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ORIGINAL RESEARCH

PRELIMINARY ASSESSMENT OF PROXIMATE COMPOSITION, MINERAL AND ENERGY CONTENTS IN LOCALLY SMOKED *PELLONULA LEONENSIS* AND *SARDINELLA MADERENSIS* FROM BADAGRY CREEK, LAGOS STATE, NIGERIA.

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Abstract:
Introduction: Knowledge of food composition is crucial in the assessment of nutritional quality and potential contribution to recommended nutrient intakes. Fish plays a major role in ensuring food and nutritional security among the poor, vulnerable and rural fishing communities. However, in Nigeria, information on the nutrition content of some locally important fish species particularly after smoking or sun-drying is either lacking or missing.
Aim: The present study was carried out to evaluate (i) the nutritional value of two locally smoked clupeids (*Sardinella maderensis and Pellonula leonensis);* (ii) in relation to recommended nutrient intakes in pre-school children (< 5 years) and elderly (men and women >70 years) and (iii) linkages between nutrient access and intake.
Materials and Methods: Fresh samples were collected from Badagry Creek, smoked using local smoking kiln and analyzed according to AOAC standard method. Data were collected in duplicates and analyzed using t-test.
Results: There were significant differences (*P* =.05) in the proximate composition except for crude fibre between the two fish species. The percentage cover of daily recommended intake of phosphorous and calcium from the two species were very low (1. 81-3.7%; 0.023% - 0.0912%) but low to moderate for zinc (2 % - 22.50%) in pre-school children and the elderly.
Conclusion: Sequel to the results obtained in this study, the two smoked fish species showed good nutritive qualities for human health despite the low to moderate contents of calcium, zinc and phosphorus.
Keywords: Badagry Creek, clupeids, nutritional quality, smoked fish, Nigeria, recommended nutrient intakes.

All co-authors agreed to have their names listed as authors.

1. INTRODUCTION

Fish is one of the most affordable sources of essential fatty acids, protein, micro-nutrients, and other essential nutrients needed by human for the maintenance of their good health. Reports have shown that regular consumption of fish promotes the defence mechanism for protection against invasion of human pathogens because fish food has antimicrobial peptide [1]. Enormous significance of fish in enhancing food security both among developing and under developed nations has been reported [2]. In Nigeria, fish supplies 5.6% of total protein and 38.2% of animal protein [3] while fishing communities with greater access to fish for direct consumption have higher animal protein intake with fish contributing as much as 75 % [4].

Fishes of the family *Clupeidae* are the most common small fish consumed in Nigeria [4]. Occurring in a wide range of aquatic environments, they constitute an affordable and important source of food and nutrition in many inland and coastal fishing communities of West Africa. *Clupieds* are also economically important fish in international markets. Nigeria exports roughly 0.6% of *Sardinella* to Ghana [5]. In the coastal zone of Badagry, South-West Nigeria, *Sardinella maderenesis* and *Pellonula leonensis* are among popular fishes exploited by the artisanal fisheries [6]. Smoking is the most popular method of fish processing in Nigeria [7]. Notwithstanding the marked preference for smoked fish, information on the nutritional value of locally key species after common postharvest processing and preservation methods, such as smoking or sun-drying in the country is limited or often missing from nutrient composition databases [8].Hence, the present research aimed to provide a preliminary assessment of the proximate composition, some mineral and energy contents in smoked *Pellonula leonensis* and *Sardinella maderensis* caught from Badagry Creek to (i): evaluate the nutritional value of each species; (ii) assess each species in relation to recommended nutrient intakes in pre-school children (under 5 years) and the elderly (adults over 70 years) and (iii) to understand links between nutrient access and intake.

2. MATERIAL AND METHODS

2.1 Study Area

Badagry Creek (Figure 1) shares boundary with Republic of Benin and lies within longitude 2°42'E and 3°42'E and stretches between latitude 6°22'N and 6°42' N. Some water bodies such as River Yewa, Bawa and Doforo Creeks empty into it. The creek is about 60km long and 3km wide while its depth ranges between 1-3m [9].

