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GHANA/NETHERLANDS ARTISANAL FISH PROCESSING PROJECT

RESEARCH PROJECT #9

STUDIES ON THE TRADITIONAL STORAGE OF SMOKED ANCHOVIES IN GHANA

PROGRESS REPORT #2

QUALITY CHANGES DURING SHORT-TERM STORAGE OF SMOKED ANCHOVY (Anchoa guineensis) AT TEMA MANHEAN

By

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ABSTRACT

A proto-type traditional anchovy storage structure was constructed at Tema Manhean (in the Greater Accra Region of Ghana) and freshly smoked anchovies (Anchoa guineensis) were stored the traditional way for a period of three months. Samples were taken at 0 and 3 month-intervals to determine the microbial, mycotoxicological, physical, chemical and sensory characteristics. Changes in the environmental conditions in the storage were monitored with a Telog Temperature/Humidity Recorder.

Storage temperature increased by about 2°C within the first three months from the original average value of about 30°C. The humidity in the structure on the other hand, decreased steadily from an initial value of 66.7% to as low as 53.6% at the end of the three-month storage period. The moisture content of samples did not show any significant change, while slight increases were observed in sensory attributes such as brittleness and chewiness. There was only a slight decrease in flavour, but hardness, aroma and colour remained the same. Storage yield in terms of overall physical damage was 91.4%. Proteolytic, lipolytic and microbial deterioration was minimal, occurring mainly in samples at the

periphery of the structure. The edible portions of the fish samples had less bacterial load than the whole fish, but the mould count was approximately the same for both samples. In general, the first three months of storage was characterized by a rapid proliferation of bacteria resulting in high viable aerobic counts. Mould growth was however not favoured much. Microorganisms isolated were Rhizopus, Aspergillus spp., Micrococci, Bacillus sp. and Yeasts. Coliforms as well as faecal coli and pathogenic microorganisms were absent from both whole fish and the edible portions of the smoked anchovies; a good indication of hygienic processing and storage conditions. The stored fish samples were also negative for aflatoxins B_1, B_2, G_1 and G_2.

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INTRODUCTION

Fish and fishery products play a significant role in the diet of the majority of people in Ghana and many other West African countries. In fact, fish constitutes the main source of animal protein in these areas; and estimates show that fish account for over 70% of the total animal protein intake with marine fish accounting for nearly 80% of the fish production (Ghana/Netherlands Project Document, 1988). Large quantities of different species of fish are landed during the season of glut between July and October of each year, and these are preserved by one of several traditional processing techniques to avoid excessive wastage (Okraku-Offei, 1970). The most significant pelagic species of fish landed by Ghanaian canoe fisheries are the sardinellas (Sardinella aurita and Sardinella eba) and the anchovies (Anchoa guineensis). Of the 221,000 metric tonnes of total fish landings in Ghana in 1989, 152,000 metric tonnes were achovies and sardinellas, both species accounting for over 68% of the total catch (Appendix 1).

The remarkable increases in anchovy landings in recent years are indicative of its increasing economic and nutritional significance in Ghana and neighbouring West African countries. Anchovies are used for direct human consumption in the preparation of adult and weaning foods, and also as a main source of protein in the animal feed industry. Among the various traditional processing methods employed in Ghana to preserve fish, smoking and sun drying are the most widely used techniques for anchovies. The development of

improved versions of the traditional fish smoking ovens, and the successful extension and adoption of the improved smoking techniques in many fish processing communities have further enhanced the popularity of smoking as a major fish preservation method in Ghana (Kagan, 1969; 1970; Nerquaye-Tetteh, 1989).

The advantages of the improved ovens in terms of increasing smoking capacity , fuel economy and a better quality product have been adequately demonstrated in training programmes under the Regional Training and Applied Research Project on Artisanal Fish Processing in West Africa (under the Ghana/Netherlands collaborative fish project). In fact, it was during one of such training programmes at Tema Manhean that the socio-economic significance of smoked anchovy production and the need for research into its storage problems were identified. Tema Manhean is a small Ghanaian fishing village where large scale anchovy smoking and marketing is undertaken. The bulk of the smoked fish has to be stored for several months for distribution during the off-season.

No studies have been undertaken on the traditional storage of smoked anchovies in particular. The situation can be explained mainly on account of the fact that large scale processing and storage of anchovies is a recent development in response to increased production and utilization for human consumption and animal feed.

In a baseline socio-economic study of Tema Manhean, Lokko (1990) discussed the economic significance of smoked anchovies in relation to the social set-up in the area. In another

preliminary survey, the authors studied one traditional storage structure at Tema Manhean in which smoked anchovies were stored by traditional processors for a period of seven months. The traditional storage was found to involve packing several hundred crates of the smoked fish in ovens lined with brown paper and polyethylene sheets with long stakes for support. A resulting heap in a dome shape measuring over 3m high and 2m in diameter is covered with more brown paper and polyethylene sheets.

An approved research project under the Ghana/Netherlands Artisanal Fish Processing Project seeks to study the traditional storage of anchovies at Tema Manhean in order to assess its effectiveness in preserving the quality of the smoked fish over a period of time. In earlier studies conducted under this project, the structural characteristics of the traditional anchovy storage technique used at Tema Manhean was established (Nerquaye-Tetteh and Plahar, 1992). In addition, freshly smoked anchovies for storage were evaluated for their physical, chemical and sensory characteristics, as well as the microbiological and mycotoxicological quality (Plahar, 1992; Hodari-Okae and Kpodo, 1992).

The purpose of the present study was to determine the quality changes in smoked anchovies during short-term traditional storage at Tema Manhean. This progress report gives information on the effectiveness of the storage structure in the quality preservation of smoked anchovies within a three-month period of storage.

