Research Article

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Effects of Drying Methods on the Biochemical Composition and Organoleptic Properties of Two Freshwater Fish Species (*Mormyrus rume and Labeo coubie*) of Cross River Obubra, Nigeria

Okey IB

Department of Fisheries, Cross Rivers University of Technology, Obubra Campus, Calabar

***Corresponding author**
Okey IB, Department of Fisheries, Cross Rivers University of Technology, Obubra Campus, Calabar, E-Mail: piusbass@yahoo.com

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Abstract

Consumers all over the world are increasingly becoming aware of the health and nutrition status of fish and fishery products. There have develop some preference for fish species and even their processing methods. This study aims to investigate the effects of two drying methods (smoking and oven drying) on the biochemical components and organoleptic properties of two less preferred food fishes abundant in the study area. The fish samples Mormyrus rume and Labeo coubie were purchased from fresh landings of fishermen at Ahaha beach. The biochemical assay of the moisture, protein, fat, carbohydrate, ash, calcium (Ca), magnesium (Mg), phosphorus (P), iron (Fe), sodium (Na) and potassium (K) were conducted in the labouratory using standard methods. The proximate composition of raw M. rume was determined as moisture 70.38%, protein 17.43%, carbohydrate 1.13%, fat 5.93% and ash 2.77% while oven dried were 18.78, 63.85, 3.37, 8.73 and 7.58% respectively. All the proximate parameters and gross energy level investigated were higher ($p < 0.05$) in M. rume except the moisture content of dried samples of L. coubie. The mineral content were in the order Ca < Mg < Fe < Na < P and < K in both species and were higher in M. rume except Na. The drying methods showed increase in the proximate and mineral compositions in the order raw < smoking and < oven drying except moisture content that decreased respectively is both species. Organoleptic properties revealed that dried samples (smoked and oven) were not significantly different ($p < 0.05$) in taste, flavour, texture and overall acceptance, however while oven dried had better colour (4.33), smoked dried taste (4.63) better. The drying methods shows concentration of the required nutrients in human diets and were also found to be most palatable by the panellist. To improve fish nutrient quality smoke and oven drying should be encourage.

Keywords: Drying Methods, Proximate Composition, Mineral Content, Organoleptic Properties

Introduction

Fish is a good source of animal protein and it provide about 30 to 80% of the protein intake of the coasted end riverine people of West Africa including Nigeria [1]. Some customers show preference in some form of processing methods and fish species worldwide. Fish constitute about 60% of the total protein intake in adults especially in the rural areas [2]. Fish is more nutritious than staple foods, providing animal proteins, essential fatty acids and micro nutrients. In cross river, fish can be consumed fresh (raw) or processed (smoke, oven dried, and sun dried). According to Adebayo, et al. fish in Nigeria is eaten cooked, preserve or processed and form much cherished delicacy that cut across socio economics, age, religious and educational barriers [3]. Fish contains important component that is suited for human diet and it also provides the much needed mineral and vitamin that are not available in cereal based diets. The amino acids found in fish compares very well with eggs, milk and meat in the nutritional value of it protein [4,5]. Fish nutritive quality is important attributes which can be affected by many factors such as food availability in ecosystem, feed composition, water quality, species and method of processing and preservation [6,7]. Fish is perishable when caught, therefore need to processed and preserved to slow down spoilage. A number of processing techniques such as smoking, freezing, chilling, salting, drying and fermentation have been employed by processors in Nigeria [8-10]. According to Oguzhan and Angis, most industrial product of aquaculture in Europe are salted, dried, smoked, cooked, frozen and canned [9]. In Germany and Poland, there is high market demand for smoked fishes such as eel, halibut, herring, mackerel and salmon. Smoking is the preferred cheap method to preventing fish spoilage and prolonging the shelf life of fish. In most West African countries including Nigeria, smoking is the affordable and most widely used method for fish preservation [11,12]. Ward reported that 70% of the total fish catch in several communities in the third world are smoked [13]. Apart from reducing moisture content, the component of the smoke can induce changes in organoleptic, nutritional, chemical and physical properties [14]. Tull reported that smoking impacted pleasant flavours to fish product [15]. Research have shown various effects of processing methods on the nutritive quality and organoleptic properties of fishes [1,9,16]. The hot smoked rainbow trout had higher percentage proximate composition and better taste parameters than cold smoke, dried and raw [9]. According to Adejonwo, et al. the protein, fat, potassium, phosphorus and iron contents of oven dried Clarias gariepinus were higher than smoked dried [1]. The chemical composition of Bonga, Sardinella and Heterotis niloticus, showed a higher percentage oven dried protein, fat, carbohydrate, Na, K, Ca, Mg and Fe than smoke dried and raw [16]. There is still paucity information on the effects of electric oven dried and smoke dried fishes especially on L. coubie and M. rume which are the major constituent of fishermen catches in the study area. This study is designed to investigate the proximate composition, mineral content and organoleptic properties of L. coubie and M. rume subjected to electric oven and smoke drying methods.