2.2 Collection of Samples

Fresh samples of two clupeid species consisting of 150 specimens each of *P. leonensis* and *S.maderensis* were collected fortnightly from fishermen at the Boekoh Quarters landing site of Badagry Creek between December 2017 and February 2018. After collection, the fishes were transported to the laboratory of Department of Fisheries, Lagos State University and stored at -10^{0}C before further analysis.

2.3 Preparation of Smoked Fish Samples

Samples of the *S. maderensis* and *P.leonensis* were weighed using Mettler Balance *(*PM-400) and then thoroughly washed with tap water. Thereafter, the fish were smoked whole for 5 hours using local half – drum smoking kiln and hard wood as fuel. The fish did not require cutting or dissecting because of their small sizes*.* After the smoking process, the smoked fish were transported to the Laboratory of The Bells University of Technology, Ota, Ogun State, Nigeria where they were analyzed for proximate composition, mineral contents and energy.

2.4 Procedures of Proximate Analysis, Mineral Contents and Metabolizable Energy

The percentage of proximate composition of fish was determined by conventional method of [10]. Duplicate determinations were carried out on moisture content, total fat, crude protein and ash content. Carbohydrate content of samples was obtained in form of difference between 100 and the sum of moisture content, protein content, fat content and ash content values. Mineral Contents (zinc, calcium and phosphorus) were analyzed using [11] and determined using an Atomic Absorption Spectrophotometer according to [10]. For energy evaluation, Metabolizable Energy (ME) was determined according to methods described by [12].

2.5 Calculation of potential contribution to recommended nutrient intakes (RNI).

The potential contribution of each species to RNIs of nutrients of interest was adopted following the method described by.[13]. It was calculated first by assigning an average RNI target for each nutrient as shown in Table 1 for pre-school children (under 5 years old) and for adults (over 70 years old) and then by calculating the contribution from a standard portion of each species (50 g/day) as a percentage of the average RNI. The nutrients of interest considered were zinc, calcium and phosphorous.

2.6 Data Analysis

Data were computed using SPSS (Version 19.0) while results were presented as Mean ± SD (standard deviation). The differences in the mean values were tested with t-test and the level of significance was employed at p =0.05.

3. RESULTS AND DISCUSSION

3.1 Results

Proximate components were reported as percentage of smoked whole fish while the three minerals were reported in mg per kg but the RNIs values were presented as mg per 100 g smoked whole fish, for ease of use after [13].

3.1.1 Proximate Composition

The proximate composition of smoked *Sardinella maderensis* and *Pellonula leonensis* is presented in Table 2. Moisture content recorded in *Sardinella maderensis*(19.16±0.23%*)* was significantly (*P*=.05*)*

higher than moisture content of *Pellonula leonensis*(11.97±0.19%). However, the crude fibre content in smoked *S. maderensis*(0.18±0.01%) and smoked *P.leonensis*(0.26±0.02%) were not significantly different (*P*= .05).The differences between the ash content in smoked *S. maderensis*(14.72±1.13%) and smoked *P.leonensis*(12.88±1.04%) as shown in Table 2 was significant (*P*=.05). Similarly, total fat (19.12±0.09%) in smoked *S.maderensis* was higher (*P* =.05) than that of *P.leonensis* (13.48±0.42%).The crude protein value in smoked *P.leonensis* (31.21±1.03%) was significantly (*P*=.05) higher than smoked *S.maderensis*(27.75±0.44%) as recorded in Table 2. The carbohydrate contents of the smoked *P. leonensis*(30.22±2.70%) was significantly(*P* =.05) higher than the values of smoked *S.maderensis* (19.08±0.37%), while the Metabolizable Energy in the samples was significantly higher (*P* =.05) in the smoked *P.leonensis* (367.10±2.55 kcal/100g) than the smoked *S. maderensis*(360.25±4.16 kcal/100g).

