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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 (STAGE TWO)

EFFECT OF TRADITIONAL STORAGE ON THE QUALITY OF SMOKED ANCHOVY (*Anchoa guineensis*) AT AKPLABANYA

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EFFECT OF TRADITIONAL STORAGE ON THE QUALITY OF SMOKED ANCHOVY (*Anchoa guineensis*) AT AKPLABANYA

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ABSTRACT

The different techniques used for the traditional storage of smoked anchovies by artisanal fish processors at Akplabanya (a coastal fishing village near Ada, in the Greater Accra Region of Ghana) were studied, and the major structural features, material requirements and methods of construction were determined. One proto-type traditional storage structure was constructed in the village to determine the effectiveness of the traditional technique. Freshly smoked anchovies (*Anchoa guineensis*) were stored the traditional way and samples 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. Three major types of smoked anchovy storage structures were identified. These include: (a) The round oven storage structure, (b) The sea-sand platform storage structure, and (c) The fenced yard structure. In general, all the structures are built with mainly locally available materials; and the choice of any of the three depends on factors such as capital input available and the volume of smoked fish to be stored. The duration of storage depends, to a large extent, on the period of time the processor can afford to

lock up the capital invested. It also depends on the demand and current market value. Generally however, such traditional storage is undertaken for a period ranging between four and seven months.

Average storage temperature increased by about 10°C within the first one month and thence dropped to about 40°C. The humidity in the structure on the other hand, decreased sharply from an initial value of 48.4% to as low as 28.5% at the end of the first month of storage. This low humidity level was maintained in the structure for the rest of the storage period. The moisture content of samples did not change with storage time. The physical characteristics and sensory attributes therefore remained unchanged. There was only a slight increase in the score for chewiness of the stored products. Storage yield in terms of overall physical damage was 91%. Proteolytic, lipolytic and microbial deterioration was minimal. In general, the microbial loads for the smoked fish were low, being about 700 bacterial counts per gram. Microorganisms isolated were *Rhizopus*, *Aspergillus* spp., Micrococci, and *Bacillus* sp. 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 aflatoxin B_1, B_2, G_1 and G_2.

INTRODUCTION

Remarkable increases in anchovy landings have been observed in recent years. This is indicative of the increasing economic and nutritional significance in Ghana and neighbouring West African countries. Anchovies (*Anchoa guineensis*) 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.

Large scale smoking and marketing of anchovies are undertaken in Ghanaian coastal fishing villages like Tema

Manhean and Akplabanya in the Greater Accra Region of the country. The bulk of the smoked fish has to be stored for several months for distribution during the off-season.

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. Apart from recent studies under the Ghana/Netherlands Artisanal Fish Processing and Applied Research Project no other 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.

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 aflatoxin which are products of the mould *Aspergillus flavus* and *Aspergillus parasiticus*. Aflatoxin 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 aflatoxin. A similar survey also showed 83% of 24 samples of dried fish to be positive for aflatoxin (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.

An approved research project under the Ghana/Netherlands Artisanal Fish Processing Project seeks to study the traditional storage of anchovies in Ghana 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.

The first stage of the project dealt with the traditional storage of smoked anchovies at Tema Manhean, a coastal fishing village near Accra. Reports were submitted on the structural characteristics of the traditional storage as well as the physical, chemical, microbiological and mycotoxicological changes during short-term and long-term traditional storage of smoked anchovies at Tema Manhean. (Nerquaye-Tetteh and Plahar, 1992; Plahar, 1992; Hodari-Okae and Kpodo, 1992; Plahar, et al. 1992a; Plahar, et al. 1992b.).

The second stage of the project is aimed at studying the traditional storage of smoked anchovies at "Akplabanya", another major fish processing village. "Akplabanya" is located near Ada, in the Greater Accra Region of Ghana. A first progress report submitted provided a detailed description of the structural characteristics of traditional storage techniques used by the artisanal fish processors (Nerquaye-Tetteh and Plahar, 1993).

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 Akplabanya to study the structural features and peculiarities of the different traditional smoked anchovy storage structures used. 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. Several crates of anchovies were smoked the traditional way and stored. The detailed description of the structures are 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.

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 the several 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 after storage was done at both the periphery and the interior 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 panellists (Plahar, *et al.*, 1991). For each sample, panellists 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).

2.7. Total viable counts (Pour plate technique)

The sterile bag containing whole fish powder was opened over 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 millilitre 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 millilitre 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 Aflatoxin

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 aflatoxin 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 Akplabanya

3.1.1. Material Requirement:

In general, three types of traditional storage structures are known to be in use for smoked anchovy storage at Akplabanya. The survey conducted into the structural characteristics of these storage methods were able to identify the major material requirements and the sources of procurement by the processors. Traditional smoked anchovy processors at Akplabanya make use of mainly locally available materials in the construction of all the storage structures. The following sections give a list and description of basic materials required for setting up a smoked anchovy storage structure at Akplabanya:

3.1.1.1. Materials for the Round Oven Storage Structure

a. Clay

Local clay is required for the construction of a traditional round oven which forms the base of the storage structure. The clay is mixed with water and kneaded well into a semi-solid smooth mouldable consistency. In many traditional set ups in the area, this type of clay is the only material available for building houses.

b. Cut Logs

Pieces of about 7.0 cm diameter logs are acquired 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. Mesh Wire

One-half or three-quarter inch mesh wire is required for the base of the oven. This material is manufactured locally in Ghana and could be purchased by the processors. Incidentally, the same type of mesh is used by the fish smokers in the construction of the smoking trays as part of the improved smoking ovens.

d. Twine or Rope for Mid-section Support

In the previous study at Tema Manhean, it was observed that several pieces of small sticks (about 1.5 cm thick) cut to equal lengths of about 105 cm were required to weave a netting to form a strong support for the mid section circumference of their traditional storage structure. At Akplabanya, only ordinary ropes are used to tie round the mid section beyond the height of the oven to support the structure. The type of rope or twine used is available locally for purchase from mainly old folks who produce it as a pass-time engagement.

e. Brown Paper Lining and Polyethylene Material Cover

Pieces of brown paper required 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.

3.1.1.2. Materials for Sea-Sand Platform Storage

a. Cement Blocks

Five-inch thick cement blocks are used to make a wall of about three layers of block arranged flat on each other without mortar. Usually about thirty pieces of such blocks are required for constructing only one side of a square platform.

b. Sea sand

Clean sea sand from the near-by beach is used to fill the platform base to the height of the block level. It is very important that the sand is clean and free of any garbage matter.

c. Jute Sacks and Brown Paper

Several jute sacks are needed to cover the sandy platform. Old cocoa or maize bags are suitable for the purpose. The sack layer is also covered with a layer of brown paper. Locally, the middle and outer layers of cement bags are used to avoid contamination with cement. More jute sacks are also needed to cover the top of the storage structure.

d. Polyethylene Material

A large sheet of black polyethylene material is required for use in covering the whole structure for protection against rain and dust. This material is obtainable from a manufacturing company, "Poly Sacs" Company, Ghana Ltd. in Accra.

e. 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.

3.1.1.3. <u>Materials for the Fenced Yard Storage Structure</u>

a. Sticks for Fencing

Several sticks measuring about 2m long are obtained

locally from young nim trees or similar species of trees in the area. The sticks must be strong and flexible enough to facilitate weaving them together into a strong netting.

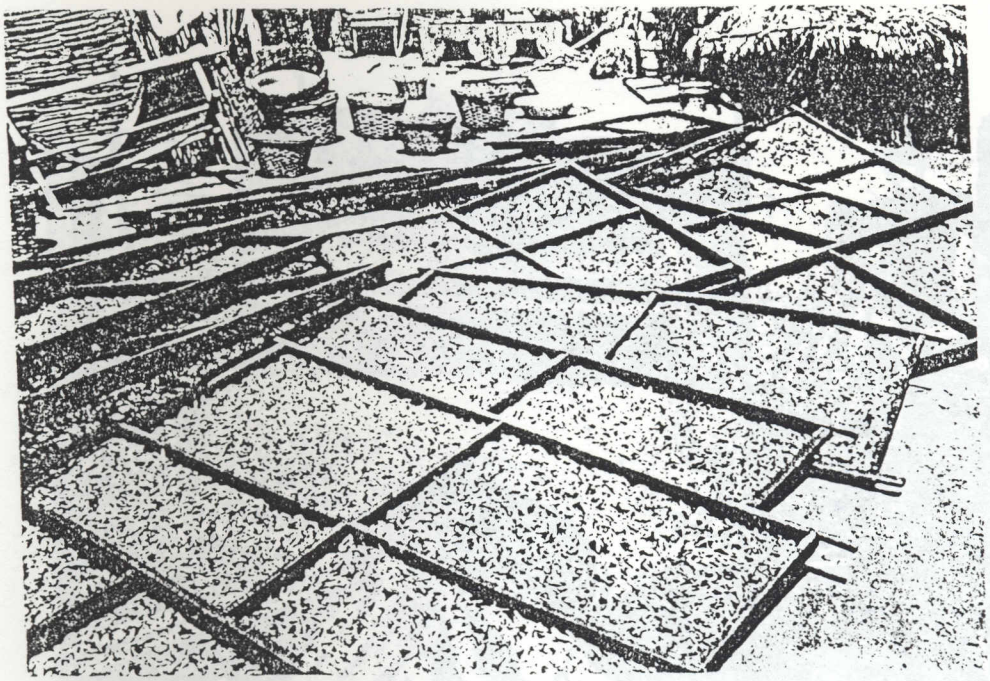
b. Polyethylene Material

A large sheet of black polyethylene material is required for use in covering the whole structure for protection against rain and dust. This material is obtainable from a manufacturing company, "Poly Sacs" Company, Ghana Ltd. in Accra.

3.1.2. Preparation of Anchovies for Storage

Anchovies for storage are either sun-dried or smoked. These constitute the two main processing techniques used for fish preservation at Akplabanya. Of these, smoking or more appropriately, smoke-drying is employed for long-term preservation of anchovies. The newly introduced improved smoking kiln, the "chorkor smoker" is used by all large-scale anchovy processors in the village in their smoking activities.

Freshly landed anchovies are purchased and prepared for smoking by washing and surface-drying. Surface-drying is carried out by spreading the fish on the smoking trays (Fig 1). The trays are left in the sun for several hours after which they are arranged on the smoking oven for the smoke-drying process (Fig 2). Earlier reports by the fish



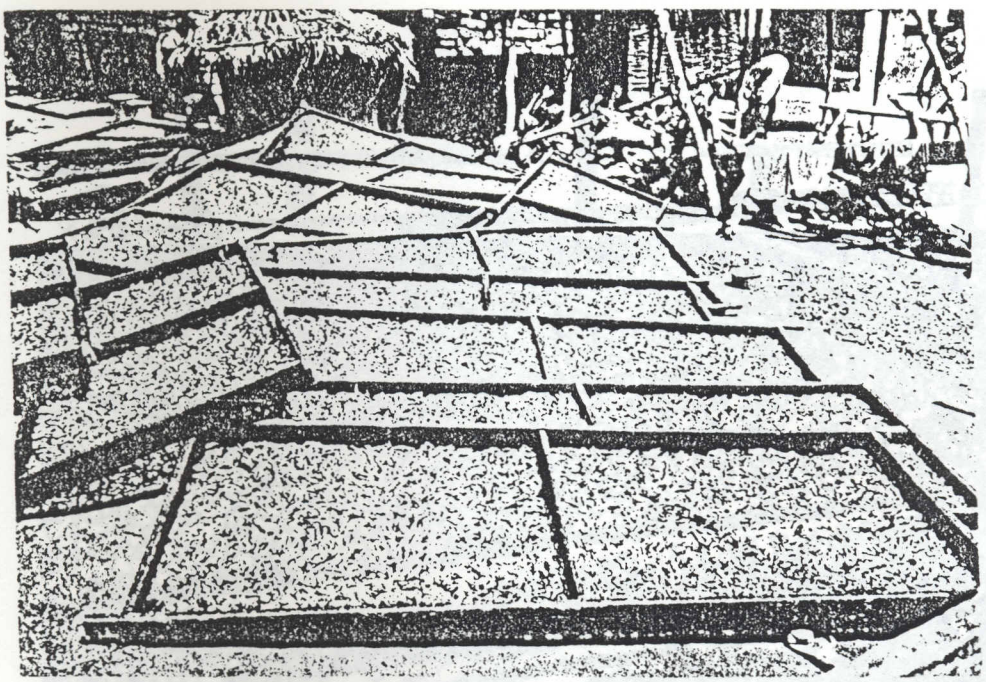


Fig 1. Trays of Anchovies being prepared for smoking.

