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EFFECTS OF PROCESSING PARAMETERS ON THE CHEMICAL QUALITIES OF SMOKED CATFISH

Famurewa J.A.V[1], Olopade F[2] & Adejumo P.O[3]

[1,2]Research Scholar, Department of Food Science and Technology, Federal University of Technology Akure, Ondo State, Nigeria

[3]Research Scholar, Department of Food Technology, Auchi Polytechnic, Auchi, Edo State, Nigeria

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ABSTRACT

The effects of osmotic dehydration (OD), fish size (FS) and smoking temperature (ST) on the chemical qualities of smoked catfish were investigated. Two sizes of fresh catfish' the small (200-450 g) and big (800-lOOO g) were osmotic dehydrated using sodium chloride (20 "brix and 25 "brix at 40 °C for 6 hours). Then smoke dried at 70 and 150 °C with sawdust - fuelled smoking kiln fitted, w ith analog temperature sensor. The control samples (fresh) OD samples and the osmotic dehydrated smoked dried samples (ODSD) were subjected to proximate analysis (moisture ash protein fat, carbohydrate)' oxidative tests (free fatty acid peroxide value, thiobarbituric acid (TBA), pH) and mineral analysis using standard methods The result indicated significant difference (P< 0.05) occurred in the moisture protein and fat contents of ODSD samples when compared with OD (control) samples. The dual processing effect had a positive effect with an increasing value in protein fat and significant reduction in moisture content compare with the control. The small sample has 25.11, 46.59, 0.45 and. 14.69, 4.56, 73.11% for protein fat and moisture content at 150 °C with 20% OD and control respectively• while at the same temperature with 25% the big sample and control has 25.28, 36.50, 6.26 and 16.94 5.58 71.58% for protein fat and moisture respectively. OD resulted to a decrease in pH from 7.20 in control sample to a range of 6.70-6.90 while ST further had the pH decreased to 6.30-6.50 and 6.5-6.70 for small and big sizes respectively. The ODSD samples were within the acceptable limit of 6.8 to 7.0. The OD samples gave a lower FFA value (0.24- 0.45) while on the ODSD samples FFA (20% 150 °C) gives 2.36% and {20% 70 °C) gives l0.00% increased with increase in drying time. The peroxide v alue also increased a s drying temperature increases with value ranging from 6.74 to 16.28 mEq/kg and 7.60 to 20.78 mEq/kg for the 150 °C small and 70 °C big respectively. The treatment yielded samples, ith high concentrations of potassium calcium and heavy metals (Cd and Cr) were within tolerable limit• the minor elements (Ni, Mn and Cu) were also in traced amount in all the samples studied. Based on the study it was found that small size Clarias gariepinus pretreated with 20% osmotic dehydration solution and smoked dried at 150 °C gave the best proximate oxidative and minerals result and was therefore recommended.

KEYWORDS: *Chemical Qualities, Preservation and Processing, physical and Mechanical Modification*

INTRODUCTION

Clarias *gariepinus* is considered to be one of the most important tropical catfish species for aquaculture, easy to culture in Nigeria and with great economic interest and many other areas [1]. Foreign exchange earning potential is attained through export of processes (smoked Catfish/Shrimps) fish and fishery by- products to international markets. Fisheries guarantee direct and indirect employment opportunities, with up to 1.6 million artisanal fishermen in the primary sector and some 200,000 workers employed in the aquaculture subsector [2].Fish, which is one of the food items people consume contains protein and other nutrients such as vitamin D and selenium and a specific type of fat, especially omega-3 fatty acids among other nutrients. Omega-3 fatty acid is of public health significance because it has the potential to reduce the risk of developing heart disease and other medical problems [3]. Therefore, regular consumption of catfish has great potential to protect against some of the non-communicable diseases, which is becoming common even, among young adult Nigerians [4].