3.1.2 Mineral Contents

Phosphorous was the most abundant mineral in smoked *P.leonensis (*25.35±0.25mg/kg) and *S. maderensis* (34.04±0.06mg/kg).This was followed by zinc with mean values of (1.35±0.00mg/kg) and (0.44±0.00mg/kg) in P. *leonensis and S.maderensis,* respectively. Also, the least concentrated mineral in P *.leonensis and S.maderensis* was calcium (1.00±0.01mg/kg) and (0.46±0.00mg/kg), respectively. The mean values of Calcium and zinc in both smoked *P.leonensis* and *S. maderensis* were not significantly (*P* =.05) different from each other as shown in Table 2. The value of phosphorus for smoked *P. leonensis*(25.35±0.25mg/kg) was significantly (*P* =.05) lower than that of *S.maderensis* (34.04±0.06mg/kg).

50 grams as a portion size was used to calculate how much of the two species studied in this work cover the recommended intake of nutrients per day Table 3. 50grams of *Pellonula leonensis* and *Sardinella maderensis* provide between 4.4 % and 22.50 % of the recommended intake of zinc per day for pre-school children. For women, the two species represent between 2.75% - 8.44% and for men between 2% and 6.13% of the recommended daily intake of zinc. For pre-school children, *P. leonensis* and *S.maderensis* cover between 2.53% -3.7% and for adults (men and women over 70 years) between 1.81% and 2.43% of the recommended daily intake of phosphorus. For pre-school children and adults, a 50 grams portion of *P.leonensis* and *S.maderensis* would provide between 0.023%- 0.0714% and between 0.0416% -0.0912% of the recommended daily intake of calcium, respectively.

3.2 Discussion

Studies have shown that nutrient content of fish is influenced by several factors including smoking method, wood types and time of smoking[15,16,17).Chemical composition of fish also varies greatly from one species and one individual to another depending on sex, age, season and environment[18].The moisture contents recorded in smoked *Sardinella maderensis* being significantly higher than moisture contents of smoked *Pellonula leonensis* could suggest that *S.maderensis* had higher water retention or lower osmo-regulation of water from their habitat. Reports have shown that low moisture levels in fish reduces susceptibility to microbial spoilage[19].The moisture contents obtained from both *S.maderensis* and *P.leonensis* in the present study were higher than that recorded in smoked *Lates niloticus, Clarias anguillaris* and *Synodontis membranaceus* respectively[20].The present moisture percentages were also higher than values recorded in smoked *S.maderensis* that were smoked with improved Nigerian Institute for Oceanography and Marine Research (NIOMR) and locally improvised Drum kilns[21].Likewise, the moisture contents obtained in the present study was higher than that reported from smoked catfishes.[22] On the contrary, the present moisture contents were similar to the values obtained in smoked *Liza falcipinni* [20] when improved NIOMR and locally improvised Drum kilns were used. However, the present moisture contents was lower than that recorded in smoked *Trachurus trachurus*[23].

According to the Ackman classification [24], both species analyzed for fat content were high in fat (>8 %) Total fat contents of smoked *P.leonensis* being significantly lower than that of smoked *S.maderensis* indicated that *S.maderensis* accumulated fat faster than *P.leonensis.*

However, both fish species could be properly exploited as a potential source of health beneficial fatty acids. Studies have shown that consumption of fish fat rich in omega-3 fatty acids aids in decreasing blood pressure[25] improving blood flow[26], decreasing the risk of psychiatric disorders and improving brain development[27].The fat content in both smoked *P.leonensis* and *S.maderensis* recorded in this study were higher than fat recorded in both smoked *Liza falcipinnis* and *Sardinella maderensis*[21].However, the fat content in the present study were lower than that reported in smoked *Trachurus trachurus*[23].