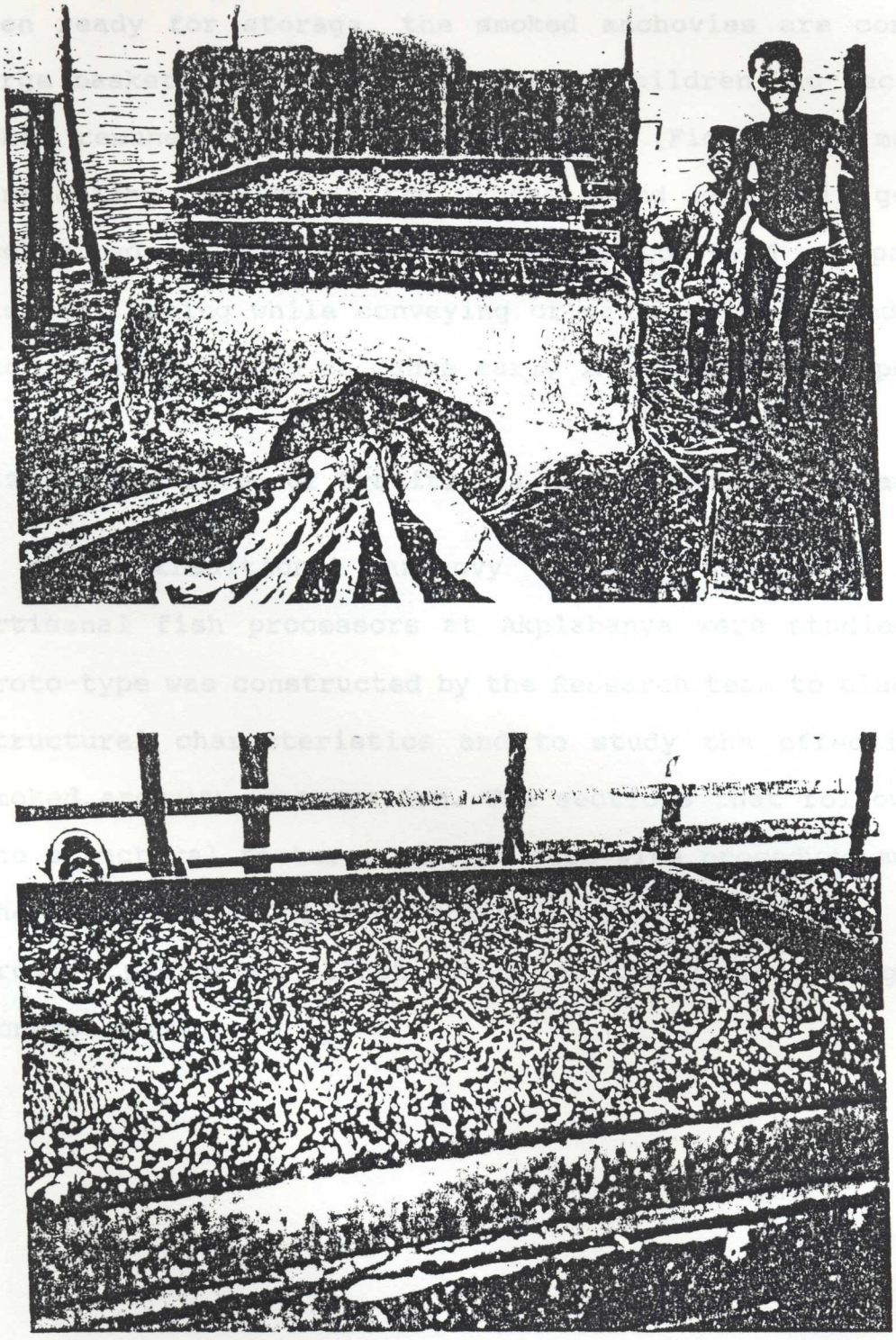


Fig 2. Smoking of Anchovies in progress

research team at the Food Research Institute provide detailed description and evaluation of the smoking process by the "Chorkor Smoking Oven" technique (Nerquaye-Tetteh, 1979).

When ready for storage, the smoked anchovies are conveyed in large baskets to the storage site by children who receive some token remuneration for their services (Fig 3). No matter the temptation, chewing of the product, and eating in general is prohibited while the fish is being conveyed or packed for storage. Eating while conveying or packing the smoked fish for storage is believed to cause early infestation and spoilage.

3.2. Construction of Traditional Smoked Anchovy Storage.

The traditional anchovy storage structures used by artisanal fish processors at Akplabanya were studied and one proto-type was constructed by the Research team to elucidate the structural characteristics and to study the effectiveness of smoked anchovy preservation. The sections that follow describe the structural features and the step-wise procedure employed in the construction of the various storage structures. They also provide pictorial illustrations of the various stages of the construction.

Fig 3. Smoked anchovies being conveyed to storage site

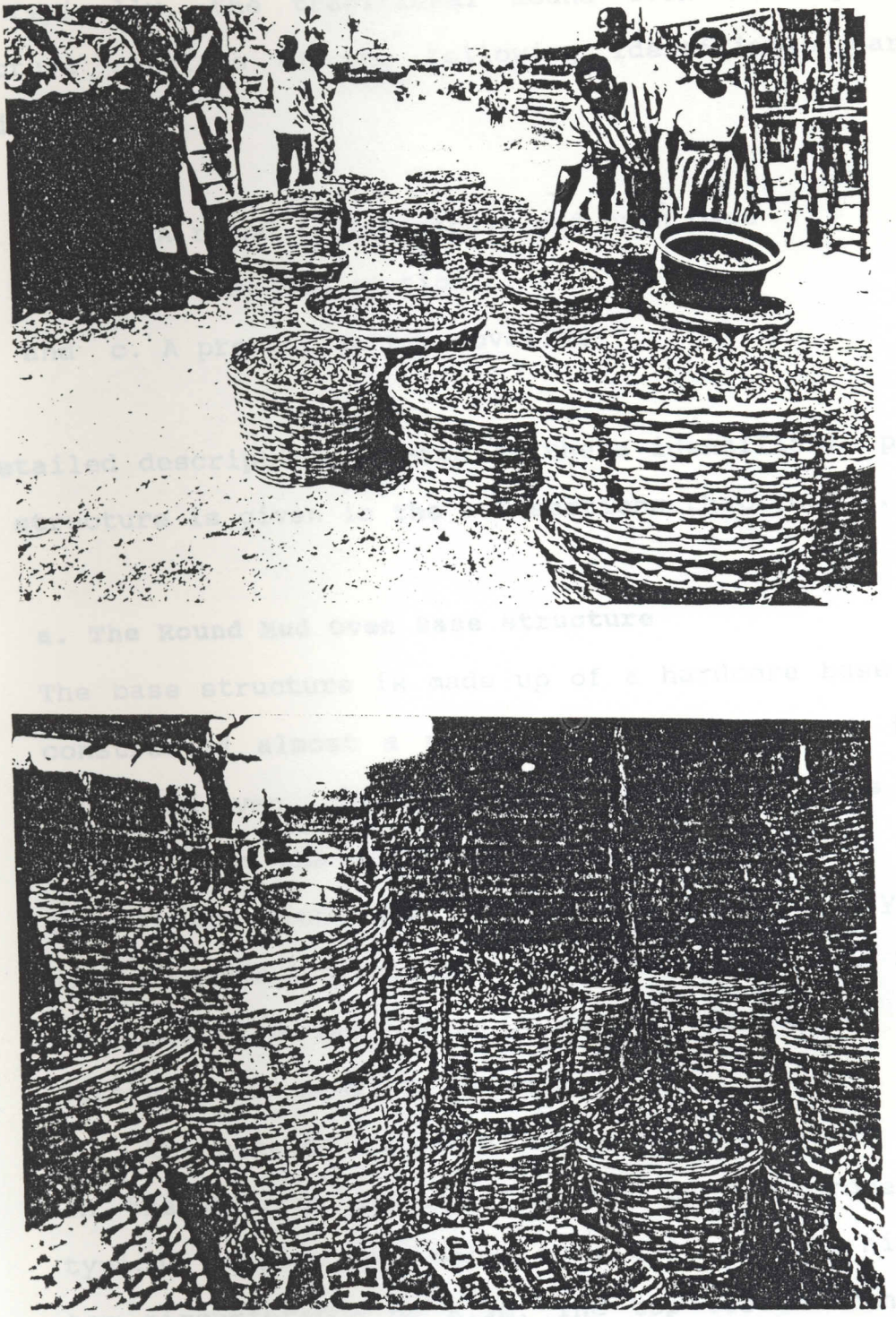


Fig 4. Smoked Anchovies ready for packing into storage

3.2.1. The Round Oven Storage Structure

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

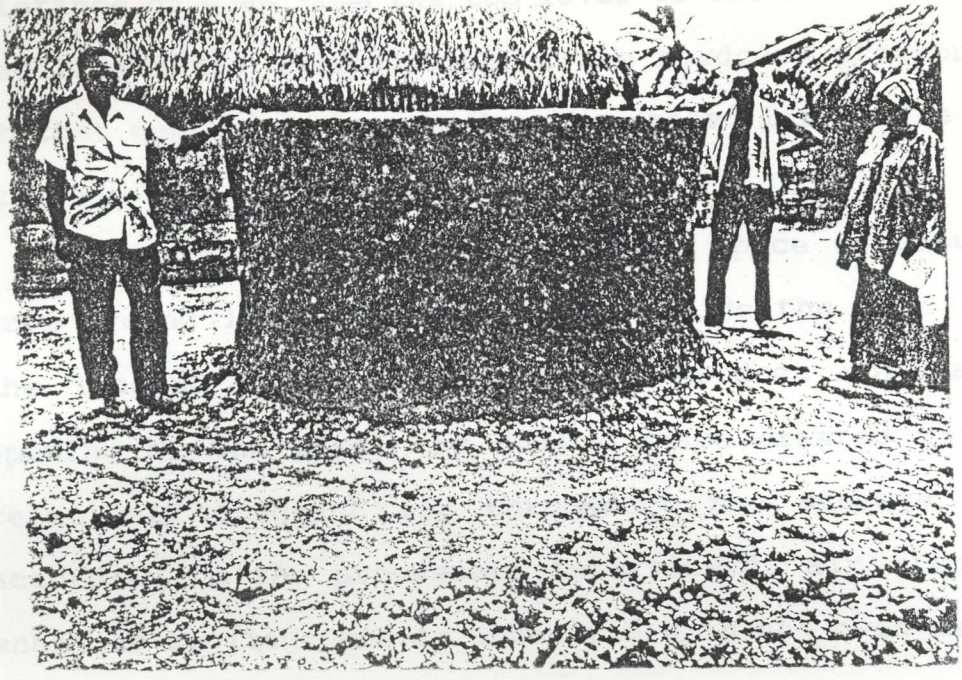
a. A round (cylindrical) mud oven base
b. A dome top section
and c. A protective top covering

