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Full Length Research Paper

Effect of processing on the nutritional qualities of three fish species (*Synodontis clarias, Trachurus trecae* and *Clarias gariepinus)*

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The effects of different processing methods (oven drying, solar drying, smoking and boiling) on the proximate composition and organoleptic properties of three fish species (*Clarias gariepinus, Trachurus trecae* and *Synodontis clarias*) were investigated. The objective of this work is to know the best processing methods, the effect of processing on organoleptic characteristics and nutritional values of fish products. The result of the proximate composition of the fish species showed that the highest protein content (61.21%) was in *C. gariepinus* processed with solar dryer. The result of moisture content indicated that solar dried products were consistently lower in all the fish products, the least (14.21%) was in the *S. clarias* while all the boiled fish products had the highest moisture percentage, as would be expected was high in all the boiled fish products. Protein was higher in the fish products processed with solar. The lipid was reduced to the least value of 1.12% in the *S. clarias* processed with solar dried. In drying, the important factors for consideration are moisture, lipids and protein, though low moisture would ensure fish product with extended shelf life or can keep for a couple of weeks. To have a longer shelf life, high protein is desirable, low lipid is equally desirable as to reduce oxidation and rancidity in the fish products which causes off- flavor and bad taste in fish products. The overall performance showed that for flavour, the highest value recorded was 2.9 in solar dried *S. clarias*. In conclusion, all the other processing methods are good and could extend the shelf life of the products with an exception of boiling method; they could keep the fish product free from spoilage and microorganisms attack for some period. Solar drying was adjudged to be one of the attractive means of processing fish products. The organoleptic properties of the fish species were determined using questionnaires. This study clearly indicated that the proximate values obtained could be of help in choosing fish based on nutritional values.

Key words: Oven drying, solar drying, smoking and boiling, processing, *Clarias gariepinus, Trachurus trecae*, *Synodontis clarias*.

INTRODUCTION

Fish is an extremely perishable food item (Agbo et al., 2002). The resultant effect is the decomposition of the fish (Akinola et al., 2006). Various factors are responsible for fish spoilage. The enzymes begin to break down fish tissues. Prior to death, the enzymes were involved in the digestion of ingested food and all enzymatic reactions are controlled. In the dead fish, the control system fails and the enzymes begin to act on the alimentary system and fish flesh, thereby resulting in soft destructive changes. This process is referred to as autolytic spoilage.

The reason for fish processing is to give the product a form which is attractive to the consumers and storage life of fish is extended. The characteristics (for example

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organoleptic flavour) of processed fish to be stored should ensure full health safety of the product, proper sanitary conditions as well as rendering it impossible for the development of harmful micro-organisms and toxins (Ita, 1972). Davies (2005) suggested appropriate processing technologies to enable maximal use of raw material and thus contribute to increase economic profitability. The poor handling and preservation practice after capture affects the degree of spoilage of the fish (Akinneye et al., 2007). Fresh fish after capture should be properly handled if the keeping quality and shelf life are to be improved reasonably (Anthonia, 1970). This will reduce the period the fish will remain in rigor or stiffened; thereby, accelerate bacteria attack and spoilage. Catfishes are known to remain alive for a long time after capture and should not be stunned. Other species should be demobilized by piercing the brain with a sharp object or by giving a blow to the head to ensure instant death. Fresh fish deteriorates very rapidly. It is necessary to ensure that fish and fish products get to the consumer in acceptable quality. The initial handling of freshly caught fish prior to processing must fulfill certain conditions to maintain the acceptable quality (Azeza, 1979). Fish should be chilled to minimize microbial spoilage (Davis, 2006, 2005). Fish is a major source of protein and its harvesting, handling, processing and distribution provide livelihood for millions of people as well as providing foreign exchange earning to many countries (Al-Jufaili and Opara, 2006). Thus, it is imperative to process and preserve some of the fish caught in the period of abundance, so as to ensure an all year round supply. This will invariably reduce post harvest losses, increase the shelf-life of fish, and guarantee a sustainable supply of fish during off season with concomitant increase in the profit of the fishermen (Eyo, 1997).