Differences in the crude fibre contents for both *P.leonensis* and *S.maderensis* examined in this study were not significant but lower than those reported by [20,28] and higher than that recorded in smoked *Trachurus trachurus* [23].The ash content in any fish sample is an indication of its mineral content[16]. The values of ash in this study suggested that the two fish species are good sources of minerals[29].The lower ash content of *P.leonensis* in comparison with *S.maderensis* could be due to amount of bone in *P.leonensis* and as well could suggest that *S.maderensis* had better mineral contents than *P.leonensis*. The ash contents recorded in this study was similar with the ranges obtained in smoked catfishes but higher than that in smoked *Oreochromis niloticus*[22]. The ash contents were also higher than those obtained in smoked *Lates niloticus, Clarias anguillaris* and *Synodontis membranaceus*[20]. In contrast, the ash contents in the present study were lower than that of *Liza falcipinnis* and *Sardinella maderensis* [21].

The crude protein values obtained in both smoked *P.leonensis* and *S.maderensis* indicated that both

species are better sources of protein than those of sheep meat (17.2g/100), cow meat (19.6g/100) and pork (19.4g/100) [20]. The high crude protein contents in both species (>15%) showed that the fish belong to the high protein fish category [30]. The crude protein of the smoked *P.leonensis* being significantly higher than that of smoked *S.maderensis* imply that *P. leonensis* is better in protein quality than *S.maderensis*. The crude protein contents of the smoked *P.leonensis* and *S.maderensis* in this study were similar to the findings of [20] and [31] who reported on chemical composition of smoked *Ethmalosa fimbriata*, but were lower than that reported by [21]. Also, the crude protein content in this study were lower than that recorded in smoked *Clarias gariepinus* using both NIOMR smoking kiln and local oven[32]. Similarly, the crude protein content reported [7] which compared crude protein level of C. *gariepinus* dried with local cut drum oven and NSPRI developed smoking kiln, and the findings on *Clarias gariepinus*, *Synodontis budgetti*, and *Oreochromis niloticus* respectively using Futy Smoking Kiln, Improved Hanger Smoking Kiln and Hybrid Solar Drier [33] exceeded the level obtained in the present study. On the other hand, the crude protein contents recorded in this study were higher than that in smoked *Trachurus trachurus*[23]. The present findings could also suggest that protein nitrogen was not lost during smoking. Fish protein is an excellent source of methionine, cysteine and lysine [16].However, the significant differences in the crude protein values of smoked *P.leonensis* and smoked *S.maderensis* could be due to absorption capability and conversion potentials of essential nutrients from their diets or their local environment [34].

The carbohydrate values obtained from the proximate analysis in this study indicated that both smoked *P.leonensis* and smoked *S.maderensis* were very rich in carbohydrates, although *P.leonensis* had the higher value. The carbohydrate contents recorded in this study were higher than that reported by [21] and [23]. Metabolizable energy recorded in both smoked *P.leonensis* and *S. maderensis* indicated that both fish species had very good quality energy. Similar findings have been reported in literatures [7]. The appreciable values of carbohydrate could be due to the presence of elements like calcium and potassium in their diets [29].

The content of primary macroelements occurring in fish (calcium, phosphorus, magnesium) is much higher than in other types of foods and the highest mineral contents are found in products containing whole, small fish such as sprats and sardines [35]. In the present study, phosphorus levels were lower than that reported in *Lates niloticus, Clarias anguillaris* and *Synodontis membranaceus* respectively [20]. Relative abundance of phosphorous may be due to the availability of the element in the water body and the ability of the fish to absorb it from their diet and the environment where they live [20, 33, 36].

