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GHANA/NETHERLANDS ARTISANAL FISH PROCESSING PROJECT

RESEARCH PROJECT #9

STUDIES ON THE TRADITIONAL STORAGE OF SMOKED ANCHOVIES IN GHANA

FINAL REPORT (PHASE ONE)

EFFECT OF TRADITIONAL STORAGE ON THE QUALITY OF SMOKED ANCHOVY (Anchoa guineensis) AT TEMA MANHEAN

By

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EFFECT OF TRADITIONAL STORAGE ON THE QUALITY OF SMOKED ANCHOVY (Anchoa guineensis) AT TEMA MANHEAN

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ABSTRACT

The most widely used traditional storage techniques for smoked anchovies by artisanal fish processors at Tema Manhean (in the Greater Accra Region of Ghana) was studied, and the major structural features, material requirements and method of construction were determined.

The structural characteristics established in the study were used to construct a proto-type anchovy storage structure in the village to determine the effectiveness of the traditional structure. Freshly smoked anchovies (Anchoa guineensis) were stored the traditional way and samples taken at 0, 3, and 6 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 and thence dropped to 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 45.5% at the end of the six-month storage period. This situation resulted in the drying of the smoked fish

during storage, thus enhancing preservation. The moisture content of samples decreased from 13% to less than 10% resulting in slight increases in sensory attributes such as hardness, brittleness and chewiness. There was only a slight decrease in flavour, but aroma and colour remained the same. Storage yield in terms of overall physical damage was 85%. 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 microbial loads for the smoked fish were low, ranging between 760 and 850 bacterial organisms per gram of fish and between 320 and 450 moulds per gram. 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.

INTRODUCTION

In Ghana and many other West African countries fish constitute 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 (Table 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. 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 general, very little has been done to assess, for the purposes of preventing, post-processing losses and general quality deterioration of smoked fish during storage. No studies have been undertaken on the traditional storage of smoked anchovies in particular. The situation can be explained mainly by 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.

Methods and general conditions of traditional fish

storage in West Africa are known to be unsatisfactory due to frequent insect infestation, microbial decomposition and rodent attack (Caurie, et al., 1979; Nerquaye-Tetteh, 1979). Although no statistics are available on storage losses of dry-smoked anchovies in Ghana, reports have indicated post-processing losses of unprotected dried fish as high as 20 - 70 %, (Kagan, 1970; James, 1976; Osuji, 1976; Waterman, 1976; Plahar, et al., 1991). Recent studies were conducted on the storage characteristics and microbial changes in smoked dry herrings in Ghana. From one of such studies, Lu et al (1988) reported decreases in total nitrogen, fat, thiamine and niacin content during storage but observed no changes in the amino acid and fatty acid patterns. There was, however, an increase in the acid value of the fish with storage time. Plahar et al. (1991) determined the relative effectiveness of several storage methods in preserving the quality of smoked dry herrings. A modification of the traditional storage technique was found to give 97% storage yield over a 6 month period, while 30% losses were encountered in the traditional storage set-up. The salient features of the modified structure were to prevent insect infestation while providing an improved ventilation. Because of low insect and microbial infestation, proteolytic and lipolytic activities, as measured by total volatile bases, non-protein nitrogen, acid value and peroxide value, were minimal (Plahar et al., 1991). Major microorganisms in stored smoked herrings were Micrococci, Bacillus spp. Aspergillus spp., Penicillium, Rhizopus, spp. and yeasts (Lu, et al. 1988; Plahar et al., 1991).

The need to protect smoked anchovies from excessive microbial infection can also be considered in the light of increased awareness of the hazards of mycotoxins in stored foods. Mycotoxins can be produced by certain strains of a number of species of fungi when grown under favourable conditions on a wide variety of different substrates. The most important and toxic mycotoxins are the aflatoxins which are products of the mould Aspergillus flavus and Aspergillus parasiticus. Aflatoxins have been detected in several commodities including smoked, dried and salted fish from South East Asia. In a survey in the Philippines, 93% of 15 samples of smoked fish were found to contain aflatoxins. A similar survey also showed 83% of 24 samples of dried fish to be positive for aflatoxins (FAO, 1979). With the fast growing smoked anchovy industry in Ghana and its socio-economic and nutritional significance, there is the urgent need to study the traditional storage techniques for possible improvements.

The purpose of this approved research project under the Ghana/Netherlands Artisanal Fish Processing Project was therefore 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. A knowledge of the status of the smoked anchovy after storage, as well as identification of the conditions that support the changes in quality is important to prevent excessive storage losses, organoleptic deterioration, nutritional losses and possible mycotoxicological health hazards.

2 MATERIALS AND METHODS

2.1. Study and Construction of the Traditional Anchovy Storage Structure

A survey was undertaken among the anchovy processing community at Tema Manhean to study the structural features and peculiarities of the traditional smoked anchovy storage structure. The raw material requirements, source of procurement and the method of construction of the storage structure were determined. The structural characteristics established in the study 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 description of the structure is given under Results and Discussion.

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, 3, and 6 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. Structural Characteristics of Traditional Anchovy Storage at Tema Manhean

3.1.1. Material Requirement:

Traditional smoked anchovy processors at Tema manhean make use of mainly locally available materials in the construction of storage structures. The following give a list and description of basic materials required for setting up a smoked anchovy storage structure:

a. Large Stones

Several pieces of large stones with an average diameter of about 7 cm are collected from the nearby beach. Number of pieces required varies with the size of structure to be constructed but it is just enough to cover the floor space area of the structure. Usually this is about 3.0 cm^2.

b. Cut Logs

Pieces of about 12 cm diameter logs are purchased and cut to traverse the base length of the structure. Only a few of such pieces are required to provide the needed base support of the structure.

c. Straw Mats

Traditional straw mats are used for base cushioning. Usually these are 8 cm thick, and a single layer is required to provide the needed cushioning at the base. In addition more

of such straw mats are required for the protective top covering.

d. Sticks and Twine or Rope for Mid-section Stick Netting

Several pieces of small sticks (about 1.5 cm thick) are obtained and cut to equal lengths of about 105 cm. The number of sticks required depends on the size of the structure to be built. It should be enough to surround the mid-section circumference of the structure when arranged at intervals of about 10 cm. Local twines and ropes are purchased for use in weaving the sticks together to form a strong netting support during the construction of the storage structure.

e. Brown Paper Lining and Polyethylene Material Cover

Pieces of brown paper are needed to line the bottom and sides of the structure. A large sheet of black polyethylene material is also required to cover the whole structure to protect it from rain and dust.

f. Baskets

About eight small baskets 20 cm high with 30 cm and 10 cm open end and bottom diameters respectively are required for top protective covering of the structure.

g. Aluminium Roofing Sheets, Battens and Nails

These materials are required for the construction of a rectangular base. Old aluminium roofing sheets or similar materials are used. This should be enough to construct a base

structure with approximate dimensions of 180 x 160 x 82 cm.

3.1.2. Construction of traditional structure and storage of smoked anchovy

The traditional anchovy storage structures used by artisanal fish processors at Tema Manhean were studied and a proto-type constructed by the Research team to elucidate the structural characteristics and to study the effectiveness of smoked anchovy preservation. The following is a detailed description of the structural features and the step-wise procedure employed in the construction of the storage structure. It also provides pictorial illustrations of the various stages of the construction.