Different types of processing methods include: drying, smoking, freezing, chilling and brining. But the most prominent fish preservation in Niger Delta is smoke drying. This could be adduced to the fact that most of the fish communities have no access to electricity to freeze their products. Electricity itself is fast becoming a less reliable source of energy for fish processing and preservation (Akinola et al., 2006).

This includes upgrading the traditional fish processing technology and adoption of solar dryer. Artificial dryers such as solar dryer, kiln, and oven and so on have long been in existence, some of them are powered electrically, by sun, gas or natural fuel such as firewood, charcoal, and wood and saw dust (Akinola et al., 2006). This is adduced to the fact that exportation of processed fish to developed countries is becoming increasingly stringent because of the emerging set of Food Safely and Agricultural Health Standard, along with buyers changing their requirements (Ito, 2005). Studies have shown that the development of appropriate fishing machinery and techniques that employed effective production, handling, harvesting, processing and storage, cannot be over-emphasized especially in the age when aquaculture development is fast gathering momentum in Nigeria (Akinola et al., 2006). Tawari (2006) reported 10-15% losses during fish drying and 12-20% during storage in Niger Delta. Eyo (1997) reported a loss of 1000 metric tonnes of fish to 35% in Kainji Lake which was estimated to about ₦80 million and was lost during handling of fresh fish alone in 1995. The aims and objectives were:

1. To determine proximate (lipid, protein, fats, moisture and carbohydrate) composition of the three fish species processed by different methods: solar drying, smoking and electric oven dried.
2. To determine the organoleptic properties of the fishes.

MATERIALS AND METHODS

Collection of experimental fish

Three fish species: *Synodontis clarias*, *Trachurus trecae* and *Clarias gariepinus* were used for the experiment. The fish species which were purchased from Otuocha market in Anambra State (about 120 km from Nsukka) was then transported to the laboratory in polystyrene boxes which was perforated at the upper side so as to allow for the entry of air. These fish were divided into three groups (A, B and C), with 15 fish in each group. Prior to boiling, solar drying, smoking and oven drying, the fish groups were salted using the procedure outlined below. The fish was clear with clean water and soaked for 1 h (1.5 h for large fish) in not too strong brine; the brine was made by dissolving 300 g of salt in every four litres of water. By submerging the fish in this brine, the blood and slime are removed. The fishes were then removed after some minutes and washed with clean water, after washing; the fishes were then placed in a saturated brine solution: 3.0-3.5 kg of salt, in 10 L of water. Group A: *S clarias*, Group B: *T. trecae*, and Group C: *C. gariepinus*, were placed on a clean board with clean washed stones on top of the container until the fishes were covered by the brine. The fishes were left for 6 h in the brine. After the 6 h, they were taken out of the brine and placed on a bamboo rack to drain, taking care not to let the fish overlap while on the rack to facilitate faster moisture removal. The fishes were placed in the electric oven solar dryer and smoker and allowed to dry. The salting method described in the foregoing was carried out for the four processing methods. The fillets from each fish species were divided into four groups for boiling, solar drying, oven drying and smoking as described below, 3 g of each were measured out in four places (according to their individual grouping under each fish species group) to be used for proximate analysis. Fish were placed inside the solar and kept in the solar dryer till the end of the drying period. It took three days for solar dryer to be completed; oven drying and smoking was carried out using the same treatments and methods. Oven was set at 110°C for 10 h while

smoking was uncontrolled and lasted for 2 days. Temperature and humidity was measured with temperature and humidity indicator. At the end of the drying period, fish was stored away in clear polythene bags for chemical and microbiological analysis. 3 g of each fish was weighed out to be used for proximate analysis. Data from organoleptic flavour of each fish groups were obtained using questionnaires (Larmond, 1977).