Calcium contents were very low, averaging 1.0mg/100g in *P. leonensis* and less than 1 in *S. maderensis* but both fish had moderately high phosphorus content. The calcium contents recorded in this study were lower than that reported in smoked *Trachurus trachurus* [23] in smoked *Clarias gariepinus* [32], in smoked *Lates niloticus, Clarias anguillaris* and *Synodontis membranaceus* [20], in *Clarias gariepinus*, *Synodontis budgetti*, and *Oreochromis niloticus* [33]. Poor calcium concentration could be attributed to any or some of the following factors : (i) losses of macro- and micro elements are among undesirable changes that occur in products as a result of processing methods that raw fish are subjected. There could be (i) physical loss of lipids, amino acids, and micronutrients during the smoking process when fats and more water drips from the fish [35]; and (ii) sediments of Badagry Creek are sandy, slightly acidic and poor in nutrients [37].

In the two fish species, differences in concentration levels of minerals may be species-specific or attributed to their distinct chemical nature. The calcium content recorded in smoked *P.leonensis* and smoked *S.maderensis* being not significantly different could imply that both fishes had equal absorption capacity for calcium from their habitat. The phosphorus values of smoked *S.maderensis* being higher than that of *P.leonensis* could imply that *S.maderensis* had higher proportion of bone to flesh as the fish grows. Similar findings have been documented in literatures [16]. None significant differences in the zinc contents of both smoked *P.leonensis* and *S.maderensis* could be as a result of equal absorption of zinc from their natural environment[33].The zinc contents obtained in this study were lower than that reported by [20,32] respectively.

Compared to the equivalent of a 50g portion of hot-smoked sprats which contained over 15% of that of calcium and more than 25% of the recommended dose of phosphorous [35], the coverage of adequate daily intake for calcium from the two fish species appeared very low and may be linked to loses that might have occurred during processing. In the case of zinc, the two fish species can be said to effectively supplement low to moderate amounts of zinc while bioavailability may be higher than other food groups, such as plants [38].

4. CONCLUSION

In the present study, the two smoked fish species could be considered versatile in terms of nutritive values. However, since there is probability that the findings might have been influenced by the type of wood used in the smoking, future studies on the chemical composition of the firewood, the macronutrients of fresh samples of both fish species as well as detailed studies of micronutrients profiles should be undertaken in future studies. In addition, research will be needed to accurately interpret the real contributions of micro - and macro-nutrients based on availability and access for consumption.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

Fakoya, Kafayat Adetoun conceived and designed the study; undertook editing and reviewed manuscript.
Owodeinde, Fatai Gbolahan was involved in the write-up of the manuscript and also reviewed the manuscript.
Mekuleyi, Gabriel Olarinde performed the statistical analysis and was involved in the write-up of the manuscript.
Oyinlola, Akeem Adetunji.collected fish samples, conducted the experiment and was involved in the write –up of the manuscript.