2. MATERIALS AND METHODS

2.1. Smoking and Storage of Anchovies

The structural characteristics established in a previous study (Nerquaye-Tetteh and Plahar, 1992) were used to construct a proto-type structure in the village to determine its effectiveness in preserving the quality of smoked anchovies. One hundred and ninety crates of anchovies were smoked the traditional way and stored. This was the quantity of fish required to fill the normal storage capacity with height of 2.6m and 7.8m base circumference. The detailed features of the structural set up was described in Progress Report #1A (Nerquaye-Tetteh and Plahar, 1992).

2.2. Monitoring Environmental Conditions in Storage Structure

A temperature and Humidity recorder (Model R-2126, Telog Instruments Inc., Rochester, NY) and the Telog 2100 series Support Software were used to monitor the temperature and humidity changes in the structure during the period of storage. The instrument was placed in a rectangular box made of framed wire mesh and mounted at the mid section of the fish pile. It was programmed to sample temperature and humidity at one minute intervals for 180 days. It was also to record the minimum, average and maximum temperatures and humidities in the structure.

2.3. Sampling and sample Preparation

Fish samples were taken at 0, and 3 month intervals and analysed for the microbiological, mycotoxicological, physical, chemical and sensory characteristics. To determine the quality of freshly smoked anchovies before storage (zero month sampling), five samples of freshly smoked anchovies were randomly taken from each of forty large baskets filled with smoked anchovies prepared for storage. The samples were bulked together and mixed thoroughly. Sub-samples were taken from the bulk and these were evaluated for physical damage in terms of physical disintegration, visible mould damage, and insect infestation. The sub-samples were then rebulked and divided into two batches. One batch was milled whole in a laboratory hammer mill while the other batch was treated to obtain the edible portion by removing the scales, the head and the tail. This was also milled as before and the milled samples were kept in separate sterile polyethylene bags for analysis.

Sampling during storage was done at both the periphery and the interior (about 20 cm deep) of the structure to obtain two sets of samples. For each set, five samples were taken from different locations, bulked and treated as described earlier.

2.4. Evaluation of physical characteristics

To determine the percent overall physical damage in the smoked anchovies, samples were examined and grouped with respect to the type of physical damage experienced during

processing, handling and storage. Weighed samples of the smoked fish were separated into the following four groups:

i. whole unbroken pieces,

ii. broken pieces,

iii. insect infested ,

iv. visible mouldiness.

Each group was weighed separately and expressed as a percentage of the total weight taken. The overall physically damaged portion was calculated based on the broken pieces, insect infested samples and samples showing visible mouldiness.

2.5. Sensory evaluation of fish samples

A quantitative descriptive sensory analysis was used to assess the sensory quality of the smoked anchovy samples. This involved a detailed descriptive sensory evaluation of the texture, flavour, aroma and colour of the fish, provided by expert panelists (Plahar, et al., 1991). For each sample, panelists used an unstructured score card with sensory descriptions at each end of a 10 cm long line to make marks in relation to the description of the attribute (Johnson et al., 1988). The distance of the tail end of the line to the mark was used as the numerical score. For each attribute, the mean score was obtained from several scores.

2.6. Proximate composition and chemical quality of smoked anchovies

Samples of milled edible portions as well as whole fish were analysed for moisture, fat, protein and ash following

standard methods (AOAC, 1984). The method of Pearson (1970) was used to determine the total volatile bases (TVBN) in the samples. Non-protein nitrogen (NPN) was determined by precipitating the protein with 5% trichloroacetic acid, centrifuging at 10,000 x G and determining the nitrogen content of aliquots of the filtrate (Lu et al., 1988). Fat extracts were analysed for fat acidity (AACC, 1984, method 02-01) and peroxide value (AOCS, 1980).

2.7. Total viable counts (Pour plate technique)

The sterile bag containing whole fish powder was opened near a bunsen burner flame and 10g of the sample was aseptically removed into a sterile sample bottle. A 90 ml portion of quarter strength Ringers solution was added and mixed thoroughly by shaking several times. The suspension was allowed to stand for 5 min. to soak well. The mixture was again shaken vigorously and 1 ml portion was pipetted and used to prepare 10^{-1} to 10^{-6} serial dilutions. One milliliter of each serial dilution was then pipetted into sterile plates in duplicate. Each plate was overlaid with about 20 ml of Plate Count Agar cooled to 45°C. Thorough mixing was ensured by clockwise and anti-clockwise rotation of the plates. The plates were allowed to stand to solidify after which they were incubated at 30°C for 72 hr. The edible portion of the smoked anchovy was treated in the same way to obtain the total viable counts (Harrigan and McCance, 1966).

2.8. Mould and Yeast Counts

For the enumeration of yeast and mould, a low acid medium was used. This medium was prepared by sterilizing 250 ml of Potato Dextrose Agar (PDA) and adding 7.5 ml of sterilized acid (i.e. 1.5 ml acid to 50 ml of PDA). Employing the Pour Plate technique, 1.0 ml of the 10^{-1} dilution of smoked fish suspension was pipetted into duplicate sterile petri dishes. This was overlaid with acidified PDA and carefully rotated in a clockwise and anti-clockwise direction for thorough mixing. The plates were then incubated at 30°C for 24 hr.

2.9. Enumeration of Enterobacteriaceae (Coliforms)

MacConkey broth with glass vials in test tubes were prepared and sterilized. One milliliter of 10^{-1} and 10^{-2} dilutions of fish suspension were pipetted into 10 ml duplicate broths. These were incubated for 72 hr at 37°C. Incubated samples were then identified for acid and gas production. For direct plating out, streaks were made on MacConkey agar plates using the stock fish solution prepared from each of the samples. The plates were then incubated at 37°C for 48 hr.

2.10. Pathogenic Organisms

2.10.1. Staphylococcus sp.

A 5g sample of smoked fish powder was aseptically weighed and placed in cooked meat medium with 10% salt added. It was mixed thoroughly and incubated for 12 - 18 hr at 37°C. The sample was then subcultured onto Mannitol salt agar and

incubated for 72 hr at 37°C for pure culture isolation and identification.