The large water percentage constituent of fish makes it susceptible to bacterial attack causing spoilage. Spoilage occurs as a result of the action of enzymes (autolysis) and bacteria present in the fish and also chemical oxidation of the fat which causes rancidity. At the high temperatures prevalent in tropical countries like Nigeria, bacterial and enzymes are enhanced. The high ambient temperature in the tropic cause rapid growth of spoilage which is responsible for about 50% wastage of the total catches worldwide [5]. An estimated 40% of total fish landing in Nigeria is lost as post-harvest losses [6]. It was estimated that 20 to 50% of the fish produced in the remote costal centers and many tropical countries perish before they reach consumers due to poor handling, preservation and processing practices adopted by artisanal fishermen, fish farmers and fisheries entrepreneurs [6]. In addition, significant quality is lost through the absence of adequate technology and expertise to prevent losses in many tropical countries [7]. Fresh fish contains up to 80% of water. It is a highly perishable material and having a short storage life [8].

In order to curb fish spoilage, increase shelf life and add value to products, various preservation techniques are employed including Chilling, Freezing, canning, salting, drying and smoking. In Nigeria, the most affordable and widely used method of preservation is smoking [9]. Smoking of fish from smouldering wood for its preservation dates back to civilization [10]. It is also noted that apart from giving the product a desirable taste and odour, smoking provides a longer shelf life through its anti-bacterial and oxidative effect, lowering of pH, imparting desirable colouration as well as accelerating the drying process and acting as antagonist to spoilage agents [11], [12].

Osmotic Dehydration (OD)

OD is one of most important complementary treatment and food preservation technique in the processing of dehydrated foods, since it presents some benefits such as reducing the damage of heat to the flavor, color, inhibiting the browning of enzymes and decrease the energy costs [13], [14]. Osmotic dehydration as a pre-treatment to many processor improves nutritional, sensorial and functional properties of the food without changing its integrity. It is often applied as a pre-processing step before foods are subjected to further processing techniques such as air drying or freezing [15], [16].

Smoking Temperature and Kiln

Olayemi *et al.*, [17] reported on proximate composition of smoked catfish using a developed kiln shows drying of fish to safe moisture content which can make it suitable for export and a positive significant influence of drying in the

proximate compositions of catfish making it nutritionally suitable for all. Abid *et al.*, [18] stated that the quality of dried product is greatly affected by drying conditions. Higher temperature applied leads to several irreversible biological or chemical reactions as well as structural, physical and mechanical modification such as inactivation of bacteria and enzymes changes of shape and texture, loss of nutrients and aroma.

Justification and Objectives

As cheap as smoking is compare with other methods of fish storage which are not widely used because of low-level of technological development and erratic power supply yet great losses are still encountered during processing, storage, transportation and marketing.

Therefore this study is considering certain processing parameters which will yield a better quality of smoked catfish which includes pre-treating two sizes of the sample with sodium chloride and using a smoking kiln at two different temperatures. The main objective is to determine the effect(s) of temperature and osmotic dehydration on the chemical properties of different sizes of smoked catfish.

MATERIALS AND METHODS

Sample Preparation

A total of fifty piece of *Clarias gariepinus* with two different sizes(250 - 400 g (small) and 800 -1000 g (big) were purchased from Royal Pond in Ondo State Nigeria and were kept in fiber glass prior the time of slaughtering. The fish were gutted, washed thoroughly with water to remove slime and blood, thereafter bent into horse-shoe shapes, dressed and then weights were taken.

Osmotic Solution

Salt solution (Nacl) (20 ^{o}brix and 25 ^{o}brix) was prepared for the osmosis dehydration.

The fresh weight of the samples was determined using electronic balance, the ratio of solute to small catfish was 7:1w/w, while that of big catfish was 4:1w/w.

Sample Treatment

The samples with its salt solution inside baking pan were placed inside the constant water bath (40^{o}C). A triplicate from each sizes were treated differently with salts solution for a period of six hours. The samples were removed from each solution at an interval of 1hour and was immediately rinsed in flowing water and placed on tissue paper to remove the surface moisture to eliminate excess solution from the surface before weighing.

The samples were further smoked dried in smoking kiln using sawdust at 70 ^{o}C and 150 ^{o}C until a constant drying time was obtained.