Materials and Methods

Collection of samples

The Labeo coubie and Mormyrus rume samples were purchase from fresh landings of fishermen at Ahaha beach. The samples were put in a plastic container and carried to the Fisheries wet Labouratory of Cross River University of Technology (CRUTECH) Obubra campus. The samples were descaled, beheaded, thoroughly washed with distilled water and packed into separate bags, labelled and sealed to reduce microbial infestation. Three groups were constituted for each species, based on the processing method. Group A. (Oven – drying), B (Smoking drying) and C (Raw samples). Samples of group A were subjected to drying using electric oven at between 60 – 80°C in 5 hours to reduce their moisture content to below 10% while those of group B was done using a traditional drum (Kiln) for 12 hours and the fish were periodically turned at 20 minutes intervals to prevent charring [17]. The dried samples were wrapped using newsprint and polyethene bags and later taken to the laboratory for proximate analysis and organoleptic test.

Preparation of fish samples for analysis

The fish samples for each species and methods were chopped into pieces, blended and homogenized using mortar and pestle. They were packed in different bottles and labelled accordingly. The samples were analysed for protein, fat, moisture, ash and carbohydrate according to in each case, three replicates were maintained [18].

Determination of Crude Protein

This was measured following the kjeldahl method based on the total mineralization of the biological material in an acid environment, followed by distillation of nitrogen in ammonia form [18]. About 2g of the sample was weighed into a kjeldahl flask. Concentrated sulphuric acid was added in the presence of small amount of copper sulphate ($CuSO_4$), with selenium Oxide (SiO_2) and potassium sulphate (K_2SO_4). Mercury was also added as a metal catalyst. The flask was placed on an electric heater in a fume chamber until blacking occurs. Heating was continued for about 1hr after the solution had cleared until the black specks disappear and becomes greenish blue or blue indicating complete digestion. The content will then be transferred into a 25ml volumetric flask and allowed to cool. The digestion was followed by the addition of a strong base (NaOH) to liberate ammonia. The ammonia distilled, trapped in 0.5% boric acid indicator will then be titrated with 0.01N HCl. The percentage of gross proteinous nitrogen was calculated and converted to protein using the appropriate conversion factor (6.25) according to AOAC [18].

$$\text{Crude Protein (\%)} = \frac{V2 - V1 \times N \times 14 \times 100 \times 6.25}{1000 \times W}$$

Where: V1 = Volume of HCl used in blank titration
V2 = Volume of HCl used in sample titration
N = Normality of HCl used in titration
W = Weight of dried sample
14 = Conversion factor from Ammonium sulphate to nitrogen
6.25 = Conversion from nitrogen to protein

Determination of Fat

A quantity of about 5g of the sample was weighed and introduced into an extraction cartridge covered by cotton wool. The cartridge was placed in a 150ml glass soxhlet [18]. The solvent container was weighed and 400ml of n-hexane was added. The soxhlet will then be introduced into the container, placed on the heating mantle connected to a cryostat cooling thermostat. After 60minutes, the flask was disconnected and the solvent allowed to evaporate. The container with the fat was placed in an oven for 4hours at 100°c and then in a desiccators' for 30minutes and weighed. The weight difference gives the fat content of the sample.

$$\text{Lipid (\%)} = \frac{\text{Weight of the extracted lipid content}}{\text{Weight of sample}} \times 100$$

Determination of Moisture Content

The moisture content of the sample was determined by oven method. Petri dishes was washed and dried in an oven, cooled in desiccators and weighed two grams (2g) of the crushed sample was added to the separate dish labelled 1 and 2 and transferred to the oven set at 100°c for 5 hours. The dishes was removed after drying and allowed to cool before reweighing. The weight difference shows the moisture content [18].