2.10.2. Salmonella sp.

Twenty-five gram sample of smoked fish powder was weighed and placed in 100 ml Selenite enrichment broth and mixed well by shaking. The broth was then incubated for 12 - 18 hr at 37°C. This was subsequently subcultured onto Bismuth Sulphite agar and the plates incubated for 72 hr at 37°C.

2.11. Culture Identification

Smears of growth from the plates were made on clean slides with sterile loop. These were Gram stained and viewed under the microscope to identify the morphology and Gram reaction. Selective identification for Aspergillus flavus/parasiticus was performed using a specific medium prepared with Aspergillus Flavus Parasiticus Agar (AFPA) Base (Oxoid Limited, Hampshire, England).

2.12. Hydrogen Ion Concentration (pH)

pH of the samples were determined with a Metrohm 620 pH meter (Swiss-made). Approximately 10g of fish powder was weighed into 200 ml beakers and 90 ml of carbon dioxide-free distilled water was added and thoroughly mixed. The mixture was left to stand for 5 min. before pH measurements were taken. The pH meter was calibrated prior to sample measurements using a standard buffer solution of pH 7.0.

2.13. Extraction and Estimation of Aflatoxins

The method of extraction was based on that of Romer (1975). Ground samples were extracted with 250 ml acetone : water (85 :15 v/v). The extract was filtered through Whatman #1 filter paper. Clean-up of filtrate was carried out using cupric carbonate and ferric gel (170 ml sodium hydroxide + 30 ml ferric chloride). After a second filtration the first 250 ml of filtrate were collected and aflatoxins extracted into chloroform (2 x 10 ml). The chloroform layer was run off into 100 ml potassium hydroxide wash solution in a separating funnel which was gently swirled for 15 seconds and the layers allowed to separate. The chloroform layer was run through a bed of anhydrous sodium sulphate, then evaporated to dryness. The residue was picked up in 200 ul chloroform.

Thin layer chromatography was carried out on silica gel 60 aluminium-backed TLC plates (Merck No 5553, BDH Ltd., Dorset, U.K.). Bi-directional development was carried out first in diethyl ether to remove interferences followed by chloroform : acetone (9 : 1 v/v).

Visual comparison of the intensity of fluorescence under ultraviolet light using a Chromato-vue Ultra violet light cabinet fitted with a UVL 56 Blakray lamp (Ultra Violet Products Ltd., Cambridge, U.K.) of sample aliquots and aflatoxin standards (Sigma Chemical Co. Ltd., U.S.A.) was undertaken. All chemicals and reagents used were of the AnalaR grade (British Drug House, BDH Chemicals Ltd., Poole, U.K.).

2.14. Statistical analysis

Statistical significance of observed differences among means was evaluated by analysis of variance, and the least significant difference test (LSD) was used for comparison of the means (Steel and Torrie, 1980).

3. RESULTS AND DISCUSSION

3.1. Changes in the Temperature and Humidity Conditions in the Storage Structure

The temperature recordings showed a gradual increase in the storage temperature during the first three months (Fig 1). The storage structure was so compact that the micro-environment created inside could not effectively equilibrate with, or be influenced by the environmental conditions outside it. The initial rise in the temperature was the result of generation of heat from microbial activities. Increased numbers of viable organisms were observed within the first three months of storage.

Humidity on the other hand fell contantly from an initial average value of 66.7% to 53.6% at the end of the third month of storage. At the initial stages of storage the structure was occasionally aerated by removing the polyethylene covering for a few hours each day. This practice most probably, caused the escape of moisture which might have risen to the periphery from the relatively hot interior of the structure.

3.2. Physical and Sensory characteristics of smoked anchovies

Results of the physical characteristics of the smoked fish samples are given in Table 1. Almost 97% of the fish prepared for storage were physically sound and whole. There were no visible mouldiness in any of the samples examined while only 0.35% were found to be infested with