Osmotic Dehydration Characteristics

Water Loss

Water loss is the quantity of water lost by food during osmotic dehydration. The water loss (WL) is defined as the net weight loss of the catfish on initial weight basis and can be estimated as, [19].

$$\text{Water loss, \% WL (wb)} = \frac{WWO-(TW-WS)}{WWO+WSO} \times 100\text{g} \ /H_2O/\text{g Initial wt of sample}$$

Solid Gain

The solids from the osmotic solution get added to the samples during osmotic dehydration. The loss of water from the sample takes place in osmotic dehydration consequently it increases the solid content. The solid gain is the net uptake of solids by the catfish on initial weight basis and computed using following expression [19].

$$\text{Solid gain, \% SG (wb)} = \frac{WS-WSO}{WWO+WSO} \times 100\text{g g solids/100g initial wt. of sample}$$

Proximate Analysis

Moisture content, crude proteins, Crude fat, Ash were determined using methods of [20]. The oxidative properties which include the peroxide value (PV) measured as milliequivalent per kg of sample, thiobarbituric acid (TBA) using UV-Vis spectrophotometer (model UV-5300, jenway, Japan). TBA was expressed as milligram malonaldehyde absorbance measured at 532 mm per kg of fish sample, Free Fatty Acid (FFA) expressed as % and pH using the standard of [21] and Minerals were determined using AAS Aanalyst 400 by Perkin Elemer.

Statistical Analysis

All measurements were carried out in triplicates and subjected to tests. Data on the physical, proximate and oxidative analysis of the fresh, osmoses dried (OD) and osmotic dehydrated smoked dried (ODSD) fish were analyzed with one-way analysis of variance (ANOVA) where mean are significantly different ($P<0.05$), the Duncan multiple range test (DMRT) was used to separate the means. Statistical package for Social Science (SPSS version 17.0) was used

RESULTS AND DISCUSSIONS

Table 1: Proximate Composition of Different Sizes of Smoked Catfish using Different Osmotic Solution

Treatment	Ash	Fat	Moisture	Protein	Carbohydrate
20% OD Small	12.67 ± 1.24^{bc}	10.16 ± 3.34^{b}	61.34 ± 5.61^{a}	10.78 ± 1.08^{a}	5.05 ± 2.80^{ab}
20% OD Big	10.91 ± 7.48^{bc}	4.47 ± 1.81^{a}	66.20 ± 2.58^{ab}	9.22 ± 2.52^{a}	9.20 ± 1.61^{b}
25%OD Small	16.00 ± 2.60^{c}	5.88 ± 1.90^{a}	63.45 ± 2.27^{a}	11.31 ± 1.05^{a}	3.35 ± 2.09^{ab}
25% OD Big	11.84 ± 1.29^{bc}	3.91 ± 1.93^{a}	62.19 ± 0.33^{a}	16.67 ± 2.56^{b}	5.10 ± 5.57^{ab}
Control Small	2.47 ± 1.31^{a}	4.56 ± 1.35^{a}	73.11 ± 3.40^{c}	14.69 ± 0.96^{b}	5.17 ± 3.28^{ab}
Control Big	6.75 ± 2.73^{ab}	5.58 ± 0.62^{a}	71.58 ± 1.47^{bc}	16.94 ± 2.36^{b}	1.95 ± 0.90^{a}

Means in the same column and with homogenous superscript are not significantly different ($p>0.05$); All values are expressed as Mean±SD

Effect of Osmotic Dehydration on the Proximate Composition of Different Sizes of Smoked Catfish

The Osmotic dehydration treatment impact on nutritional improvement could be noticed through influence of two solutions on the proximate value of fresh catfish. The table1 shows that the ash contents of the fish varied slightly difference. The OD treatment for both sizes was higher in value than that of control. This finding agreed with the work of Oetterer *et al.*, [22] who showed that increase in ash content was directly related to the presence of salt in sardine muscle. The small size sample had a higher fat content than the big sample and control.

It is seen that the OD causes moisture content reduction. The control has the highest moisture content of 71.58, 73.11% for big and small size respectively but with 25% O.D the big sample was reduced to 62.19% while 20% OD brought the small sample to 61.34%.

Also there is reduction in protein value form control big with value of (16.94) to 16.67 and 9.22 with 25% and 20% O.D, likewise same trend is observed in the control small from (14.69) to 11.31 and 10.78 with 25% an 20% respectively. This is in agreement with Ezeama and Udoh [23] which showed that there was a significant reduction in crude protein from 69.56% for the unfermented to 64.60% for the fermented 15%w/w salted samples.

