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EFFECTS OF TEMPERATURE AND SALT ON THE SHELF QUALITY OF CURED *CHRYSICHTHYS NIGRODIGITATUS*

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ABSTRACT

The effects of different drying temperatures (60°C, 75°C, 90°C, 105°C, 120°C) and salting, on the preservation and shelf life of smoked *Chrysichthys nigrodigitatus* caught from the upper reaches of the Cross River was studied. Freshly caught fishes with weight ranges of 150-230g were randomly sorted into two batches, gutted and washed. One batch was salted (360gNaCl/l) and the other batch was unsalted. All the fishes in the batches were cold smoked at the same level. Some representatives of the two batches were oven dried at the selected temperatures for 4 hours. Weight changes and microbial growth was monitored on the stored finished fish products.

Organoleptic and microbial results show that temperature (90°C optimum) was the most critical factor for fish preservation and longer shelf life. Salting had no significant advantage on fish preservation ($P>0.05$). The highest total viable count (TVC) of 1.2×10^8 cells of bacteria/g and mould growth was found on the unsalted fish and the least TVC of 1.0×10^6 cells of bacteria/g was found on the salted fish. A "best before period" of 12 days for consumption was suggested for the fish so preserved.

KEYWORDS: Temperature, Salting, *Chrysichthys nigrodigitatus*, microbial growth, shelf life.

INTRODUCTION

Protein of animal origin is in very short supply in Nigeria. There is an over-dependence on beef from cattle. There is therefore the need to supplement animal protein with fish protein. There is however a wide gap between fish production and fish made available to consumers due to spoilage and short shelf life. Fish preservation, handling and storage procedure in the artisanal sector of the industry are traditional, characterized by lack of precaution against spoilage microorganisms. As a result, a loss of 45% in original weight of fish produced is generally the case for the artisanal fisheries (Tobor 1969).

The purpose of fish preservation is to prevent loss due to spoilage and keep the fish close to its fresh state or minimize changes in its appearance, taste and texture. This can be achieved by providing conditions, which will adversely affect the activity of undesirable spoilage microorganisms and enzymes. Salting, smoking and application of low temperatures (freezing) have been used to suppress microbial activity and enzymic deterioration of preserved fish (Huss 1988). The long storage life of some smoked fish products is due mainly to the water removal by heat- drying and cooking than to the preventive value of the chemical compounds deposited on the fish by the smoke (Clucas 1982).

Major fish species either caught or farmed in Nigerian waters include: (*Gymnarchus niloticus, Heterotis niloticus, Lates niloticus, Oreochromis niloticus, Alestes spp, Clarias gariepinus, Chrysichthys spp.* and *Heterobranchus spp*). Of these fish species, Chrysichthys spp. are some of the highly priced catfishes in the Nigerian market and it abounds in very large quantities in the early rainy season. A substantial amount of these fish products are lost to microbial deterioration due to lack of proper preservation techniques (Ezeronye and Erondu 1999). In a developing country like Nigeria, fish preservation by refrigeration cannot be assured due to irregular power supply or total absence of power in rural fishing communities. Fish curing i.e. smoking, drying, salting and fermentation, remain the only viable option that will ensure fish preservation and widen distribution to consumers. Cured fish is an integral component of the average Nigerian daily meal. Any research that will enable the resource-poor fish producer improve his skill and preservation methods for a better finished product will be of obvious economic advantage. We assess here the effect of temperature and salt on the shelf quality of cured (smoked) *Chrysichthys nigrodigitatus*. The obtained result, where favourable will give support to the improved traditional methods of producing salted, dried and smoked fish described in this study.

MATERIALS AND METHODS

Dressing and Salting

Fresh *Chrysichthys nigrodigitatus* of commercially available sizes (150-230g) were bought

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Table 1: Weight changes of salted and unsalted *C. nigrodigitatus* smoked and dried at different temperatures during storage for 16 days.

Weight (g)	Temperatures (°C)									
	60		75		90		105		120	
	S	U	S	U	S	U	S	U	S	U
Initial	133.0	203	253	141	234	192	190	201	201	184
Final	35	49	83	35	66	38	55	48	56	52
% Weight Loss	74	76	67	75	72	80	71	76	72	72

S Salted before smoking.

U Unsalted before smoking.

from local fishermen at the upper reaches of the Cross River, Unwana, Ebonyi State, Nigeria. Fishes were dressed by gutting and washing to remove blood. The fishes were randomly sorted into two batches, one batch was salted and the other batch was unsalted. Salt was applied to the fishes by the brine salting method. A salt solution of 360g/l was prepared having a brine strength of 100% (Clucas, 1982). The fishes were then totally submerged inside the brine solution for one hour. To increase the rate of salt penetration and water removal plenty of brine was used and the fishes were stirred frequently making salting uniform.

