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Variations in Proximate Composition of Clupea harengus (Fillet & Skin, Head and Bones (SHB)) after Different Heat Treatment

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Abstract
Clupea harengus is a table fish locally called *sawa* in south west Nigeria. It is among the freshwater fishes that are abundant and economically cheap. Present study assessed the effect of heat treatment on proximate composition and sensory qualities in the fillet and SHB (skin, head and bone) of *Clupea harengus*; using smoking (wood and coal) and poaching methods. Proximate analysis was done via standard analytical techniques and sensory evaluation of the processed fish was conducted by categorical ranking. All processing methods significantly (p<0.05) increased levels of protein and ash, but (p<0.05) reduced the fat and crude fibre contents in the fillet. Wood smoking of SHB recorded highest protein, ash and crude fiber contents of 55.65±4.20, 15.26± 0.53 and 13.40± 1.14 respectively. Highest protein concentration was obtained for wood & charcoal smoked in both fillet and SHB; but lowest in the poached fish (fillet and SHB). Moisture content was highest (72.07± 1.29%) in the poached SHB; but lowest in charcoal smoked fillet & SHB (44.01± 0.03 & 44.01± 0.00%) respectively. Wood and charcoal smoked fish samples were found most palatable by the panellists. Data obtained from this study demonstrated that processed fillet and SHB could be a veritable source of valuable ingredients for human consumption and animal feeds.
Keywords; Heat treatment; *Clupea harengus*; proximate; sensory evaluation, agricultural waste; discards

1. Introduction

Fish has long been recognized as a valuable source of high quality protein in the human diet. It is an important source of PUFAs, vitamin D, iodine and selenium (Swedish National Food Administration, 1994). In recent years, fish lipids have also assumed great nutritional significance owing to their protective role against the development of cardiovascular disease and rheumatoid arthritis (Kumaran *et al*, 2012; Ajayabhaskar, 2002). Hence, consumption of fish, is therefore being encouraged. *Clupea harengus* also called herring / *C. Harengus* (locally called *sawa* in south west Nigeria) is a table fish preferred and consumed by all the economic group of people; it is also considered low cost fish.

The knowledge on biochemical composition of any edible organisms is extremely important since the nutritive value is reflected in its biochemical contents. The demand for protein rich food is increasing, especially in developing countries, stimulating the exploration of unexploited or non-traditional resources. Fresh water fish are essential in the human diet, since it is an important source of nutrient and provides an inexpensive source of protein with a high biological value, essential minerals and vitamins that is required for body growth and maintenance(Adeyemi *et al*, 2013; Sinduja *et al*, 2013).

However, fishes need to be preserved, because they get spoilt very quickly even in temperate regions (Adeyemi *et al*., 2014). FAO (1986) gave three main fish processing methods as drying, salting and smoking. Heating is one of the common methods in food processing, applied to foods or fishes in different ways; boiling, baking, roasting, frying and grilling to enhance their flavour and taste and also to increase shelf–life (Oluwaniyi and Dosumu, 2009; Silva *et al.,* 2009). During cooking of fish products, chemical and physical reactions take place that improve or impair their nutritional value. Cooking induces water loss in the fish, but in turn increases its lipid content in most cases, and only some fats are lost in the case of the lean fish species (Gall *et al.,* 1983; Agbo, 2014). Smoking is the removal of most of the moisture content from the fish and the deposition of preservative chemicals on the fish flesh.

The flesh of moderately fat herring contains 11% fat (Stroud and Station, 1979), but there still remains scantiness of scientific information on the nutrient composition of processed *Clupea harengus,* especially the SHB, which is often discarded by most processors & consumers. In this study, *Clupea harengus* was chosen due to good consumer acceptance and economic availability (Nadcisa *et al*, 2001). In view of the increasing demands of fish supply and consumption in Nigeria, the present study was conducted to provide scientific information on the effect of processing methods on the proximate compositions in the raw, poached and smoked (coal and wood) fillet and SHB of *Clupea harengus* together with their sensory abilities.

2. Materials and Methods

2.1 Sample Collection

A total of 20kg of *Clupea harengus* was purchased from two popular major cold fish distributors (Asake and Heritage fisheries) in Ipata market, Ilorin, Nigeria. The mean length and weight of the fish was 30.52 ± 0.22 cm and 197.66 ± 3.67g respectively. *C. harengus* was prepared using handling process (i.e. thoroughly washed, eviscerated) and cooked by boiling and smoking using either firewood or charcoal. The processing methods were grouped into four (WSS: Wood Smoked *Sawa*; CSS: Charcoal Smoked *Sawa*; PKS: Poached *Sawa*; RS: Raw *Sawa*).