The Carbohydrate big treatment increased while the small treatments decrease.

Table 2 Proximate Composition of Different Sizes of Smoked Catfish with Different Osmotic Dehydration and Temperature

Treatment	Ash	Fat	Moisture	Protein	Carbohydrate
20% 150 Small	25.87±1.76^{de}	46.59±1.95^{e}	0.45±0.28^{a}	25.11±4.26^{c}	1.98±1.06^{a}
20% 150 Big	17.25±1.04^{c}	28.33±1.26^{b}	8.97±0.21^{c}	27.26±0.20^{cd}	18.19±2.29^{c}
20% 70 Small	24.67±1.06^{d}	33.17±0.29^{c}	14.06±0.61^{d}	18.77±2.98^{b}	9.33±2.16^{b}
20% 70 Big	14.81±1.35^{c}	36.50±0.50^{d}	18.80±1.42	26.66±1.85^{cd}	3.24±1.40^{a}
25% 150 Small	24.67±2.07^{d}	28.00±0.50^{b}	1.26±0.23^{a}	30.01±0.61^{e}	16.05±1.90^{c}
25% 150 Big	29.30±0.28^{f}	36.50±1.32^{d}	6.26±0.11^{b}	25.28±1.37^{c}	2.65±0.30^{a}
25% 70 Small	24.26±1.61^{d}	37.50±3.04^{d}	16.80±0.33^{e}	17.27±0.92^{ab}	4.17±2.91^{a}
25% 70 Big	27.77±1.03^{ef}	26.83±0.29^{b}	21.16±0.92^{f}	23.42±2.97^{c}	2.19±2.08^{a}
Control Small	2.47±1.31^{a}	4.56±1.35^{a}	73.11±3.40^{g}	14.69±0.96^{a}	5.17±3.28^{a}
Control Big	6.75±2.73^{b}	5.58±0.62^{a}	71.58±1.47^{g}	16.94±2.36^{ab}	1.95±0.90^{a}

Means in the same column and with homogenous superscript are not significantly different ($p>0.05$); All values are expressed as Mean±SD

Effect of Osmotic Dehydration and Temperature on the Proximate Composition of Different Sizes of Smoked Catfish

Smoking of fish and/or meat products is one of the most ancient processing technologies. It has been for centuries used for preservation, and is still widely used for this purpose among several communities in the third world where up to 70% of the catch is smoked for preservation [24]. The table 2 shows that the quality parameters measured generally increases as the drying temperature increases. The ash content of ODSD samples increases with drying time ranging from 14.81 to 29.30% and 24.26 to 25.87% for big and small sample respectively. The increase could be attributed to the presence of high salt content which is in agreement with sun- dried salting and sun-dried salt plus turmeric Fish [25] where ash content was found to be 22.80%, and 22.41 %, in fresh-processed respectively. Similar levels of ash content in salted fish were noticed by several workers [26].

The fat percentage are higher in value than that of the control, which is in line with report of Oily, that smoking results in concentration of nutrients like protein and fat [27], [28],[29].

ODSD has dual effects such as the lowering of the water activity (aw) level and a specific inhibitory effect on the growth of some species of microorganisms through the Na+ ion. So the two steps are interrelated to reduce the moisture sufficiently. The decrease in moisture is due to osmotic migration of salt into and water out of the fish. [30], [31].

Decrease in moisture led to increase in salt content and consequently extend shelf life of the products [32],[33].In present experiment, moisture content of the small initially found to be 73.11 was reduced to 0.45 with 20%, 150 ^{o}C while the big sample was reduced from 71.58 to 6.26 with 25%, 150 ^{o}C. It was observed that generally higher temperature favours lower moisture content, while as per osmotic dehydration the 20% OD and 25% OD are preferable for small and big sample respectively.

The results also showed that crude protein increased with increase in temperature. The ODSD has no effect on the big sample as all were not significant different ($p \geq 0.05$) though higher than the initial value of the control, while for the small sample the treatment 25%150 ^{o}C yields the highest protein of 30.01% compare with the control value of 14.69%.