$$\text{Lipid (\%)} = \frac{\text{Weight of the extracted lipid content}}{\text{Weight of sample}} \times 100$$

Estimation of ash content: Ash was determined by muffling the sample at 6000-7000°C to dry ash. A clean porcelain crucibles were heated in a muffle furnace at 6000°C and crucibles was then be weighted until a constant weight was obtained. The sample with the crucible was weighed and recorded. The sample was ignited at 6000°C for 6h or until the residue is uniformly greyish to white. Afterwards crucibles were transferred to the desecrator to cool them at room temperature for few minutes. Heating, desiccating, weighing, was repeated till a constant weight is obtained. Final constant weights of the crucibles were recorded. The following equation will then be used to determine the ash content of the dry fish samples

$$\textbf{Ash \%} = \frac{\text{Weight of Ash}}{\text{Weight of Sample}} \times 100$$

Estimation of carbohydrate: The percentage of carbohydrate was calculated by simply subtracts the total percentage of protein, fat, moisture and ash from 100. The following equation was used to determine the amount of carbohydrate according to Emendu and Emendu, [19].

Calculation: Carbohydrate (%) 100 – (% Protein + % Ash + % Moisture + % Fat).

Gross energy value

Gross energy values (kcal/g) was calculated by overall addition of the protein content multiplied by 4.27 and the total lipids content multiplied by 9.02 and using Atwater's conversion factors. The energy values were expressed as kcal/100 g.

Gross energy value= (4.27 x protein content) + (9.02 x fat content)

Mineral analysis

Some major minerals (Ca, Na, K, P, and Mg) and some trace minerals (Fe, Cu, Mn, and Zn) were analysed in the two fish species using Atomic Absorption Spectrophotometer (AAS) and Flame photometer. For mineral analysis accurately weighted ash samples were treated with nitric acid ($HNO3$), $HClO4$ and deionized water [18]. The concentration of mineral elements (sodium, iron, calcium, magnesium, zinc and manganese) was determined by Atomic Absorption Spectrophotometer (AAS). Phosphorus and potassium were determined using the calorimetry method at the appropriate wavelength. All determinations were done in triplicates and calculated as mean mineral content in (mg/100g dry weight).

Organoleptic Assessment

This was performed by semi-trained panellist using structured questionnaires on the following attribute (Table 1). Ten (10) members panel of assessors were recruited from the staff and students of Fisheries Department and each was presented with a questionnaire comprising of the attributes with the value of 1(poor) corresponding to the lowest and 5 (excellent) to the highest score for each parameter [20]. The fish samples were steamed cooked for 15 minutes using kerosene stove without any spices. Drinking water was given to the panellist to rinse their mouth between evaluations of the samples. The judges were asked to tick for each parameter of all the samples. The values of the parameter was denoted as follows

1. Poor
2. Fair
3. Good
4. Very Good
5. Excellent

Table 1: Organoleptic attributes used for steamed fish flesh evaluation

S/N	Attributes	Description
1.	Colour (Appearance)	Intensity of "whitish"/"creamish" colour, typical of steamed / dried fish.
2.	Flavour (Odour)	Intensity of perceived taste.
3.	Taste (Juiciness)	Intensity of juiciness of steamed fish flesh while chewing.
4.	Texture (Tenderness)	Intensity of softness perceived at the time of chewing.
5.	Oiliness	Intensity of oiliness perceived taste of a typical steamed fish flesh.
6.	Overall quality	Overall impression of the steamed fish based on the above.

Source: Alam et al (2012)

Data Analysis: The data from the study was analyzed using the Analysis of Variance (ANOVA) and means were separated using Duncan multiple range test (DMRT) with Statistical Package for social sciences (SPSS version 25) as describe by Steel and Torie [21]. The results were expressed in mean percentages and standard deviation.