Smoking and Oven drying

Both the salted and unsalted fish were smoked for 1h. The fish were hung by means of a wire hooked through the operculum and the mouth over a fire source from a local smoking kiln. The different batches of smoked fish were immediately transferred to the oven for proper drying for 4h. The fish were labelled according to the different drying (smoking) temperatures viz 60°C, 75°C, 90°C, 105°C and 120°C respectively. After processing and drying, the fish (salted and unsalted) were stored in clean paper cartons for 16 days and a number of tests were carried out on the fish within the period to assess the fish quality.

Microbiological Analysis

Standard microbiological procedures were used to determine the microbiological quality of the stored fish (Pelzer and Chan 1977). Total viable count (TVC) of mesophilic aerobic bacteria was determined by the pour plate technique. One gram of each of the different fish samples dried at different temperatures was blended in 9ml sterile distilled water for 2 min with a mechanical blender. Serial (10-fold) dilutions up to the 10^5 dilution was done prior to inoculation in plate count Agar (merck) and incubated at 28°C for 3 days. Yeast and mold were cultured on Potato Dextrose Agar (Oxoid) fortified with an antibiotic (Chloramphenicol 25mg/l). The microbial

Table 2: Growth of mould on salted and unsalted *C. nigrodigitatus* smoked and dried at different drying temperatures during a storage period of 16 days.

Time (days)	Temperatures (°C)									
	60		75		90		105		120	
	S	U	S	U	S	U	S	U	S	U
1	-	+	-	-	-	-	-	-	-	-
4	+	+	+	-	-	-	+	-	-	-
8	+	+	+	-	-	-	+	-	+	-
12	+	+	+	+	+	-	+	-	+	-
16	+	-	+	-	-	-	-	-	-	-

S Salted before smoking.

U Unsalted before smoking.

\+ Presence of mold on stored fish

— Absence of mold on stored fish.

Table 3: Test of mean differences in bacterial load (cfu per ml x 10^7) between salted (S) and unsalted (U) fish at 60°C and 120°C after 16 days.

Characteristics	Mean of characteristics cfu per ml x 10^7		S^2_p	t calculated	± 8df 0.05	Decision
	X_1	X_2				
Salted at 120°C Vs Salted at 60°C	2.06	2.38	8.314	-0.175	-1.860	Not significant
Unsalted at 120°C Vs Unsalted at 60°C	2.52	3.96	12.769	-0.637	"	"
Salted at 60°C Vs unsalted at 60°C	2.38	3.96	12.545	-0.596	"	"
Salted at 120°C Vs unsalted at 60°C	2.06	2.52	3.537	-0.387	"	"
						(P>0.05)

Table 4: Average scores of sensory evaluation of smoked dried fish at different temperatures using a ten-man taste panel in a nine point hedonic scale.

Sensory Parameters	60°C	75°C	90°C	105°C	120°C
Taste	1	4	8	8	8
Texture	2	6	8	8	8
Freshness	2	5	8	8	8
Colour	3	6	8	8	8
Dryness	3	6	7	8	9

load (cfu per ml) was determined by methods recommended by the International Commission of Microbial Specification for Foods (ICMSF, 1974).

Sensory Evaluation

Sensory quality of the smoked fish was evaluated by a ten-man taste panel. A nine point hedonic scale (where 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4= dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely) was used (Larmond, 1977). The fish were evaluated for taste, texture, freshness, colour, dryness and firmness.

RESULTS

The results of the weight changes of salted and unsalted fish smoked and dried at different temperatures and stored within 16 days are shown in Table 1. The fishes had a marked loss in weight during the period for all temperatures. Percentage weight loss ranged between 67 and 80%. Weight loss was gradual and progressive with time for all drying temperatures. Fig.1 show bacterial load at different drying temperatures for salted and unsalted fish during a storage period of 16 days. Drying (smoking) temperatures from 60 to 75°C were not able to inhibit microbial growth. Fig.1 shows that there was little or no growth of bacteria on the stored fish within the first 12 days after which the bacteria growth increased to a level as high as 1.2 x 10^8 cfu/ml in unsalted fish and 9 x 10^7 cfu/ml in salted fish dried at 60°C on the 16^{tn} day. The same pattern of result was also obtained for fish dried at 120°C. There was a general increase in bacterial load after 12 days of storage. The growth of mould on the stored smoked fish dried at different temperatures is shown in Table 2. Growth of mould was highly reduced in fishes dried in temperatures between 90-120°C. The longer the fish are stored the less the growth of mould (Table 2). The results of testing the mean differences between salted and unsalted smoked-dried fishes at the highest and lowest limits of the experimental temperatures are presented in Table 3. No significant difference was obtained in all the combinations tested (P>0.05). Organoleptic results show that smoked fish dried at temperatures of 90°C, 105°C and 120°C scored higher than those dried at lower temperatures (Table 4).

