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Qualities of *Tilapia zillii* products from solar tent dryers in a humid tropical environment

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ABSTRACT

The use of sun in drying as a means of preservation in food production is currently attracting attention as a good technique given the various difficulties and the negative effects associated with other techniques. This study aimed to examine the nutritional constituents of dried *Tilapia zillii* products, produced from different types of solar tent dryers. The aim of this study was to identify the best type of solar tent dryer for producing solar dried fish in a tropical humid environment.

The type of dryer used for the study was designed by Doe (1977) and cited in Olokor *et al*., (2009a). The dryers had wooden frames with dimensions 4x3x3m and trays made with chicken wire over wooden frames. Three types of dryers were set up: a solar tent dryer with collector covered with transparent white polythene (CTP); a solar tent dryer without collector but covered with transparent white polythene (NCTP) and a solar tent dryer without collector covered with black polythene (NCBP). Fish samples of equal weight (350 ± 10.5g) and length (22±2.5cm) were prepared, treated with 30% brine and exposed to gradual solar influence from under the tents. Products were allowed to dry and were then analyzed for nutritional quality. Statistical analysis was based on Analysis of Variance (ANOVA) using SPSS (15.0) for windows.

NCTP produced the best results in terms of protein, lipids, ash and moisture ($p<0.05$). Fish drying can be achieved in a humid environment using a solar tent covered with transparent nylon without a solar collector. The dryer was environmentally friendly, cheap, easy to operate and all material used for construction were sourced locally.

Keywords: *dryer, fish products, humid tropics, nutrients and Tilapia zillii, nutrients, preservation*

INTRODUCTION

The continuous over exploitation of fisheries' resources to meet the demand of increasing human yearning for an animal protein diet as well as financial viability are major concerns to fisheries conservation organizations and managers. In addition to the directly biological approach to tackle the problem, there is the need to minimize losses resulting from processing. This is both as a means of increasing fisher folk's income and increasing supplies of fish protein to the populace. Research has demonstrated that 50% of fish are degraded to a bad condition for consumption barely twelve hours after harvesting, some are then discarded completely and others are disposed off at very low prices because of this loss in quality (Raji (2009).

Various preservation techniques are used to process fish, they include smoking, which was traditionally a combination of drying with the addition of chemicals from the smoke to flavour the fish, thereby preserving and adding flavour to the final product. Most of the fish smoked these days are exposed to smoke just long enough to provide the desired flavour with little, if any, drying. The shelf lives of such products are short, even under refrigeration as a result of high water activity that encourages the growth of organisms that cause spoilage.

The use of coal and wood in smoking has raised various environmental issues such as contributing to deforestation, emissions of injurious chemicals and environmental degradation in general. The use of gas or petroleum based fuel is also limited due to fluctuating supply, ever increasing costs and the negative effects of the products of combustion on the environment. The use of refrigeration and freezing has remained an expectation yet to be realized in most fishing communities because they are usually in remote locations far from electricity supply, especially in the developing world (Arfaoui 2009). The use of solar energy for drying food is an ancient skill but its application has mostly been limited to certain products such as, cassava and potato in the humid tropics, even though it is more widely used for crops and animal products in dryer regions. It is commonly used for drying fish in the Lake Chad area where wood is scarce (Ogali & Eyo 1996). The sun has also been used to dry small non-fatty fish in the Lake Kainji region and animal products such as kilishi in the dry northern region of Nigeria (Raji 2009 and Ogbonaiya 2009). Various modifications have been introduced to the ancient conventional practice of spreading fish on the ground or on mats in the open, which was largely limited to dryer regions where periods of sunlight far exceed 10 hours/day and relative humidity is below 40% and the temperature is over 30^0C. The process of solar drying relies on the interplay between relative humidity, sunshine duration, radiation and wind speed.

The tent dryer designed by Doe (1977) in Bangladesh was modified and used by Olokor (2009a) in one of the dryer regions of Nigeria and was adapted for use under the humid conditions of southwestern Nigeria for this study. Solar drying offers protection against vermin, dust and rain and thus yield products which are generally of better quality. This study aimed to identify the quality of fish products dried using solar dryers under the humid environmental conditions of the tropical zone. This experiment was set up to assess the nutritional constituents of *Tilapia zillii* produced under different types of solar tent dryers.

METHODOLOGY

Three tents were set up and tent covers were made of either transparent or black polythene.

