studied. The nutritional elements showed variable values in the fishes analysed; with moisture recording the highest values and lipid recording the lowest. The fish examined belonged to high-protein (15 to 20%). The low ash, carbohydrate, fat, nitrogen free extract (NFE), high protein and moisture content values obtained from the proximate analysis agreed with other analysis carried out by earlier researchers such as Effiong and Mohammed [6], Mumba and Jose [7] and Abdullahi [8].

The moisture content of the dried fish which is of great importance in storage is still at safe level of 7.3% which is in between the recommended safe moisture content of dried fish (6 to 8%). The significant decrease in protein levels (P < 0.05) in fried, smoked and boiled when compared with the fresh fish, suggested that protein nitrogen was lost during boiling, smoking and frying. This is also in accordance with the findings of Puwastien *et al.* [9], Gokoglu et al. [10] and Tao and Linchun [11]. Fishes with fat content of above 5% are considered not lean [12,13].

Fish samples were fried and smoked reduced (p<0.05) the moisture content of the fish samples. Smoking and frying often results in decrease in moisture content that results in desirable nonenzymatic browning reactions. These may be because the smoking and frying temperature was higher than the boiling point of water. Thus reduction in moisture content in both will improve the quality of the fishes for longer preservation time, because low moisture levels in fish reduces the fishes' susceptibility to microbial spoilage and oxidative degradation of polyunsaturated fatty acids [14,15,16].

Ash is a measure of the mineral content of food item. It is the inorganic residue that remains after the organic matter has been burnt off [17], the increase in ash with processing indicates that the fish is a good source of minerals [18]. The levels of crude fibre in the fish ($p<0.05$) was low, and decreased considerably with processing compared with the raw sample. Crude fibre is responsible for ease of bowel movement [18].

In general, there were significant influences of boiling, smoking and frying on the proximate compositions of the fish. Although, the influence was not much on the protein, lipids, ash, fibre, vitamins and mineral contents of fish. These results showed that different nutritional components of fish undergo different changes at elevated temperatures.

All the fish samples examined contained appreciable concentrations of sodium, calcium, phosphorus, potassium, magnesium and iron suggesting that these fishes could be used as good sources of minerals. Sodium was observed to dominate other minerals in all samples. The variations recorded in the concentration of the different nutritional components in the fish processed through different method. This is supported by the findings of Adewoye *et al*; [19] and Fawole *et al.* [20]. All the elements varied in concentration among the four methods of preservation studied. Minerals are important for vital body functions such as acid, base and water balance. Calcium is good for growth and maintenance of bones, teeth and muscles [21]. Normal extra cellular calcium concentrations are necessary for blood coagulation and for the integrity, intracellular cement substances [22]. Sodium is an activator of transport ATP-ases in animals and possibly also in plants [23]. There is also direct relationship of sodium intake with hypertension on human [24].

All the processing methods are equally good as they could help in extending the shelf life of the fish products, with an exception of boiling method. These methods could keep the fish products free from spoilage microorganisms attack for some time.

5. Conclusions

Moisture, Proteins and lipids contents were the major constituents, which had been considered in evaluating the nutritional value of the fishes studied. The nutritional elements showed variable values in the fishes analysed; with moisture recording the highest values and lipid recording the lowest. The fish examined belonged to high-protein (15 to 20%).

There were significant influences of boiling, smoking and frying on the proximate compositions of the fish. Although, the influence was not much on the protein, lipids, ash, fibre, vitamins and mineral contents of fish.

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