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Effects of Processing Temperature on the Proximate and Mineral Composition of *Oreochromis niloticus*

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ABSTRACT

This research was conducted to determine the effect of processing temperature on the proximate and mineral analysis of *Oreochromis niloticus*. The fish sample was dried at temperatures between 60 ^{o}C to 100 ^{o}C. The proximate and mineral analyses were carried out on the fishes. The moisture content ranges from 4.43 % to 55.39 %. The highest value was found in Control while the lowest value was in ON_{100}. Ash content ranged from 3.73 % to 10.79 %. Protein content ranges from 23.68 % to 67.63 %. Carbohydrate content show ranges of 2.18 % to 7.73 % with the highest value recorded in Control and lowest value recorded in ON_{100}, Fat content ranges from 8.53 % to 13.52 %.The results of the mineral composition shows that the values of phosphorus ranges from 3.18 mg/g to 6.35 mg/g, iron ranges from 0.66 m/g to 1.83 mg/g and potassium ranges from 0.84 mg/g to 2.61 mg/g. The results obtained in this study clearly indicates that processing temperature have effect on the nutrient value of fish samples. This would be useful to help consumers in choosing a less harmful processing temperature when processing fish samples. The result obtained from this study indicates that these fishes analyzed were of high food value, but there is need to use regulated temperature during preservation to enable consumer to derive the appropriate benefit from their consumption.

Keywords: Proximate Analysis, Processing Temperature, Mineral Analysis, *Oreochromis niloticus.*

Introduction

In the diets of Africans, fish contributes to about 50% of total animal protein which makes it an important source of food [1]. Fish serves as a good source of essential micronutrients and protein, thus plays an important role in prevention of human diseases [2]. In Africa, 10% of the populations depend wholly or partially on the fisheries sector, either as source of food or source of their livelihood [3].

Due to its intrinsic characteristics, fish meat deteriorates easily. Fish processing methods are often used to prolong the shelf life of fishery products, preventing the action of mechanisms

that lead to their deterioration [4,5]. Fish is highly susceptible to deterioration if kept without any preservative or processing measures. Hence, preservation methods such as freezing and canning are technologies used to minimize these losses. The methods commonly used are the traditional techniques such as smoking, salting and sun drying, which reduce spoilage and increase fish availability to the consumers [6].

Drying is the oldest form of preservation hence regarded as a traditional and least expensive method of fish preservation, it is carried out by sun drying method, which is the most popular, primitive, low-cost and widely used as fish preservation method[7]. It is of vital importance in the developing countries of the world. About six million tons of fish (32 -37 %) of the present world catch for human consumption are dried, salted, smoked, or treated by some combination of these processes each year [8,9]. However, 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. The intensity of heat applied during processing greatly affects the fish protein concentration and essential micronutrients of the fish. It is therefore important to ascertain how the drying temperatures affect some of the nutritional properties of dried fish.

Materials and Methods

Raw material

Samples of *Oreochromis niloticus* were obtained from popular market in Akure, Ondo state, Nigeria. The weight and size range of the fish sampled were as follows; 312.19 - 411.34g; 11.56-16.50cm. The fish samples were washed and oven dried at temperature range 60 – 100 ^{o}C for 3hrs after which each samples was finely crushed into powder form for analysis.

Proximate analysis

The Proximate analysis was carried out using [10] method.

- **Determination of Moisture Content**

Exactly 2 g each of the samples were weighed and dried at about 105 ^{o}C in the oven for four hours to constant weight. The moisture content was reported as percentage loss in weight.

$$\text{Moisture content} = \frac{W2 - W3}{W2 - W1} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{Equation 1}$$

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

➢ Determination of Ash Content

The ash content was determined by igniting 5 g of dry sample in a muffle furnace at about 550 ^{o}C to constant weight. It was cooled in a desiccator and weighed. The ash content was reported as a percentage dry mass.

$$\text{Percentage Ash} = \frac{\text{Weight loss } (W_2 - W_3)}{\text{Weight of sample } (W_1)} \times 100 \quad \text{.....Equation 2}$$

Where: W_1 = weight of sample

W_2 = weight of sample + crucible
W_3 = weight of sample + crucible (constant weight after drying)

➢ Determination of Crude Protein

Exactly 5 g of the samples were weighed and digested in macro-Kjeldahl apparatus with concentrated sulphuric acid. The ammonia liberated from the resulting ammonium sulphate after adding sodium hydroxide was distilled into 1 M boric acid and then titrated with 0.1 M HCl. The nitrogen value estimated was multiplied by 6.25 (protein factor) to obtain the value of the crude protein, expressed as the percentage of sample mass[11].