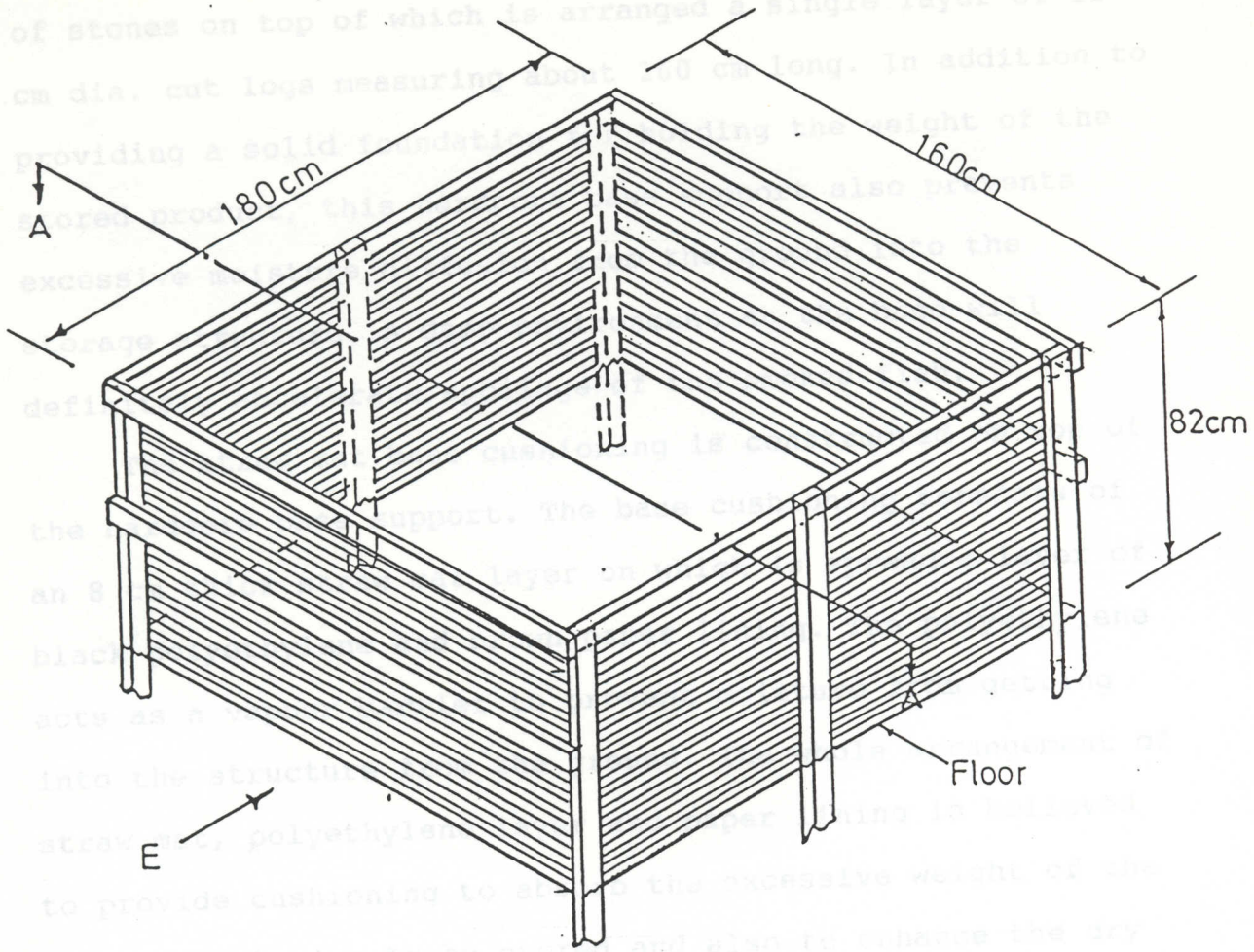
Typically, the traditional anchovy storage structure consists of the following identifiable parts or sections:

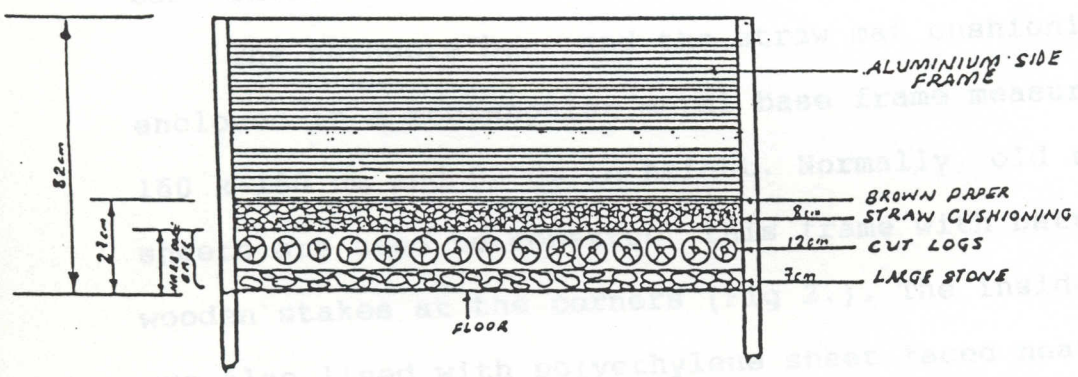
a. The base structure
b. The middle stick netting support section
c. The dome top section
and d. The protective top covering

A detailed description of each of these identifiable parts of the structure is given in the sub-sections that follow.

3.1.2.1. The Base Structure

The base structure is made up of a hardcore base support and a straw mat base cushioning arranged in a rectangular metal side frame support. These parts are illustrated in Figure 1.





sectional elevation

Fig. 1 Shows the base of traditional anchovy storage structure

The hardcore base support is built with a 7.0 cm layer of stones on top of which is arranged a single layer of 12 cm dia. cut logs measuring about 160 cm long. In addition to providing a solid foundation for holding the weight of the stored product, this hardcore base support also prevents excessive moisture diffusion from the ground into the storage structure. A damp environment at the base will definitely accelerate spoilage of the smoked fish.

The straw mat base cushioning is constructed on top of the hardcore base support. The base cushioning consists of an 8 cm thick straw mat layer on which is spread a layer of black polyethylene and brown paper lining. The polyethylene acts as a vapour barrier to prevent moisture from getting into the structure from the ground. The whole arrangement of straw mat, polyethylene layer and paper lining is believed to provide cushioning to absorb the excessive weight of the pile of anchovies to be stored and also to enhance the dry base environment.

The hardcore base and the straw mat cushioning are enclosed in a rectangular metal base frame measuring about 160 x 180 cm and 82 cm in height. Normally, old roofing sheets are used to construct this frame with battens and wooden stakes at the corners (Fig 2.). The inside surfaces are also lined with polyethylene sheet faced neatly with brown paper lining. Figure 3 shows the base structure being lined with polyethylene and brown paper.

The base structure thus complete has a storage space with internal dimensions of 160 x 180 x 55 cm (the internal height