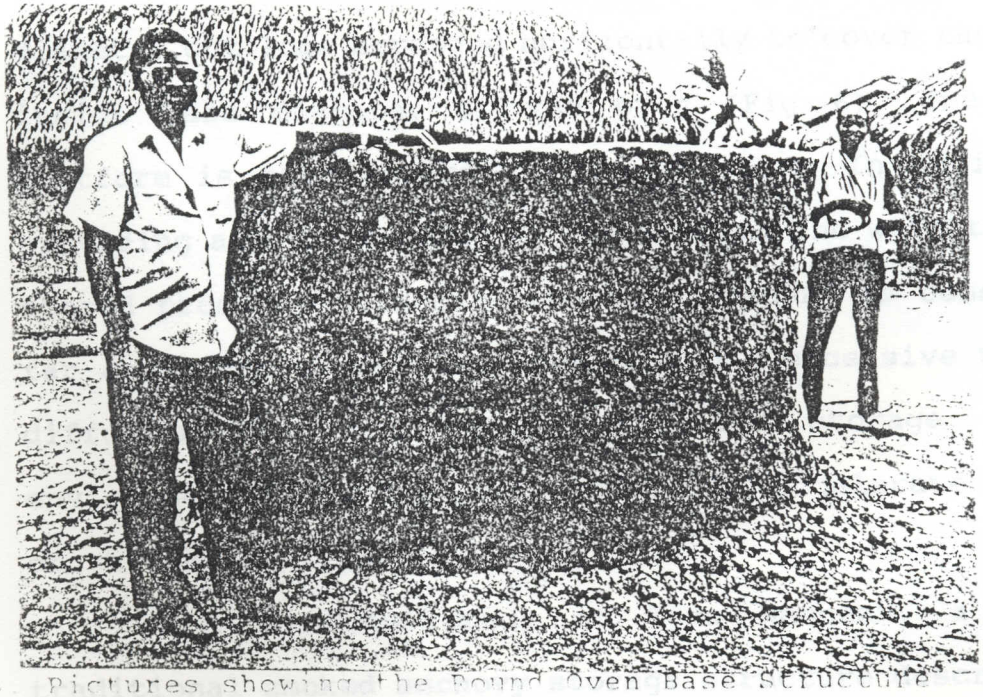
A detailed description of each of these identifiable parts of the structure is given in the sub-sections that follow.

a. The Round Mud Oven Base Structure

The base structure is made up of a hardcore base support constructed almost a meter above ground level inside a round mud oven. The traditional round oven forms the base housing for the whole storage structure. The oven is constructed with clay that have been thoroughly kneaded into a smooth and mouldable consistency. The oven is always constructed a few weeks in advance for it to dry well before it is used for storage.

The size of the oven base structure varies depending on the desired storage capacity by the processor. A typical storage oven shown in Fig 5, is 1.2m high with a top circumference of 8.3m. The top circumference tapers down slightly to a mid-section and base circumference of





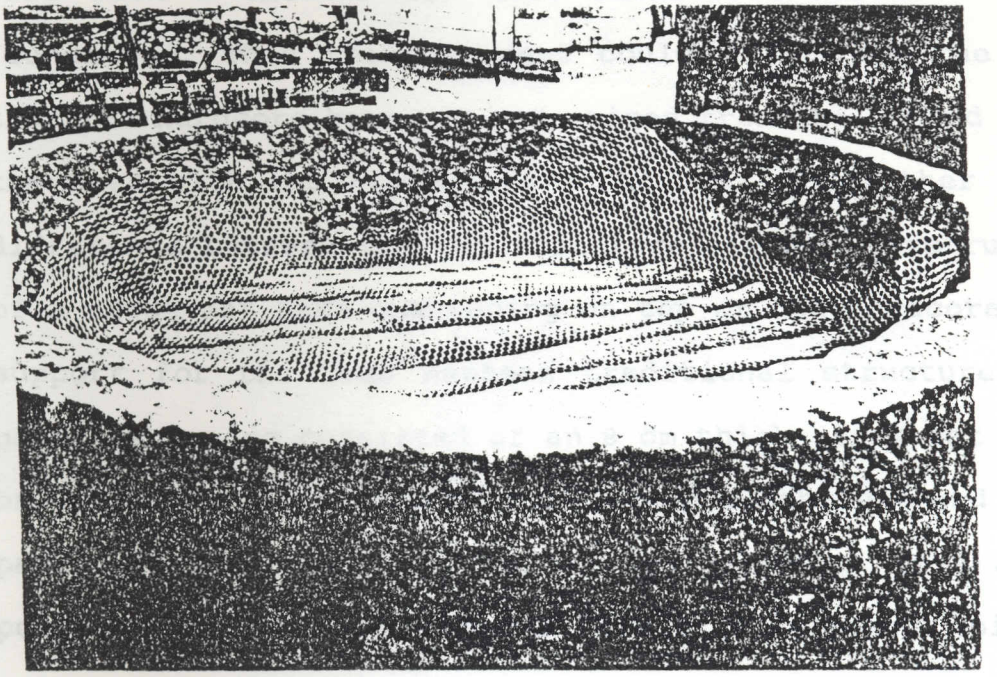
Pictures showing the Round Oven Base Structure

8.0m. The slight indentation of the circumference is at a distance of 0.4m from the top level of the oven. This is to facilitate the construction of the hardcore platform base at that depth in the oven for the smoked fish to be loaded on.

With this arrangement, a hollow space of about 0.8m from ground level up, is created inside the oven beneath the loading level. Since the oven does not have any opening at the base, the hollow space created retains a relatively stagnant air throughout the storage period. According to the processors interviewed, air circulation enhances spoilage and is undesirable in the oven method of smoked anchovy storage.

The hardcore base support platform on which the smoked fish to be stored is dumped is built with a layer of 7.0 diameter cut logs arranged horizontally to cover the entire inside base diameter of the oven (Fig 6). The wooden platform is then covered with mesh wire. In addition to providing a solid foundation for holding the weight of the stored product, this hardcore base support is constructed far above the ground in order to avoid excessive moisture diffusion from the ground into the storage. A damp environment at the base will definitely accelerate spoilage of the smoked fish.

In a previous study at Tema Manhean, a similar traditional smoked anchovy storage structure described by



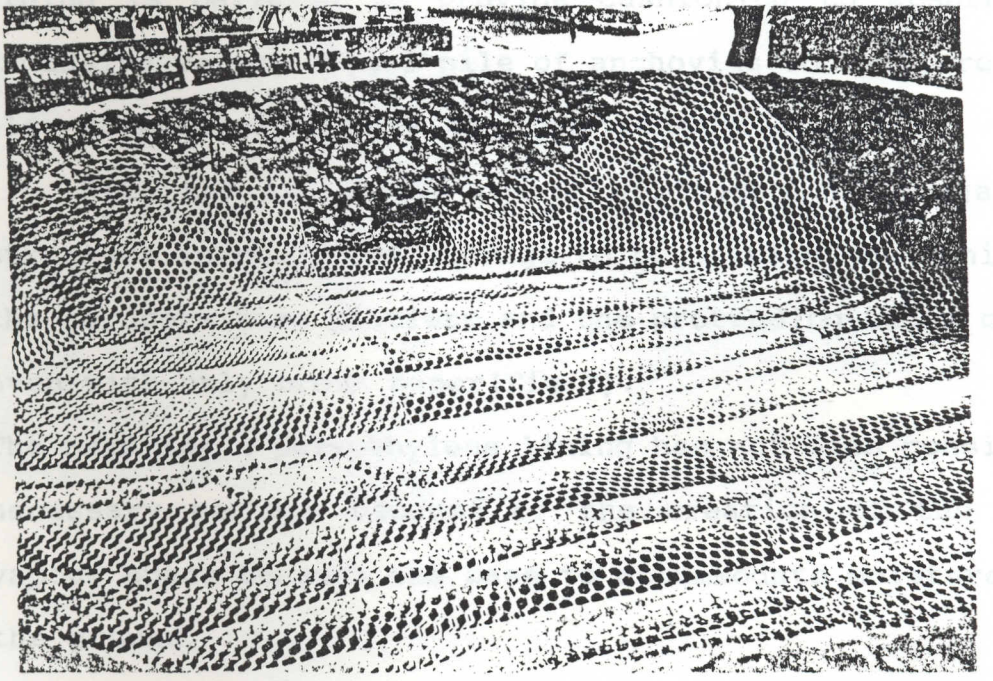


Fig 6. Pictures showing the Oven Base Platform

Nerquaye-Tetteh and Plahar (1992) had a rectangular metal base with a thicker and more reinforced hardcore floor foundation. This reinforcement could be due to the fact that the hardcore base was not raised from the ground as is the case with the Akplabanya structure. One other major difference between the two structures is the construction of a straw mat base cushioning on top of the hardcore base support for the Tema Manhean traditional structure. The base cushioning consisted of an 8 cm thick straw mat layer on which was spread a layer of black polyethylene and brown paper lining (Nerquaye-Tetteh and Plahar, 1992). 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.

With the Akplabanya round oven type of storage, the structure is ready for storage to begin with the lining of the hardcore base platform and the protruding sides of the oven with only brown paper(Fig 7).

The need for a polyethylene lining has not been considered necessary perhaps because of the creation of the large vapour space beneath the base to accommodate moisture from the ground.

