PROXIMATE AND ORGANOLEPTIC CHARACTERISTICS OF SUN AND SOLAR DRIED FISH

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ABSTRACT

The sun and solar drier were evaluated for their drying effectiveness with three species of freshwater fish; Gymnarchus niloticus, Heterotis niloticus and Clarias gariepinus. The highest mean temperature that could be attained in the solar dryer was 70^{0}C at time 14.00 hour while the ambient temperature and insulation were 33.5^{0}C and 857.6 w/m^2 respectively. Proximate and organoleptic characteristics of the sun and solar dried products were carried out. It was found out that quality of the fish products dried in the solar drier were superior to those sun-dried. Organoleptic characteristics of the solar dried were better, especially the odour and moisture reduction was more in solar than in sun dried products. It took only three days for the fish to be completely dried in the solar drier compared with sun dried fish products which took seven days to dry.

Keywords: Fish, *Gymnarchus niloticus, Heterotis niloticus, Clarias gariepinus,* Solar drying, Sun drying, Proximate composition, Organoleptic characteristics

INTRODUCTION

Traditional methods used for preserving fish for centuries are the smoking, salting and drying. Salting and drying, is used on their own or in conjunction with each other to reduce spoilage. Fish spoilage are brought about by microbiological activity, autolytic changes, chemical spoilage the development of rancidity and mould attack are the cause of spoilage of many preserved fish products stored at temperatures above 0^{o}C (Huss, 1990; Conne,1995) .

Autolytic spoilage or autolytic changes are responsible for early quality loss in fresh fish but contribute very little to the spoilage of chilled fish and fish products. Chemical spoilage or development of rancidity can be prevented by rapid handling on board of the catches and storage of products under anoxic conditions (vacuum packed or modified atmosphere packed) (Conne, 1995).

Moulds can cause losses of fish due to discolouration and disintegration. They may also produce mycotoxins which can have a variety of harmful effects on products with water activity as low as 0.60, although 0.70 is the minimum as water activity which sustains the growth of most spoilage moulds.

The ambient temperature in the tropics cause fish to start to decay a few hours of being caught, unless fish is preserved or processed in some way to retard spoilage (Conne, 1995).

Reducing the moisture content of fresh fish by drying to 25% water content will stop bacterial growth and reduce autolytic activity. Salting reduces the susceptibility of the dried fish to insect infestation (BOSTID, 1988).

Simple processing of fish is not restricted to drying, other ways of preservation and processing of fish are, freezing, canning, fermentation, boiling and frying. Fish is usually heated to destroy autolytic enzyme and to kill microorganisms involved in spoilage (UNIFEM, 1988). Another method of preservation and processing of fish is solar drying. There has been a great deal of interest in the area of solar drying. The development of variety of solar driers as an improved method of drying fish in developing countries is an indication of preparedness to tackle the problem of fish spoilage associated with the use of traditional techniques.

This study assessed and compared the proximate composition and organoleptic characteristics of sun and solar dried *Gymnarchus niloticus, Heterotis niloticus* and *Clarias gariepinus*.

MATERIALS AND METHODS

Fish Procurement and Preparation: *H. niloticus, G. niloticus* and *C. gariepinus* used for the study were bought from Anambra River fish landing port at Otuocha, Anambra State. Fishes weighing about 2 ± 0.3 kg were used for the study. The fishes were gutted, cut lengthwise into uniform sizes, washed and salted in brine solution of the following strength; 0^o (control), 10^o, 40^o, 50^o, 60^o, 80^o and 100^o. 360 grams of common salt (NaCl) dissolve in one litre of water represented 100^o brine (saturated salt solution). The various brine solutions were labeled batches 1 – 7 respectively.

The fishes were weighed and soaked in the different brine solutions for one hour, placed inside the solar drier in seven batches and monitored until dryness. Sun drying was carried out using the same treatment methods.