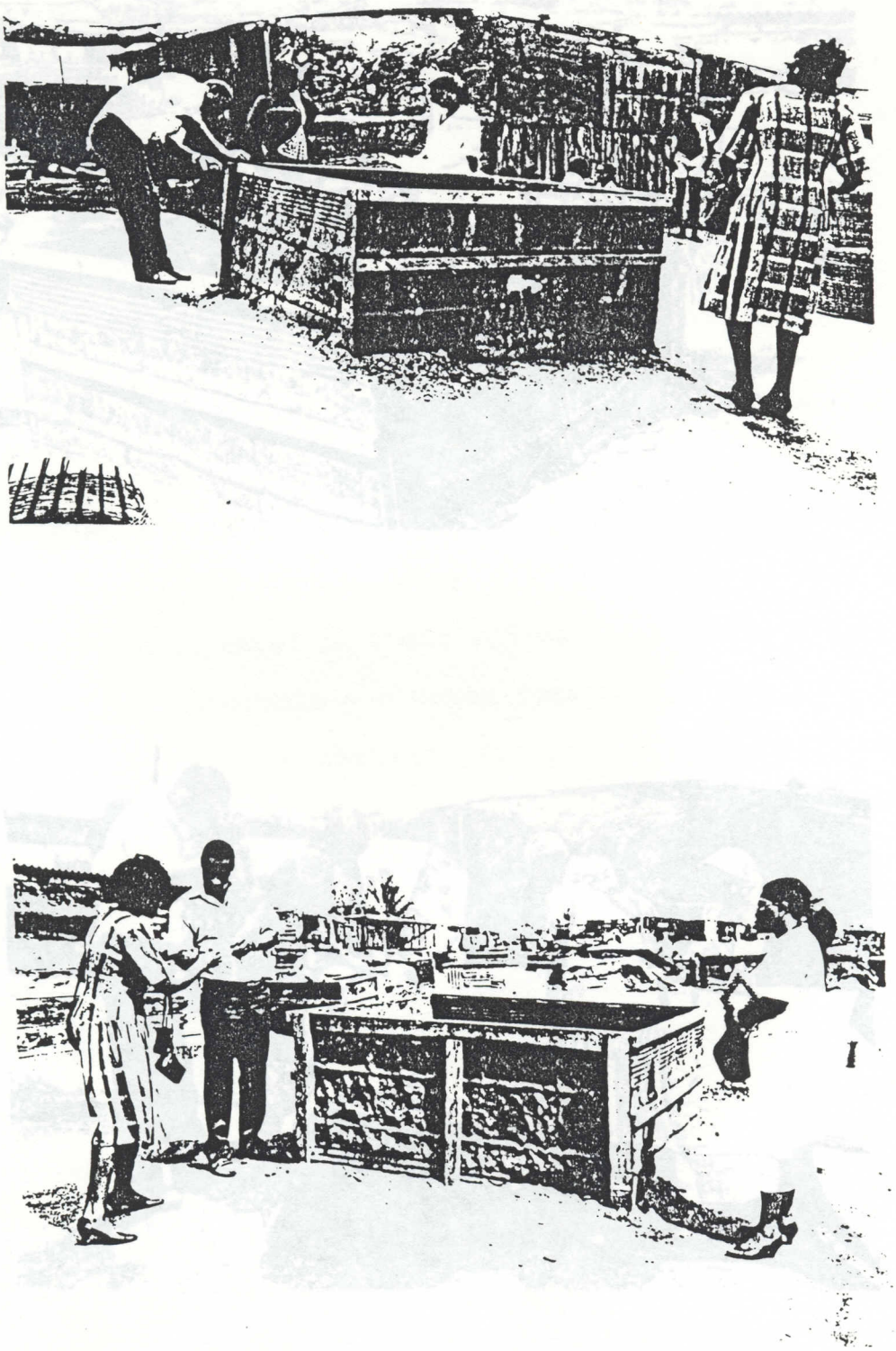


Fig 2. Pictures showing the rectangular metal base structure

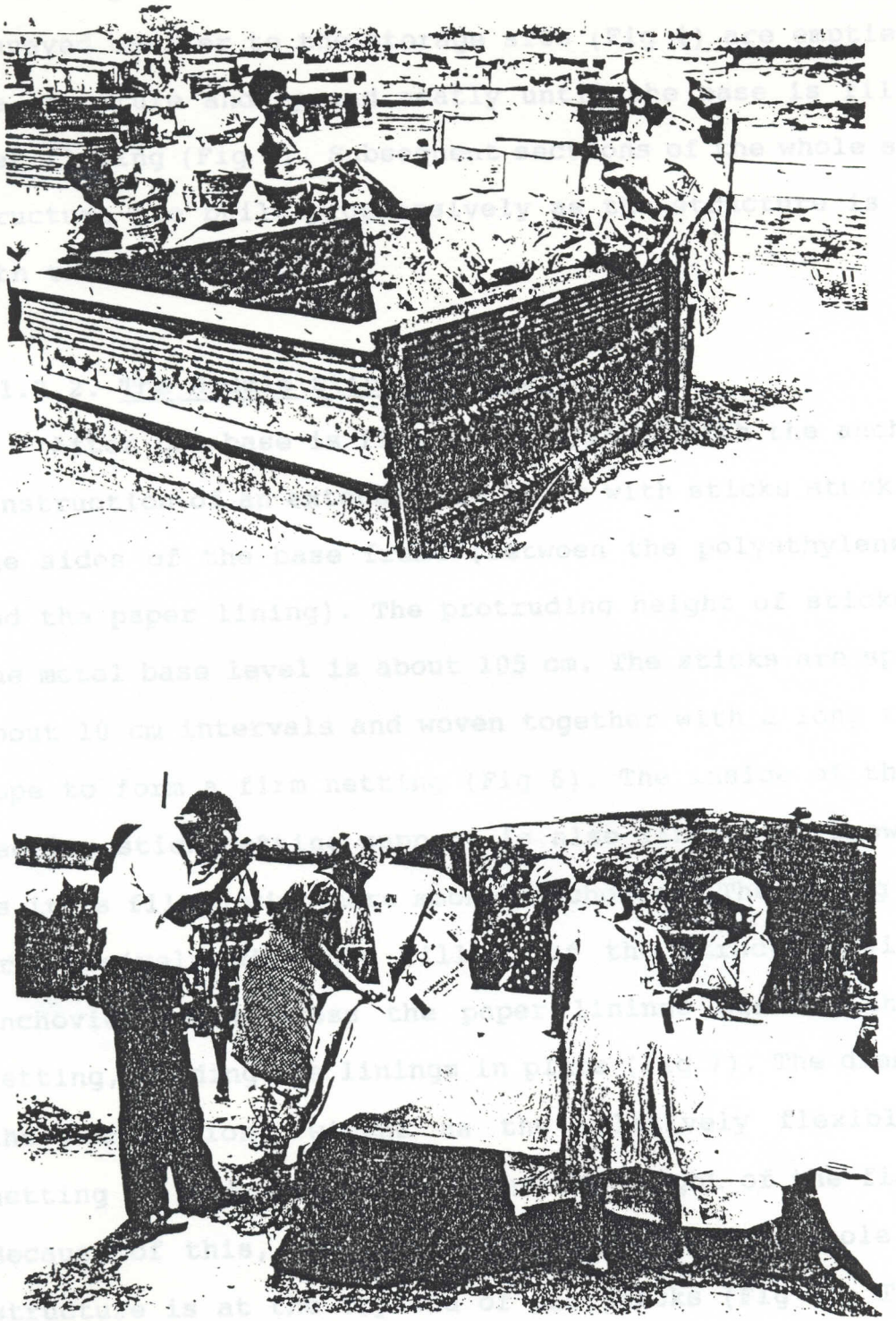


Fig 3. Lining of the base structure with polyethylene and brown paper

is reduced by the 27 cm thick floor). The base is then ready for storage to begin. Several baskets full of smoked anchovies conveyed earlier to the storage site (Fig 4) are emptied into the structure and spread neatly until the base is filled to over-flowing (Fig 5). Subsequent sections of the whole storage structure are built progressively as the structure is filled with the anchovies.

3.1.2.2. The Middle Stick Netting Support

After the base is filled to capacity with the anchovies, construction of an extension is built with sticks stuck around the sides of the base frame (between the polyethylene layer and the paper lining). The protruding height of sticks above the metal base level is about 105 cm. The sticks are spaced at about 10 cm intervals and woven together with a long twine or rope to form a firm netting (Fig 6). The inside of this mid-section stick netting support is also lined with brown paper as it is filled with more smoked anchovies. The lining is done progressively with the filling of the structure with more anchovies which press the paper linings against the stick netting, holding the linings in place (Fig 7). The diameter of the mid-section widens as the relatively flexible stick netting is pushed outwards under the weight of the fish load. Because of this, the greatest diameter of the whole storage structure is at the top end of the sticks (Fig 8). This also forms the mid-section which has a circumference of about 780 cm. At this point, the structure assumes the shape of a large dome.