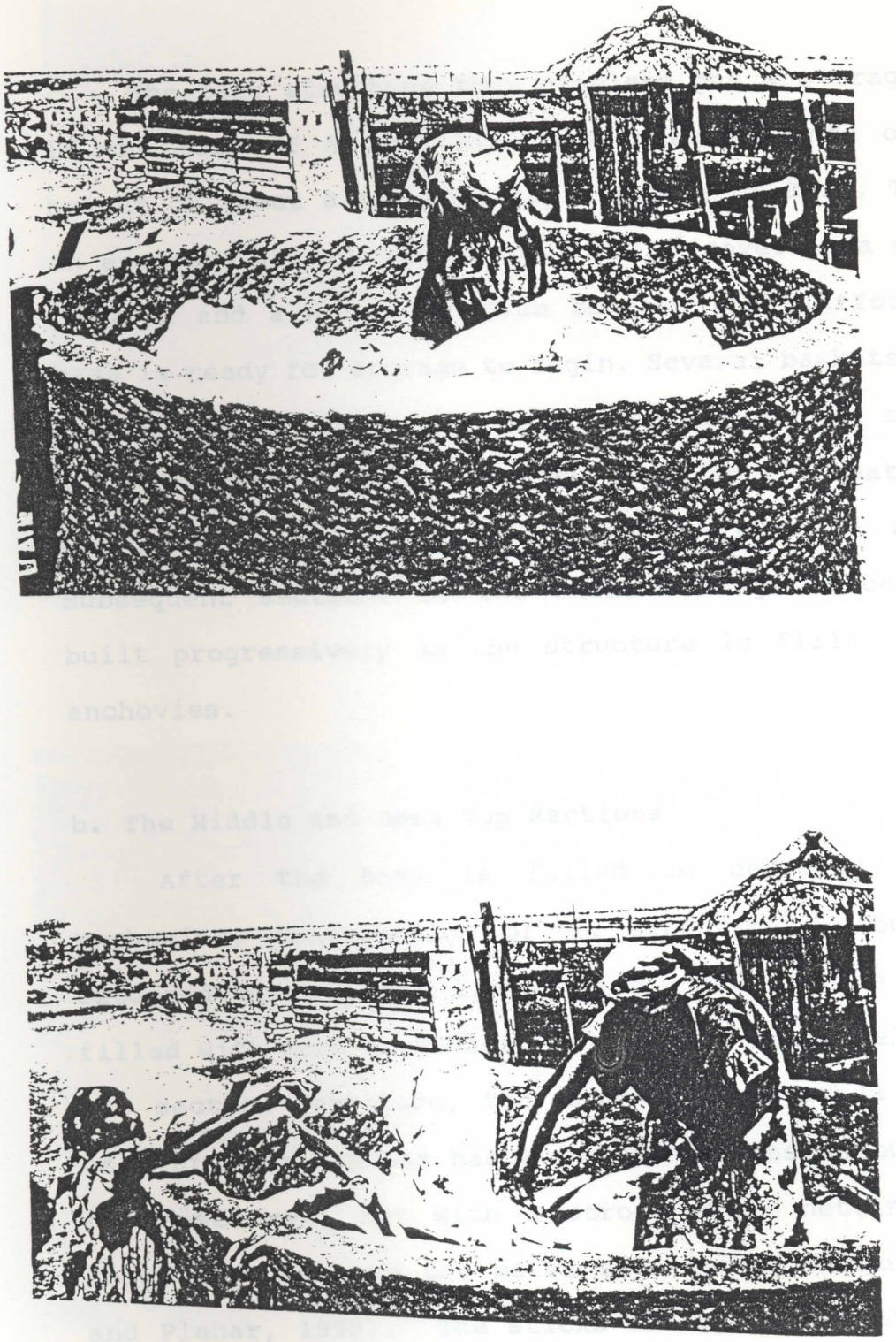


Fig 7. Lining of the base with brown paper

The base structure thus complete has a storage space in the form of a cone with base circumference of 8.0m, height of about 0.4m and a top diameter of 8.3m. This has an enclosed air volume of about 3.32m^3 covering a diameter of 2.3m and a height of 0.8m beneath the platform. The base is 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 (Figs 8a and 8b). Subsequent sections of the whole storage structure are built progressively as the structure is filled with the anchovies.

b. The Middle and Dome Top Sections

After the base is filled to capacity with the anchovies, construction of an extension is built with extended brown paper lining tied round with a rope and filled with more anchovies. Unlike this relatively fragile mid section structure, the traditional storage structure used at Tema Manhean has a similar extension built above the base level but with a strong stick netting support about 105 cm above the metal base level (Nerquaye-Tetteh and Plahar, 1992). The sticks are spaced at about 10 cm intervals and woven together with a long rope.

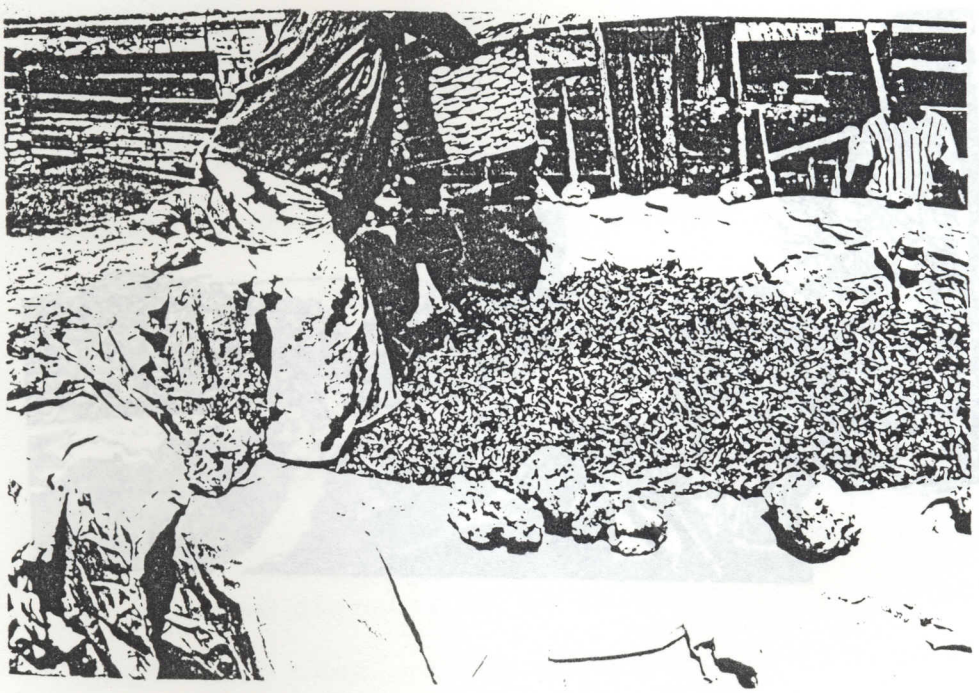


Fig 8a. Filling of the oven base structure with smoked anchovies.

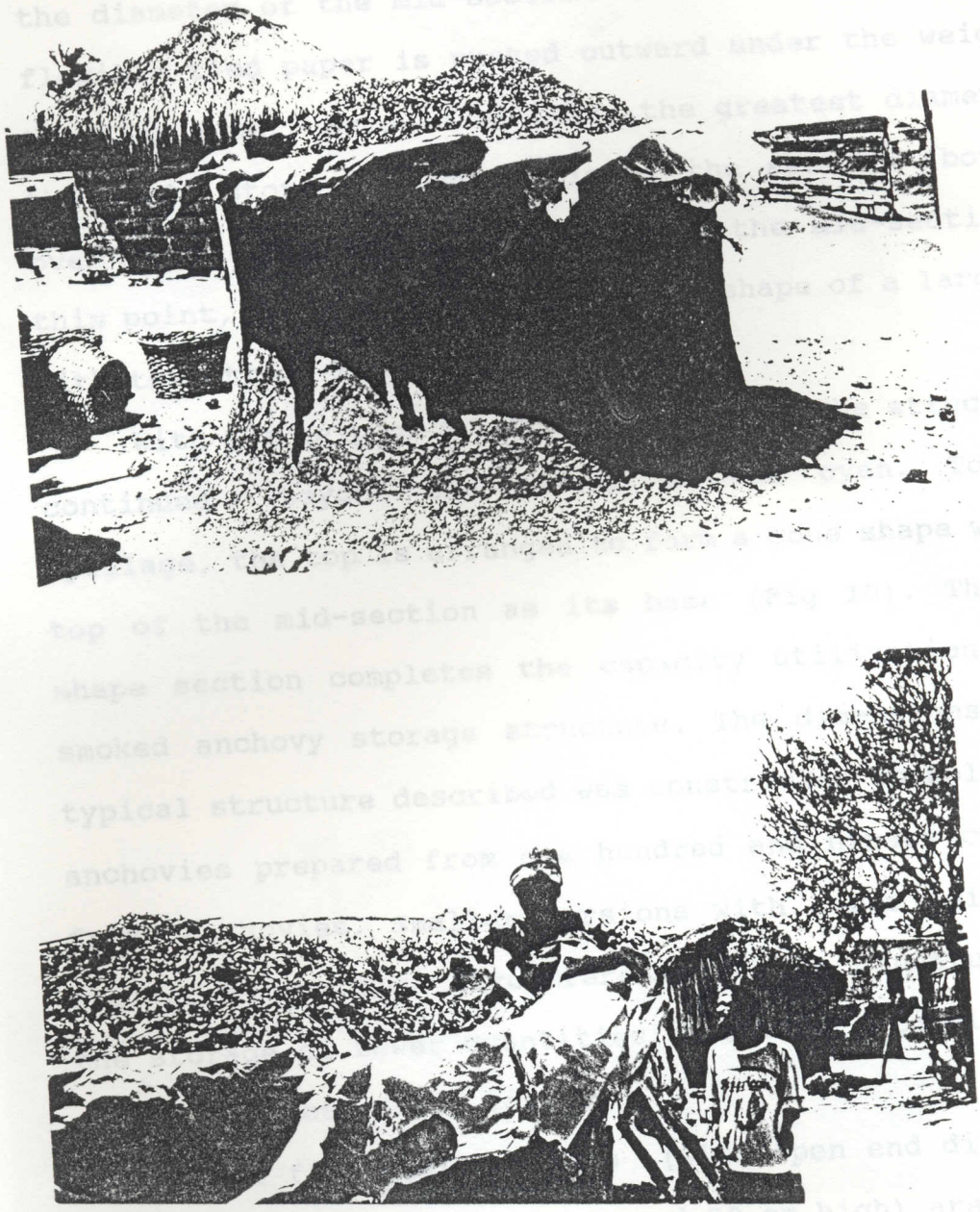


Fig 8b. Filling of the oven base structure with smoked anchovies.

With the Akplabanya round oven structure under study, the diameter of the mid-section widens as the relatively flexible tied paper is pushed outward under the weight of the fish load. Because of this, the greatest diameter of the whole storage structure is at the section above the oven level (Fig 9). This also forms the mid-section. At this point, the structure assumes the shape of a large dome with the strong round oven base.

With the help of a ladder, filling of the structure is continued beyond the height of the oven. To avoid spillage, the top is arranged to form a cone shape with the top of the mid-section as its base (Fig 10). This cone shape section completes the capacity utilization of the smoked anchovy storage structure. The dimensions of the typical 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 circumference can be constructed for the storage of fewer quantities of smoked anchovies.

c. The Protective Top Covering

About five 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 11. The whole structure is covered with a large sheet of thick black polyethylene. The baskets are to prevent the polyethylene cover from a direct contact with the fish.