Proximate analysis

The hot oven method was adopted for moisture content, whereas the AOAC (2005) (Official methods of analysis of the Association of Analytical Chemist) method was used for ash content. The Microkjelahl method of Hilditch and Williams (1964) was used in the determination of the crude protein content, and carbohydrate determination was estimated by standard methods. Determination of ash content was done following standard method by Association of Official Analytical Chemists (AOAC, 2005). Determination of crude fat content was done. Soxhlet extractor was used (Renee and Griffiths, 1998). The percentage fat content was calculated using the following formula:

% Fat = C-B/A*100/1

Where A = weight of empty flask, B = weight of sample, and C = weight of flask + oil after drying.

Organoleptic characteristics method

Subjective analysis was used for organoleptic characteristics analysis, in which staff and students were used to carryout the tests. Twenty members of the panel were selected for each parameter like flavour, texture, appearance and palatability trained on the rudimentary aspects of organoleptic characteristics and how to apportion mark to each parameter. Fish products samples were issued out in conjunction with questionnaires. The fish samples were given out with questionnaires for the panel members to feel and taste the fish products and scored based on how it appealed to the taste, texture, palatability and odour. The questionnaires were returned and marks were appropriately apportioned to each parameter (Oparaku, 2012).

RESULTS

Effect of oven drying on proximate composition

The moisture percentage in oven-dried fish products from different fish species: *C. gariepinus*, *S. clarias* and *T. trecae* were 8.92, 15.60 and 33.05%, respectively. The moisture percentage composition in *T. trecae* was highest as compared to the other two fish species (*C. gariepinus* and *S. clarias*), indicating that it might have high susceptibility to microbial spoilage as a result of high moisture percentage composition.

The crude protein levels in the fishes were 32.40, 56.915, and 45.71% for *C. gariepinus, S. clarias* and *T. trecae*, respectively. The protein level in oven-dried fish products was high and significant ($P<0.05$) in *S. clarias* compared to *T. trecae* and *C. gariepinus* that had the least level of crude protein (32.40%). The ash content gave a remarked decrease in all the fish species. However, *C. gariepinus, S. clarias* and *T. trecae* had 13.15, 6.55 and 8.83% ash content respectively. The carbohydrate level in the oven-dried fishes was remarkable in *C. gariepinus* with 25.18% compared to *S. clarias* and *T. trecae* with 8.24 and 6.413%. The lipid of the fishes was non significant and was seen in traces except *S. clarias* that had 12.60% lipid composition which was quite high.

Effect of boiling on proximate composition

The boiled *C. gariepinus* showed the following proximate composition: moisture (61.85%), protein (22.33%), ash (13.15%), carbohydrate (9.252%) and lipids (1.71%) compared to *S. clarias* with nutritional composition of 58.50% moisture, 28.89% protein, 8.30% ash, 1.705% carbohydrate and 2.60% lipids. *T. trecae* had 33.05% moisture, 45.71% protein, 8.83% ash, 6.413% carbohydrate and 6.0% lipids. It was evident that boiled fishes especially in *C. gariepinus* showed a remarkable increase in moisture compared to *T. trecae* and *S. clarias.* Moisture content in *C. gariepinus* exposed to solar dryer was 15.62%, while *S. clarias* and *T. trecae* had 14.21 and 17.21% respectively. The higher protein percentage composition was recorded in *C. gariepinus* with 61.21% compared to other fishes. Solar dried fish nutritional composition was as follows: ash (3.62%), carbohydrate (3.84%) and lipids (1.96%) for *C. gariepinus*. *T. trecae* had 2.12% ash, 3.12% carbohydrate and 4.02% lipids, while *S. clarias* proximate composition was given as ash (2.91%), carbohydrate (3.81%) and lipids (1.121%). The moisture level of smoked fishes showed a significant increase in smoked *S. clarias* with 21.10% compared to *C. gariepinus* and *T. trecae* with 19.35 and 19.21% respectively. The protein levels of the smoked fishes were 21.3, 32.14 and 21.14% for *C. gariepinus*, *S. clarias* and *T. trecae* respectively. *S. clarias* appeared to have a slight increase in protein level compared to other fish species. The ash content, carbohydrate and lipids were slightly low as shown in Table 1. In summary, the result of moisture content indicated that solar dried products were consistently lower in all the fish products, the lowest (14.21%) was in *S. clarias* while the highest as would be expected was in all the boiled fish products. Protein was higher in the fish

Table 1. Effect of different processing methods on proximate composition of the fish species (*Synodontis clarias*, *Trachurus trecae* and *Clarias gariepinus*).