Fish prepared for sun drying were placed on a rack suspended one metre above the ground and allowed to dry for 9 hours (9.00 – 6.00 pm) daily. Hourly radiation, temperature and humidity measurements were taken with aid of solarimeter, thermometer and humidity indicators respectively. Weights of the fish products were taken every two hours. Weight loss was estimated thus: $W_1 - W_2$, where W_1 = initial weight of fish and W_2 = final weight of fish. At the end of the drying period, fish were stored in clean polythene bags for proximate and organoleptic analyses.

Proximate Analysis: The sun and solar dried fish products from batch 7 (100^0) were analysed for their proximate compositions (AOAC, 1984).

Moisture content: The hot oven method as described by Pearson (1976) was adopted.

Ash content: The AOAC (1984) method was used.

Protein content: The Microkjelahl method as described by Pearson (1976) was used in the determination of the crude protein content.

Fibre content: Two grains of the sample was hydrolysed in a beaker with 20 ml of 1.25% sulphuric acid (H_2S0_4) for 30 minutes. The mixture was filtered under suction, washed with hot distilled water and then boiled again for another 20 minutes in 200 ml of 1.25% NaOH. The digested sample was washed with 1% HCl to neutralize the NaOH and several times with hot distilled water. The residue collected was put into a weighed crucible and dried at 100^oC for 2 hours in an oven. The ash obtained was cooled in a desiccator and weighed. The percentage crude fibre was calculated using the expression. % Crude fibre = Loss in weight after drying / 1 x 100.

Carbohydrate content: Carbohydrate was determined by subtracting the sum of ash, protein fat, moisture and crude fibre from 100 thus: % Carbohydrate = 100 - (% ash + % protein, + % fat + % moisture + % crude fibre).

Determination of acid value or free fatty acids (FFA): 25 ml of diethyl either was mixed with 25 ml ethanol and 1ml of phenolphthalein solution (1%) and neutralized with 0.1M sodium hydroxide. 1 – 10g of the oil or melted fat extracted from the fish was dissolved in the mixed neutral solvent and titrated with aqueous 0.1M sodium hydroxide shaking constantly until a pink colour which persisted for 15 second was obtained. Acid value = titration (ml) / weight of sample used x 5.61. The FFA value is usually calculated as oleic acid, where 1ml of 0.1 M sodium hydroxide = 0.0282 g of oleic acid, in which case the acid value = 2 x FFA.

Peroxide value: A 100ml of round bottomed flask with a ground glass join is attached to a plain reflux tube, long 9 mm internal diameter the upper 15cm of which are cooled by a water jacket. 10 ml of chloroform and 10 ml of glacial acetic acid was added to the flask and, using a micro gas flame close to the flask, the mixture was boiled to top of the tube where it was condensed by the water jacket. One gram of potassium iodide dissolved in 1.3 ml was poured slowly down the condenser when the mixture was boiling steadily so that the refluxing was not interrupted 0.3 ml water was added to redissolve any precipitated iodide. 1 g of the sample was added down the condenser without interrupting the refluxing and condenser water was turned off so that the entire sample was washed into the flask. The mixture was boiled for more 4 minutes; the flask was removed, and cooled rapidly. 50 ml of water was added and the liberated iodine titrated against 0.01M sodium thiosulphate using starch as an indicator.

Thiobarbituric acid (TBA) value: 10g of fish was macerated with 50 ml of water for 2 minutes and washed into a distillation flask with 47.5 ml water. 2.5 ml of 4 M hydrochloric acid to bring the pH to 1.5, followed by an antifoaming preparation and a few glass beads. The flask was heated by means of an electric mantle so that 50 ml distillate was collected in 10 min from the time boiling commenced. 5 ml of distillate was pipetted into a glass stoppered tube; 5 ml of TBA reagent (0.2883 g/100 ml of 90% glacial acetic acid) was added stoppered, shook and heated in boiling water for 35 minutes. A blank was prepared similarly using 5 ml of water with 5 ml.

Organoleptic Assessment: Samples of sun and solar dried *C. gariepinus* were subjected to physical and organoleptic assessments. Organoleptic characteristic like colour, odour, flavour, texture (mouth feel), juiciness and general acceptability (Table 1) were evaluated by 20 panelists randomly selected from the University community.