Fig 1. Temperature and Humidity Changes in Storage Structure

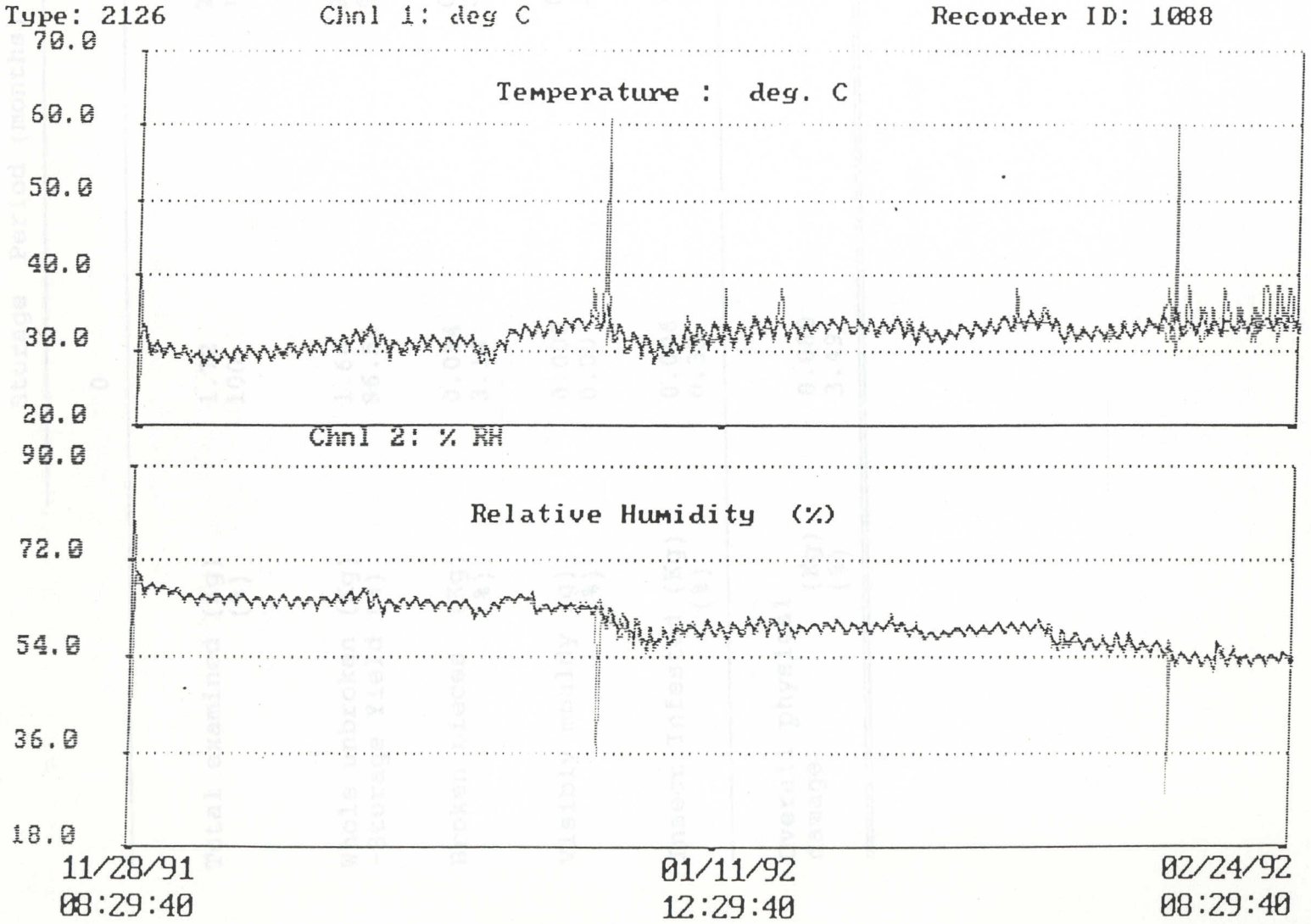

Table 1. Changes in the physical characteristics of smoked anchovies (Anchoa guineensis) during short-term storage

		Storage Period (months)	
		0	3
Total examined	(Kg)	1.72	2.65
	(%)	100	100
Whole unbroken	(Kg)	1.66	2.42
-Storage Yield	(%)	96.51	91.39
Broken pieces	(Kg)	0.054	0.125
	(%)	3.14	4.72
Visibly mouldy	(g)	0.000	0.080
	(%)	0.00	3.01
Insect Infested	(Kg)	0.006	0.023
	(%)	0.35	0.87
Overall physical damage	(Kg)	0.060	0.228
	(%)	3.49	8.63

insects. The few broken pieces observed could be the direct result of handling during packaging and storage, but not due to physical deterioration.

The normal practice of fish smoking for storage involves a great deal of physical handling. Apart from turning the fish over on the smoking kiln for uniform smoking during processing, the smoked fish had to be spread to cool and then packed in large baskets which may be piled on each other until ready for storage. Such packaging techniques could cause a lot of the relatively dried pieces of fish to break under the pressure of the weight. About three percent physically damaged pieces of freshly smoked anchovies observed in this study is considered far below the normal anticipated breakages. Both processing and handling were therefore adequate, resulting in a high quality product for storage.

Freshly smoked anchovies that have not been stored are not usually expected to be infested with insects. The few insect infestation recorded in the samples examined could be the result of carry-on attack from previous storage. Tema Manhean is an area noted for large scale anchovy processing and storage with a number of old (and perhaps highly infested) storage structures. This could be a good source of infestation to newly packaged samples for storage.

The results of the three-month storage showed a storage yield of over 91.4% physically sound product (Table 1). The remaining 8.6% was made up of physically damaged samples such as broken pieces, insect infestation, visible mouldiness etc. which in actual fact are only sold at reduced rates for animal feed. They

are not complete losses as such. During the first three months in storage visible mouldiness was responsible for the major physical damage. The main insect identified was the dermestid beetle (most likely, Dermestid maculatus)

Table 2 shows the results of the quantitative descriptive sensory analysis of the smoked anchovies. This analysis is very useful in characterising the sensory properties of the samples quantitatively for reliable comparisons to be made. Typical of freshly smoked fish (Plahar et al., 1991), the smoked anchovies studied scored very highly for flavour, aroma and colour in relation to the expected freshness values. The freshly smoked samples possessed the characteristic fresh smoky aroma with the freshly-smoked fish flavour. Other quantitative descriptive scores also characterized the samples as firm to hard, chewy as well as being neither brittle nor crumbly. These are some of the typical quality attributes that are expected to be preserved by the storage techniques employed in order to enhance product safety and consumer acceptability.

During the first three months of storage, there was no significant change in the physical characteristics of the samples. The freshly smoked quality attributes were adequately preserved by the traditional storage.

3.3. Proximate composition and chemical properties

The smoked anchovy samples prepared for storage were found to be a very good source of protein (62.5% - 65.4%) and minerals (Table 3). Both the fat and moisture contents were

Table 2. Quantitative descriptive analysis of traditionally stored smoked anchovies (Anchoa guineensis).

Sensory characteristic	Mean Score for Samples stored:	
	0 month	3 months
Hardness	6.4 ± 0.3	6.5 ± 0.4
Brittleness	6.0 ± 0.6	6.3 ± 0.2
Chewiness	5.8 ± 0.6	6.1 ± 0.3
Flavour	9.6 ± 1.2	9.4 ± 1.4
Aroma	9.8 ± 1.0	9.8 ± 0.2
Colour	9.5 ± 1.6	9.3 ± 0.5

Scoring system:

Hardness : 0=very soft, 5=firm, 10=hard.
Brittleness: 0=crumbly, 10=brittle
Chewiness : 0=tender, 5=chewy, 10=tough
Flavour : 0=off flavour, 10=typical freshly smoked
Aroma : 0=mouldy or rancid, 10=fresh smoky aroma
Colour : 0=black, 10=light brown

low enough to present little deterioration problems during storage. High-fat smoked fish samples develop rancidity problems within a short period of storage. With moisture, earlier work by Okoso-Amaa et al. also indicated that the shelf-life of smoked Sardinella spp. varied according to the moisture content.