Fish species	Treatment	Moisture (%)	Crude protein (%)	Ash (%)	Carbohydrates (%)	Lipids (%)
Clarias gariepinus	Oven drying	18.92	31.40	13.15	25.81	1.71
	Boiling	61.85	22.33	4.30	9.252	2.27
	Solar drying	15.62	61.21	3.62	3.84	1.96
	Smoking	19.35	21.3	3.92	2.78	5.2
Synodontis clarias	Oven drying	15.60	56.915	6.55	8.34	8.34
	Boiling	58.50	28.89	8.30	1.705	2.60
	Solar drying	14.21	49.701	2.91	3.81	1.121
	Smoking	21.10	32.14	2.49	3.91	13.41
Trachurus trecae	Oven drying	33.50	45.71	8.83	6.413	2.023
	Boiling	51.60	37.403	3.950	1.547	1.671
	Solar drying	17.21	53.23	2.12	3.12	4.226
	Smoking	19.21	21.14	4.32	2.65	1.21

products processed with solar. The lipid was reduced to 1.12% in *S. clarias* processed with solar dried.

The organoleptic properties

The organoleptic properties of smoked, oven dried, solar dried and boiled *C. gariepinus, T. trecae* and *S. clarias* are shown in Table 2. The overall performance showed that for flavour, the highest value recorded was 2.9 in solar dried *S. clarias*, solar dried *T. trecae* and boiled *C. gariepinus*, while the least value was 1.8 in the boiled *C. gariepinus* followed by 1.9 in oven dried *T. trecae* and *S. clarias* smoked product. Boiled *C. gariepinus* had 2.8 in the appearance parameter followed by 2.5 in oven dried *T. trecae* and the least value was 1.5 in the smoked *T. trecae*. Boiled clarias had 4.0 which was the highest in the texture parameter followed by 3.9 in boiled and smoked *S. clarias* and 3.5 in smoked *T. trecae*, the least was 1.3 in solar dried *T. trecae*. The palatability parameter showed that oven dried *C. gariepinus* had 3.0 followed by solar dried *T. trecae* (2.4), while the least was 1.3 in *C. gariepinus* smoked-dried product. The flavour of smoked *C. gariepinus* significantly differed ($p>0.05$) from that of boiled *C. gariepinus*. There were non-significant differences ($p> 0.05$) in the flavour of oven dried, solar dried, boil and smoked, oven dried and solar dried. The appearance parameter of smoked significantly differed ($p>0.05$) from that of boiled and non-significantly difference ($p>0.05$) in the appearance of oven dried, solar dried and boiled, and also in smoke oven dried and solar dried. There were non-significant differences ($p>0.05$) in texture of smoked and boiled fish product. The texture of oven dried, solar dried significantly differ ($p<0.05$) from smoked and boiled. However, there were non-significant differences ($p>0.05$) seen in smoked, solar dried and boiled in palatability of *C. gariepinus* while the palatability of oven dried significantly differed ($p<0.05$) from solar dried, smoked and boiled as shown in Table 2.

The solar dried products had the highest in the flavour and palatability parameter. The oven dried fish products had the highest values in appearance; boiled fish product was the highest in the texture parameter, closely followed by smoked fish products.

No significant difference ($p>0.05$) was seen in the flavour of oven dried, solar dried, smoked and boiled *T. trecae.* Also, no significant difference ($p>0.05$) was seen in the appearance of the four processing methods. The texture of smoked and boiled significantly differ ($p<0.05$) from that of solar dried and dried. No significant difference was seen in between smoked and boiled and also between solar dried and oven dried. No significant difference ($p>0.05$) was seen in the palatability of the processing methods as shown in Table 3.