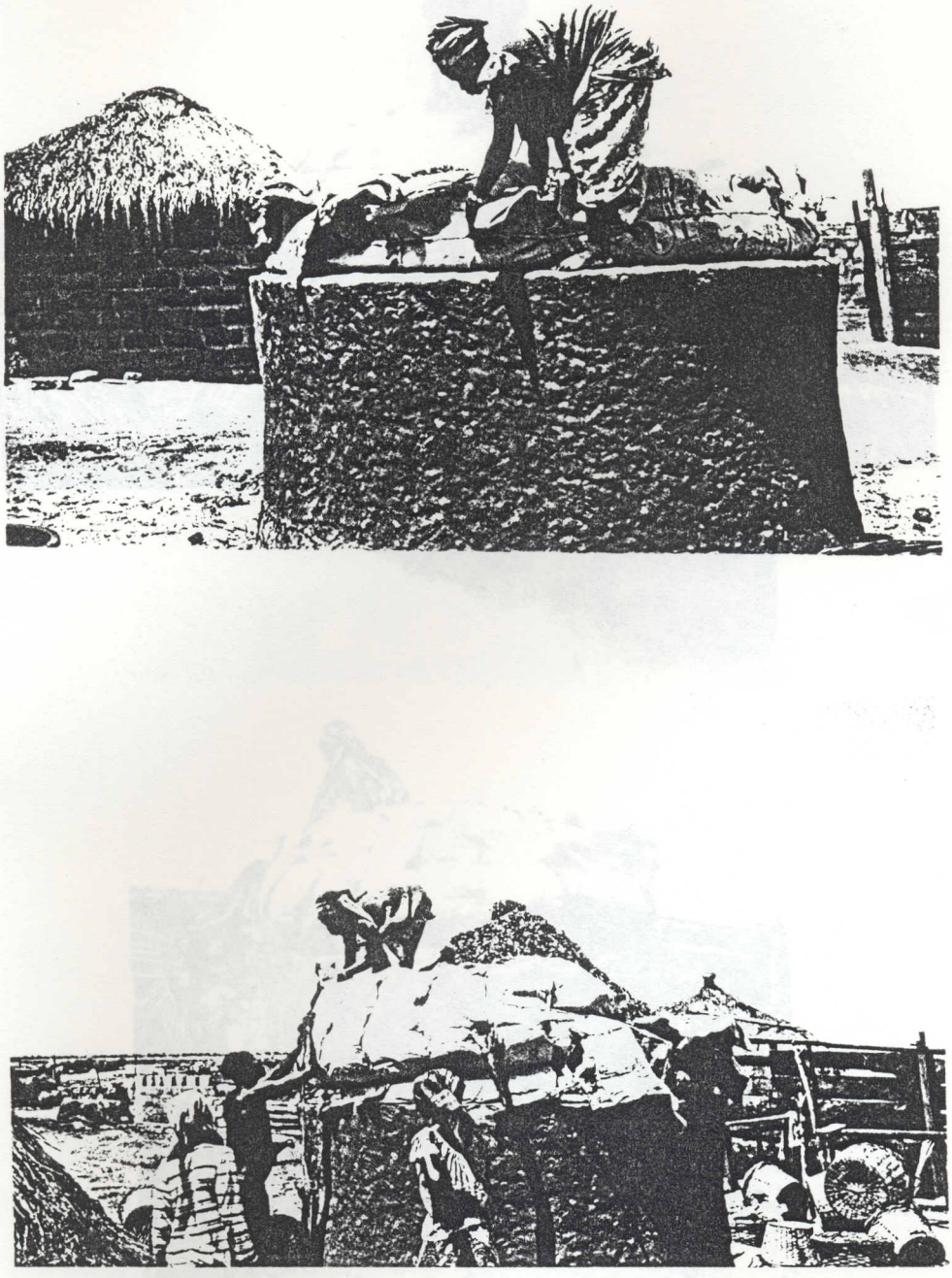


Fig 9. Construction of the Mid-section structure

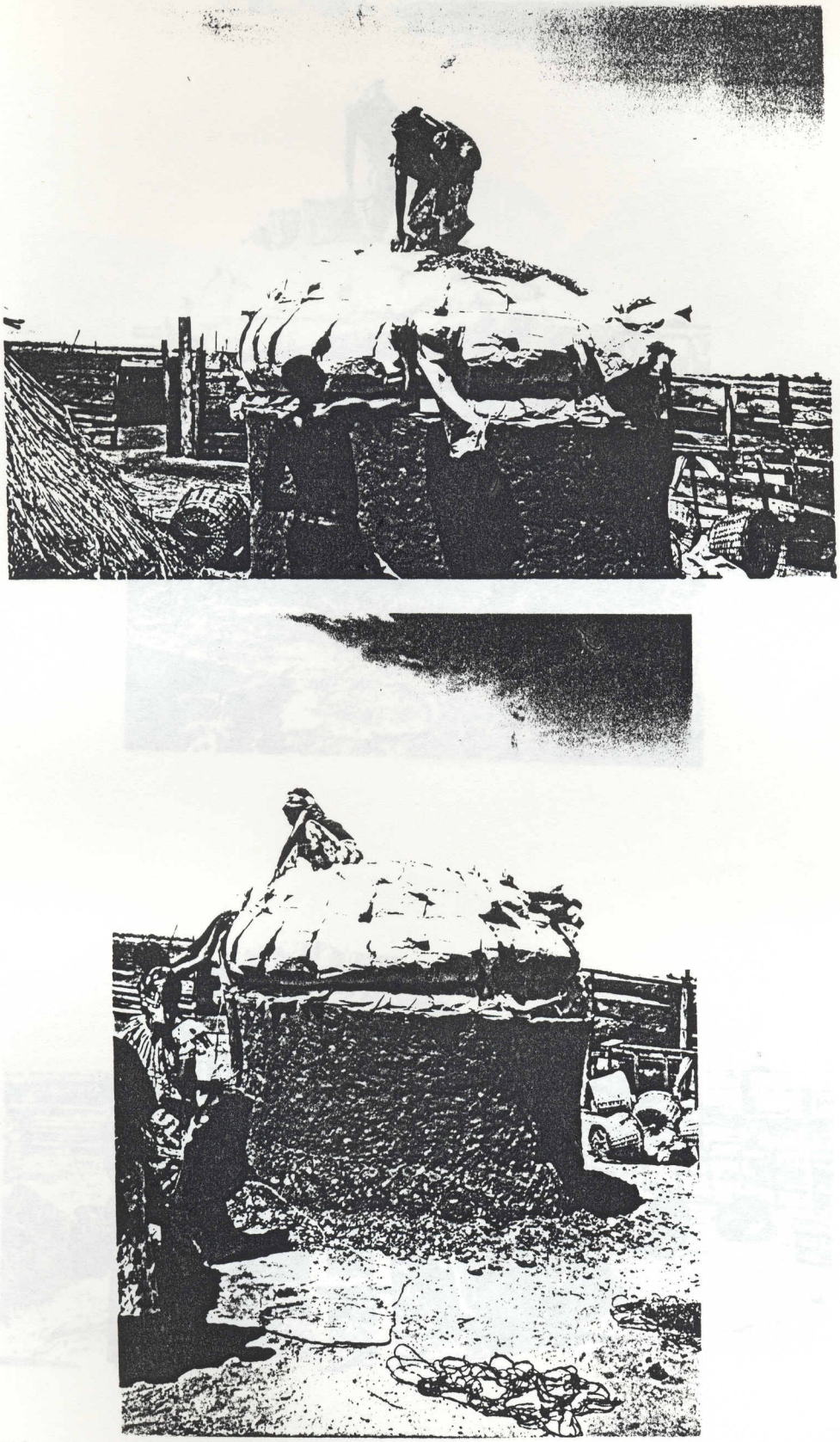


Fig 10. Traditional Round Oven anchovy storage structure filled to capacity

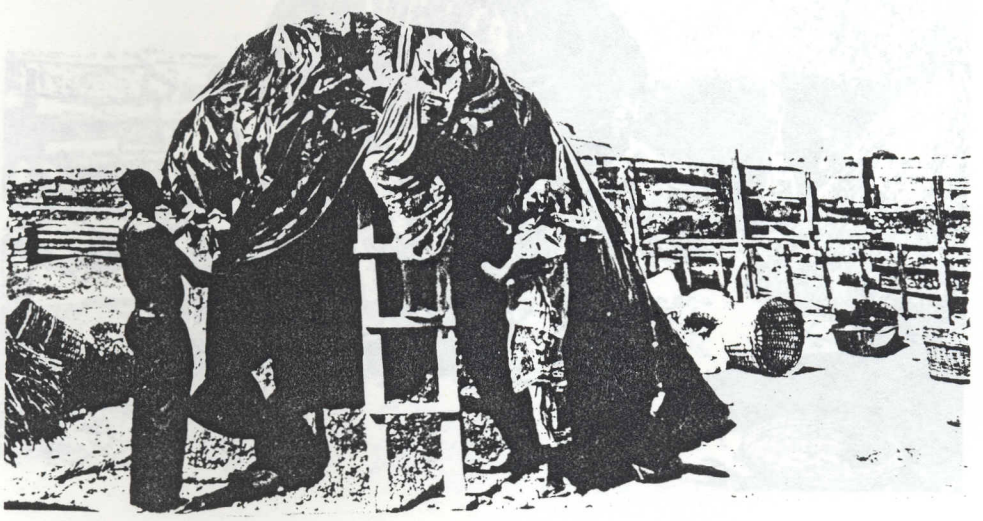


Fig 11. Top protective cover: Basket cover (top picture) and Polyethylene cover (bottom picture).

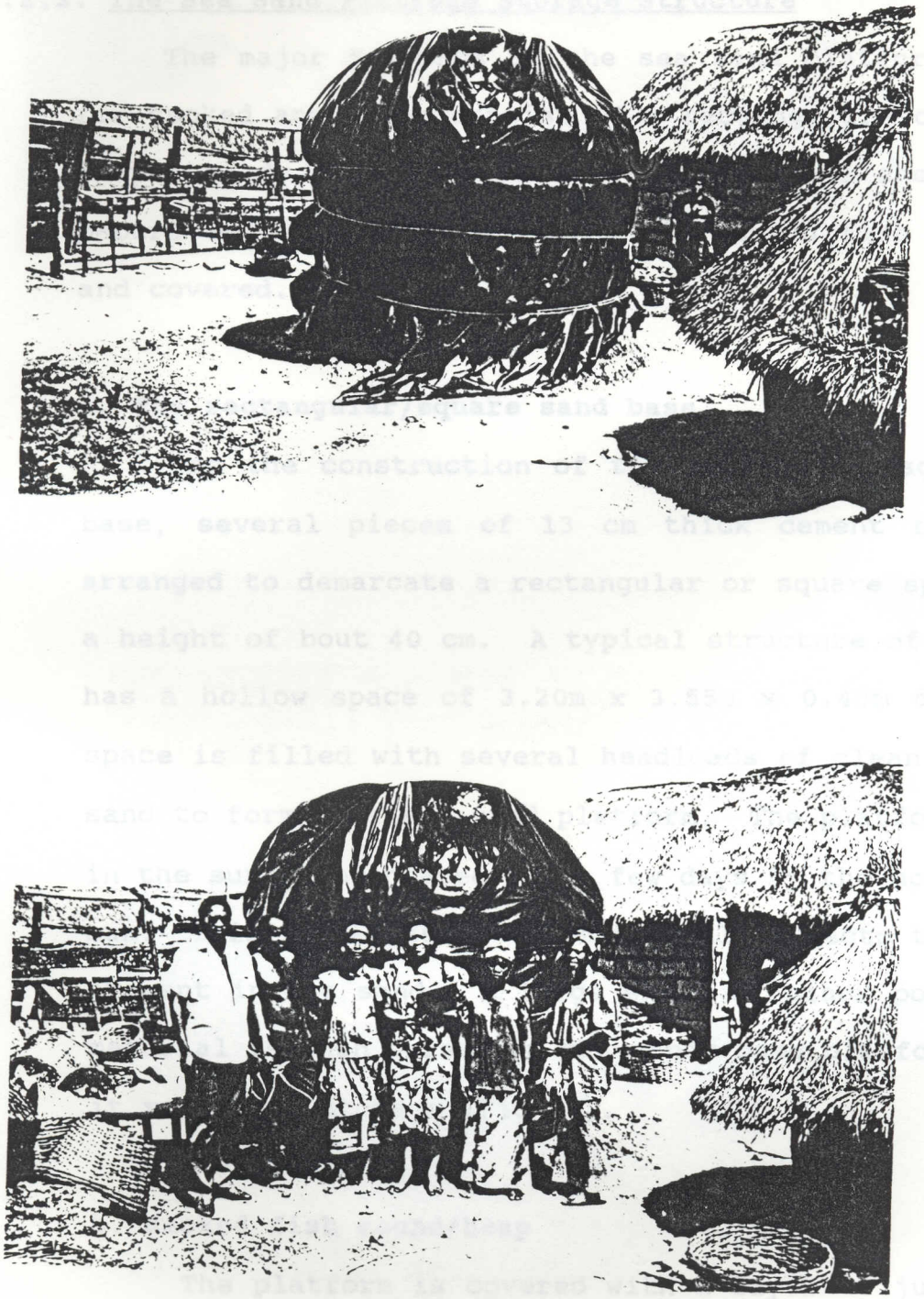


Fig 12. Smoked anchovies in traditional round oven storage.