Statistical Analysis: Two-way analysis of variance was used in the analysis of organoleptic assessment characteristics. Fisher's least significant difference at ($P < 0.05$) was used to test the level of significance in the means.

RESULTS AND DISCUSSION

Proximate analysis of solar and sun dried fishes indicated that the solar dried *H. niloticus* (21.0 ± 0.5 %) had lower moisture content than the sun dried *H. niloticus* (26.0 ± 0.5%) (Table 2). For solar dried *C. gariepinus* (17.0 ± 0.34%) the percentage moisture was lower than those recorded for the sun dried *C. gariepinus* (28.0 ± 2.0%). From all the treated samples, the lowest moisture content was recorded in solar dried *G. niloticus* (11.6 ± 0.4%) followed by solar dried *C. gariepinus (*17.0 ± 0.34%) (Table 2).

Percentage crude protein recorded in the sun and solar dried fishes showed that the crude protein content was higher in sun dried fishes than solar dried fishes. The highest percentage crude protein was recorded in the sun dried *C. gariepinus* (17.0 ± 0.20%) while the lowest percentage crude protein was recorded in solar dried *H. niloticus* (10.3 ± 0.1%) (Table 2).

Percentage fat of fish products recorded in the sun and solar dried products indicated that the percentage fat content were higher in the solar dried than in sun dried fish products. Differences could be attributed to the differences in their moisture contents. It appears that *Gymnarchus niloticus*, *H. niloticus* and *C. gariepinus* were fatty fish. Solar dried *G. niloticus* (16.1 ± 0.10%) had the highest fat followed by solar dried *H. niloticus* (14.6 ± 1.0%), while the least percentage fat was recorded in sun dried *C. gariepinus* (9.0 ± 1.0%) (Table 2).

Percentage crude fibre was higher in the solar dried than in the sun dried fish products.

Table 1: Criteria for organoleptic assessment of the sun and solar dried fish products

Parameters	1	2	3	4	5	6	7
Colour	Extremely dark	Very dark	Moderately dark	Neither bright nor dark	Moderately bright	Very bright	Extremely very bright
Flavour	Excellent	Good	Fair	No salt	Moderately salty desirable	Too slightly undesirable	Extremely too salty undesirable
Texture	Extremely	Too soft	Moderately soft	Neither hard nor soft	Moderately hard and tough	Too hard / tough	Extremely too hard/tough
Juiciness	Extremely dry	Very dry	Moderately dry	Neither juicy nor dry	Moderately juicy	Very juicy	Extremely juicy
Odour	Extremely offensive	Very offensive	Moderately offensive	Neither pleasing nor offensive	Moderately pleasing	Very pleasing	Extremely pleasing
General acceptability	Extremely disliked	Very much disliked	Moderately disliked	Neither liked nor disliked	Moderately liked	Very much liked	Extremely liked

Table 2: Proximate composition, thiobarbituric value, peroxide value, acid value and free fatty acid content of sun and solar dried fish