The flavour of smoked *S. clarias* significantly differ ($p<0.05$) from that of solar dried, oven dried and boiled, and no significant difference ($p>0.05$) was seen in the flavour of oven dried, solar dried and boiled. No significant difference ($p>0.05$) was seen in the appearance of the four processing methods. No significant difference ($p>0.05$) was seen in the texture between smoked and boiled also between oven dried and solar dried, but the texture of smoked and boiled significantly differed ($p<0.05$) from that of solar dried and oven dried. However, no significant difference ($p>0.05$) was seen in the palatability of the four processing methods.

The overall performance showed that for flavour, the highest value recorded was 2.9 in solar dried *S. clarias*, solar dried *T. trecae* and boiled *C. gariepinus*, while the least value was 1.8 in the boiled *C. gariepinus* followed

Table 2. Organoleptic properties of *Clarias gariepinus*.

Processing method	Flavour	Appearance	Texture	Palatability
Smoked	1.8 ± 0.92^{a}	2.0 ± 1.15^{a}	3.9 ± 0.32^{c}	1.3 ± 0.67^{a}
Oven dried	2.0 ± 0.94^{ab}	2.2 ± 0.79^{ab}	2.6 ± 0.70^{a}	3.0 ± 0.94^{c}
Solar dried	2.2 ± 1.23^{ab}	1.8 ± 0.78^{ab}	3.3 ± 0.95^{b}	1.8 ± 0.78^{a}
Boiled	2.9 ± 1.20^{b}	2.8 ± 1.23^{b}	4.0 ± 0.00^{c}	1.9 ± 0.86^{a}

Figures with the same alphabet in superscript are not statistically different ($P<0.05$).

Table 3. Organoleptic properties of *Trachurus trecae*.

Processing method	Flavour	Appearance	Texture	Palatability
Smoked	2.0 ± 0.94^{a}	1.5 ± 0.85^{a}	3.5 ± 0.71^{b}	1.5 ± 0.85^{a}
Oven dried	1.9 ± 1.10^{a}	2.5 ± 0.97^{a}	1.6 ± 0.84^{a}	2.0 ± 1.05^{a}
Solar dried	2.9 ± 1.10^{a}	2.2 ± 1.14^{a}	1.3 ± 0.67^{a}	2.4 ± 1.17^{a}
Boiled	2.8 ± 1.23^{a}	2.2 ± 1.23^{a}	4.0 ± 0.00^{b}	2.2 ± 1.03^{a}

Figures with the same alphabet in superscript are not statistically different ($P<0.05$).

Table 4. Organoleptic properties of *Synodontis clarias*.

Processing method	Flavour	Appearance	Texture	Palatability
Smoked	1.9 ± 0.88^{a}	1.9 ± 1.10^{a}	3.9 ± 0.32^{b}	1.6 ± 0.84^{a}
Oven dried	2.5 ± 0.79^{b}	1.6 ± 0.84^{a}	1.8 ± 0.63^{a}	2.0 ± 0.94^{a}
Solar dried	2.9 ± 0.99^{b}	2.1 ± 1.10^{a}	1.4 ± 0.07^{a}	1.6 ± 0.84^{a}
Boiled	3.1 ± 1.10^{b}	2.1 ± 1.10^{a}	3.9 ± 0.31^{b}	2.1 ± 1.10^{a}

Figures with the same alphabet in superscript are not statistically different ($P<0.05$).

by 1.9 in oven dried *T. trecae* and *S. clarias* smoked product. Boiled *C. gariepinus* had 2.8 in the appearance parameter followed by 2.5 in oven dried *T. trecae* and the least value was 1.5 in the smoked *T. trecae*. Boiled and smoked *S. clarias* had 3.9 (Table 4) which was the highest in the texture parameter followed by 3.5 in smoked *T. trecae*, and the least was 1.3 in solar dried *T. trecae*. The palatability parameter showed that oven dried *C. gariepinus* had 3.0 followed by solar dried *T. trecae* (2.4), and the least was 1.3 in *C. gariepinus* smoked dried product.