Result

The result of the moisture, protein, carbohydrate, fat and ash content of raw, smoked and oven dried M. rume and L. coubie are shown in Figures 1 and 2. It shows that the highest moisture content (%) of 70.33± 2.68 and 66.60± 1.13 was recorded in raw and lowest of 18.75±0.73 and 31.10±1.87 in oven dried sample of M. rume and L. coubie respectively. The moisture content for the both species on the various drying methods was in order; Raw > Smoked > Oven dried. Other parameters such as protein, carbohydrate, fat and ash content of the methods decreased in the order of oven dried < smoked < raw in both species. Table 2 indicates comparison of the concentration and percentage of proximate composition (%) of raw. Smoked and oven dried in M. rume and L. coubie. The result revealed that moisture in L. coubie (66.60%) was lower than ($p<0.05$) in M. rume (70.38%) for raw samples. Smoked and oven dried samples also recorded higher (p<0-05) moisture content (%). The protein content (%) of raw (fresh), smoked and oven dried showed a higher value ($p<0.5$) in M. rume and L. coubie. similar trend on increase was recorded for carbohydrate, and fat except ash content which was not significant ($p<0.5$) in both species across the various methods.

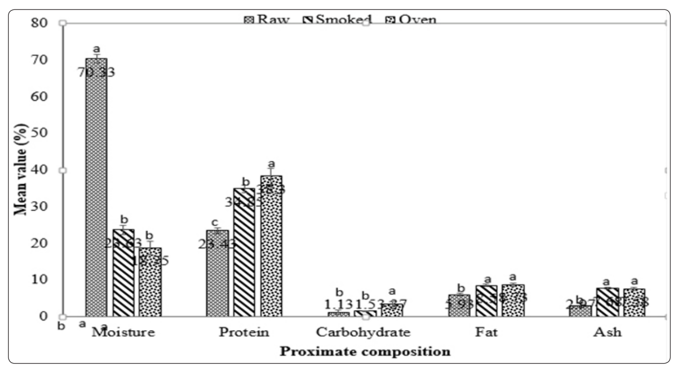

Figure 1: The mean values of the proximate composition of M. rume under different drying methods

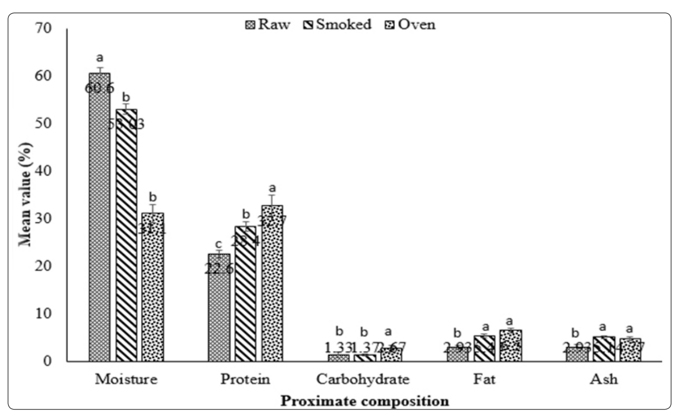

Figure 2: The mean values of the proximate composition of L. coubie under different drying methods

Table 2: Comparison of the proximate composition gross energy level of L.coubie and M. rume samples

		Drying Methods		
Parameter	**Species**	**Raw**	**Kiln**	**Electric**
Moisture	L. coubie	66.60^{b}	53.03^{a}	31.10^{a}
	M.rume	70.38^{a}	23.63^{b}	18.78^{b}
Protein	L.coubie	22.60^{a}	28.40^{b}	32.70^{b}
	M.rume	23.43^{a}	34.85^{a}	38.85^{a}
Carbohydrate	L.coubie	1.33^{a}	1.37^{a}	2.67^{a}
	M.rume	1.13^{a}	1.50^{a}	3.37^{a}
Fat	L.coubie	2.93^{a}	5.40^{b}	6.50^{b}
	M.rume	5.93^{a}	8.50^{a}	8.73^{a}
Ash	L.coubie	2.70^{a}	5.10^{a}	4.77^{b}
	M.rume	2.77^{a}	7.68^{a}	7.58^{a}
Mean with the same superscript are not significant at P< 0.05				

Gross energy level of M. rume and L. coubie

The gross energy level of the species is shown in figure 3. The result shows that electric (oven) dried samples of M. rume had the highest energy level 333.80±13.10kcal/100g, while the least of 112.97±8.63kcal/100g was recorded in raw sample. Similar trend of the drying methods in the order; Raw<smoked<oven dried was also observed in L. coubie. Comparison in the gross energy level of the species on the drying method shows that it was not significantly different (p>0.5) in fresh samples, whereas, smoked and oven dried samples of M. rume had a higher (p<0.05) energy level than L. coubie.