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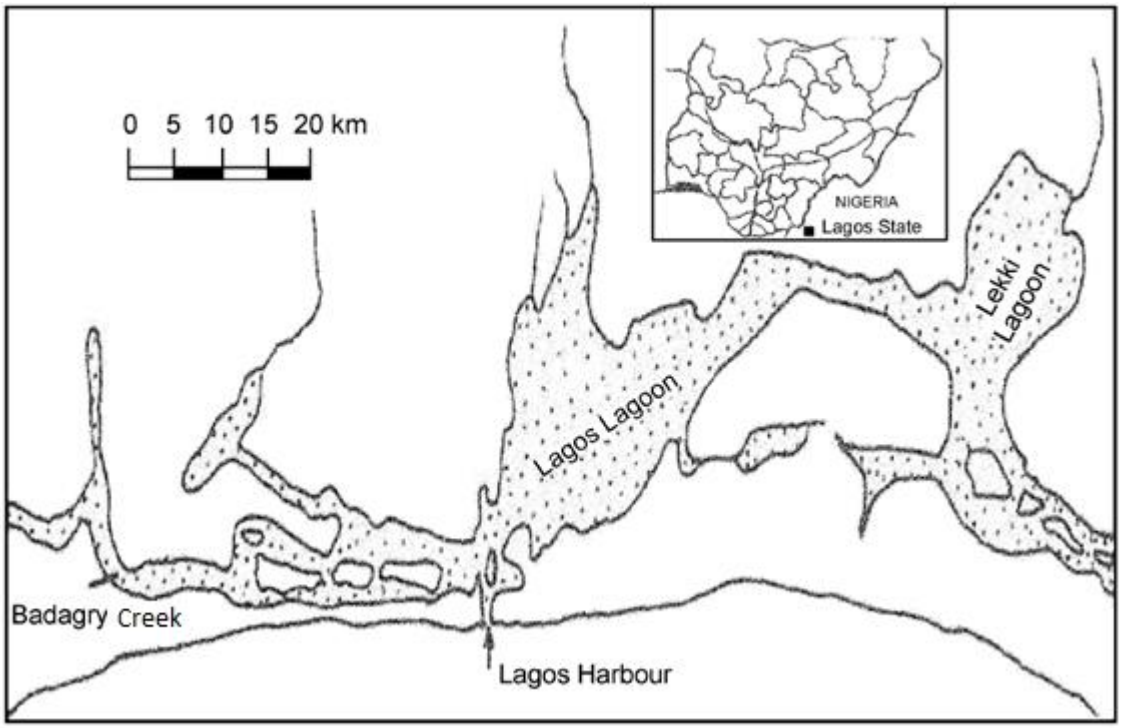

Figure 1: Map showing Badagry Creek in Lagos State, Nigeria

Table 1: The recommended intake of calcium, phosphorous and zinc [14]

Recommended dietary allowance:	**Calcium (mg/day)**	**Phosphorous (mg/day)**	**Zinc (mg/day)**
Pre-school children (1-5 years old)	700-1000	460-500	3-5
Men (over70 years old)	1200	700	11
Women (over 70 years old)	1200	700	8

Table 2: Proximate Composition and Mineral Contents of *Pellonula leonensis and Sardinella maderensis*

Parameters	**Smoked *Pellonulaleonensis***	**Smoked *Sardinellamaderensis***
Moisture Content (%)	11.97±0.19[a]	19.16±0.23[b]
Crude fibre (%)	0.26±0.02[a]	0.18±0.01[a]
Ash content (%)	12.88±1.04[a]	14.72±1.13[b]
Total Fat(%)	13.48±0.42[a]	19.12±0.09[b]
Crude Protein(%)	31.21±1.03[a]	27.75±0.44[b]
Carbohydrate(%)	30.22±2.70[a]	19.08±0.37[b]
Calcium(mg/kg)	1.00±0.01[a]	0.46±0.00[a]
Zinc(mg/kg)	1.35±0.00[a]	0.44±0.00[a]
Phosphorus(mg/kg)	25.35±0.25[a]	34.04±0.06[b]
Metabolizable Energy(kcal/100g)	367.10±2.55[a]	360.25±4.16[b]

Mean value with different superscript in the rows are not significantly different

Table 3: Potential contribution of smoked *Pellonula leonensis* and *Sardinella madarensis* in a standard portion, to average daily RNI (%) for pre-school children (1-5 years old) and adults (>70 years old)

RNI/ Mineral	**Age Group**	**Smoked *P.leonensis*** **Daily RNI (%)**	**Smoked *S. maderensis*** **Daily RNI (%)**
% RNI/50g Zinc	Pre-school children (1-5 years)	13.5-22.50	4.4-7.33
	Men (>70 years)	6.13	2
	Women (>70 years)	8.44	2.75
%RNI/50g Calcium	Pre-school children	0.05-0.0714	0.023-0.0328
	Adults (>70 years)	0.0416	0.0912
% RNI/50g Phosphorous	Pre-school children	2.535-2.755	3.404- 3.7
	Adults (>70 years)	1.811	2.431