Fig 4. Baskets full of smoked anchovies ready for storage

Fig 5. Filling of the base structure with smoked anchovies

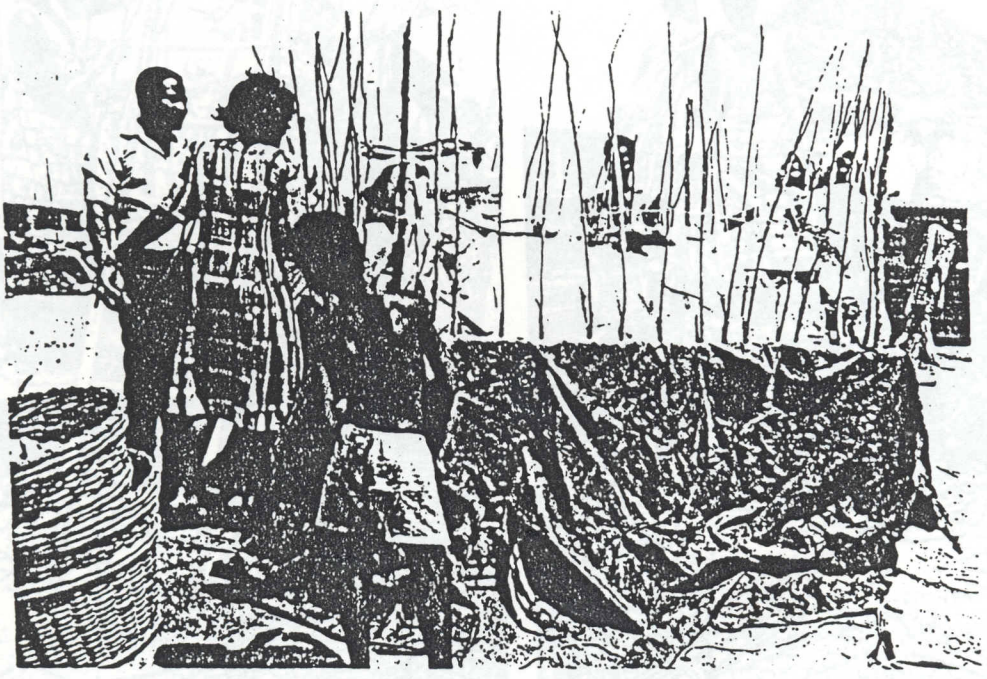


Fig 6. Construction of the mid-section stick netting support

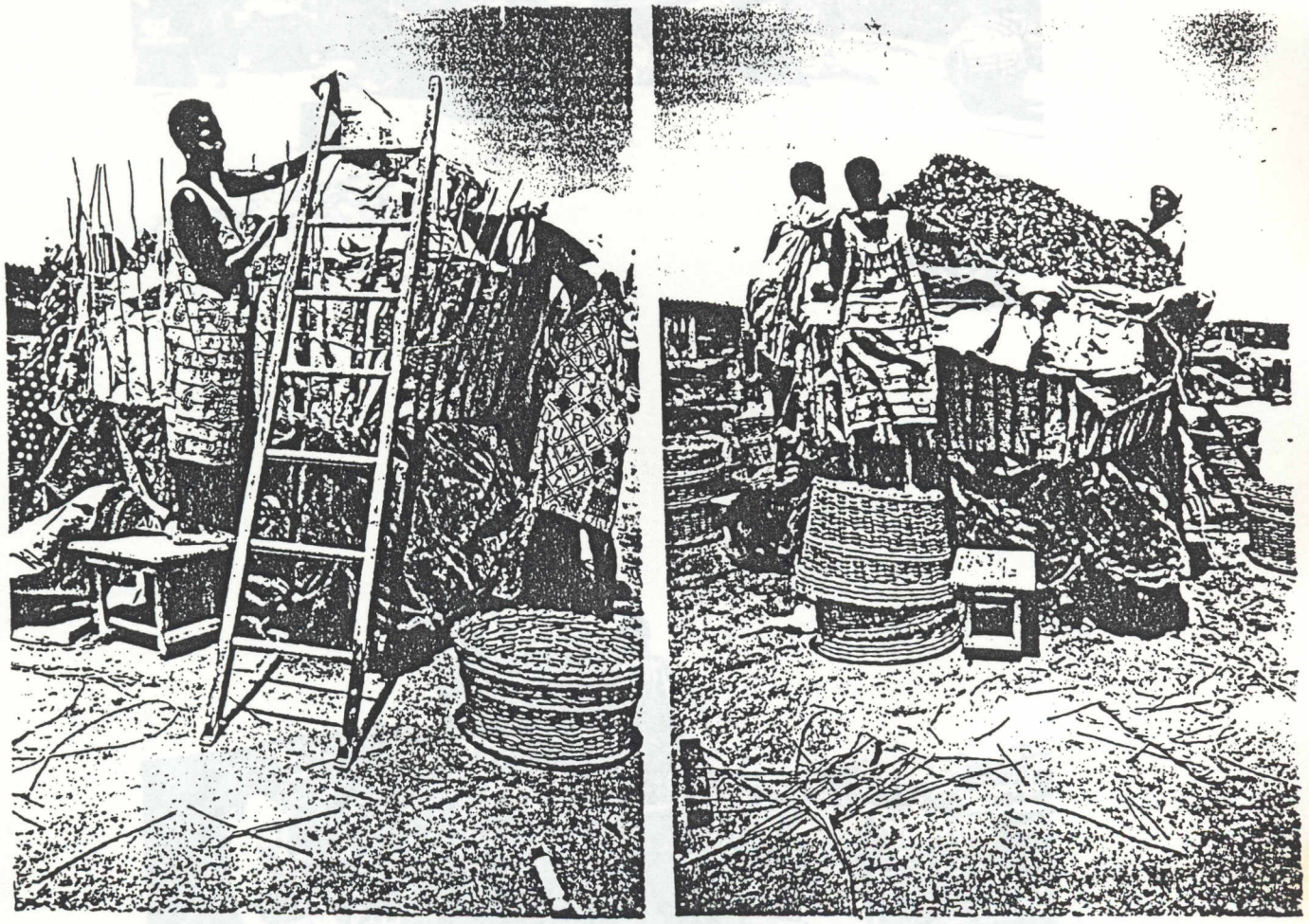


Fig 7. Lining and filling of the mid-section structure

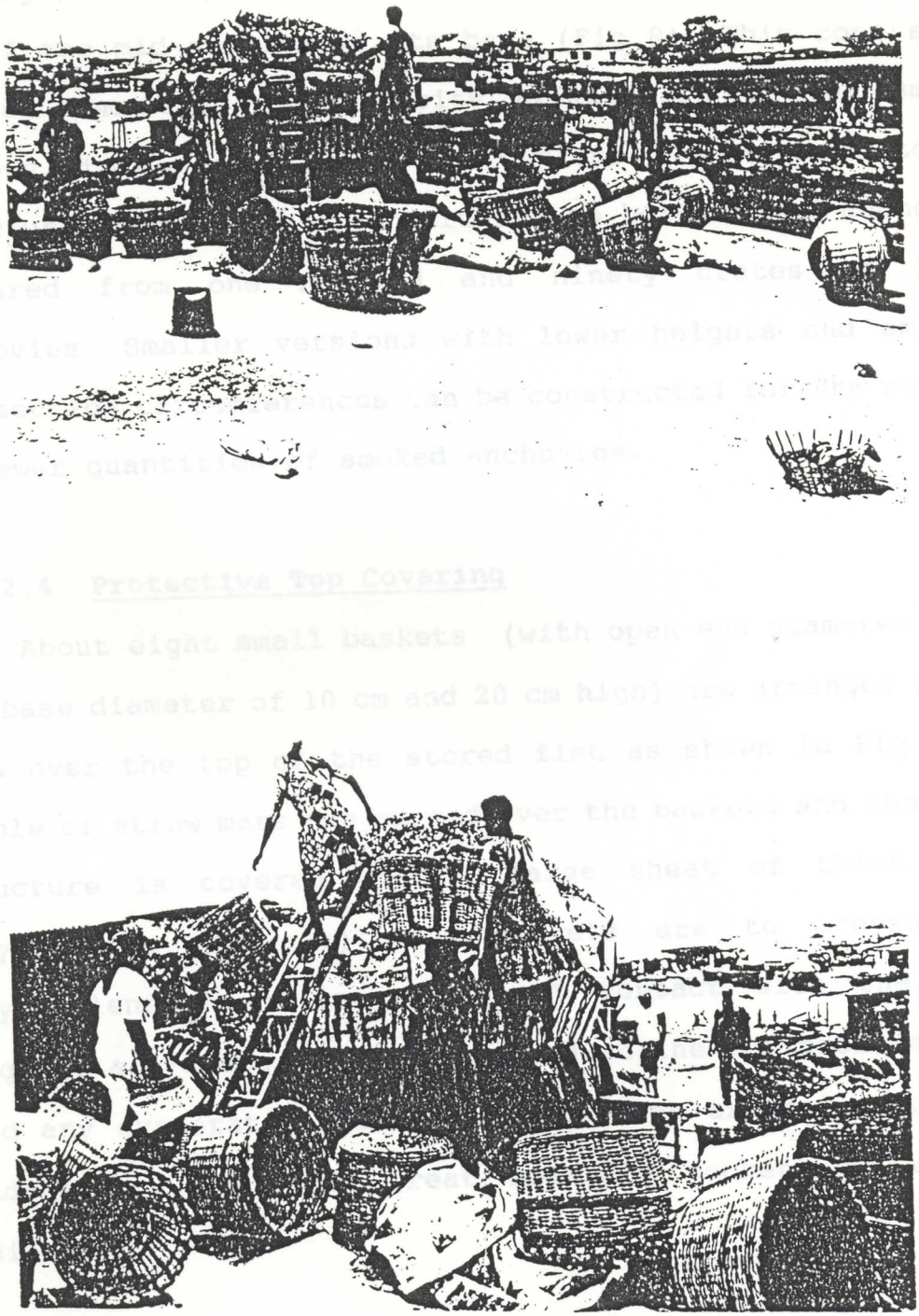


Fig 8. Pictures showing the mid-section shape after filling

3.1.2.3. The Dome Top Section

With the help of a ladder, filling of the structure is continued far beyond the height of the stick netting. To avoid spillage, the top is arranged to form a cone shape with the top of the mid-section as its base (Fig 9). This cone shape section completes the capacity utilization of the smoked anchovy storage structure. The typical traditional storage structure described was constructed to hold smoked anchovies prepared from one hundred and ninety crates of fresh anchovies. Smaller versions with lower heights and smaller mid-section circumferences can be constructed for the storage of fewer quantities of smoked anchovies.