3.2.2. The Sea Sand Platform Storage Structure

The major features of the sea sand platform storage for smoked anchovies consist of a rectangular- or square-shaped sandy base covered with polyethylene sheet, brown papers and jute sacks on which the smoked fish is heaped and covered.

a. The rectangular/square sand base

For the construction of the rectangular/square sand base, several pieces of 13 cm thick cement blocks are arranged to demarcate a rectangular or square space up to a height of bout 40 cm. A typical structure of this type has a hollow space of 3.20m x 3.55m x 0.45m deep. The space is filled with several headloads of clean white sea sand to form a raised sand platform. The platform is left in the sun to be heated for a few days by the hot tropical sun. This is necessary to destroy all insects that may be present in the sand. A large sheet of black polyethylene material is then spread on the sandy base platform to make it ready for storage (Fig 13).

b. Smoked fish mound/heap

The platform is covered with a layer of jute bags on top of which is spread several sheets of brown paper. The smoked anchovies to be stored are then heaped on the raised platform to form a large dome. Here again, the height or

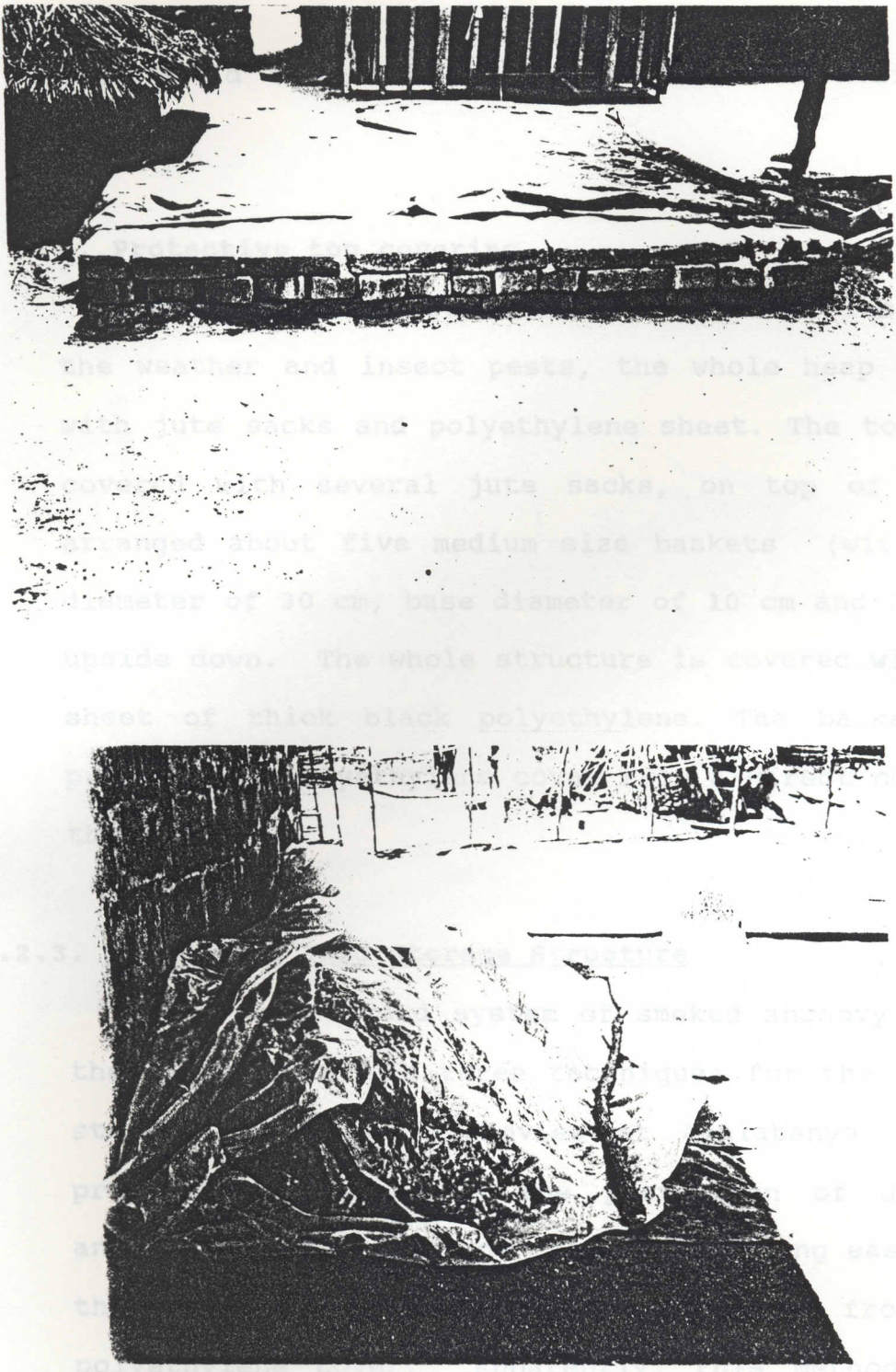


Fig 13. The sea-sand platform storage structure

size would depend on the amount of fish available for storage.

c. Protective top covering

To protect the fish excessive storage losses due to the weather and insect pests, the whole heap is covered with jute sacks and polyethylene sheet. The top is first covered with several jute sacks, on top of which are arranged about five medium size baskets (with open end diameter of 30 cm, base diameter of 10 cm and 20 cm high) upside down. The whole structure is covered with a large sheet of thick black polyethylene. The baskets are to prevent the polyethylene cover from a direct contact with the fish.

3.2.3. The Fenced Yard Storage Structure

The fenced yard system of smoked anchovy storage is the simplest of the three techniques for the traditional storage of smoked anchovies at Akplabanya. The main protection effected is the prevention of domesticated animals such as goats and sheep from having easy access to the stored fish; in addition to protection from rain with polyethylene cover. Apparently, this method of smoked anchovy storage is only a temporary one used when the product would have to be disposed of within a relatively short period of time.

Fig 14. Picture showing a traditional fenced yard storage structure constructed with timber board pieces.

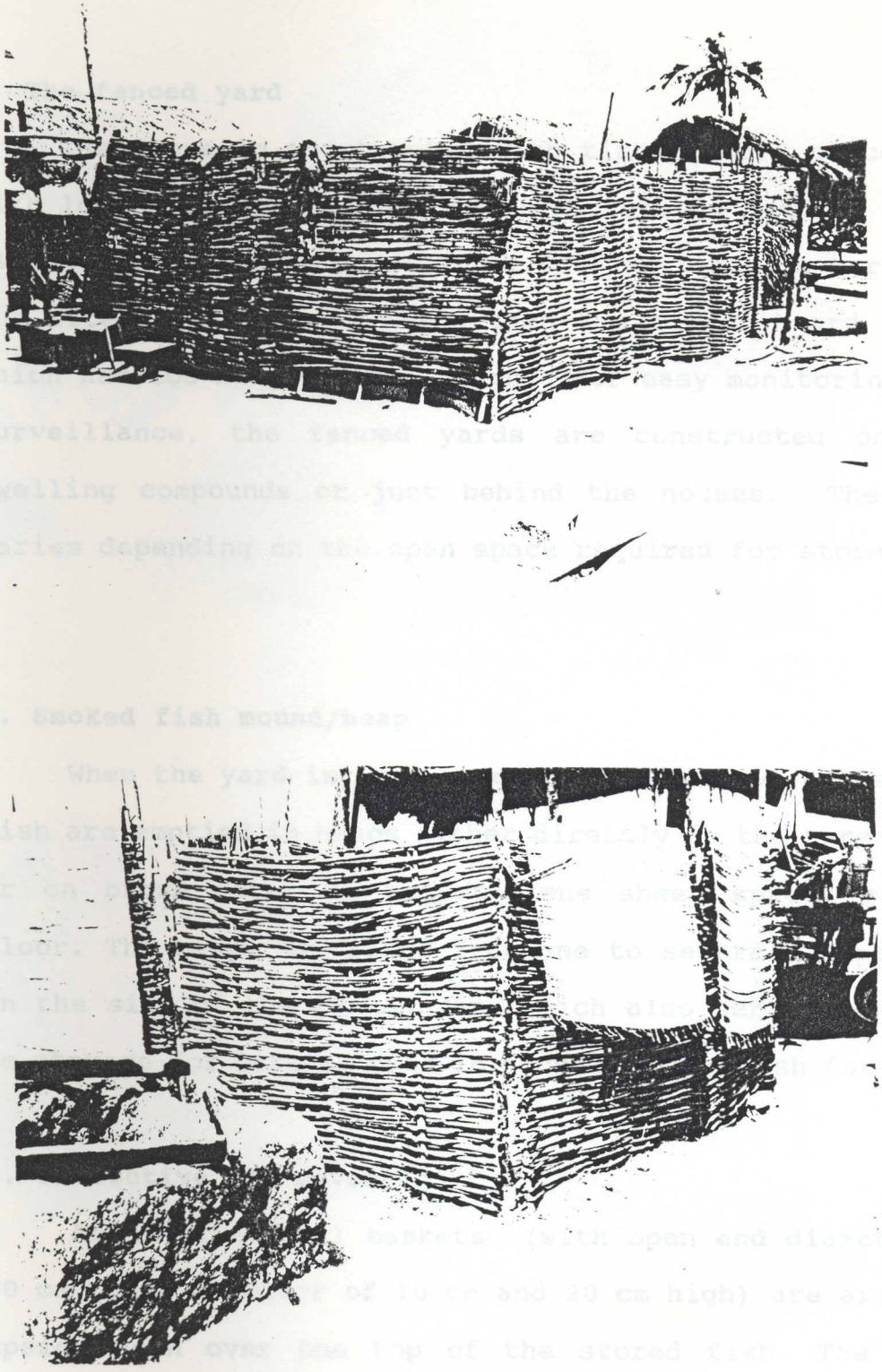


Fig 15. Pictures showing a fenced yard traditional storage structure constructed with woven sticks.

a. The fenced yard

The fence is constructed with timber board pieces or with long sticks interwoven to form a strong netting (Figs 14 and 15). The interwoven stick netting fence is stronger and offers better protection than the timber board fence which has too many wide openings. For easy monitoring and surveillance, the fenced yards are constructed on the dwelling compounds or just behind the houses. The size varies depending on the open space required for storage.

b. Smoked fish mound/heap

When the yard is ready, several baskets of the smoked fish are emptied in heaps either directly on the bare floor or on brown paper or polyethylene sheet spread on the floor. The heaps may range from one to several, depending on the size of the fenced yard which also serves at times as storage for baskets used in packaging the fish for sale.

c. Protective top covering

About five 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. The whole structure is covered with a large sheet of thick black polyethylene. The baskets are to prevent the polyethylene cover from a direct contact with the fish.