2.2 Sample Processing

A portion of the fish was poached in water at 60^{o}C for 15 min and the remaining portion hot smoked using either charcoal or firewood in a conventional smoke kiln as described by FAO/UN (2007). All cooking processes were done without addition of any ingredient.

2.3 Analytical Method

After poaching and smoking, fish samples were dried in a microwave oven to constant weight at 60^{o}C, and the flesh of each fish was separated from its bones, skin and head. The skin, head and bones were collectively homogenized while the fillet alone was homogenized using a kitchen blender and analyzed to determine the proximate composition in each of the fish samples on dry matter basis.

The crude fiber was analyzed according to the method of Antia *et al* (2006) whereas moisture, fat, ash and protein of the fish samples were determined following the method described by AOAC (2002). Five grams (5.0g) of dry ground sample was digested in 100 ml of 1.25% H_2SO4 for 30 min. The digested sample was cooled and filtered and the residue was collected into a beaker and further digested with 100ml of 1.25% NaOH. The residue was collected after filtration and oven dried at 100^{o}C to constant weight. Dried residue was incinerated in the muffle furnace at 550^{o}C for 5 h. Crude fiber value was obtained from loss in weight of the fish samples on ignition of dried residue remaining after digestion of free fat samples. % crude fibre = (loss of weight on ignition/ Weight of sample used) × 100%.

Moisture content was determined by heating 2.0g each of sample to a constant weight in a crucible placed in an oven maintained at 105ºC. Crude fat was obtained by exhaustively extracting 5.0g of each sample in a Soxhlet apparatus using petroleum ether (40 – 60^{o}C) as the extractant. Crude protein (% total nitrogen x 6.25) was determined by the Micro-Kjeldahl method of AOAC (1984) modified by Okalebo *et al.,* (2002). Ash content was carried out by incinerating 1.0 g of the fish sample in a muffle furnace maintained at 550^{o}C for 5h.

2.4 Sensory Evaluation

Sensory evaluation was conducted using the categorical ranking (highest, good, fair and rejected quality), by taste panel consisting of ten experienced judges using the guidelines described by DOCE (1989) and Eyo (2001).

2.5 Statistical Analysis

Significant differences between means of experiments were determined by least significant difference. SPSS 14.0 statistical tool was used to analyze the data obtained (SPSS, 2005). Results were considered statistically significant at $p < 0.05$ with Duncan's multiple range test (Duncan 1955).

3. Results

3.1 Proximate composition: The results of proximate analysis of raw and processed fillet and SHB are presented in Table 1 & 2. The values obtained for the proximate analysis indicated that there was significant ($p<0.05$) increase in the levels of protein and ash in the smoked fillet compared with the raw sample, for all processing methods. Values were; 66.06±1.52, 61.76±2.08 & 48.67±4.86 for the crude protein contents of WSSF, CSSF compared to RSF: 5.06± 0.24, 5.00± 0.12 compared to 4.66± 0.82 for ash contents of CSSF, WSSF, & RSF respectively. Conversely, the level of fat significantly ($p<0.05$) decreased i.e. 8.21±0.00, 8.06± 0.02, 7.89± 0.01 & 9.16± 0.09 for PSF, WSSF, CSSF, and RSF respectively.

Additionally, data showed that all processing methods significantly ($p<0.05$) increased in protein, ash and crude fibre contents i.e. 55.65±4.20 = 55.60±4.18 > 40.59±1.39 to 47.59±0.88 for crude protein contents of WSSHB = CSSHB > PSHB & RSHB: 15.26± 0.53 > 13.46±0.58 > 11.53±0.31 compared to 9.06± 0.33 for ash contents of WSSHB, CSSHB, PSHB to RSHB: 13.40± 1.14 > 8.40± 0.12 = 8.13± 0.13 to 4.66± 0.68 for WSSHB, CSSHB, PSHB to RSHB respectively. The fat content was significantly ($p<0.05$) increased and was highest in CSSHB (12.92± 0.01) followed by the PSHB (8.26± 0.18) compared to RSHB (7.43±0.26). Furthermore processing methods altered ($p<0.05$) the moisture content, were the CSSHB (44.01± 0.00) & WSSHB (46.67± 0.02) had significantly the lowest ($p<0.05$) values compared to the RSHB (71.22± 0.71). Thus findings emphasized that both raw and processed SHB had significantly high ($p<0.05$) amounts of protein, fat,

ash and crude fibre than in the raw and processed fillets.