	% Moisture	**% Protein**	**% Fat**	**% Fibre**	**% Ash**
1. Solar dried *H. niloticus*	21.0 ± 0.5	10.3 ± 0.1	14.6 ± 1.0	1.6 ± 0.2	3.1 ± 0.1
2. Sun dried *H. niloticus*	26.0 ± 0.5	13.6 ± 0.2	13.3 ± 0.10	1.3 ± 0.3	3.6 ± 0.2
3. Solar dried *Clarias gariepinus*	17.0 ± 0.34	14.6 ± 0.2	11.1 ± 1.0	1.4 ± 0.4	3.8 ± 0.03
4. Sun dried *Clarias gariepinus*	28.0 ± 2.0	17.0 ± 0.20	9.0 ± 1.00	1.2±0.52	3.9 ± 0.9
5. Solar dried *Gymnarchus niloticus*	11.6 ± 0.4	15.0 ± 0.50	16.1 ± 0.10	1.0±.34	2.1 ± 0.17
	% Moisture	**TBA Value**	**Peroxide Value**	**Acid value**	**FFA**
1. Solar dried *H. niloticus*	21.0 ± 0.5	0.67 ± 0.12	6.6 ± 0.2	17.9 ± 0.1	0.51 ± 0.03
2. Sun dried *H. niloticus*	26.0 ± 0.5	0.78 ± 0.1	4.4 ± 0.4	18.5 ± 0.5	0.53 ± 0.03
3. Solar dried *Clarias gariepinus*	17.0 ± 0.34	0.75 ± 0.05	2.4 ± 0.2	17.4 ± 1.16	0.49 ± 0.2
4. Sun dried *Clarias gariepinus*	28.0 ± 2.0	0.78 ± 0.11	2.0 ± 0.1	18.9 ± 1.24	0.50 ± 0.04
5. Solar dried *Gymnarchus niloticus*	11.6 ± 0.4	1.06 ± 0.03	5.8 ± 0.1	20.2 ± 0.2	0.57 ± 0.02

The highest percentage fibre was in solar dried *H. niloticus* (1.6 ± 0.2 %), followed by sun dried *C. gariepinus* (1.4 ± 0.4 %). Furthermore, the lowest percentage crude fibre occurred in solar dried *G. niloticus* (1.0 ± 0.34%).

The ash contents in both sun dried and solar dried fishes showed that the sun dried *C. gariepinus* (3.9 ± 0.9 %) had the highest ash content while the lowest ash content was recorded in solar dried *G. niloticus* (2.1 ± 0.17 %).

Thiobarbituric Acid Test (TBA): There was no much difference in the value of thiobarbituric acid in the sun and solar dried fish products. *G. niloticus* has the highest TBA value of 1.06 ± 0.03%, while the lowest TBA value of 0.67 ± 0.12% occurred in solar dried *H. niloticus* (Table 2). TBA measured the deterioration in both extractible and non-extractible lipids and therefore had relevant application in the fatty foods especially fresh fish. Initial high TBA values in pre processed products were reduced by the drying process. The resulting low TBA values indicated low level of lipid oxidation (Abramson, 1949).

Peroxide Value: Peroxide value is commonly used to assess rancidity development. A rancid taste often becomes noticeable at peroxide value of 10 – 20%. Peroxide value was low in both the solar and open sun dried products. The highest peroxide value was 6.6 ± 0.2% in solar dried *H. niloticus* followed by 5.8 ± 0.1% in solar dried *G. niloticus*. The lowest value was 2.0 ± 0.1% in sun dried *C. gariepinus* (Table 2).

Acid Value: Acid value content was found to be the highest in solar dried *G. niloticus* (20.2 ± 0.2%). The lowest value was obtained in solar dried *C. gariepinus* (17.4 ± 1.6%). Acid value of sun dried *C. gariepinus* (18. 9 ± 1.24%) was higher than the solar dried fish (17.4 ± 1.16%). The value for solar dried *H. niloticus* (17.9 ± 0.1%) was lower than the sun dried *H. niloticus* (18.5 ± 0.5%) (Table 2).

Free Fatty Acid (FFA): Free fatty acid (FFA) content measures the extent of lipid hydrolysis by lipase action. As rancidity could be accompanied by FFA (free fatty acid) formation. The free fatty acid values recorded in this study were low (see Table 2) and hence there is no fear of rancidity which could result in high free fatty acid values, as a result of mould development, high water activities and high degree of enzymic activity (Abramson, 1949).

Physical and Organoleptic Characteristics: Solar dried fish performed better than sun dried *Clarias gariepinus.* The most outstanding characteristic was the odour. The odour of solar dried *C. gariepinus* was very pleasant in all seven batches. While the odour characteristic of sun dried C. gariepinus was slightly offensive in batches 4 – 7, while batches 1 – 3 were neither pleasant nor offensive. Although batches 4 – 7 of sun dried *C. gariepinus* were offensive, the dried *C. gariepinus* products were still acceptable despite the slight putrefying odour. Both sun and solar dried fishes were not rejected.