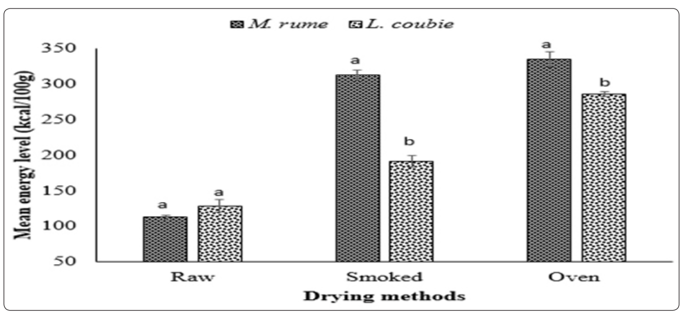

Figure 3: The mean values of the gross energy level of M. rume and L. coubie under different drying methods

Mineral composition of M. rume and L. coubie

The mean values of the mineral composition of M. rume and L. coubie is shown in figure 4 and 5. The result shows that K (238.00±3.62mg/100g) had the highest concentration while Ca (35.87±3.29mg/100g) was the least in raw M. rume. The minerals were decreasing in the order; K>P<Na<Fe<Mg and< Ca in each of the drying method. The drying method showed that the mineral were increasing in the order; Raw>Smoked dried and >oven dried. Similar trend in the concentration of minerals was also recorded in L. coubie with K (235.76±7.36mg/100g) having the highest concentration and Ca (30.30±5.56mg/100g) recording the least concentration in raw samples. On like in M. rume, the minerals decrease in the order; K>Na>P>Fe>Mg and>Ca. The least concentration for each element was recorded in raw samples while the oven dried had the highest mean concentration in all the element. The main values of the elements in both species showed that all the minerals were more concentrated in M. rume except Na which was highest in L. coubie. However, they were not significantly higher (p>0.05) in Ca, Mg and K elements.

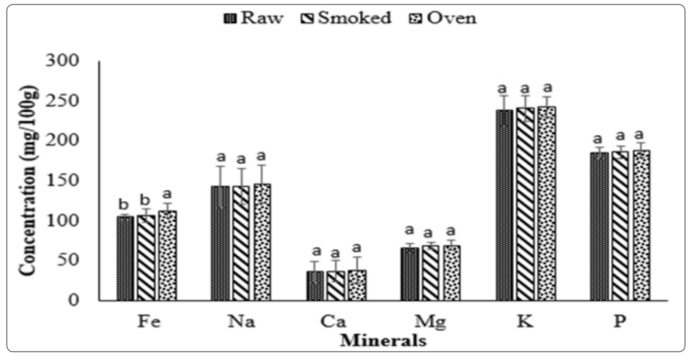

Figure 4: The mean values of the Minerals composition of M. rume under different drying methods

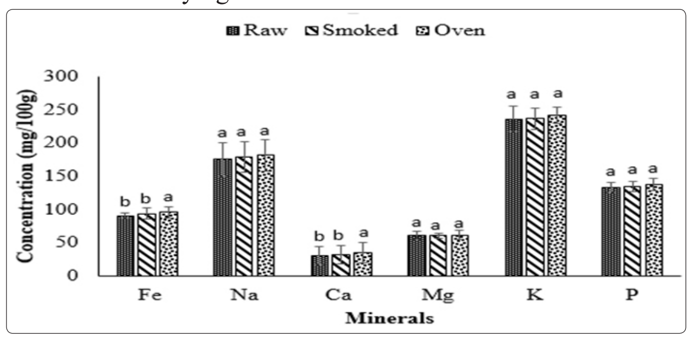

Figure 5: The mean values of the Minerals composition of L. coubie under different drying methods