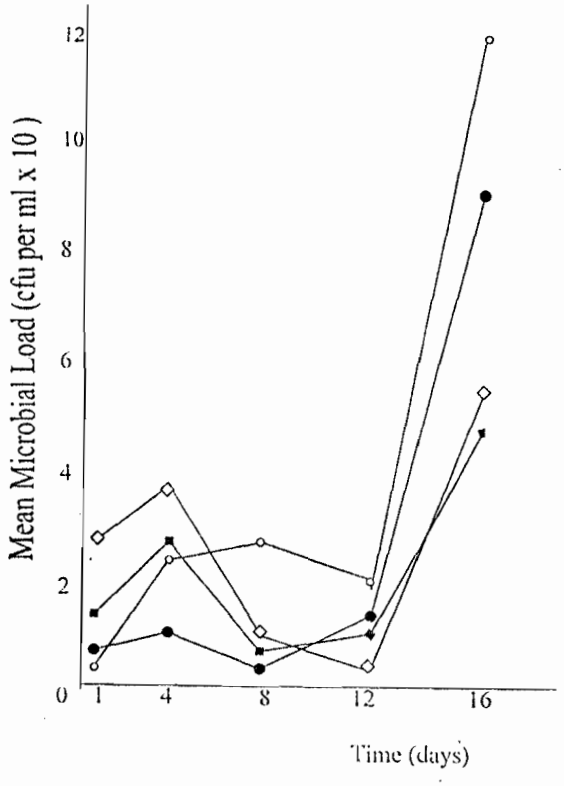

Fig.1: Bacterial load at drying temperatures 60°C (○= unsalted; ● = salted) and 120°C (◇ = unsalted; = salted) for♦ fish at the end of a storage period of 16 days

DISCUSION

The result obtained from this research reveal an improved method of smoking and oven drying fish. The preliminary drying at low temperature (cold smoking) was less fuel (wood) consuming and served to impart the smoke flavour to the fish and also condition the skin for further drying in hot oven temperatures. Fish dried at temperatures between 90-120°C were better irrespective of brining. This was evidenced by a drastic reduction in microbial growth on stored fish smoked and dried at these temperatures. The slight growth of bacteria or mold in salted fish dried at 120°C could be due to contamination from the commercial salt used for brining which also agree with the report of Clucas (1982). The organoleptic result also agree with the high quality of the smoked fishes dried at temperatures of 90°C, 105°C and 120°C (Table 4). Akande and Tobor (1993) had earlier advocated the use of hot-smoking temperatures between 65-120°C to produce a better quality stored fish product. The result generally showed that fishes smoked and dried at lower temperatures (60-75°C) spoil fast as evidenced by off-odours within 24h of drying due to microbial degradation.

Huss (1988) indicated that at low temperatures, the increased number of bacteria is accompanied by qualitative changes. Clucas (1982) reported that long storage life of some smoked fish product is due to more drying and cooking than the preservative value of chemicals deposited on the fish from the smoke. Our result agree with this view and recommends that temperatures at which fish is smoked and dried is critical to its preservation and shelf life.

Salting fish before smoke drying did not show any special advantage in keeping down microbial load based on the results of the T-test statistics ($P>0.05$). There was however individual taste preference for salted than unsalted fish. Moreover, the salted fish commands a higher market price than the more shrivelled unsalted fish if sold by sight. The progressive reduction in weight of the stored fish is mainly due to loss of water by evaporation. The percentage loss in weight of the salted fish 67–74% and for unsalted fish 72-80% were higher than those recorded by Tobor (1969) 38.8 – 43.2% for *Lates niloticus*, *Heterotis niloticus*, etc. The profile of bacterial growth in stored smoked fish show that there was little or no growth within the first 12 days, after which a general increase in bacterial load was observed for both salted and unsalted fish. This result is expected because the fishes were smoked, which imparted some elements of carbonic acid, phenolics and tar materials all of which are acidic and bacteriostatic. In such extreme environment microorganisms cannot thrive without some degree of adaptation in their metabolism. So the 12 days period represent a period of incubation and intense metabolic activity inorder to overcome the adverse acidic environment of the fish. Growth of the organisms were therefore deterred within the 12 day period. However this period can be extended by re-drying in ovens as at the initial treatment. The observation that the longer the fish are stored the less the growth of the mould can be explained to have resulted from the exhaustion of nutrient. Bacterial load after 12 days started increasing in population, resulting in competition for microbial nutrients which may have exhausted the available nutrients with adverse effect on mould growth. Besides, the available water for microbial use (water activity-a_w) had become depleted with time due to drying which also affected the growth of the mould Frazier and Westhoff (1988). The result show that fish dried by this method will keep well and reach distant markets and consumers in good condition without recourse to the use of protective chemicals, which often prove a health hazard to consumers (Ihekoronye and Ngoddy, 1985). It is therefore recommended that where traditional smoking kilns alone must be used, they should be modified to concentrate smoke and heat on the fish placed above the fireplace.

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