3.1.2.4. Protective Top Covering

About eight small baskets (with open end diameter of 30 cm, base diameter of 10 cm and 20 cm high) are arranged upside down over the top of the stored fish as shown in Fig 10. A couple of straw mats are spread over the baskets and the whole structure is covered with a large sheet of thick black polyethylene (Fig 11). The baskets are to prevent the polyethylene cover from a direct contact with the fish. Adequate air-space is thus provided at the top presumably to hold any evaporated moisture and prevent excessive moisture condensation that may creat moisture pockets to enhance spoilage.

Fig 9. Traditional anchovy storage structure filled to capacity

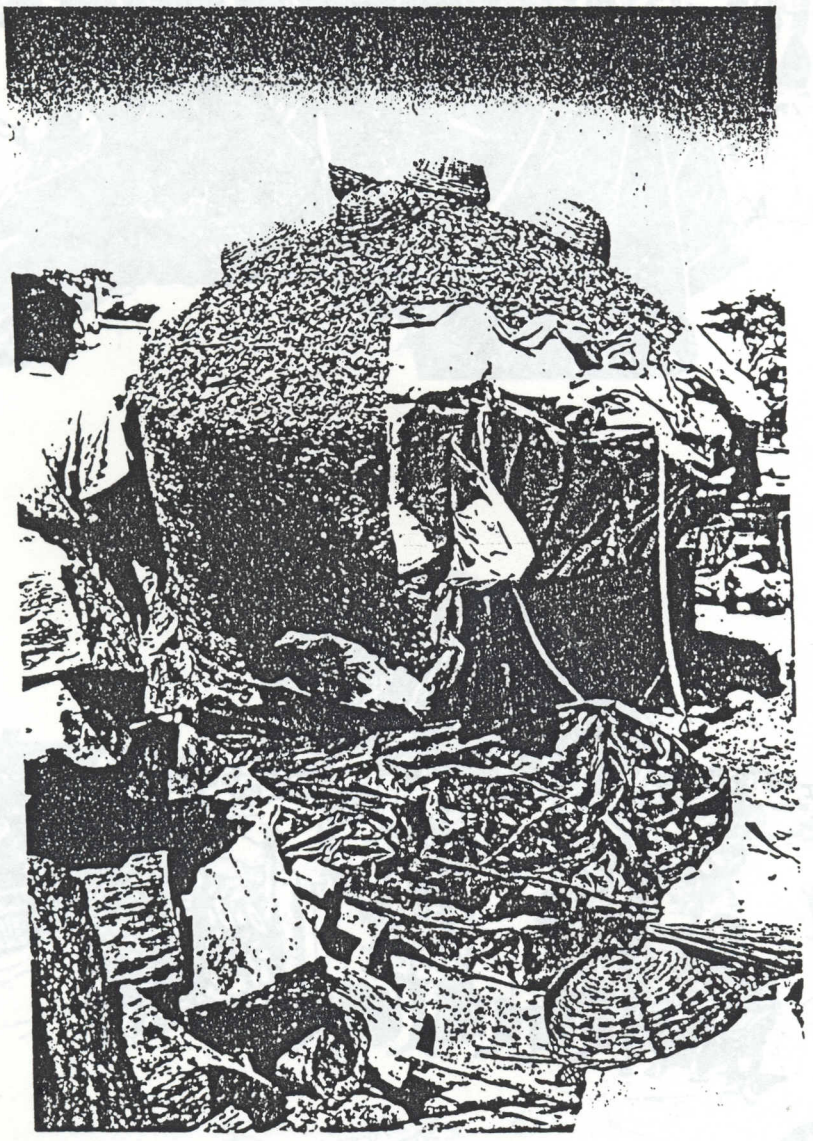


Fig 10. Basket cover at the top to avoid direct contact of polyethylene cover with fish