Table 3: Comparison of the Mineral composition of M. rume and L. coubie samples

		Drying method		
Element	**Species**	**Raw**	**Smoked**	**Oven**
Fe	M. rume	104.37± 5.62^{a}	106.03± 2.44^{a}	112.42± 4.46^{a}
	L. coubie	90.86± 4.53^{b}	93.59± 1.92^{b}	95.68± 3.17b
Na	M. rume	142.31± 3.90^{b}	142.92± 2.77^{b}	145.11± 3.44^{b}
	L. coubie	175.12± 5.61^{a}	178.73± 4.61^{a}	181.27±3.45^{a}
Ca	M. rume	35.87± 3.29^{a}	36.44 ± 8.32^{a}	38.04 ± 6.46^{a}
	L. coubie	30.30 ± 5.56^{a}	32.54± 1.66^{a}	35.54 ± 3.69^{a}
Mg	M. rume	65.56± 1.45^{a}	68.41±5.26^{a}	68.78± 3.22^{a}
	L. coubie	60.85± 4.85^{a}	60.83± 4.63^{b}	61.41± 5.62^{b}
K	M. rume	238.00 ± 3.62^{a}	240.48 ±1.33^{a}	242. 34± 8.52^{a}
	L. coubie	235.76± 7.39^{a}	236.12 ±1.37^{a}	241.67 ±7.35^{a}
P	M. rume	184.79± 4.58^{a}	186.09±3.26^{a}	188.34±3.33^{a}
	L. coubie	133.25 ±7.75^{b}	135.13± 5.22^{b}	137.69± 6.46^{b}
Mean with the same superscript under the same column are not significant at p < 0.05				

Organoleptic properties

The mean score of the sensory properties of L. coubie and M. rume on raw, kiln and oven dried sample is presented in Table 4. The result showed that there were changes in all the sensory properties after subjecting the fishes to different drying methods. The best taste of 4.63 and 4.67 was recorded for kiln (smoked) dried samples of L. coubie and M. rume respectively. Although these were not significantly different from the oven dried samples. Similar result was also recorded in the flavour, texture and overall acceptability of the fishes. However the colour showed over dried samples 4.33 for both species to be more attractive that kiln dried samples (3.33).

Table 4: Mean scores of the sensory properties of L. coubie and M. rume processed by kiln (smoking) and oven (electric) drying methods

Sample	Method	Taste	Colour	Flavour	Texture	Oiliness	Overall Acceptable
L. coubie	Raw	3.33 ± 0.58^{b}	3.67 ± 0.58^{ab}	3.33 ± 0.58^{b}	3.67 ± 0.58^{b}	3.67 ± 0.58^{a}	3.33 ± 0.58^{b}
	Kiln	4.63 ± 0.58^{a}	3.33 ± 0.58^{b}	4.33 ± 0.58^{a}	4.00 ± 1.00^{a}	4.00 ± 0.00^{a}	4.67 ± 0.58^{a}
	Oven	4.33 ± 0.58^{a}	4.33 ± 0.58^{a}	4.33 ± 0.58^{a}	4.00 ± 0.00^{a}	3.67 ± 0.58^{ab}	4.33 ± 0.58^{a}
M. rume	Raw	3.33 ± 0.58^{b}	3.67 ± 0.58^{b}	4.33 ± 1.15^{a}	3.67 ± 0.58^{b}	4.33 ± 0.58^{a}	3.67 ± 0.58^{b}
	Kiln	4.67 ± 0.58^{a}	3.00 ± 0.00^{c}	4.33 ± 0.58^{a}	4.33 ± 0.58^{a}	4.33 ± 0.58^{a}	4.67 ± 0.58^{a}
	Oven	4.33 ± 0.58^{a}	4.33 ± 0.58^{a}	4.33 ± 0.58^{a}	4.33 ± 0.58^{a}	4.00 ± 0.00^{a}	4.33 ± 0.58^{a}
Mean with the same superscript under the same column are not significant at $p < 0.05$							