DISCUSSION

The high moisture content in boiled fish samples was expected and evident in all the boiled fish products which indicated that the fish may be liable to microbial spoilage after 24 h if no further preservative measure was done. The products could be kept in the refrigerator as a preservative measure, and the test was carried out to know the best method of processing which would improve the nutritive value and again be acceptable in terms of organoleptic characteristics. Elderly and people living with dentary defects would found boiled fish palatable than other processed methods.

Oxidative degradation of polyunsaturated fatty acid would consequently decrease the quality of the fish species during prolong period of preservation. Solar dried fishes showed a significant decrease in moisture content making it efficient when compared to the smoked and oven-dried fishes. The result is in line with that of Oparaku (2012) who observed the efficiency of solar dryer when compared with other methods of processing in which the relatively high to moderate percentage crude protein may be attributed to the fact that fishes are good source of protein, but the differences observed in values obtained was in consonance with the studies of Payne et al. (1999) and Puwastein et al. (1999), who observed that the fish consumption or absorption capability and conversion of potential essential nutrient from their diets or their local environment into such biochemical attribute are needed by the body. The significant increase in nutritional composition (15.65%) of solar dried *C. gariepinus* suggests that protein nitrogen was not lost during drying compared to other fishes. This is in accordance with the findings of Puwastein et al. (1999)

and Gokoglu et al. (2004). The lowest value of ash in the processed fishes may be attributed to analysis which was carried out on the edible portion of the fish not incisive of the bone. 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 which was found in little non-significant traces in the fish sampled. A good source of instant energy that comes to the mind is the carbohydrates. It also helps in the body development and growth. The carbohydrates content in the fish is small and practically considered zero (Osibiona et al., 2006). This coincides with the result obtained in this work indicating that the various species of fishes processed are poor sources of carbohydrates. The relatively low values of carbohydrates could be due to higher values of moisture and relatively high value of protein contents. The treatments methods adopted showed that lipids of the fishes showed a marked decrease. The oven dried samples retained higher lipid content ($P<0.05$) than the boiled, smoked and solar dried samples. This result indicated that the fat loss phenomenon was intensive in the boiling and solar dried fish than in smoked samples. Fat may exude with the moisture evaporation through extended heat treatment. Smoking, solar-dried and boiling seems to enhance this phenomenon. Lipids are soluble in ether hence they are ether extractable (Hilditch and Williams, 1964). They serve as a source of energy during starvation and fasting. The oil content of catfish was relatively low in the treatment methods adopted especially in oven-dried and solar dried fish sample compared to smoking. The other fish species also had increase lipid level in oven dried and smoked *S. clarias* compared to *T. trecae* that showed decrease in lipid level in smoked sample. According to Ackman (1989), generally fish can be grouped into four categories according to their fat content: lean fish (<2%), low fat (2 to 4%), medium fat (4 to 8%) and high fat (>8%). The low concentration of lipids in the muscle of the fish species in this result could also be attributed to poor storage mechanism and the use of fat reserves during spawning activity (Ackman, 1989).

Conclusion

This study clearly indicated that the proximate value obtained could be useful to help the consumers in choosing fish based on their nutritional values, besides providing an up to date nutritional qualities of food consumed. However, different nutritional components of fish changed at elevated temperatures. Oven dried, solar dried and smoking could improve the protein quality and prevents lipid oxidation in fishes. The result of moisture content indicated that solar dried products were consistently lower in all the fish products, the least was 14.21% in the *S. clarias* while the highest, as would be expected, was in all the boiled fish products. Protein content % was higher in the fish products processed with solar. The lipid was reduced to the least value of 1.12% in the *S. clarias* processed with solar dried. In drying, the important factors for consideration are low moisture content in the final fish product; this is to ensure that fish product with longer shelf life is produced. High protein is desirable for a growing child and low lipid is equally desirable as to reduce oxidation and rancidity in the fish products which cause off-flavor and bad taste in fish products. Finally, all the other 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, therefore solar drying was adjudged to be the best due to lower moisture in the final products. The organoleptic properties of the fish species were determined using questionnaires. This study clearly indicated that the proximate values obtained could be of help in choosing fish based on nutritional values.

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