The result of statistical analysis conducted using two-way analysis of variance indicated that brining had no effect on the organoleptic properties (Table 4). Flavour and colour appeared to be the two most important characteristics that influenced panel's preference for products. Flavour ratings may however be related to saltiness. Since products with acceptable salt concentrations as judged by panel members had higher flavour ratings. The effect of juiciness on overall acceptability could be regarded as secondary. Colour, flavour, texture, juiciness and general acceptability of sun and solar dried fish were acceptable by panelists; but solar dried *C. gariepinus* was superior to sun dried C*larias gariepinus.*

From the results it was obvious that solar dried products provided fish with better organoleptic qualities. It is evident that the thermal energy generated helped in drying up the fish products. This heat was then transfer to the air by contact between the air and absorber (Lwand, 1966). This resulted in the higher temperature and thereby increased drying rate and also high quality of the solar dried products

Table 3: Physical and organoleptic characteristics of sun and solar dried *Clarias gariepinus*

Batch	Colour	Flavour	Texture	Juiciness	Odour	General Acceptability
			Sun dried *Clarias gariepinus*			
1	5.37±1.18	5.42±.53	5.00±0.89	3.8±1.09	6.44 ±0.89	5.14 ±2.03
2	4.75±1.48	4.57±1.6	4.85±0.37	3.00±1.0	6.0±1.41	5.71±0.95
3	4.37±1.30	5.14±1.06	4.42±0.97	3.18±1.30	6.8±1.07	5.71±1.60
4	5.0±0.92	4.44±2.070	4.51±1.38	3.50±1.0	6.2±1.5	5.33±2.36
5	4.37±1.48	4.0±1.36	4.5±1.7	3.00±0.81	6.2±1.5	5.14±2.73
6	4.89±1.80	4.0±1.7	4.4±1.6	3.81±1.92	6.7±0.5	6.0±0.51
7	5.0±0.92	4.85±0.37	5.00±2.08	3.0±0.89	6.0±1	5.6±1.54
			Solar dried *Clarias gariepinus*			
1	55.7±1.22	4.0±1.58	5.2±0.98	3.8±1.09	6.4±0.89	5.33±1.52
2	5.5±1.70	4.4±1.51	5.0±0.63	3.0±7.07	6.0±1.41	5.66±1.15
3	4.88±0.98	4.5±1.73	4.0±0.816	3.8±1.30	6.8±1.07	5.5±1.51
4	5.66±1.47	4.5±1.0	4.8±1.6	3.5±1.0	6.2±1.5	5.0±2.6
5	4.6±1.36	4.22±1.5	4.6±1.36	3.0±0.816	6.2±1.5	5.8±2.65
6	5.5±0.83	6.00±1.09	5.5±0.83	3.3±1.92	6.7±0.5	6.6±0.57
7	4.33±1.86	3.5±1.29	4.33±1.36	3.0±0.70	6.0±1.0	6.0±1.73

Table 4: Effect of salt concentration on organoleptic characteristics of sun and solar dried *C. gariepinus*

Batch	Colour	Flavour	Juice	Odour	Texture	General Acceptability
1	5.5	5.0	3.4	5.9	4.7	5.4
2	4.7	4.7	2.6	5.3	5.0	5.9
3	4.6	5.1	3.7	5.7	4.6	5.9
4	5.0	4.9	3.2	5.2	4.7	4.9
5	4.7	4.1	2.8	5.5	4.6	3.6
6	5.2	5.0	3.7	5.6	5.0	6.6
7	4.7	4.7	2.9	5.1	4.8	6.1
LSD(0.05)	NS	NS	0.8	NS	NS	1.2

If the difference between any two means ≥ LSD, then those two means are significantly different.

(Doe *et al*, 1977; Curan *et al.,* 1985; Yewas and Obi, 2001).