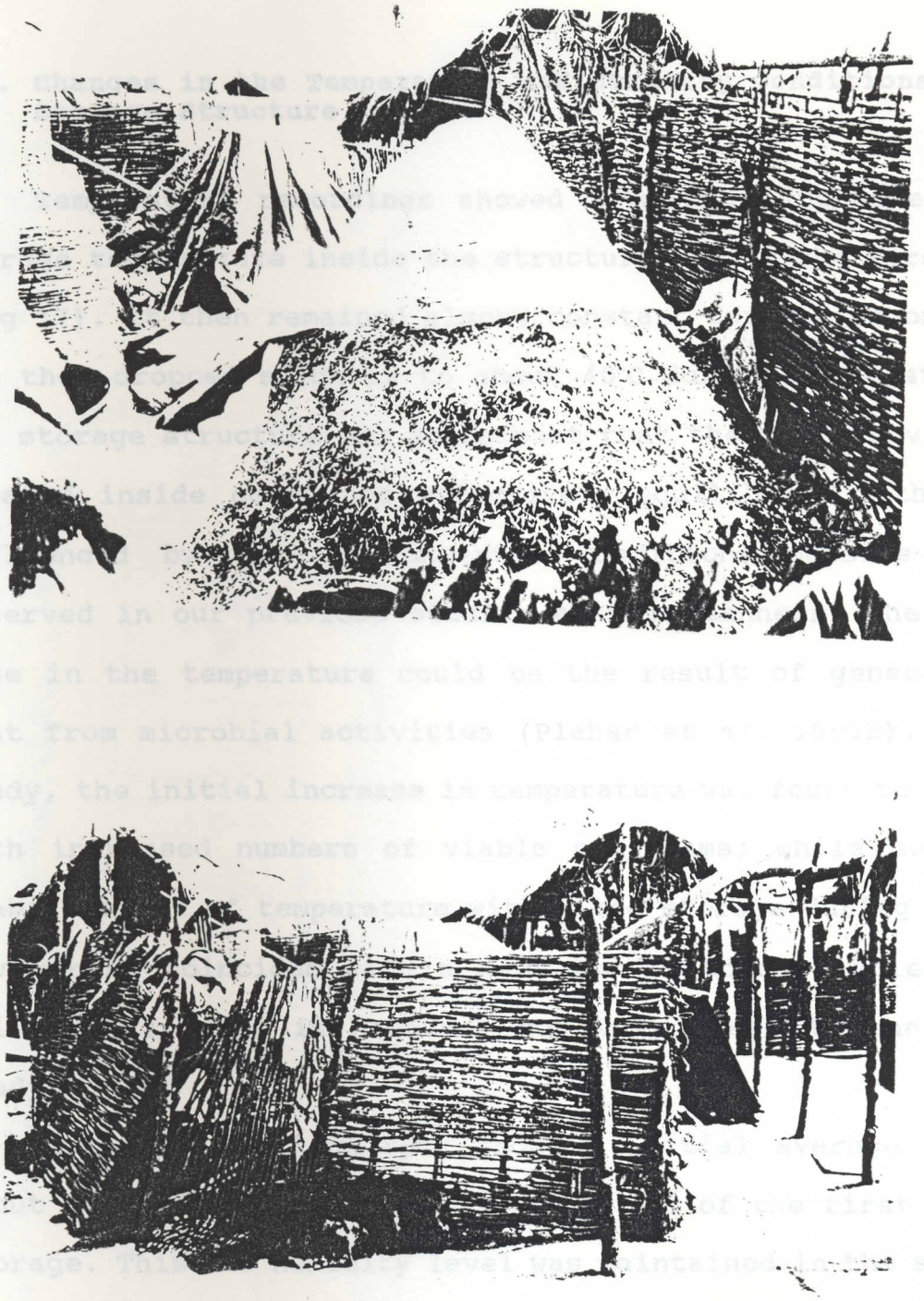


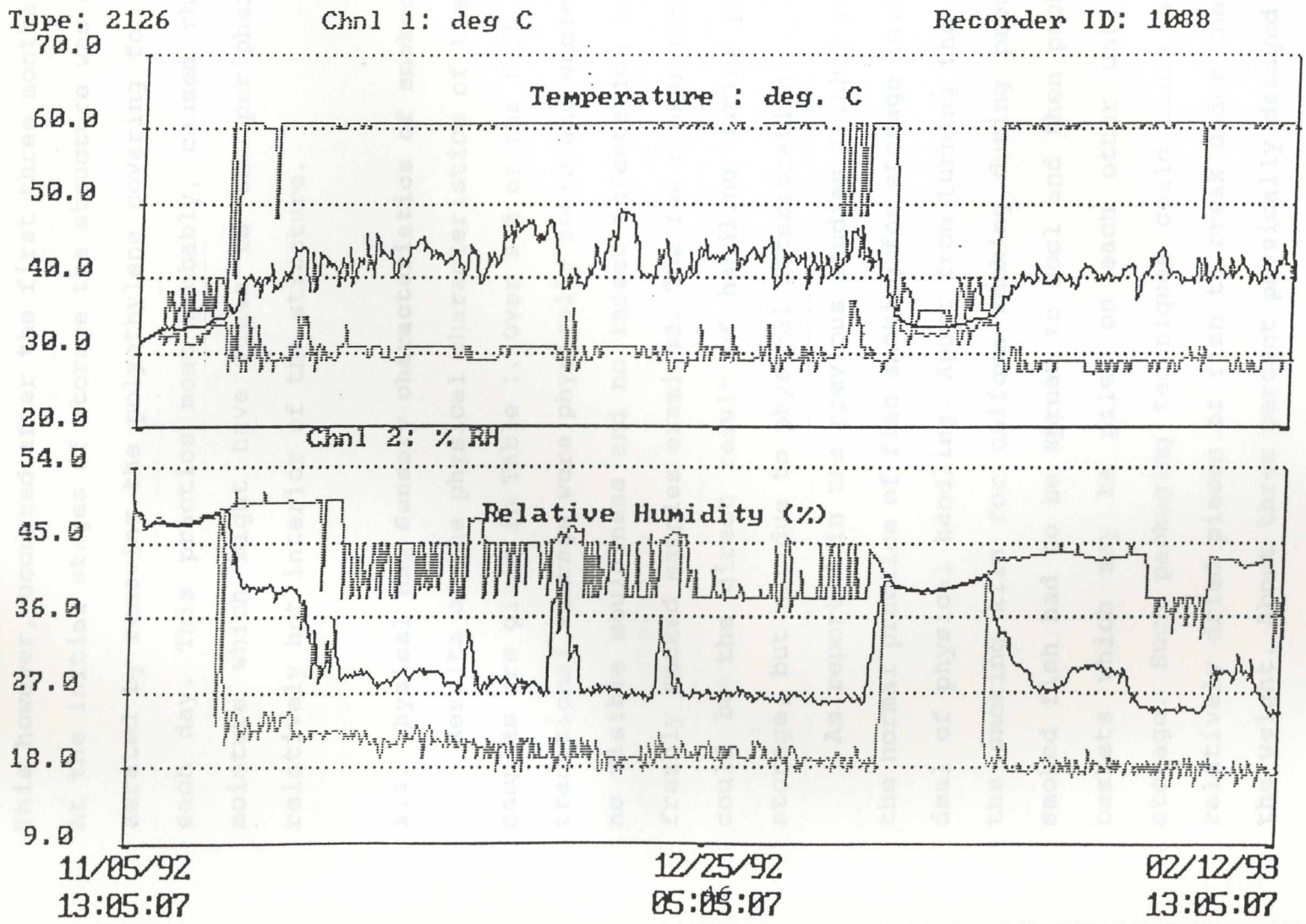
Fig 16. Pictures showing fenced yard storage with baskets ready for packaging.

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

Temperature recordings showed a gradual increase in the storage temperature inside the structure during the first month (Fig 17). It then remained almost constant for the second month and then dropped slightly to about 40°C during the last month. 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. As observed in our previous studies at Tema manhean, the initial rise in the temperature could be the result of generation of heat from microbial activities (Plahar *et al.* 1992b). In that study, the initial increase in temperature was found to coincide with increased numbers of viable organisms; while subsequent stabilisation of temperature within the storage during the last few months coincided with a decrease in total viable counts. This relationship is however, not very clear in the present study.

Humidity fell sharply from an initial average value of about 48.4% to as low as 28.5% at the end of the first month of storage. This low humidity level was maintained in the structure with occasional slight fluctuations for the rest of the storage period. The drop in humidity did not cause any significant decrease in the moisture content of the already well dried anchovies in storage. Although higher initial and final humidities were recorded in the structure studied at Tema

Fig 17. Temperature and Humidity Changes in Traditional Storage



Manhean, the decrease resulted in the further drying of the samples to enhance quality preservation (Plahar *et al.* 1992b). This however, occurred after the first three months 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.

3.3. Physical and Sensory characteristics of smoked anchovies

Results of the physical characteristics of the smoked fish samples are given in Table 1. Over 97% of the fish prepared for traditional storage were physically sound and whole. There were no visible mouldiness and no insect infestation in any of the freshly smoked samples examined. The few broken pieces observed could be the direct result of handling during packaging and storage, but not due to physical deterioration.

As reported in the previous studies (Plahar *et al.* 1992b) 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

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

		Storage Period (months)	
		0	3
Total examined	(Kg)	4.52	5.21
	(%)	100	100
Whole unbroken -Storage Yield	(Kg)	4.40	4.76
	(%)	97.34	91.43
Broken pieces	(Kg)	0.12	0.25
	(%)	2.65	4.85
Visibly mouldy	(g)	0.00	0.17
	(%)	0.00	3.30
Insect Infested	(Kg)	0.00	0.03
	(%)	0.00	0.48
Overall physical damage	(Kg)	0.12	0.45
	(%)	2.65	8.64

freshly smoked anchovies observed in this and other studies is considered far below the normal anticipated breakages. Both processing and handling were therefore adequate, resulting in a high quality product for storage.

The results of the three-month storage showed a storage yield of over 91% physically sound product (Table 1). The remaining 9% 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 three-month storage period visible mouldiness and broken pieces were responsible for the major physical damage during storage. Insect infestation in the samples was very low. 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 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

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

Sensory characteristic	Mean Score for Samples stored:	
	0 month	3 months
Hardness	6.8 ± 0.2	7.0 ± 0.3
Brittleness	6.3 ± 0.4	6.4 ± 0.2
Chewiness	5.4 ± 0.3	6.5 ± 0.1
Flavour	9.8 ± 1.0	9.5 ± 1.0
Aroma	9.8 ± 1.1	9.6 ± 0.3
Colour	9.6 ± 1.3	9.5 ± 0.4

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

storage techniques employed in order to enhance product safety and consumer acceptability.

During the three months of storage, there was no significant change in most of the physical characteristics of the samples. The freshly smoked quality attributes were adequately preserved by the traditional storage except for chewiness which changed to give a slightly tougher product. This slight change observed could be attributed to the decrease in the relative humidity during 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 (67% - 76%) 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.* (1978) also indicated that the shelf-life of smoked Sardinella spp. varied according to the moisture content.

There was no significant reduction in the moisture content of the smoked fish samples. Earlier work at Tema Manhean recorded a significant reduction in the moisture content from an initial value of about 13% to less than 10% by the end of the six-month storage period (Plahar *et al.* 1992b). No significant changes were observed in the moisture content during the first three months of storage in that study also. Longer periods of

Table 3. Effect of traditional storage on the proximate composition and mineral content 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 (%)	12.40	12.40	13.20	13.50
Protein (%)	67.58	68.38	73.04	75.72
Fat (%)	6.28	5.94	4.95	4.97
Ash (%)	19.63	19.41	14.75	12.95
Calcium (mg/100g)	2,456.2	2,687.8	1,573.4	1,414.1
Iron (mg/100g)	21.92	42.69	34.69	31.91
Phosphorus (mg/100g)	1,610.5	1,719.3	1,218.3	1,113.9
Storage structure periphery:				
Moisture (%)	12.40	12.70	-	-
Protein (%)	67.58	70.45	-	-
Fat (%)	6.28	5.38	-	-
Ash (%)	19.63	18.44	-	-
Calcium (mg/100g)	2,456.2	2,914.2	-	-
Iron (mg/100g)	21.92	42.69	-	-
Phosphorus (mg/100g)	1,610.5	1,719.3	-	-

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

storage than three months are required for humidity decreases to cause any significant reduction in the moisture levels of stored anchovies.