$$\% \text{ Nitrogen} = \frac{\text{Vol. of acid used} \times \text{Molarity} \times 0.014 \times \text{Dilution factor}}{\text{Weight of sample}} \times 100 \text{.....Equation 3}$$

$$\% \text{ Protein} = \% \text{ N} \times 6.25 \text{.....Equation 4}$$

➢ Determination of Fat

The crude fat was extracted from 5 g of each sample using a solvent extraction apparatus (Soxhlet apparatus) with low boiling point petroleum ether as solvent. The weight of the lipid obtained after evaporating off the solvent from the extract gave the weight of the lipid present in the sample [12].

$$\text{Percentage of Crude fat} = \frac{\text{Weight loss } (W_2 - W_3)}{\text{Weight of sample } (W_1)} \times 100 \text{.....Equation 5}$$

Where: W_1 = weight of sample

W_2 = weight of sample + filter paper
W_3 = weight of sample + filter paper (constant weight after drying)

➢ Determination of Crude Fibre

Exactly 5 g of sample were weighed and exhaustive extraction of substances soluble in 1.25 % boiling sulphuric acid and 1.25 % boiling sodium hydroxide was employed. The residual matter of crude fibre and inorganic material recovered and ash yielded the crude fibre expressed as percentage loss in weight of ashed residue[13].

$$\text{Percentage of Crude fibre} = \frac{\text{Weight loss } (W_2 - W_3)}{\text{Weight of sample } (W_1)} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{Equation 6}$$

Where: W_1 = Initial weight of sample

W_2 = weight of sample + crucible before ashing

W_3 = weight of sample + crucible after ashing (constant weight after drying).

➢ Carbohydrate Content Determination

Carbohydrate content was determined by difference. The percentage total carbohydrate is estimated to be equal to the sum of percentage moisture, protein, ash and fibre subtracted from 100.

$$\%\,\text{Carbohydrate} = 100 - (\%\,\text{protein} + \%\text{fat} + \%\text{fibre} + \%\text{ash} + \%\,\text{moisture}) \ldots\ldots\ldots\text{Equation 7}$$

Mineral Analysis

➢ Determination of Potassium (K) and Iron (Fe) Contents

2 g of the sample was weighed into small a porcelain crucible and ashed in the furnace at 650 ^{o}C for three hours. The ash was extracted by half filling the crucible with 2 mL HCl, boiled gently and the solution was transferred to a 50 mL beaker using Pasteur pipette. The precipitates were washed with distilled water, filtered into the filtrate and solution made up to 50 mL mark distilled water. Blanks were prepared using only distilled water. Potassium was determined using flame photometer with standard solutions while Iron was determined by Atomic Absorption Spectrophotometer (AAS) with standard solutions[14].

➢ Determination of Phosphorus Content

5 g of fish samples solution (from dry digestion) was pipetted into a 50 mL volumetric flask and 30 mL of distilled water was added. Within 5 minutes, 10 mL of vanado-molybdate reagent was added, contents were mixed and allowed to stand for 10 minutes before the transmittance percent was determined at 400 nm[15].

Statistical Analysis

All analyses were done in triplicate to evaluate experimental reproducibility and reported as Mean ± Standard Deviation. The data obtained were subjected to one way analysis of variance (ANOVA) using SPSS version 21. Duncan's multiple range test (DMRT) was used to determine means that were significantly different at a level of significance (α) of 0.05.

Results and discussion

The moisture content of fish at difference temperature was recorded and ranges from 4.43 % to 55.39 %. The highest value was found in the Control while the lowest value was in ON_{100}. It was observed that moisture content decreases with increase in the temperature applied on the fish. According to [16], the water content in fish affects the microbiological and chemical

stability, physical properties, processing, storage and distribution of fish. A safe moisture level of 6 to 8% in dried fish has been recommended in order to prevent spoilage due to microbe and pest proliferation [17]. Ash content ranged between 3.73 % to 10.79 %, these values are higher than 3.17% in *Mystus bleekeri* recorded by [18], and 2.75% in *Pangasius pangasius recorded* by [19]. The highest ash content was found in Control and the lowest was found to be ON_{100}. It was observed that ash content increases with decrease in temperature. Protein content ranges from 23.68 % to 67.63 %, Control had the lowest value and ON_{100} had the highest protein content, the relatively high to moderate percentage crude protein may be attributed to the fact that fishes are good source of pure protein. These values were higher than earlier researchers that worked on protein content of 15.01% protein found in *Mystus bleekeri* [18], 14.87% protein was reported in *Clarias batrachus* [20], 18.43% protein was recorded in *Mystus nemurus* [21]. In the present investigation protein content was observed to increase with increase in temperature applied and the protein content, this increase of protein may be attributed to the dehydration of water molecule present between the proteins thereby causing agitation of protein and thus resulting in the increase in protein content as temperature increases [22]. Carbohydrate content show ranges of 2.18 % to 7.73 % with the highest value recorded in Control and lowest value recorded in ON_{100}. These values are within the range of 1.80% reported by [23] in *Clarias gariepinus*. Fat content ranges from 8.53 % to 13.52 %. The highest value of fat content was recorded in Control whereas lowest was in ON_{100}. It was observed that the fat content increasees with increase in temperature. The relationship between moisture and lipid is well established in this research. The lipid contentvaries inversely to moisture content. This result agrees with [1] and [24].Fat content in fish shows wide variation from as low as 2% to as high as 65% in some species [25,26].