Three months of storage did not cause any significant reduction in the moisture content. There was rather a slight increase in the moisture content of the smoked fish samples from the initial value of about 13.2% to about 13.8% by the end of the three-month storage period. The edible portions of the fish samples were significantly higher in protein content than the whole fish samples. This is because of the removal of the less proteinaceous parts such as the head and skin. The observed higher ash content of samples from the periphery of the storage structure during the third month of storage was the result of a greater deterioration of the fleshy parts of these samples. High levels of insect infestation and consequent reduction in the flesh component of the samples resulted in lower protein content and higher ash values after storage.

Proteolytic and lipolytic, as well as physical deterioration occurred mainly in samples at the periphery of the structure. This outside layer of two to three fish thickness showed visible mouldiness and insect damage. The smoked fish in the interior of the structure were relatively sound with excellent physical and sensory characteristics.

Protein decomposition, as measured by non-protein

Table 3. Effect of short-term traditional storage on the proximate composition of smoked anchovies (*Anchoa guineensis*)[1].

Component and source	Whole fish		Edible portion	
	0 mo.	3 mo.	0 mo.	3 mo.
Internal section of storage:				
Moisture (%)	13.15	13.86	13.53	13.83
Protein (%)	71.90	71.10	75.63	76.59
Fat (%)	4.26	3.66	4.51	3.83
Ash (%)	16.65	16.76	11.10	10.56
Storage structure periphery:				
Moisture (%)	13.15	13.63	-	-
Protein (%)	71.90	65.88	-	-
Fat (%)	4.26	3.82	-	-
Ash (%)	16.65	21.81	-	-

[1]Values are means of triplicate determination expressed on dry-weight basis (except for moisture).

nitrogen (NPN) and total volatile base nitrogen (TVBN) content was very low in both the whole fish and the edible portion of freshly smoked anchovy (Table 4). The TVBN values obtained in this study ranged between 119 mg N/100g edible portion and 133 mg N/100g whole fish sample. Farber (1965) reported a suggested upper limit of 60 mg N/100g for marine fish. Based on about 80% moisture for fresh marine fish, this upper limit value is about 300 mg N/100g sample. The samples prepared for storage were therefore far below the limit suggested for TVBN content. In a recent study, Hodari-Okae et al. (1991) obtained TVBN values of between 18 - 22 mg N/100 g fresh fish for some species of marine fish purchased from some fish markets in Ghana. On dry weight basis, these values are also between 90 - 110 mg N/100g sample. During storage there was virtually no change in the TVBN concentration of the fish sampled from the interior of the storage structure within the first three months. Non Protein Nitrogen content of the whole smoked fish however decreased slightly during storage. A similar trend was observed in traditionally stored smoked herrings by Plahar et al. (1991).

Fat acidity was also low. The initial value of about 3 mg KOH/g sample decreased to about one-half the value during the first three months in storage. Lipolytic activity and oxidative rancidity were therefore negligible due to the freshness of the samples. Hodari-Okae et al.(1991) observed a possible relationship between high fat acidity and marine fish freshness.

Table 4. Effect of traditional storage on the fat acidity, total volatile base nitrogen (TVBN) and non-protein nitrogen (NPN) content of freshly smoked anchovies (Anchoa guineensis

Sample and source	Fat acidity (mg KOH/g)	TVBN (mg N/100g)	NPN (g N/100g)
Samples from internal section of storage structure:			
Whole Fish			
0 month	3.10	133.79	2.10
3 months	1.39	125.39	1.82
Edible portion			
0 month	2.19	119.81	1.62
3 months	1.53	115.35	1.62
Samples from Storage structure periphery:			
Whole Fish			
0 month	3.10	133.79	2.10
3 months	1.21	184.09	1.70

3.4. Microbiological Quality of Smoked Anchovies

Tables 5, 6 and 7 show the results of microbiological analysis of whole and edible portions of smoked anchovies (Anchoa guineensis) sampled before and during traditional storage at Tema Manhean. Microbial examination of anyprocessed food product provides information which serves as the most important criterion for judging the success of the process used, the effectiveness of the production controls as well as the microbiological stability and safety of the food. In this study, both the whole and edible portions of the freshly smoked anchovies had very low and acceptable bacterial and fungal loads.

Whole freshly smoked fish samples had slightly higher bacterial loads (85 x 10^1 per gram) than the edible portions (76 x 10^1 per gram). This difference may be attributed to the fact that the skin and head portions of the fish that were removed and discarded from the edible portion had excess bacteria as compared to the flesh. On the other hand, the absence of significantly higher mould counts in the whole fish samples as compared to the edible portions may be indicative of the fact that much of the mould growth was on the inner core of the fish and not on the skin. Removal of the skin did not therefore reduce the mould counts on the edible portion to any significant extent. In addition, the smoke treatment might have destroyed most of the surface skin contaminating moulds during processing.

Samples taken from the interior of the storage structure after three months showed increased levels of aerobic

Table 5. Effect of traditional storage on the microbiological quality of whole smoked anchovies (*Anchoa guineensis*) sampled from interior of storage structure.

Test	Storage Period (months)	
	0	3
Viable organisms		
Aerobic bacterial count per gram	85×10^1	$>300 \times 10^6$
Mould and yeast count per gram	32×10^1	13×10^1
pH	6.5	5.7
Culture	*Rhizopus*, *Asp.* sp. *Micrococci* *Bacillus* sp. Yeast	G +ve cocci *Micrococci* *Mucor* *Penicillium* *Asp.* sp
Coliforms (in 0.1 g)	Absent	Present
Faecal coli	Absent	Absent
Pathogens		
Salmonella	Nil	Nil
Staphylococci	Nil	Nil

Table 6. Effect of traditional storage on the microbiological quality of edible protion of smoked anchovies (*Anchoa guineensis*) sampled from interior of storage structure.