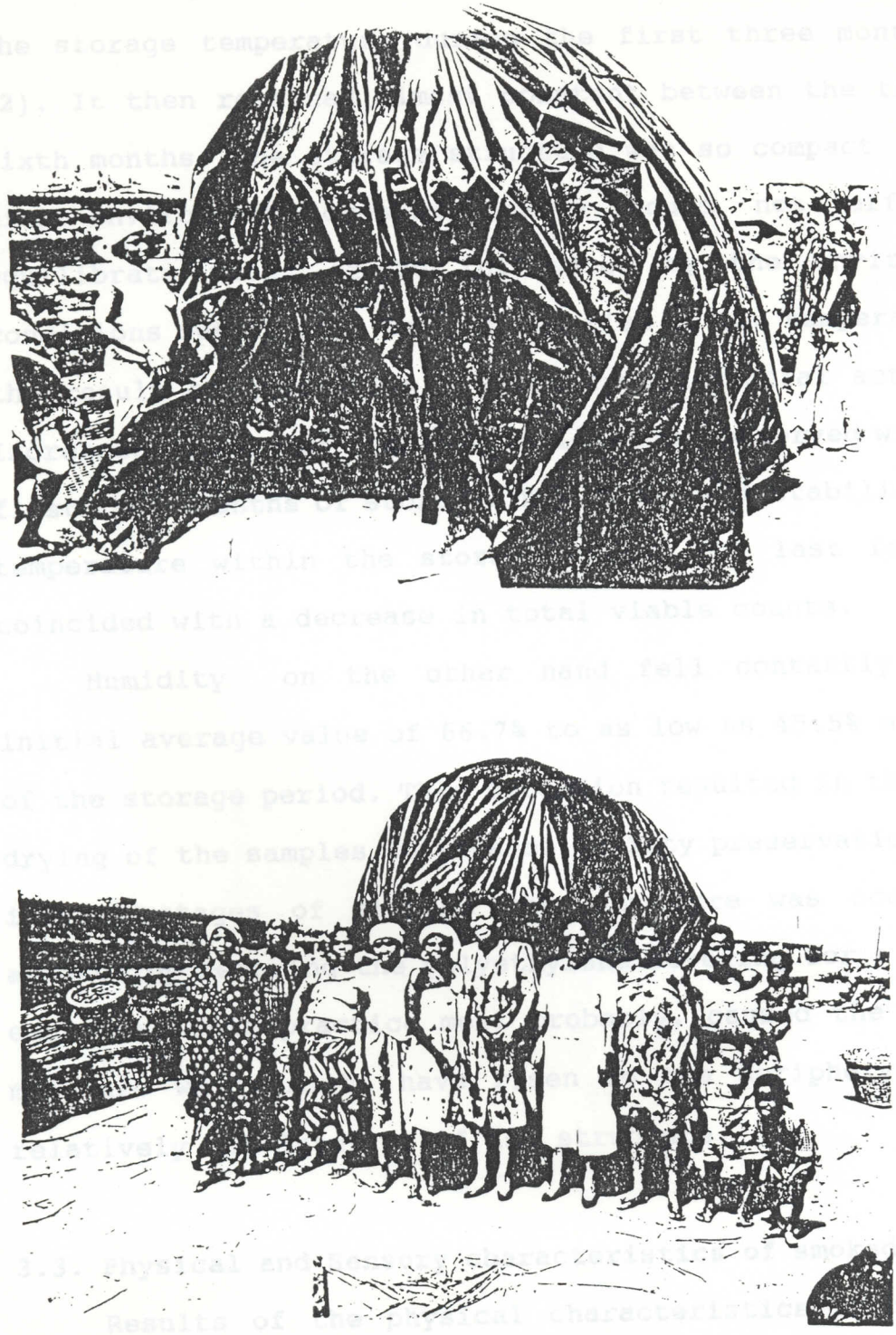


Fig 11. Smoked anchovies in storage

3.2. 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 12). It then remained almost constant between the third and sixth months. 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. The subsequent stabilisation of temperature within the storage during the last few months coincided with a decrease in total viable counts.

Humidity on the other hand fell contantly from an initial average value of 66.7% to as low as 45.5% at the end of the storage period. This situation resulted in the further drying of the samples to enhance quality preservation. 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.

3.3. 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 traditional storage were physically sound and

Fig 12. Temperature and Humidity Changes in Storage Structure

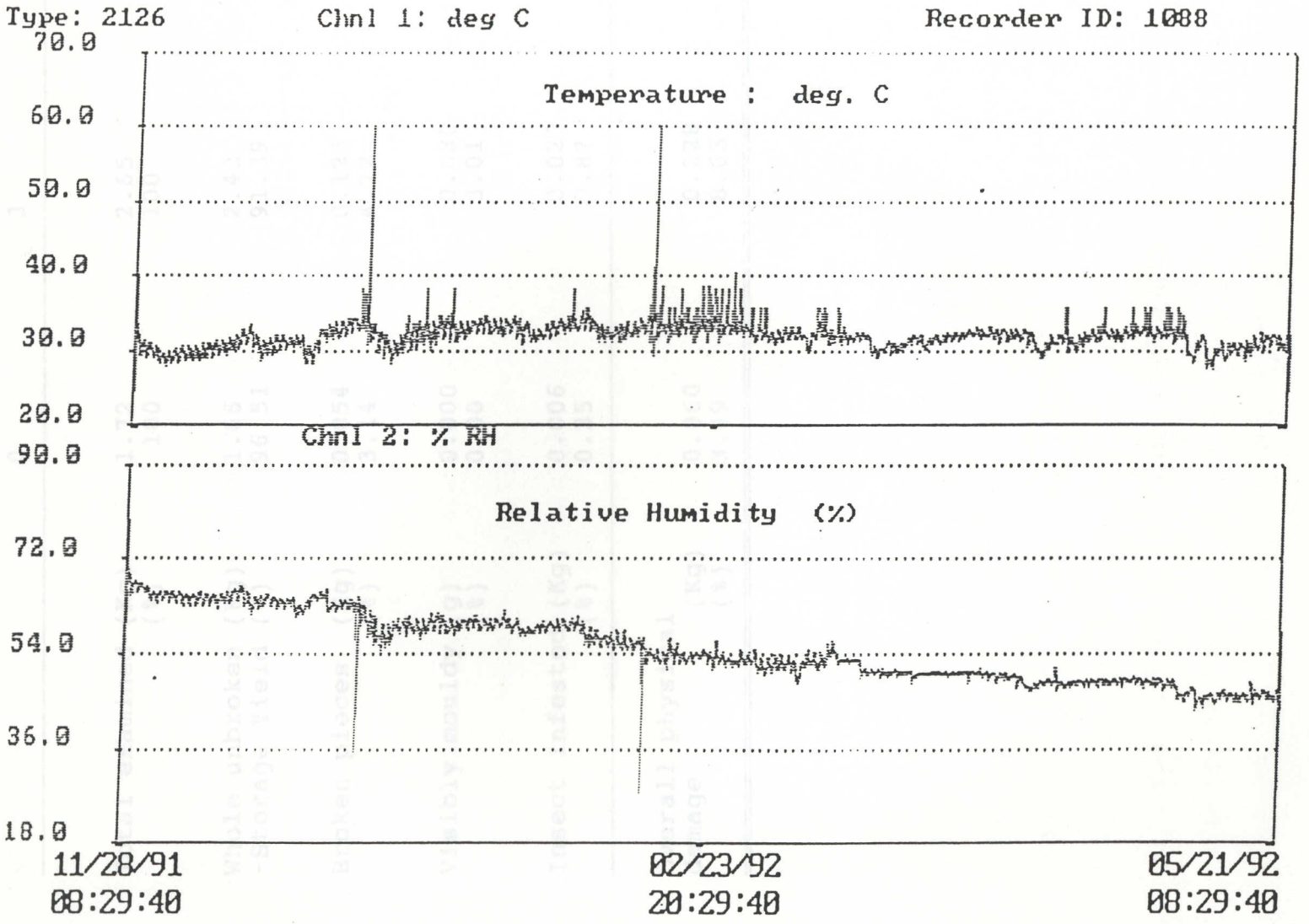


Table 1. Changes in the physical characteristics of smoked anchovies (Anchoa guineensis) during storage

		Storage Period (months)		
		0	3	6
Total examined	(Kg)	1.72	2.65	4.21
	(%)	100	100	100
Whole unbroken -Storage Yield	(Kg)	1.66	2.42	3.58
	(%)	96.51	91.39	85.13
Broken pieces	(Kg)	0.054	0.125	0.351
	(%)	3.14	4.72	8.34
Visibly mouldy	(g)	0.000	0.080	0.173
	(%)	0.00	3.01	4.10
Insect Infested	(Kg)	0.006	0.023	0.102
	(%)	0.35	0.87	2.43
Overall physical damage	(Kg)	0.060	0.228	0.626
	(%)	3.49	8.63	14.90

whole. There were no visible mouldiness in any of the samples examined while only 0.2% were found to be infested with 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 six-month storage showed a storage yield of over 85% physically sound product (Table 1). The remaining 15% 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 visible mouldiness was responsible for the major physical damage during storage. Thereafter the rate of mould infestation reduced considerably, giving an increase of only about 1% within the second three-month storage period. At this time, physical breakages and insect infestation became more important in product 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