The solar tent dyers

Three tents were set up made of wooden poles, each with structural dimensions of 4x3x3m. The shape was after that cited in Olokor *et al.,* (2009a) with slight modifications. The sheets of polythene were either black or transparent; they were sown and worn onto the frames. They were then held in place with one inch nails on wooden tent poles, the zip at the opening of the tent in Olokor's KSTD (Kainji Solar Tent Dryer) was replaced with an extension of the polythene at one end to form a flap which slightly overlapped the edge of the opposite end and was held in place by adhesive. Racks were fixed and consisted of 3 layers; the first layer was 1m above the ground and other layers were separated from each other by 0.5m. Trays of 75cm x 50cm were made of wire mesh. The collector was made of a 1x1m iron sheet painted black and placed on the windward side at 0.5m above the ground.

Three types of tent were set up as follows:

- Solar tent with collector covered with transparent white polythene (CTP).
- Solar tent without collector covered with transparent white polythene (NCTP)
- Solar dryer without collector covered with black polythene (NCBP)

Preparation of the fish

Live samples of *Tilapia zillii* of about the same size; mean weight of 350± 10.5g and standard length 22±2.5cm were collected for the study. The fish were prepared by washing in clean water, descaled, eviscerated from the dorsal part and soaked in 30% brine for 30 minutes and then drained on a sieve. The drained samples were arranged on the drying tray under the tent at 8am. This was to ensure that samples received gradual heating from the sun and were not exposed to intense sudden heat. Turning was done at two hourly intervals. Weight measurement was taken every morning and evening until a constant weight was attained. Temperature readings within each tent were also taken.

Environmental factors

Data on environmental factors, temperature (^{0}C), relative humidity (%), rainfall (mm) and wind speed (Km/hr) were taken from the University Weather Station.

Proximate composition

Samples were analyzed using the method described by the Association of Official Analytical Chemist (AOAC, 2005).

Product yield

The product yield was expressed as the ratio of the final weight of a dried product to the initial weight of a fresh fish sample and was estimated using Kembi *et al.,* (2002).

Statistical analysis

Data were subjected to analysis of variance by Least Significant Difference (LSD) using SPSS (15) for windows. Level of significance was set at ($p < 0.05$).

RESULTS

Environmental condition and time taken to dry.

Prevailing environmental conditions at the time of the experiment are presented on Table 1. Mean temperature was 25.5^{0}C the maximum was 28.5^{0}C; the period coincided with the onset of the dry season. The temperature inside the tent was the highest in CTP (30.57^{0}C ± 2.05) followed by NCBP (29.85^{0}C ± 1.50) and the least in NCTP. This was expected as the black collector in CTP and the black polythene cover in NCBP enhanced the heat capacities of the tents. There were however significant differences in the mean number of days taken to achieve total dryness of the products in NCBP on one the hand and CTP and NCTP on the other. Constant weight was recorded between the fifth and the sixth day (Table 2).

Nutritional constituents

Moisture content: The proximate compositions of products from the dryers are presented on Table 3. The moisture content of fresh *T. zillii* was 60.13±0.84. Moisture contents of dried products were 23.64±.05, 23.07±0.57 and 25.59±0.44 for CTP, NCTP and NCBP respectively.

Nutrients contents of the products significantly differed from one another ($P < 0.05$); products from NCTP were richer in protein (53.88), ether extract (7.39) and fibre (1.92). Values obtained for CTP were of better quality in terms of lower moisture and ash contents than those of NCBP. Fresh fish had lower nutritional value because of its high moisture content (60.3) there was no concentration of nutrients (Table 3). The highest product yield was recorded in NCBP and the lowest was recorded in NCTP.

DISCUSSION

The meteorological data recorded around the tents was different from that recorded in Olokor *et al.,* (2009a) in tents located in various ecological zones in Nigeria. While

Table 1. Mean meteorological data at drying sites

Environmental Factor	Maximum	Mean	Minimum
Temperature (^{0}C)	28.5	26.50	25.0
Wind speed (Km/hr)	6.6	5.6	4.5
Relative humidity (%)	65	60	55
Rainfall (mm)	93.3	58	11.9

Weather station record, 2010

Table 2. Drying time, Mean daily temperature and percentage daily moisture loss of the various set ups

Variables	CTP	NCTP	NCBP
Drying time	5.5 ± 0.51^a	5.50 ± 0.51^a	5.00 ± 0.83^b
Temperature (^{0}C)	31.87 ± 2.05^a	30.83 ± 1.50^a	33.20 ± 1.28^b
Percentage moisture loss	14.42 ± 11.68	19.26 ± 14.02	16.02±19.84

Means on the same row with different superscripts are significantly different

Table 3. Nutritional properties of *T. zillii* dried under different Solar Dryers