Discussion

Drying is a common practice in meat, fish and other animal protein based industry. It preserved its quality for an extended time and offers several advantages such as insignificant alterations and minimum deterioration in the product [16]. The moisture content of the samples was found to reduce in the order; Raw (fresh) <Smoke>Oven dried while the other parameters increased from Raw<smoke<oven dried. According to Olayemi, et al. processing by heating reduces moisture drastically and stated that it reduces the fishes susceptibility to microbial spoilage, oxidative degradation of poly unsaturated fatty acids hence maintaining the quality of the fishes for longer preservation time [22]. Similar reduction in moisture content of fishes subjected to various heating methods have also been reported by several researchers [16,23,24]. According to Effiong and Mohammed, water content in fish affects the microbiological, chemical stability, physical properties, processing, storage and distribution of fish [25]. A safe moisture content of 6 to 8% in dried fish is recommended in order to prevent spoilage due to microbe and pest proliferation [26]. The significant increases recorded in protein, fat, carbohydrate and ash content in the dried samples of the both species. When compare with the raw was in accordance with the findings of [27,28]. A higher mean values were recorded in oven dried samples of the both species similar to the report of Adewumi, et al. on C. Gariepinus [8]. The increase in protein composition in the dried samples especially oven dried suggest that Nitrogen is not lost during the process of drying. Similar increases were recorded for fat, carbohydrate and ash in both species in this study. This was in line the reports of Oguzhan and Angis using hot and cool smoking methods on Oncorhyncus mykiss and on Clarias gariepinus using smoking and electric oven drying methods [8,9]. The higher values of the parameters in oven dried samples which incidentally have the least moisture content in this study implies that there are affected by dehydration. Salan, et al. and Adewumi, et al. reported that oven dried fish had higher protein than fresh fish because of increase in protein due to dehydration of water molecule present between the proteins thereby causing aggregation of protein thus resulting in the increase in the protein content [17, 29]. The study also showed electric oven dried samples retain higher fat content than smoke dried. According to Norimab, et al. drying methods (sun, oven heating and evaporation) increased the fat content of the fish [30]. Lipid content has an effect on the eating quality of rainbow trout [31]. Fish with moderate fat contain low cholesterol and are good source of omega 3 fatty acids which protects against heart rhythm disorder and has benefit for blood clotting and vessel function [32]. According to Ackman, classification of fat L. coubie (45%) belong to medium fishes while M. rume (8.73%) belong to high fat fishes [33]. The variation in fat content among the species could be attributed to the different ability of fat metabolism and species differences. Holden, et al. revealed that lipid contents of fishes fluctuate considerably with age, feed and sexual cycle of fishes [34]. The increase in the amount of carbohydrate content on the dried samples in this study was in agreement with and on various fishes [16,17]. The carbohydrate content of fishes is generally very low compared with protein or fat [35]. Carbohydrate provides energy to perform various muscular and physiological activities. According to Adewumi, et al. low carbohydrate diet is recommended especially to diabetes patients by lowering blood pressure, weight loss and improving insulin sensitivity [17]. The result from this study revealed that, increase in ash content in the dried samples was due to loss in humidity. Similar observation was reported by [9,16,17]. The ash content was higher in M. rume than L. coubie. Differences in ash content of fishes have been reported by in Bonga species, Sardinella spcies and Heterotis niloticus subjected to various drying methods [16]. The total ash value is an indicator of the total mineral element contents in fish [36].

However, in spite of the revealed increase in the various parameters, some studies have shown that heat can reduce the nutritional quality of protein. The loss in available lysine from 6 - 33% at 25°c to 53 – 56% at 40°c during heating in plaice and haddock fishes have been reported by Huss, [37]. Lysine reduction was directly proportional to the temperature and duration of smoking [38]. Positive effects of drying methods on shelf life of fish have been reported by various researchers [39,40].

The gross energy value signifies the level of energy reserved in the fish and is a basic nutritional requirement because maintenance of life processes take priority over growth and other function [41]. Insufficient and excess energy level may result to reduce growth. The energy level in this study increase in the processing order raw < smoke < oven dried and higher in M. rume than L. coubie. They were far higher than the range of 19.51 to 27.30kj/g and 24.12kj/g reported for African catfish, Clarias gariepinus [42,43]. However these were lower than the range of 546.5 – 576 kcal/100g reported for Alestes baremose [44]. According to Akinyi, et al. high gross energy is a functional requirement for fish migration, growth and reproduction [45].