The significant increase in protein levels ($P < 0.05$) in dried catfish, when compared with the raw fish, suggested that protein nitrogen was not lost during drying. This is also in accordance with the findings of [28], [29] and [30]. Smoking enhances fish flavor, increases utilization, reduces waste, prolongs the shelf life of fish and increases protein availability [34], [35]. Smoking gradually increases the carbohydrate content of the sample.

Table 3: Oxidative Properties of Different Sizes of Smoked Catfish with Different Osmotic Solution

Treatment	PH	FFA	TBA	Peroxide
20% OD Small	6.80±0.00^{a}	0.24±0.03^{a}	0.19±0.01^{a}	14.98±1.80^{bc}
20% OD Big	6.80±0.00^{a}	0.39±0.06^{ab}	0.46±0.12^{b}	12.37±2.19^{ab}
25% OD Small	6.90±0.00^{a}	0.34±0.06^{ab}	0.11±0.01^{a}	11.51±2.35^{ab}
25% OD Big	6.70±0.00^{a}	0.45±0.11^{b}	0.56±0.02^{c}	20.33±1.04^{d}
Control Small	7.20±0.00^{a}	1.92±0.06^{c}	0.10±0.06^{a}	12.93±0.59^{ab}
Control Big	7.20±0.00^{a}	3.23±0.13^{d}	0.18±0.03^{a}	17.76±0.25^{cd}

Means in the same column and with homogenous superscript are not significantly different ($p>0.05$); All values are expressed as Mean±SD

Effect of Osmotic Dehydration on the Oxidative Properties of Different Sizes of Catfish

The pH value is a reliable indicator of the degree of freshness or spoilage. The pH in fresh condition fresh water fish flesh is almost neutral as reported by [36]. In the post-mortem period, decomposition of nitrogenous compounds leads to an increase in pH in the fish flesh [37]. The increase in pH indicates the loss of quality. The pH value of fresh Catfish was 7.20 for both big and small. The pre-treatment with salt addition causes a decrease in pH value due to increase of acidic compound; 25% OD favoured the big sample while for the small 20% OD.

The FFA in the control ranges between 1.92 and 3.23 for small and big respectively which are significantly different from the sample treatment. A great reduction in value of FFA was observed in the treatment which is due to the salt addition.

The TBA for all the samples were generally low. All the osmotic concentration has effect on the samples with increasing value due to lipid oxidation and hydrolysis. It can be observed that 25% OD had the highest peroxide value**.** This is because while salt, through lowering of water activity can inhibit or delay microbial growth and spoilage, it can also promote lipid oxidation, which causes off-flavour (rancidity).

Table 4: Oxidative Properties of Different Sizes of Smoked Catfish with Osmotic Solution and at Different Temperatures

Treatment	PH	FFA	TBA	Peroxide
20% 150 Small	6.50±0.00^{a}	2.36±0.09^{ab}	0.08±0.03^{a}	6.76±0.04^{a}
20% 150 Big	6.70±0.00^{a}	6.02±1.26^{d}	0.20±0.05^{b}	11.30±1.66^{c}
20% 70 Small	6.40±0.00^{a}	3.10±0.20^{b}	0.09±0.03^{a}	10.65±2.03^{bc}
20% 70 Big	6.60±0.00^{a}	10.00±0.43^{e}	0.10±0.01^{a}	7.60±2.74^{ab}
25% 150 Small	6.50±0.00^{a}	2.61±0.33^{ab}	0.35±0.01^{c}	16.28±0.69^{de}
25% 150 Big	6.40±0.00^{a}	3.27±0.71^{b}	0.10±0.02^{a}	18.67±3.21^{ef}
25% 70 Small	6.30±0.00^{a}	2.65±0.15^{ab}	0.41±0.04^{d}	11.15±1.61^{bc}
25% 70 Big	6.50±0.00^{a}	4.64±0.96^{c}	0.10±0.00^{a}	20.78±3.44^{f}
Control Small	7.20±0.00^{a}	1.92±0.06^{a}	0.10±0.06^{a}	12.93±0.59^{cd}
Control Big	7.20±0.00^{a}	3.23±0.13^{b}	0.18±0.03^{b}	17.76±0.25^{ef}