Nutrient	Fresh fish	CTP	NCTP	NCBP
Moisture	60.13 ± 0.084^a	23.64 ± 0.025^b	23.07 ± 0.57^c	25.59 ± 0.44^d
Protein	28.71 ± 0.73^a	51.99 ± 0.61^b	53.88 ± 0.62^c	52.99 ± 0.72^d
Ether extract	3.11 ± 0.018^a	6.39 ± 0.009^b	7.26 ± 0.70^c	6.83 ± 0.27^d
Fibre	0.55 ± 0.022^a	1.66 ± 0.041^b	1.92 ± 0.13^c	1.62 ± 0.35^d
Ash	7.45 ± 0.12^a	16.78 ± 0.15^b	13.55 ± 0.36^c	12.79 ± 0.17^d
Product yield		39.23±2.19	36.57±1.14	41.14±2.15

Values in the same row followed by different superscripts are significantly different ($p<0.05$)

the minimum and maximum temperatures in this study were 25.5^{0}C and 28.5^{0}C respectively the team recorded 28.1^{0}C and 38.1^{0}C as minimum and maximum temperatures. Data were less favourable for drying than those obtained in previous studies (Olokor *et al.,* 2009b). Mean temperatures within CTP and NCTP tents differed significantly from those in NCBP ($p<0.05$). Temperature inside the tent was highest in CTP followed by NCBP and the least in NCTP, this was expected as the black collector and the black polythene cover in CTP and NCBP respectively enhanced heat capacities. Meteorological factors are understood to have strong correlation with drying.

The moisture content of fresh *T. zillii* was 60.13±0.84, and that was lower than that recorded in fresh *Tilapia nilotica* (81.49±0.35)(Ali *et al.*, 2011). Moisture contents of dried products were 23.64±.05, 23.07±0.57 and 25.59±0.44 for CTP, NCTP and NCBP respectively.

The removal of moisture brought about a significant increase in concentrations of nutrients in the products and thus higher percentages of protein, ash, fibre and lipids ($p<0.05$). These results agree with other findings reported on *Oreochromis niloticus* (Ogbonaiya 2009), *Citharinus citharus* (Eyo 1998) and suya (Igene and Ekanem 1985). The mean moisture values of final products of *T. zillii* were generally higher than those recorded for hot smoked *T. nilotica* (Ali *et al.,* 2011), kiln dried and electric-dried *Oreochromis niloticus* (Ogbonaiya 2009). The reduced water levels were achieved because of the high temperature and cooking that accompanied these processes of drying, unlike solar drying that was achieved at a lower temperature. Sun-dried fish flesh generally has more residual moisture than those that have been smoked/hot dried irrespective of the species of fish. The shelf life, sensory characteristics and processing potential of flesh is significantly influenced by its moisture contents. The removal of moisture is important in fish preservation as it reduces the activities of microorganisms especially the xerophytic ones.

There were significant differences between the nutritional properties of the products when compared with one another ($p<0.05$) (Table 2). As expected the relationship between lipid and moisture concentration was inverse. Lipid contents recorded in this study were lower than those of Tilapia meal, and *Clarias lazera* (Dale *et al.,* 2004, Aremu and Ekunade 2008), this could have been as a result of the removal of visceral organs where fish oil is stored. Lipids are not desired in stored dried products as oxidation could lead to the production of undesired substances. Protein content was similar to those found for Tilapia meal samples (Dale *et al.,* 2004), *Tilapia niloticus, Arius parkii* and *Silurus glanis* (Ali, *et al.,* 2011) but less than those of *Clarias spp* (Aremu and Ekunade 2008). Products from NCTP have higher protein and lower moisture contents than those of the other treatments but ash content was lower than products from CTP but higher than that of NCBP. The high product yield (41.14±2.15%) recorded for NCBP was due to its higher moisture content (25.59±0.44%) which is detrimental to storage. Spoilage organisms multiply rapidly under high moisture conditions so an alternative strategy for preservation would be needed if such dried fish were to be kept for a longer period. The practice has always been to re-dry. High moisture content does not only encourage bacteria and biochemical reactions that can lead to spoilage but also opens up the way for pest invasion on stored products (Eyo 2001).

CONCLUSION

Constant drying was attained in all the three set-ups within 6 days of drying *Tilapia zillii* in each of the tents. However, the solar tent dryer without a collector covered with transparent polythene (NCTP) gave the best final products in terms of low moisture content, highest protein and higher fiber values. The low moisture content has significant implication on shelf life of dried products, microbial activities and deterioration processes proceed faster with increasing moisture levels, thus affecting organoleptic characteristics, processing potential and consumer acceptability of fish products. The better preservation method is therefore one that produces a final product that retains its nutritional properties to a level that is beneficial to consumers at the time of consumption. It can therefore be stated that of the three dryer set-ups tested in this study, the solar tent dryer without a collector and covered with transparent white polythene (NCTP) can be recommended as the best option.

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