3.2 Sensory Evaluation

The scores given by the panellists according to the Standard National Indonesia, (1991) scheme for each parameter in both the raw and processed fish parts are presented in Table 3 and 4 respectively. The merit points calculated for each fish part in decreasing order of acceptance by the panellist in terms of flavour, texture and color as follows; WSS > CSS > PS. The CSS had the best ($p < 0.001$) score for odour (9.20) and colour (9.60) respectively, while WSS had best ($p < 0.001$) score for flavour (9.80) and texture (8.20) compared to the other processing methods. Furthermore, the organoleptic results (Table 3&4) showed that the WSS had the best scores of 9.80 point for flavour/taste; 8.20 for texture and 9.60 for colour compared to the other processing methods.

Table 1. Proximate Composition (%) of Raw and Processed Fillet*

GROUPS (%)	RSF	CSSF	WSSF	PSF
PROTEIN	48.67±4.86 ^{b}	61.76±2.08 ^{b}	66.06±1.52 ^{a}	52.38±5.27 ^{b}
FAT	9.16± 0.09^{a}	7.89± 0.01^{b}	8.06± 0.02^{b}	8.21±0.00^{b}
ASH	4.66± 0.82^{b}	5.06± 0.24^{a}	5.00± 0.12^{a}	4.20±0.23^{b}
CRUDE FIBRE	1.66± 0.67^{a}	1.26±0.18^{b}	1.53±0.07^{a}	1.20± 0.01^{b}
MOISTURE	71.22±0.00^{a}	44.01± 0.03^{b}	46.67± 0.02^{b}	72.05± 1.14^{a}

*Data= Mean ± SEM, n=3. Values with different superscripts along a row are significantly different ($p < 0.05$). CSSF: charcoal smoked *Sawa* fillet; WSSF: wood smoked *Sawa* fillet; PSF: poached *Sawa* fillet; RSF: Raw *Sawa* fillet.

Table 2. Proximate Composition (%) of Raw and Processed (SHB)*

GROUPS (%)	RSHB	CSSHB	WSSHB	PSHB
PROTEIN	47.59±0.88 ^{b}	55.60±4.18 ^{a}	55.65±4.20 ^{a}	40.59±1.39 ^{c}
FAT	7.43±0.26^{b}	12.92± 0.01^{a}	4.65± 0.02^{c}	8.26± 0.18^{b}
ASH	9.06± 0.33 ^{c}	13.46±0.58 ^{a}	15.26± 0.53 ^{a}	11.53±_0.31 ^{b}
CRUDE FIBRE	4.66± 0.68^{c}	8.40± 0.12^{b}	13.40± 1.14^{a}	8.13± 0.13^{b}
MOISTURE	71.22± 0.71^{a}	44.01± 0.00^{b}	46.67± 0.02^{b}	72.07± 1.29^{a}

*Data= Mean ± SEM, n=3. Values with different superscripts along a row are significantly different ($p < 0.05$). CSSHB: charcoal smoked *Sawa* SHB; WSSHB: wood smoked *Sawa* SHB; PSHB: poached *Sawa* SHB; RSHB: Raw *Sawa* SHB.

Table 3. Showing Result of Sensory Evaluation of Processed *C. harengus* *

PARAMETERS	CSS	WSS	PS
Odour	9.20±0.32^{a}	8.80±0.32^{a}	8.72±0.55^{a}
Flavour/Taste	9.20±0.32^{a}	9.80±0.20^{a}	8.00±0.54^{b}
Texture	8.00±0.79^{a}	8.20±0.62^{a}	7.09±0.62^{b}
Colour	9.60±0.27^{a}	9.60±0.40^{a}	7.27±0.82^{b}

*Data=Mean ± SEM, n=10. Values with different superscripts along a row are significantly different ($P < 0.05$). CSS: Charcoal smoked *Sawa* WSS: Wood smoke *Sawa*; PS: Poached *Sawa*

Table 4. Showing Result of Sensory Evaluation of Raw *C. harengus* *

Parameters	Eyes	Gills	Skin Colour	Flesh texture
RS	6.40 ±0.97	8.00±0.42	8.80 ±0.44	9.20±0.44
GRADE	2.60±0.85	1.70±0.26	1.70±0.26	1.70±0.26