Test	Storage Period (months)	
	0	3
Viable organisms		
Aerobic bacterial count per gram	76×10^1	225×10^3
Mould and yeast count per gram	46×10^1	13×10^1
pH	6.4	5.7
Culture	*Rhizopus*, *Asp.* sp. *Micrococci* *Mucor* Yeast	G +ve cocci *Micrococci* *Penicillium* *Bacillus* sp.
Coliforms (in 0.1 g)	Absent	Present
Faecal coli	Absent	Absent
Pathogens		
Salmonella	Nil	Nil
Staphylococci	Nil	Nil

bacterial count, with pH decreasing from 6.5 to 5.7 (Table 5). A similar increase in bacterial load was observed in samples from the periphery of the structure. The viable bacterial load count increased a hundred thousand fold. The initial temperature and humidity conditions in the structure were quite ideal for the rapid proliferation of the few bacteria present in the freshly smoked samples. Mould growth was however, not favoured.

Microorganisms isolated from both whole and edible samples were Rhizopus, Aspergillus sp., Micrococci, Bacillus sp. and Yeasts. Plahar et al.(1991) isolated similar organisms in freshly smoked herring (Sardinella eba). Mucor and penicillium showed up during the third month of storage. Also, coliforms were found in 0.1 g samples at the third month of storage period.

Coliforms as well as faecal coli and pathogenic microorganisms were absent from both whole fish and edible portions of the freshly smoked anchovies. The absence of Escherichia coli (coliforms) in the freshly smoked anchovy samples shows that there was no faecal contamination of the fish. Coliforms, other than E. coli are a good indicator of unsatisfactory processing or sanitation. The absence therefore of other coliform organisms shows that proper and hygienic procedures were used during the drying and smoking of the anchovies.

3.5. Mycotoxicological quality of stored anchovies

Mycotoxin formation in foods is closely linked to fungal growth. Without growth of the producing fungi, generally mycotoxin production will likewise not occur. However, the presence of mycotoxic fungi in a product does not automatically indicate the presence of mycotoxins especially if growth has not occurred. On the other hand, the toxins may persist long after vegetative growth has occurred and the moulds have died.

Both freshly smoked and stored fish samples analysed were all negative for aflatoxins B_1, B_2, G_1 and G_2. Aflatoxins are toxic mycotoxins produced by the moulds Aspergillus flavus and Aspergillus parasiticus under favourable conditions of temperature and moisture, especially during storage. They have been detected in various processed fish samples (FAO, 1979), but nothing has been reported of aflatoxins in freshly smoked fish. Aflatoxin contamination of foods is mainly a storage problem and this usually occurs when foods are stored under conditions that are conducive to fungal growth.

Production of aflatoxins is favoured by temperatures of between 25°C to 30°C although they can be produced below 8 to 10 °C in very small amounts over much longer periods of time. Aflatoxins are produced in highest amounts at temperatures of about 25°C (Diener and Davis, 1966).

During the three-month storage period, daily average temperatures inside the structure ranged from 29.2 to 34.0 °C. Although microbiological examination revealed the presence of Aspergillus sp., the use of Aspergillus flavus parasiticus

Table 7. Effect of traditional storage on the microbiological quality of whole smoked anchovies (Anchoa guineensis) sampled from the periphery of storage structure.

Test	Storage Period (months)	
	0	3
Viable organisms		
Aerobic bacterial count per gram	85×10^1	46×10^6
Mould and yeast count per gram	75×10^1	30×10^1
pH	6.5	6.3
Culture	Rhizopus, Asp. sp. Micrococci Bacillus sp. Yeast	G +ve cocci Micrococci Mucor Penicillium Asp. sp
Coliforms (in 0.1 g)	Absent	Present
Faecal coli	Absent	Absent
Pathogens		
Salmonella	Nil	Nil
Staphylococci	Nil	Nil

agar (AFPA), specific for aflatoxin producing moulds, showed absence of Aspergillus flavus and Aspergillus parasiticus. Obviously the temperatures in the structure were too much on the higher side to favour the growth of the aflatoxin-producing organisms as well as the production of the toxins.

The moisture content of the substrate or the relative humidity surrounding it is another important factor that affects growth and aflatoxin production (Diener and Davies, 1969). Previous work showed that optimum relative humidity for growth was 85% or greater (Austwick and Ayerst, 1963; Ayerst, 1969). Most foods with moisture contents of above 13% are known to be susceptible to growth of toxic moulds and potential mycotoxin formation (Bullerman, et al.,1984). The maximum average daily relative humidity in the storage structure was 67.0%. This decreased progressively throughout the storage period to as low as 53.6% by the end of the three months. The moisture content of the samples also decreased from 13% to about 10 %. These conditions would definitely not favour development of aflatoxin producing moulds in the traditional storage structures.

CONCLUSIONS

1. The traditional structure employed in the storage of smoked anchovies was effective in preserving the product against excessive physical damage. A storage yield of 91.4% was obtained within three months of storage.
2. The temperature inside the traditional storage structure was almost stable while humidity decreased steadily from 66.7% to 53.6%. There was a slight increase in the moisture content of the samples (from 13.2% to 13.8% moisture content).
3. Proteolytic, lipolytic and microbial deterioration was minimal, occurring mainly in samples at the periphery of the structure. Quantitative descriptive analysis of samples showed only slight changes in the sensory characteristics. The samples became slightly harder, were more brittle and chewy. Flavour also decreased slightly but aroma and colour did not change with storage.
4. Microorganisms isolated from stored samples include Rhizopus, Asp. sp., Micrococci, Bacillus sp. and Yeasts. Although microbiological examination revealed presence of Asp. sp., specific tests for aflatoxin producing moulds using AFPA were negative. The temperature and humidity conditions as well as the low fish moisture content were not conducive to the proliferation of aflatoxin producing organisms. Both freshly smoked and stored fish samples were negative for aflatoxins B_1, B_2, G_1 and G_2.