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

Sensory characteristic	Mean Score for Samples stored:		
	0 month	3 months	6 months
Hardness	6.4 ± 0.3	6.5 ± 0.4	7.6 ± 0.4
Brittleness	6.0 ± 0.6	6.3 ± 0.2	7.4 ± 0.3
Chewiness	5.8 ± 0.6	6.1 ± 0.3	7.8 ± 0.1
Flavour	9.6 ± 1.2	9.4 ± 1.4	8.5 ± 1.0
Aroma	9.8 ± 1.0	9.8 ± 0.2	9.0 ± 0.3
Colour	9.5 ± 1.6	9.3 ± 0.5	9.5 ± 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

preserved by the traditional storage. After six months in storage, however, the samples became slightly harder, more brittle and tougher. The flavour and aroma scores also reduced slightly. The colour attributes, however, remained the same. The slight changes observed could be attributed to the decrease in the relative humidity and consequent drying of samples during storage. Increased brittleness of products was responsible for the physical breakages observed in samples analysed after six months in storage.

3.4. 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 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.

There was a reduction in the moisture content of the smoked fish samples from the initial value of about 13% to less than 10% by the end of the six-month storage period. This situation helped a great deal in the preservation of the fish in terms of proteolytic and lipolytic deterioration as well as microbial and mycotoxicological quality. Three months of storage did not cause any significant reduction in the moisture content. The edible portions of the fish samples were

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

Component and source	Whole fish			Edible portion		
	0 mo.	3 mo.	6 mo.	0 mo.	3 mo.	6 mo.
Internal section of storage:						
Moisture (%)	13.15	13.86	9.76	13.53	13.83	10.76
Protein (%)	71.90	71.10	72.14	75.63	76.59	78.44
Fat (%)	4.26	3.66	2.95	4.51	3.83	5.31
Ash (%)	16.65	16.76	18.00	11.10	10.56	11.10
Storage structure periphery:						
Moisture (%)	13.15	13.63	10.22	-	-	-
Protein (%)	71.90	65.88	67.51	-	-	-
Fat (%)	4.26	3.82	4.37	-	-	-
Ash (%)	16.65	21.81	20.77	-	-	-

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

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 and sixth months 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 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

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
6 months	3.14	209.44	1.24
Edible portion			
0 month	2.19	119.81	1.62
3 months	1.53	115.35	1.62
6 months	3.72	182.00	1.33
Samples from Storage structure periphery:			
Whole Fish			
0 month	3.10	133.79	2.10
3 months	1.21	184.09	1.70
6 months	5.00	294.74	0.89

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. At the end of the six-month storage period, TVBN increased by about 50% of the original value. The increase was less in the edible portion. Samples from storage structure periphery showed higher increases in TVBN over the six-month period of storage. Periphery samples were obviously spoilt. Non Protein Nitrogen content of the smoked fish however decreased 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. At the end of the six-month storage period, the fat acidity increased again to about the original value. 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.

3.5. 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 any processed food product provides information which serves as

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	6
Viable organisms			
Aerobic bacterial count per gram	85×10^1	$>300 \times 10^6$	87×10^1
Mould and yeast count per gram	32×10^1	13×10^1	1×10^1
pH	6.5	5.7	6.4
Culture	Rhizopus, Asp. sp. Micrococci Bacillus sp. Yeast	G +ve cocci Micrococci Mucor Penicillium Asp. sp	Micrococci Bacillus sp. Asp. sp. Rhizopus Yeast
Coliforms (in 0.1 g)	Absent	Present	Absent
Faecal coli	Absent	Absent	Absent
Pathogens			
Salmonella	Nil	Nil	Nil
Staphylococci	Nil	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	6
Viable organisms			
Aerobic bacterial count per gram	76×10^1	225×10^3	65×10^2
Mould and yeast count per gram	46×10^1	13×10^1	2×10^1
pH	6.4	5.7	5.6
Culture	Rhizopus, Asp. sp. Micrococci Bacillus sp. Yeast	G +ve cocci Micrococci Penicillium	Gram +ve cocci Mucor
Coliforms (in 0.1 g)	Absent	Present	Absent
Faecal coli	Absent	Absent	Absent
Pathogens			
Salmonella	Nil	Nil	Nil
Staphylococci	Nil	Nil	Nil

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 (85×10^1 per gram) than the edible portions (76×10^1 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 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.

With prolonged storage, fairly anaerobic conditions and low humidity development in the structure caused a drastic reduction in the aerobic count, giving a final product with microbiological quality similar to that of the original samples stored. Periphery samples, which had adequate oxygen supply still maintained viable bacterial counts higher than for samples inside the structure.

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 and sixth months of storage. Also, coliforms were found in 0.1 g samples at the third month of storage but these disappeared by the end of the six-month 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.

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	6
Viable organisms			
Aerobic bacterial count per gram	85×10^1	46×10^6	116×10^3
Mould and yeast count per gram	75×10^1	30×10^1	11×10^1
pH	6.5	6.3	5.8
Culture	*Rhizopus*, *Asp.* sp. *Micrococci* *Bacillus* sp. Yeast	G +ve cocci *Micrococci* *Mucor* *Penicillium* *Asp.* sp	Gram +ve cocci. *Asp.* sp. *Bacillus* sp. *Mucor*
Coliforms (in 0.1 g)	Absent	Present	Absent
Faecal coli	Absent	Absent	Absent
Pathogens			
Salmonella	Nil	Nil	Nil
Staphylococci	Nil	Nil	Nil

3.6. 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 six-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

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 45.5% by the end of the six 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 material requirements and structural characteristics of traditional anchovy at Tema Manhean have been adequately stablished in the study. A typical storage structure consists of a base structure measuring 160 x 180 x 82 cm, a middle stick netting support 105 cm high with a mid section circumference of 780 cm, a dome top section and a protective top covering. Such a structure can take smoked anchovies prepared from up to 190 crates of fresh anchovies.
2. The traditional structure employed in the storage of smoked anchovies was effective in preserving the product against excessive physical damage. A storage yield of 85% was obtained within six months of storage.
3. The temperature inside the traditional storage structure was almost stable while humidity decreased steadily from 66.7% to 45.5%, causing a 3% moisture decrease in the samples (from 13% to 10% moisture content).
4. 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.
5. 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 SIX-MONTH PERIOD