Means in the same column and with homogenous superscript are not significantly different (p>0.05); All values are expressed as Mean±SD

Effect of Oxidative Properties of Smoked Catfish with Different Osmotic Solution Concentrations and Temperatures

The pH value is a reliable indicator of the degree of freshness or spoilage. The pH in fresh- water fish flesh is almost neutral [38]. In this study the ODSD brought the pH of small sample between 6.30 and 6.50, while for big between 6.50 and 6.70.This result is similar to that obtain in sun dried salted shoal fish with pH of 6.20 at day (0) and sun-dried salt +turmeric with 6.30 at day (0).The fish product are within the acceptable limit according to [39] which say 6.8 to 7.0 is usually the limit of acceptability.A higher value of FFA was obtained when OD sample was subjected to a lengthen period of heat compare with when only osmosized dehydrated. The FFA content in a product is an indication of the quality of the product [38]. Results suggests that lengthen period of drying promotes FFA production. The peroxide value increased with increase drying time with value ranging from 6.74 to 16.28 mEq/kg and 7.60 to 20.78 mEq/kg for the dehydrated smoked small and big respectively.Since peroxide value is used to estimate the degree of rancidity, the product is within acceptable limit as values corresponding to incipient spoilage are usually in the order of 20-40 mEq/kg of sample [6]. Furthermore; the high salt concentration may have decreased the solubility of oxygen thereby retarding fat oxidation.

Table 5: Trace Element of Osmotic Dehydrated and Smoke Dried Content of Various Catfish

Treatment	CR	NI	MN	CU	CD
20% 150 Small	0.01±0.01^{ab}	0.06±0.01^{bcd}	0.07±0.01^{c}	0.03±0.01^{bcde}	0.02±0.01^{abc}
20% 150 Big	0.03±0.01^{de}	0.07±0.01^{d}	0.08±0.01^{cd}	0.03±0.01^{bcde}	0.02±0.00^{abc}
20% 70 Small	0.04±0.01^{ef}	0.15±0.01^{f}	0.11±0.00^{e}	0.03±0.01^{bcde}	0.03±0.01^{c}
20% 70 Big	0.01±0.00^{ab}	0.06±0.01^{cd}	0.03±0.01^{b}	0.02±0.01^{abc}	0.01±0.00^{a}
25% 150 Small	0.02±0.00^{bcd}	0.52±0.00^{bc}	0.04±0.01^{b}	0.02±0.01^{abcd}	0.01±0.00^{ab}
25% 150 Big	0.06±0.01^{g}	0.12±0.01^{e}	0.13±0.01^{f}	0.05±0.01^{e}	0.02±0.01^{abc}
25% 70 Small	0.01±0.00^{ab}	0.06±0.01^{bcd}	0.05±0.01^{b}	0.03±0.01^{abcd}	0.01±0.01^{a}
25% 70 Big	0.04±0.01^{ef}	0.52±0.01^{g}	0.12±0.01^{ef}	0.02±0.01^{abcd}	0.02±0.01^{abc}
20% OD Small	0.00±0.00^{a}	0.01±0.01^{a}	0.05±0.01^{b}	0.02±0.01^{abcd}	0.01±0.01^{ab}
20% OD Big	0.01±0.00^{abc}	0.00±0.00^{a}	0.01±0.00^{a}	0.01±0.00^{a}	0.01±0.00^{ab}
25% OD Small	0.04±0.01^{ef}	0.05±0.01^{b}	0.16±0.01^{f}	0.03±0.01^{cde}	0.02±0.01^{abc}
25% OD Big	0.05±0.01^{fg}	0.06±0.01^{cd}	0.15±0.01^{f}	0.04±0.01^{de}	0.02±0.01^{abc}
Control Small	0.01±0.01^{ab}	0.00±0.00^{a}	0.02±0.01^{a}	0.01±0.01^{ab}	0.01±0.00^{ab}
Control Big	0.03±0.01cde	0.02±0.01a	0.09±0.01d	0.12±0.01f	0.02±0.01ab

Means in the same column and with homogenous superscript are not significantly different (p>0.05); All values are expressed as Mean±SD

Table 6: Essential Element of Osmotic Dehydrated and Smoke Dried Content of Various Catfish