*Data= Mean ± SEM, n=10. RS values were graded as described by Baremo de Classification de Frescura, (1989) & Eyo, (2001) Rk: Raw *Sawa*

4. Discussion

Biochemical components such as protein, carbohydrates and lipids are essential for body growth and maintenance. Fishes are consumed as a major protein source in food, it is therefore important that the protein content be not compromised during table preparation. It is significant to note from current findings of this study that all processing methods increased ($p<0.05$) the crude protein contents of both the fillet and SHB parts. Also the raw *Clupea harengus* had ($p<0.05$) high crude protein content in SHB, which was lower ($p<0.05$) than the crude protein contents of *S. Scombrus* (66.28%) and *T. Trachurus* (65.65%) respectively (Oluwaniyi & Dosumu, 2009; Adeyemi *et al.*, 2013).

Present investigation showed that the maximum level of protein (61.76±2.08 & 66.06±1.52%) and ash (5.06± 0.24 & 5.00± 0.12) were recorded in the smoked (wood & charcoal) fillet respectively. This result opposes the reports of Oluwaniyi & Dosumu, 2009, who reported significant reduction in the protein content after smoking, but agrees with the report of Adeyemi *et al.,* (2013). Also, wood smoking significantly ($p<0.05$) decreased the oil content of *Clupea harengus* fillet & SHB, thus suggesting that some volatile oil materials in the fish may have been expelled at this high temperature.

Furthermore, fish samples were smoked at 110ºC; these processing method reduced ($p<0.05$) moisture content of the fish samples. Smoking often results in decrease in moisture content that results in desirable non-enzymatic browning reactions. These may be because the smoking temperature was higher than the boiling point of water. Thus reduction in moisture content in both the fillet and SHB, invariably improved the quality of the fishes for longer preservation time, because low moisture levels in fish reduces the fishes' susceptibility to microbial spoilage and oxidative degradation of polyunsaturated fatty acids (Allen, 1987; Frankel, 1991; Oparaku & Nwaka, 2013).

It is important to also not that the SHB had high ($p<0.05$) level of protein (55.60±4.18 & 55.65±4.20), which also increased ($p<0.05$) with smoking (wood & charcoal) methods but decreased ($p<0.05$) with poaching. Also SHB had ($p<0.05$) high level of ash in raw sample, which increased ($p<0.05$) with all processing method, i.e., WSSHB (15.26± 0.53) > CSSHB (13.46±0.58) > PSSHB (11.53±_0.31) compared to RSHB (9.06± 0.33). Ash is a measure of the mineral content of food item. It is the inorganic residue that remains after the organic matter has been burnt off (Olagunju *et al*., 2012), the increase in ash with processing indicates that *C. harengus* is a good source of minerals (Adeyemi *et al.,* 2013).

The levels of crude fibre in the SHB were also ($p<0.05$) high, and increased considerably with processing compared with the raw sample i.e. WSSHB (13.40± 1.14) > CSSHB (8.40± 0.12) = PSSHB (8.13± 0.13) compared to RSHB (4.66± 0.68). Crude fibre is responsible for ease of bowel movement (Adeyemi *et al.,* 2013). The increase in crude fibre with processing indicates that *C. harengus* is a good source of fibre.

Changes in the moisture contents of the poached fillet, as well as the moisture and fat content of the poached SHB were significant ($p>0.05$). This might be because the poaching temperature (60ºC) was not high enough to cause any morphological change in the fish samples. Similar results were reported by Oluwaniyi & Dosumu, (2009). In addition data obtained from sensory evaluation revealed that both raw and processed fish were in good quality that warranted general acceptance.

All the processing methods are equally good as they could help in extending the shelf life of the fish products, with an exception of boiling method. These methods could keep the fish products free from spoilage microorganisms attack for some time, but wood smoking was observed to be the best in terms of lower moisture and highest levels of protein, lipid, ash and crude fibre in the final products.

5. Conclusion

We conclude from our studies that all the processing methods for had selective effect on the proximate composition of both the fillet & SHB of *Clupea harengus*. However, the wood smoked method showed the best result in terms of protein, ash and crude fibre content. Our data revealed that leftovers or discards (i.e. SHB) were equally rich in some nutrients, thus could be an appropriate item for human diet or potential ingredient for animal feeds. Further studies are highly needed to evaluate the toxic effect of these methods in animal models.

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