Saved Recorder Status Type: 2126 Rec ID: 1088
Time at Recorder: 05/21/92 12:33:03 Last Update: 11/28/91 08:29:40
Sample Rate: 1 min
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]
02/24/92	08:29:40	31.0	33.3	38.2	51.1	53.1	54.4	(T)H]
02/25/92	08:29:40	32.1	33.5	38.2	51.3	53.8	56.7	(T)[H
02/26/92	08:29:40	32.0	33.3	40.4	51.6	53.0	54.5	(T H]
02/27/92	08:29:40	31.8	33.1	38.2	51.3	52.5	53.5	(T)H
02/28/92	08:29:40	31.8	32.6	33.3	51.7	52.4	53.1	(T H
02/29/92	08:29:40	31.1	32.4	35.8	51.9	53.3	54.9	T) H]
03/01/92	08:29:40	31.3	32.4	35.8	51.8	53.0	54.3	T) H]
03/02/92	08:29:40	31.1	32.4	35.8	50.8	53.0	55.1	T) H]
03/03/92	08:29:40	30.6	31.7	32.6	50.1	51.7	53.5	T) H
03/04/92	08:29:40	30.6	31.8	32.8	49.7	51.8	53.5	T) H
03/05/92	08:29:40	31.0	32.1	33.0	50.5	52.0	53.9	T) H]
03/06/92	08:29:40	31.2	32.2	33.2	50.7	52.1	53.9	T) H]
03/07/92	08:29:40	31.2	32.2	33.2	50.7	52.3	54.0	T) H]
03/08/92	08:29:40	29.4	31.1	32.2	48.3	50.8	53.2	T [H
03/09/92	08:29:40	29.4	31.5	32.6	48.3	51.2	53.1	T)[H
03/10/92	08:29:40	31.4	32.7	35.8	51.5	52.8	55.1	(T H]
03/11/92	08:29:40	30.7	32.1	35.8	51.0	52.5	54.7	T) H]
03/12/92	08:29:40	30.7	31.8	32.8	50.8	52.3	54.4	T) H]
03/13/92	08:29:40	30.7	32.0	35.8	51.3	53.8	56.1	T) [H
03/14/92	08:29:40	30.8	31.9	33.1	52.1	54.0	56.8	T) [H
03/15/92	08:29:40	30.9	31.5	32.1	51.9	52.6	53.1	T H
03/16/92	08:29:40	31.2	31.9	32.6	52.3	52.8	53.4	T) H
03/17/92	08:29:40	31.2	31.9	32.4	52.2	52.7	53.2	T H
03/18/92	08:29:40	29.3	31.0	32.1	49.3	51.7	53.0	T H
03/19/92	08:29:40	28.8	29.6	30.4	49.7	50.4	51.2	(T H
03/20/92	08:29:40	28.8	29.8	30.3	49.9	50.5	51.2	(T H
03/21/92	08:29:40	29.3	30.4	31.2	49.5	50.3	51.2	T H
03/22/92	08:29:40	29.3	30.2	30.9	49.7	50.4	51.2	T H
03/23/92	08:29:40	29.4	30.5	31.0	49.9	50.5	51.2	T H
03/24/92	08:29:40	30.2	31.2	31.8	49.7	50.4	51.0	T H
03/25/92	08:29:40	30.8	31.5	32.1	49.9	50.4	50.9	T H
03/26/92	08:29:40	30.0	31.0	32.1	48.5	49.8	51.0	T [H
03/27/92	08:29:40	30.0	31.0	31.6	49.3	50.1	50.6	T H
03/28/92	08:29:40	30.7	31.4	32.1	49.7	50.2	50.6	T H
03/29/92	08:29:40	30.7	31.4	32.1	50.0	50.4	50.8	T H

03/30/92	08:29:40	31.0	31.8	32.4	50.0	50.4	50.8	T H
03/31/92	08:29:40	31.2	32.0	32.6	49.7	50.3	50.7	T) H
04/01/92	08:29:40	31.3	32.0	32.6	49.9	50.4	50.7	T) H
04/02/92	08:29:40	31.8	32.3	32.8	49.9	50.4	50.8	T) H
04/03/92	08:29:40	31.3	32.3	33.0	48.5	50.3	50.9	T)[H
04/04/92	08:29:40	31.3	32.2	32.8	49.8	50.4	50.9	T) H
04/05/92	08:29:40	31.3	32.3	33.0	49.5	50.3	51.2	T) H
04/06/92	08:29:40	30.9	32.0	32.8	48.8	50.0	50.8	T)[H
04/07/92	08:29:40	30.8	31.9	32.8	48.5	49.5	50.6	T)[H
04/08/92	08:29:40	30.9	31.9	32.7	48.9	49.7	50.4	T) H
04/09/92	08:29:40	31.3	32.1	32.8	48.9	49.7	50.5	T) H
04/10/92	08:29:40	30.3	32.0	32.8	47.1	49.4	50.3	T)[H
04/11/92	08:29:40	30.4	31.7	32.6	48.1	49.1	49.9	T)[H
04/12/92	08:29:40	28.7	29.8	31.1	46.7	47.5	48.3	(T H
04/13/92	08:29:40	28.9	30.3	31.1	46.9	47.7	48.4	(T H
04/14/92	08:29:40	30.0	31.1	31.9	47.7	48.4	49.0	T H]
04/15/92	08:29:40	30.7	31.6	32.2	47.9	48.7	49.3	T H]
04/16/92	08:29:40	29.4	32.0	35.8	46.7	49.3	51.5	T)[H
04/17/92	08:29:40	29.4	30.6	31.7	47.1	47.9	48.6	T H
04/18/92	08:29:40	29.7	30.9	31.9	47.3	48.2	48.8	T H
04/19/92	08:29:40	30.3	31.6	32.4	47.7	48.5	49.0	T H]
04/20/92	08:29:40	30.9	31.9	32.8	47.6	48.5	49.0	T)H]
04/21/92	08:29:40	31.1	32.1	33.2	47.6	48.5	49.1	T)H]
04/22/92	08:29:40	31.2	32.2	35.8	47.7	48.5	49.1	T)H]
04/23/92	08:29:40	30.9	32.0	32.8	47.5	48.5	49.3	T)H]
04/24/92	08:29:40	30.8	31.8	32.7	47.5	48.4	49.3	T)H]
04/25/92	08:29:40	30.9	32.1	33.0	47.7	48.5	49.2	T)H]
04/26/92	08:29:40	31.3	32.3	35.8	47.6	48.6	49.3	T)H]
04/27/92	08:29:40	31.6	32.4	33.4	48.1	48.9	49.4	T)H]
04/28/92	08:29:40	31.7	32.6	35.8	48.1	48.9	49.6	(TH]
04/29/92	08:29:40	31.1	32.3	35.8	47.3	48.6	49.5	T)H]
04/30/92	08:29:40	31.2	32.2	33.0	47.5	48.5	49.3	T)H]
05/01/92	08:29:40	31.6	32.6	35.8	47.5	48.7	49.5	(TH]
05/02/92	08:29:40	30.9	32.3	35.8	46.8	48.4	49.5	T)H]
05/03/92	08:29:40	31.0	32.2	35.8	47.2	48.2	49.2	T)H]
05/04/92	08:29:40	29.8	32.1	34.7	45.1	48.0	49.3	T)H]
05/05/92	08:29:40	28.2	29.2	29.9	44.6	45.7	46.3	T) H
05/06/92	08:29:40	28.3	30.3	31.3	44.7	46.2	46.9	(T H
05/07/92	08:29:40	27.9	31.0	32.1	42.9	46.5	47.5	(T[H
05/08/92	08:29:40	27.4	28.2	28.8	43.8	44.9	45.8	T [H
05/09/92	08:29:40	27.7	29.4	30.2	44.2	45.6	46.3	(T H
05/10/92	08:29:40	28.4	29.9	31.2	44.4	45.7	46.8	(T H
05/11/92	08:29:40	28.7	30.1	31.0	44.7	45.9	46.6	(T H
05/12/92	08:29:40	29.1	30.2	31.0	45.1	46.1	47.2	(T H
05/13/92	08:29:40	28.4	29.9	30.9	44.4	45.6	46.7	(T H
05/14/92	08:29:40	28.7	30.2	31.2	44.5	45.6	46.5	(T H
05/15/92	08:29:40	29.6	30.9	31.9	44.7	45.9	46.7	T H
05/16/92	08:29:40	29.7	31.2	32.6	44.5	46.3	48.8	T)H
05/17/92	08:29:40	29.9	31.3	32.2	45.1	46.0	47.0	T H
05/18/92	08:29:40	30.0	31.3	32.2	44.9	46.1	47.3	T H
05/19/92	08:29:40	29.9	30.9	31.9	44.8	45.8	46.9	T H
05/20/92	08:29:40	28.9	30.7	32.0	44.1	45.5	47.0	(T[H