Treatment	CA	K	NA	FE
20% 150 Small	407.90±0.10^{f}	15.20±0.10^{a}	108.90±0.10^{c}	1.09±0.01^{e}
20% 150 Big	431.75±0.01^{g}	94.05±0.01^{l}	302.50±0.10^{i}	0.18±0.01^{a}
20% 70 Small	611.50±0.10^{l}	52.05±0.01^{h}	342.70±0.10^{j}	0.54±0.10^{cd}
20% 70 Big	129.20±0.10^{b}	45.00±0.00^{f}	451.80±0.10^{n}	1.27±0.10^{f}
25% 150 Small	297.75±0.01^{e}	24.75±0.01^{b}	205.00±0.00^{d}	3.53±0.01^{h}
25% 150 Big	452.10±0.10^{h}	33.75±0.01^{d}	293.20±0.10^{h}	2.73±0.01^{g}
25% 70 Small	206.10±0.10^{d}	71.70±0.10^{j}	380.60±0.10^{l}	0.46±0.01^{c}
25% 70 Big	480.95±0.01^{i}	30.65±0.01^{c}	261.60±0.10^{f}	0.27±0.01^{b}
20% OD Small	206.65±0.01^{d}	81.50±0.10^{k}	370.30±0.10^{k}	0.12±0.01^{a}
20% OD Big	98.85±0.01^{a}	36.55±0.01^{e}	272.20±0.10^{g}	0.14±0.01^{a}
25% OD Small	495.10±5.28^{k}	47.75±0.01^{g}	383.10±0.10^{m}	0.29±0.01^{b}
25% OD Big	617.00±0.00^{m}	36.56±0.01^{e}	228.60±0.10^{e}	0.14±0.01^{a}
Control Small	175.70±0.10^{c}	54.65±0.01^{i}	18.30±0.10^{a}	0.60±0.10^{d}
Control Big	491.85±0.01j	36.57±0.01e	31.20±0.10b	0.18±0.01a

Means in the same column and with homogenous superscript are not significantly different (p>0.05); All values are expressed as Mean±SD

Effect of Osmotic Dehyration and Smoking on Mineral Content of Catfish

The variations recorded in the concentration of the different nutritional components in the fish examined could have been as a result of the rate in which these components are available in the water body [40] and the ability of the fish to absorb and convert the essential nutrients from the diet or the water bodies where they live. This is supported by the findings of [41], [42], [43]. It could be as a result of the pre-treatment with salt. Elements (such as Copper, Manganese and Iron) varied in concentration among the sample studied. Most of these micro elements are equally important in trace amounts as observed, but they tend to become harmful when their concentrations in the tissues exceed the metabolic demands [44]. Essentials minerals are important for vital body functions such as acid, base and water balance; this includes calcium which is good for growth and maintenance of bones, teeth and muscles [45]. Normal extra cellular calcium concentrations are necessary for blood coagulation and for the integrity, intracellular cement substances [46]. Sodium is an activator of transport ATP-ases in animals and possibly also in plants [47]. There is also direct relationship of sodium intake with hypertension on human. Iron is an important constituent of hemoglobin [48]. The heavy elements include Chromium which is slightly significant as it ranges from (0.00) in 20% O.D small to the highest value of (0.06) 25%, 150 ^{o}C small and 25% O.D big (0.05). Nickel is absence in control small and 20% O.D big but has the highest value (0.52) in 25%, 70 ^{o}C big. Cadmium has the lowest value in 25%, 70 ^{o}C small (0.01) and highest value of (0.03) in 20%, 70 ^{o}C.

CONCLUSIONS

From this study, Osmotic dehydration and smoking has a positive effect on the proximate, oxidative and mineral component hence can be recommended as preservatives for fresh catfish. Osmotic dehydration 20% is more preferable than 25% brix though it has a nutritional improvement by lowering the moisture content, free fatty acid and pH to a level which inhibits or delay microbial growth and spoilage but can promote lipid oxidation which causes off-flavour (rancidity).

The temperature 70 ^{o}C which require a longer period of drying gave higher oxidative values. Conclusively 20% brix,150 ^{o}C temperature is ideal for good quality processed catfish.

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