The mineral elemental content of each fish species is a function of the availability of these element in the water body where they live and the fish physiological state [46].The concentration of the mineral (Mayor and Trace) that contribute to the total ash contents are shown to vary in fish depending on their feeding behaviour, environment and migration [47,48]. This study shoes a similar trend of increase on various elements (Ca<Mg<Fe<P<Na<K) in both species. The study also reported that increase in the mean value of the elements in the various processing methods showed a decrease in the order; Oven dried>Smoke dried>Raw. Similar result was reported by Akinneye, et al. on various fishes [9,16]. The increase of elements in the various methods were proportional to the increase in the ash content of the fishes. This variations and decreasing trends of elemental compositions agrees with the reports of Akinneye, et al. on the chemical composition of Bonga spp, Sardinella spp and Heterotis niloticus [16]. Similar decreasing order of mineral form K was reported by on oven – dried Sarotherodon galilaeus, Lates niloticus and synodontis schall [49]. In this study Zn had the lowest concentration among the micro elements (Fe, Mg and Zn), which disagrees with the study of Akinneye, et al. who reported Zn as the highest among the micro element in fresh water fish species H. Noliticus [16]. This can be attributed to type of species or the water quality of the ambient environment of the fish. The mineral elemental content of each fish species is a function of the availability of these elements in the water body where they live and the fish physiological state [46]. All the element in this species where higher than those reported by Adejonwo on Pseudotolithus spp on some important commercial fishes of Jebl reservoir, Sudan [1,50]. Literatures have reported that K and Na are needed for the regulation of the pH, osmotic pressure, water balance, nerve impulse transmission and active transport of amino acids [41]. According to Watanabe, et al. calcium is responsible for clotting, muscle contraction, formation of bones and teeth in animals [51]. In this study Ca was the lowest among the macro element (K, Na, P and Ca) similar to the study of Hei and Sarojinalini who reported that 99% of Ca is found in bones and teeth, implying that it is being completely utilized for body tissue building [52]. Iron takes part in in the formation of haemoglobin, myoglobin and haemenzyme [53]. The concentration of Fe in this study was higher than that reported by several other researchers on various species even though it is a trace element [1,50]. However, all the element investigated in this study were within the WHO [54] recommended and permissible level for aquatic species. This implies that the consumption of these fishes will in no way affect the consumers and will provide the body with the required essential element for proper growth and development.

Organoleptic properties

Organoleptic properties of colour, flavour, texture and tastes were higher in L. coubie while M. rume was oilier and slightly acceptable in this study. The variation in the properties may be attributed to species, water quality, environment and the type of diet consumed. Alam, et al. reported that the organoleptic properties of farmed Labeo rohita was better than wild L. Rohita [55]. Food colour helps to determine quality, degree of processing and spoilage level [56]. Flavour is the combination of odour and taste, and is considered an important factor in consumer's acceptance of fish [9]. In this study the kiln dried samples had better taste, flavour and overall acceptability but with fair colour in comparable with oven dried samples of both species although higher in M. rume. This may be due to the fact the smoke from the wood may have imparted some specific compounds that influence the taste and flavour. According to Agbabiaka, et al. and Eyo wood contain chemical compounds such as carbonyl, phenols and syringol typical of hard woods that are responsible for the pleasant colour, taste and flavor/aroma in smoked products [4,57]. This findings was in agreement with Obande, et al. who reported that C. gariepinus smoked with firewood had better taste, flavour and overall acceptability than that coal [58]. High flavour and oiliness is an indication of a higher fat content in fish and may affect the taste giving them the characterization of more juicy and a white flesh [55]. Rawson showed a very strong correlation of sensory fitness and juiciness to the fat content [59]. Fat have been proposed to modify tenderness, bite, lubrication, elasticity and juiciness [60]. In this study M. rume had a higher fat and protein composition but less tasty than L. coubie, meaning that fat is not the only determinant for taste and flavour. The sensitivity of the taste buds of the panellist and the perception about a particular fish species may have been responsible for the differences in the properties recorded in this study. However, undesirable reactions associated with lipids and proteins may lead to detrimental changes in nutritional sensory properties of fishes [61].

Conclusion

The study showed that there were significant influences of the drying methods on the nutritive qualities and consumer's acceptability of the fish species. Oven dried has less moisture content, higher values of protein, fat, carbohydrate and ash in both species. High percentage protein and highly rich in fat especially M. rume, shows excellent reservoir for essential amino acids and fatty acids. The percentage ash content in these fishes is an indication of their good source of minerals required in human diets. The increase in the proximate and mineral compositions in the order of raw < smoked and < oven dried indicates the concentration of nutrients which is inversely proportion to the moisture content. Labeo coubie has less fat and carbohydrate hence should be recommended more for eating than M. rume. Organoleptic properties revealed that dried samples (smoked and oven) were not significant in taste, flavour, texture and overall acceptance, however while oven dried had better colour, smoked dried taste better. Oven drying can result to longer shelf life and intake of dried fish should be encourage due to its high nutritional qualities.

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