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APPENDIX I

ARTISANAL FISH PRODUCTION (CANOE FISHERIES) IN GHANA

(1984 - 1989)

Appendix 1. ARTISANAL FISH PRODUCTION (CANOE FISHERIES) IN GHANA 1984 - 1989

SPECIES	Annual Production (Metric Tonnes)					
	1984	1985	1986	1987	1988	1989
Round Sardines (Sardinella aurita)	34,816.3	54,072.5	45,488.6	45,670.7	75,851.5	61,158.5
Flat Sardines (Sardinella eba)	10,077.1	22,233.9	16,633.5	25,479.2	10,450.4	14,097.7
Club Mackerel (Scomber japonicus)	540.3	44.2	16,865.7	397.3	7,423.5	11,036.8
Anchovy (Anchoa guineensis)	47,230.9	27,590.3	15,208.5	87,984.4	75,902.3	76,347.9
Firigate Mackerel (Auxis thazard)	7,079.1	3,521.0	3,255.7	4,689.3	6,382.5	4,129.2
Seabreams (Lethrinus atlanticus)	9,060.1	6,258.1	7,069.9	9,737.5	13,039.9	10,431.9
Burrito (Brachydenterus auritus)	15,998.6	12,369.0	19,234.1	13,516.4	8,434.2	7,611.8
Others	46,431.3	33,809.4	66,440.2	74,909.5	46,557.9	36,064.9
Total	171,233.7	159,899.4	190,196.5	262,384.3	244,557.9	220,877.7

Source: Fisheries Dept. (Research and Utilization), Ministry of Agriculture, Accra.

APPENDIX II

TEMPERATURE AND HUMIDITY RECORDINGS IN TRADITIONAL SMOKED ANCHOVY STORAGE STRUCTURE DURING THE THREE-MONTH PERIOD

Saved Recorder Status Type: 2126
Time at Recorder: 05/21/92 12:33:03 Rec ID: 1088
Sample Rate: 1 min Last Update: 11/28/91 08:29:40
Interval Length: 04:00:00 Total data logged: 175 days 04:00:00
Storage Capacity: 6492 values records: 180 days 08:00:00
Range Ch1 -40.0 - 73.7 deg°C Ch2 0.0 - 100.0 % RH
Stats Ch1 minimums averages maximums Ch2 minimums averages maximums

Output compressed by a factor of 6

Date	Time	Ch1 Min	Avg	Max	Ch2 Min	Avg	Max	
11/28/91	08:29:40	24.2	31.5	39.7	39.2	66.7	79.6	([ ) H]
11/29/91	08:29:40	28.9	30.2	31.3	65.6	67.0	68.0	(T H]
11/30/91	08:29:40	28.9	29.9	30.9	65.3	66.6	67.5	(T H
12/01/91	08:29:40	28.0	29.3	30.6	63.9	65.7	67.0	(T H
12/02/91	08:29:40	27.7	28.8	29.7	63.4	64.9	66.1	T) H
12/03/91	08:29:40	28.0	29.0	29.9	63.9	65.0	65.8	T) H
12/04/91	08:29:40	28.2	29.3	30.1	63.8	65.2	66.2	(T H
12/05/91	08:29:40	28.4	29.4	30.4	63.5	65.0	66.0	(T H
12/06/91	08:29:40	28.2	29.5	30.6	62.9	64.6	65.8	(T [H
12/07/91	08:29:40	28.3	29.5	30.6	62.9	64.5	65.6	(T [H
12/08/91	08:29:40	28.6	29.8	30.8	63.1	64.5	65.7	(T H
12/09/91	08:29:40	28.9	30.0	31.0	62.7	64.5	65.8	(T [H
12/10/91	08:29:40	29.0	30.1	31.2	62.8	64.4	65.7	(T [H
12/11/91	08:29:40	29.1	30.3	31.4	62.6	64.3	65.5	(T [H
12/12/91	08:29:40	29.3	30.7	31.7	63.2	64.6	65.5	T H
12/13/91	08:29:40	29.9	31.1	32.1	63.5	64.8	65.8	T H
12/14/91	08:29:40	30.4	31.7	32.8	63.8	65.4	66.6	T) H
12/15/91	08:29:40	30.1	32.0	33.3	62.9	65.3	67.0	T) [H
12/16/91	08:29:40	28.6	30.7	32.2	61.4	64.0	65.8	(T [H
12/17/91	08:29:40	28.6	30.2	31.2	61.6	63.7	64.9	(T [H
12/18/91	08:29:40	29.1	30.6	31.6	62.5	64.1	65.2	(T [H
12/19/91	08:29:40	29.4	30.9	31.9	62.9	64.3	65.4	T [H
12/20/91	08:29:40	29.9	31.1	31.9	62.6	64.0	64.9	T [H
12/21/91	08:29:40	30.1	31.0	31.8	62.4	63.7	64.6	T [H
12/22/91	08:29:40	30.1	31.1	31.9	62.5	63.8	64.6	T [H
12/23/91	08:29:40	28.0	30.5	32.2	61.0	63.4	65.2	(T [H
12/24/91	08:29:40	28.0	29.2	30.7	61.1	62.3	63.6	(T H]
12/25/91	08:29:40	28.0	30.3	31.4	61.7	63.2	64.4	(T [H
12/26/91	08:29:40	30.1	31.9	32.9	63.0	64.5	65.4	T) [H
12/27/91	08:29:40	31.3	32.5	33.4	64.1	65.0	66.0	T) H
12/28/91	08:29:40	31.6	32.7	33.8	61.9	64.4	66.4	(T [H
12/29/91	08:29:40	31.7	32.9	34.0	61.9	63.0	63.9	(T H]
12/30/91	08:29:40	31.9	33.3	34.3	62.2	63.1	64.3	(T [H
12/31/91	08:29:40	32.3	33.5	34.3	62.2	63.2	64.4	(T [H
01/01/92	08:29:40	32.4	33.6	38.2	61.7	63.2	64.3	(T) [H
01/02/92	08:29:40	30.6	34.0	60.9	35.1	62.3	64.8	[T H])
01/03/92	08:29:40	29.6	31.9	33.6	57.3	60.6	63.5	T) [H]
01/04/92	08:29:40	28.9	31.1	32.6	55.5	59.1	62.1	(T) [H
01/05/92	08:29:40	28.0	30.3	32.1	54.4	57.9	61.2	(T H]
01/06/92	08:29:40	28.0	30.0	31.3	55.1	57.3	60.0	(T H]
01/07/92	08:29:40	29.2	30.7	32.0	55.5	57.4	59.7	(T H]
01/08/92	08:29:40	29.8	31.7	34.7	57.9	58.9	60.8	T) [H
01/09/92	08:29:40	29.8	31.7	33.6	57.1	59.1	60.8	T) [H
01/10/92	08:29:40	30.0	32.1	33.9	57.4	59.1	61.2	T) [H
01/11/92	08:29:40	30.0	32.2	38.2	56.8	59.0	60.9	T) [H
01/12/92	08:29:40	30.2	32.2	33.9	56.9	59.1	60.6	T) [H
01/13/92	08:29:40	30.9	32.9	34.7	57.7	59.7	62.0	(T [H
01/14/92	08:29:40	31.1	32.9	34.7	57.8	60.0	62.0	(T [H
01/15/92	08:29:40	31.0	32.8	38.2	57.7	59.5	61.5	(T) [H
01/16/92	08:29:40	31.1	32.7	33.8	57.5	59.3	60.7	(T [H
01/17/92	08:29:40	31.4	32.9	33.8	57.4	59.2	60.3	(T [H
01/18/92	08:29:40	32.2	33.2	33.9	58.4	59.6	60.4	(T H
01/19/92	08:29:40	32.2	33.3	34.2	58.4	59.8	61.0	(T H
01/20/92	08:29:40	32.0	33.4	34.6	58.3	59.9	61.3	(T [H