Table 3.1 Proximate Composition of *Oreochromis niloticus*

Samples	Moisture content	Ash content (%)	Fat (%)	Protein (%)	Carbohydrate	Crude fibre
ON_{100}	4.43^{c}±0.84	10.79^{a}±1.02	13.52^{a}±0.54	67.63^{a}±2.13	2.18^{c}±0.12	1.02^{a}±0.15
ON_{90}	6.51^{c}± 0.68	10.22^{a}±0.57	12.98^{a}±0.15	65.29^{a}±1.81	3.29^{b}±0.74	0.95^{a}±0.10
ON_{80}	8.90^{b}±0.70	9.47^{b}±0.45	11.88^{b}±0.14	63.37^{b}±1.56	4.95^{a}±0.22	0.91^{a}±0.06
ON_{70}	10.53^{b}±0.34	8.32^{b}±0.70	11.69^{c}±0.36	62.15^{c}±1.80	5.63^{b}±0.16	0.88^{b}±0.11
ON_{60}	14.58^{b}±0.62	7.96^{c}±0.36	10.52^{c}±0.41	58.74^{c}±1.24	6.54^{a}±0.22	0.85^{b}±0.07
Control	55.39^{a}±2.28	3.73^{c}±0.75	8.53^{c}±0.56	23.68^{d}±0.96	7.73^{a}±0.28	0.78^{b}±0.08

Number of replicates = 3; Mean ± Standard Deviation; Mean with different superscript across rows are significantly different at ($P<0.05$)

Sample codes: *Oreochromis niloticus*dried at 60 ^{o}C denoted as ON_{60}

*Oreochromis niloticus*dried at 70 ^{o}C denoted as ON_{70}

*Oreochromis niloticus*dried at 80 ^{o}C denoted as ON_{80}

*Oreochromis niloticus*dried at 90 ^{o}C denoted as ON_{90}

*Oreochromis niloticus*dried at 100 ^{o}C denoted as ON_{100}

Table 2.Mineral Analysis of *Oreochromis niloticus*

Samples	Iron	Potassium	Phosphorus
ON_{100}	1.83^{a}±0.18	2.61^{a}±0.15	6.35^{a}±0.16
ON_{90}	1.24^{a}± 0.13	2.27^{a}±0.36	5.12^{b}±0.45
ON_{80}	1.41^{a}±0.15	2.33^{a}±0.10	5.69^{a}±0.63
ON_{70}	0.93^{b}±0.10	1.71^{b}±0.15	4.51^{b}±0.32
ON_{60}	0.89^{c}±0.12	1.54^{c}±0.17	3.98^{c}±0.56
Control	0.66^{d}±0.08	0.84^{c}±0.17	3.18^{c}±0.48

Number of replicates = 3; Mean ± Standard Deviation; Mean with different superscript across rows are significantly different at ($P<0.05$) mg/100g

The results of the mineral analysis are represented in Table 3.2. The values of phosphorus ranges from 3.18 mg/g to 6.35 mg/g, there was no significant difference between ON_{100} and ON_{80} likewise between ON_{90} and ON_{70} and between ON_{60} and control. The values of phosphorus increased with increase in temperature. Iron composition ranges from 0.66 m/g to 1.83 mg/g and potassium ranges from 0.84 mg/g to 2.61 mg/g. As earlier reported by researchers, the result obtained is in agreement with [24] who observed high values of phosphorous and low iron contents in the some tropical freshwater studied and it was observed that the value increases with increase in processing temperature. The values of phosphorus and potassium obtained in the fish samples were higher than the iron content. Freshwater fish meat is a particularly valuable source of pottasium and phosphorus as well as iron. [27] reported similar findings and observed that the presence and dominance of mineral elements in a fish depends on the water body where the fish lives. This study shows that *Oreochromis niloticus* is a valuable source of essential nutrients for human consumption. It contains huge amount of proteins, fats and minerals that are essential for both infants and adults in the appropriate quantity.

Conclusions

The results in this study showed that there were significant influences of the processing temperature on *Oreochromis niloticus* samples in relation to the proximate and mineral composition. The processing temperature could provide a relative nutritional stability for *Oreochromis niloticus* meat and also enable the fish provide higher percentage of protein, fats and minerals, which are essential nutrients that could satisfactorily supplement cereals, which are a cheap major source of protein of the Nigerian people. More intake of fish should be encouraged due to its high nutritional efficiency and the processing temperature should be monitored in order not to get rid of the essential nutrient.

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