In the proximate analysis of sun and solar dried fish low levels of moisture were achieved for products from solar dryer than were achieved in the sun dried products. This was because of the high rate of drying associated with solar drying. The percentage moisture in the sun dried fish products was not high enough to cause the fish to spoil because of the good weather at the time of drying. Harmattan weather prevailed during the drying contributed to the efficiency of both the sun and solar driers. It is important to note that all the samples lost moisture during the drying period. Addition of salt whether prickly wet or brine salting enhances the chances of losing moisture faster. Drying was normally combined with salting to reduce moisture content sufficiently to ensure longer-shelf life. Products with high moisture content (above 35%) are susceptible to attack by blow flies especially if the salt level in the product is low. This will result in development of maggots during storage. At low moisture content (below 15 %) the product is brittle and prone to fragmentation and attack of insects (Oparaku *et al.,* 2003). The batch 2 which contains 100^0 was very fast in drying followed by the rest. Batch 3 which have zero brine salt concentration proved to be the slowest in drying. The higher the salt concentration the higher was the moisture loss. The batch that contains no salt in sun dried fish developed a putrid odour. Similar findings have been reported for unsalted sun dried *Cyanoglossus senegalsis* (Bhandary, 1988).

Conclusion: Solar dried fish products quality was high because of elevated temperatures found in the solar drier. Insects, mould and bacterial infestations were low. Lower levels of moisture were achieved for products from solar dryer than for the sun dried products. The most outstanding oganoleptic characteristic was the odour. The odour of solar dried *C. gariepinus* was very pleasant in all batches while the batch that contains no salt in sun dried fish developed a putrid odour.

REFERENCES

AOAC (1984). *Official Methods of Analysis,* 14th Edition. Association of Official Analytical Chemists, Washington DC, USA.

ABRAMSON, H. (1949). Oxidation of unsaturated fatty acid in normal and scorbutic guinea pigs. *Journal of Biological Chemistry,* 178: 179 – 183.

BOSTID (1988). *Fisheries Technologies for Developing Countries*. Board on Science and Technology for International Development, National Academy Press, Washington DC, USA.

BHANDARY, C. S. (1988). Studies on salt curing and sun drying of Tonguesole (*Cyanoglossus senegalsis*). Proceedings of the FAO Expert Consultation on Fish Technology in Africa. *FAO Fisheries Report, 400:* 169 – 172.

CURRAN, C. A., NJAI, A. E., NERGUAYE-TETTE, G. and DIOUF, N. (1985). Testing a kainji lake solar dome dryer in the Gambia. Proceedings of the FAO Expert Consultation on Fish Technology in Africa. *FAO Fisheries Report,* 329: 167 – 180.

CONNE, J. J. (1995). *Control of Fish Quality.* 4th Edition, Fishing News Book, Blackwell Science Limited, USA.

DOE, P. E., ARMED, M., MUSLEMUDDIN, M. and SACHITHANANTHAN, K. A. (1977). A polythene tent dryer for improved sun drying of fish. *Food Technology,* 29: 437 – 441.

ILO (1976). *Solar drying: practical methods of food presentation*. International Labour Organization, Geneva, Switzerland.

HUSS, H. H (1990*). Fresh fish quality changes. A Training Manual Prepared for the FAO/DANIDA Training Programme on Fish Technology and Quality Contr*ol. *FAO Fisheries Series,* 29: 1 – 132.

LWAND, T. A. (1966). A solar cabinet dryer. *Solar Energy,* 10: 154 – 164.

OPARAKU, N. F, UNACHUKWU, G. O. and OKEKE, C. E. (2003). Design, construction and performance evaluation of solar cabinet with an auxiliary heater. *Nigeria Journal of Solar Energy,* 14: 41 – 50.

PEARSON, D. (1976). The chemical analysis of food. Churchill Livingstone, London.

UNIFEM (1988). *Fish processing.* United Nations Development Fund for Women, New York, USA.

YEWAS, D. S. and OBI, A. S. (2001). Development and performance evaluation of a family size solar dryer for fruits and vegetables. *Nigerian Journal of Renewable Energy,* 9(1 and 2): 67 – 70.