01/21/92	08:29:40	32.1	33.2	34.1	58.1	59.5	60.6	(T [H
01/22/92	08:29:40	31.7	33.1	34.3	58.3	59.6	60.8	(T [H
01/23/92	08:29:40	31.8	33.1	34.1	58.1	59.6	60.8	(T [H
01/24/92	08:29:40	31.6	33.2	34.6	58.7	60.1	62.1	(T H
01/25/92	08:29:40	30.7	32.3	34.1	57.9	59.4	60.9	T) [H
01/26/92	08:29:40	30.9	32.5	33.9	57.1	59.0	60.6	T) [H
01/27/92	08:29:40	30.8	31.8	32.8	57.1	58.1	58.9	T) H]
01/28/92	08:29:40	30.9	32.0	32.8	57.1	58.3	59.0	T) H]
01/29/92	08:29:40	31.6	32.6	33.7	57.7	58.7	60.0	(T [H
01/30/92	08:29:40	31.7	32.9	33.9	58.0	58.9	60.1	(T [H
01/31/92	08:29:40	32.1	33.1	34.1	58.1	59.0	60.3	(T [H
02/01/92	08:29:40	32.3	33.5	34.6	58.3	59.3	60.7	(T [H
02/02/92	08:29:40	32.4	33.6	38.2	58.1	59.3	60.7	(T) [H
02/03/92	08:29:40	32.7	33.9	35.2	58.2	59.5	61.0	T [H
02/04/92	08:29:40	32.6	34.0	35.8	58.1	59.5	61.4	T [H
02/05/92	08:29:40	30.8	32.7	34.3	55.1	57.5	60.5	(T H]
02/06/92	08:29:40	31.0	32.3	33.6	55.3	57.1	59.3	T) H]
02/07/92	08:29:40	31.0	32.1	33.0	55.1	56.8	58.8	T) H]
02/08/92	08:29:40	31.1	32.2	33.2	54.9	56.3	57.9	T) H
02/09/92	08:29:40	31.0	32.5	33.7	54.4	56.3	58.1	T) H
02/10/92	08:29:40	31.4	32.6	33.9	54.7	56.6	58.5	(T H]
02/11/92	08:29:40	31.8	32.7	33.8	54.7	56.3	58.6	(T H]
02/12/92	08:29:40	31.9	33.2	34.3	54.3	55.6	56.9	(T H
02/13/92	08:29:40	31.0	33.5	38.2	53.7	55.4	57.2	(T) H
02/14/92	08:29:40	29.2	33.6	60.0	27.6	54.3	56.9	[(T H)
02/15/92	08:29:40	31.6	33.0	38.7	51.9	53.6	54.9	(T)H]
02/16/92	08:29:40	31.0	33.2	35.8	51.9	53.5	55.1	(T H]
02/17/92	08:29:40	31.7	33.1	35.8	50.7	52.9	54.3	(T H]
02/18/92	08:29:40	31.8	33.2	38.2	51.9	54.0	57.2	(T)[H
02/19/92	08:29:40	32.2	33.5	35.8	52.1	53.8	55.9	(T [H
02/20/92	08:29:40	31.0	33.5	35.8	52.0	53.3	54.3	(T H]
02/21/92	08:29:40	32.4	33.5	38.8	51.9	53.3	54.3	(T)H]
02/22/92	08:29:40	31.0	33.5	38.8	52.7	53.6	54.7	(T)H]
02/23/92	08:29:40	32.0	33.5	38.2	51.9	53.6	54.9	(T)H]