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.

Slight proteolytic and lipolytic deterioration occurred in the fish samples at the end of the storage period. Both the interior and periphery samples had similar fat acidity, total volatile base nitrogen and non-protein nitrogen values. Samples from all sections 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 127 mg N/100g edible portion and 137 mg N/100g whole fish sample. After storage the values increased to 165 mg N/100g and 205 mg N/100g for edible and whole portions respectively. 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 fresh and stored samples 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

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	3.84	137.44	1.00
3 months	5.10	204.47	1.12
Edible portion			
0 month	3.01	127.42	1.01
3 months	4.14	164.74	1.05
Samples from Storage structure periphery:			
Whole Fish			
0 month	3.84	137.44	1.00
3 months	5.70	178.81	1.01

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. Non Protein Nitrogen (NPN) content of the smoked fish remained almost the same during storage. A decrease in NPN values was observed in previous studies for traditionally stored smoked herrings (Plahar *et al.* 1991) and for stored smoked anchovies (Plahar *et al.* 1992a; 1992b).

Fat acidity was also low. The initial value of about 3.8 mg KOH/g sample increased by about 50% during the 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.

3.5. Microbiological Quality of Smoked Anchovies

Results of microbiological analysis of samples obtained prior to and during traditional storage of smoked anchovies (*Anchoa guineensis*) are as shown in Tables 5, 6 and 7. This includes examination of whole edible portions of smoked anchovies sampled from the periphery and interior portions of the storage structure at Akplabanya.

Microbial examination of any processed 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,

bacterial and fungal loads for both the whole and edible portions of the freshly smoked anchovies were within acceptable limits.

The appearance of mould growth on the surface of the anchovies imparts an unsightly coloured appearance to the fish; and this may be due to the inability to dry the fish to a minimal acceptable moisture content for the elimination of the growth of the moulds. However, the required low moisture level of the fish before it was stored in the traditional structure was attained. Therefore samples of the dry fish taken before storage and three months after storage showed relatively low mould and yeast count/gram of less than 10 organisms/g and 2 x 10^1 respectively (Table 5).

Moulds isolated were mainly *Rhizopus* and *Aspergillus* species. Although smoke treatment during processing of the anchovies may have destroyed most of the surface skin contaminating moulds, the appearance of a mould count of 2 x 10^1 organisms/g after 3 months storage period may be due to germination of mould spores in a conducive moisture level that might have been created as a result of condensation of water molecules on the fish, partly from the atmosphere or in the immediate environment of the structure.

Aerobic bacterial counts showed no significant increase from the initial level of 67 x 10^1 to 70 x 10^1 count/g after a 3 month storage period, with a slight decrease in pH value from 5.9 to 5.7. Contaminating microorganisms mostly isolated were

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	67×10^1	70×10^1
Mould and yeast count per gram	<10	2×10^1
pH	5.9	5.7
Culture	Sporing Bacillus Gm +ve cocci	Sporing & non-sporing Bacillus *Asp.* sp.
Coliforms (in 0.1 g)	Absent	Absent
Faecal coli	Absent	Absent
Pathogens		
Salmonella	Nil	Nil
Staphylococci	Nil	Nil

Bacillus spp. These species account for a greater proportion of the bacteria organisms during the storage period probably due to germination of the spores under favourable environmental conditions. Other bacteria isolated include Micrococci and non-sporing bacilli as well. Coliforms, faecal coli as well as pathogenic *Salmonella* and Staphylococci organisms were absent. This is indicative of the fact that no faecal material was present in the fish. Thus, the hygienic procedures used in the acquisition, processing and storage of the anchovies is paramount in achieving a wholesome end product that is good for human consumption.

In Table 6, the edible portion before and after storage showed less number of bacteria organisms as compared to the respective counts for the whole anchovies. This is encouraging in that the fish is eaten after the removal of the head and skin which may have had excess microbial load on its surface. The insignificant levels of increase of both aerobic bacteria (from 71×10^1 - 67×10^1 count/g) and mould organisms (from 2×10^1 - 5×10^1 count/g) in the edible portions of the anchovies after 3 months storage (Table 6) show that although environmental conditions may have favoured the proliferation of especially the sporing bacilli under reduced pH conditions of 5.9 - 5.6, the traditional storage structure was adequate to maintain the proper storage parameters required.

Analysis of whole fish samples taken from the periphery of the storage structure (Table 7) showed an insignificant

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

Test	Storage Period (months)	
	0	6
Viable organisms		
Aerobic bacterial count per gram	61×10^1	65×10^2
Mould and yeast count per gram	2×10^1	5×10^1
pH	5.9	5.6
Culture	Sporing and non-sporing Bacillus *Aspergillus* spp.	Sporing Bacillus *Aspergillus* spp.
Coliforms (in 0.1 g)	Absent	Absent
Faecal coli	Absent	Absent
Pathogens		
Salmonella	Nil	Nil
Staphylococci	Nil	Nil

difference in total aerobic bacterial organisms from 67 x 10^1 count/g to 49 x 10^1 count/g after the 3 month storage period. This shows a good and effective storage capability of the traditional structure to maintaining a wholesome product for marketability. This may be due to the achievement of lower humidity levels at the periphery as compared to the interior of the storage structure. Mould counts also showed an insignificant increase from <10 organisms/g to 2 x 10^1 organisms/g in a reducing pH environment of 5.9 to 5.7.

On the whole, bacterial and mould counts attained in the structure for both the whole and edible anchovies were very low and insignificant. The product therefore may be considered wholesome and fit for human consumption, especially, with the absence of coliform and pathogenic microorganisms.

Microorganisms isolated from both whole and edible samples were *Aspergillus* sp., *Micrococci*, and *Bacillus* sp. Plahar *et al.*(1991) isolated similar organisms in freshly smoked herring (*Sardinella eba*). Coliforms as well as faecal coli and pathogenic microorganisms were absent from both whole fish and edible portions of the freshly smoked and stored anchovies. The absence of *Escherichia coli* 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 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		6	
Viable organisms				
Aerobic bacterial count per gram	67×10^1		49×10^1	
Mould and yeast count per gram	<10		2×10^1	
pH	5.9		5.7	
Culture	Gm +ve cocci Sporing Bacillus		Gm +ve cocci. Sporing and non- *Asp.* sp.	
Coliforms (in 0.1 g)	Absent		Absent	
Faecal coli	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 aflatoxin B_1, B_2, G_1 and G_2. Aflatoxin 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 aflatoxin 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 aflatoxin 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. Aflatoxin 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 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 48.4%. This decreased progressively throughout the storage period to as low as 24.5% by the end of the three months. The moisture content of the samples did not show any significant decrease. 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 Akplabanya have been adequately established in the study.

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 91% was obtained within three months of storage.

3. The temperature inside the traditional storage structure was almost stable while humidity decreased steadily from 48.4% to 24.5%. This did not however, cause any decrease in the moisture content of the samples.

4. Proteolytic, lipolytic and microbial deterioration was minimal in samples at both the periphery and interior of the structure. Quantitative descriptive analysis of samples showed no changes in the sensory characteristics. The samples became only slightly tougher after storage.

5. Microorganisms isolated from stored samples include *Aspergillus*. sp., *Micrococci*, and *Bacillus* sp. 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 aflatoxin 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
Frigate 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 (Brachydeuterus 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: 03/02/93 13:13:12 Last Update: 11/28/91 08:29:40
Sample Rate: 1 min
Interval Length: 04:00:00 Total data logged: 117 days 20:00:00
Storage Capacity: 6492 values records: 180 days 08:00:00
Range Ch1 -40.0 -^P 73.7 deg°C Ch2 0.0 -^P 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
11/05/92	13:05:07		31.3	31.7	32.4		46.4	48.4	50.2
11/06/92	13:05:07		31.7	32.7	33.2		46.4	47.1	47.7
11/07/92	13:05:07		31.0	33.3	38.2		47.0	47.4	48.0
11/08/92	13:05:07		30.8	33.2	38.7		46.9	47.3	47.6
11/09/92	13:05:07		31.0	33.4	38.7		46.8	47.2	47.6
11/10/92	13:05:07		31.0	33.8	40.0		47.0	47.6	48.0
11/11/92	13:05:07		32.8	34.5	40.0		47.8	48.1	48.8
11/12/92	13:05:07		27.3	35.4	60.9		23.1	48.1	49.2
11/13/92	13:05:07		27.3	37.8	60.9		20.7	44.2	51.2
11/14/92	13:05:07		27.3	39.8	60.9		21.5	40.3	49.6
11/15/92	13:05:07		27.3	39.1	60.0		21.5	39.4	49.6
11/16/92	13:05:07		27.4	39.2	60.9		21.4	39.6	51.2
11/17/92	13:05:07		28.8	40.2	60.9		22.3	39.1	49.8
11/18/92	13:05:07		28.8	43.8	60.9		22.3	39.5	50.0
11/19/92	13:05:07		28.8	40.6	60.9		21.4	38.0	49.8
11/20/92	13:05:07		27.4	42.0	60.9		21.0	33.4	50.0
11/21/92	13:05:07		28.8	40.9	60.9		21.5	30.8	50.0
11/22/92	13:05:07		30.6	41.9	60.9		21.8	31.6	50.2
11/23/92	13:05:07		30.6	41.2	60.9		21.5	28.9	44.8
11/24/92	13:05:07		29.2	42.4	60.9		21.5	29.2	44.8
11/25/92	13:05:07		29.2	43.6	60.9		20.7	29.3	44.8
11/26/92	13:05:07		28.8	42.1	60.9		19.1	27.9	44.8
11/27/92	13:05:07		29.2	42.1	60.9		20.3	28.3	44.8
11/28/92	13:05:07		30.6	44.2	60.9		20.3	29.2	44.8
11/29/92	13:05:07		30.6	44.4	60.9		21.4	29.1	44.8
11/30/92	13:05:07		30.6	43.1	60.9		19.1	29.6	44.8
12/01/92	13:05:07		30.6	42.6	60.9		20.7	29.5	44.8
12/02/92	13:05:07		29.2	42.0	60.9		20.3	28.4	44.8
12/03/92	13:05:07		28.8	43.7	60.9		20.3	27.9	44.8
12/04/92	13:05:07		28.8	40.7	60.9		19.1	31.6	47.9
12/05/92	13:05:07		28.8	42.4	60.9		19.1	28.0	47.9
12/06/92	13:05:07		29.2	45.6	60.9		19.1	28.6	44.8
12/07/92	13:05:07		30.6	46.6	60.9		17.5	28.6	44.8
12/08/92	13:05:07		30.6	46.8	60.9		17.5	27.9	44.9
12/09/92	13:05:07		30.6	45.7	60.9		17.5	28.1	44.8
12/10/92	13:05:07		30.6	45.8	60.9		19.1	27.5	44.8
12/11/92	13:05:07		27.4	39.6	60.9		17.5	35.9	46.1
12/12/92	13:05:07		27.3	39.8	60.9		18.3	36.5	46.9

12/13/92	13:05:07	28.8	40.9	60.9	17.5	30.6	46.6
12/14/92	13:05:07	29.2	42.3	60.9	18.9	27.0	44.8
12/15/92	13:05:07	30.6	46.4	60.9	17.5	27.4	44.8
12/16/92	13:05:07	30.6	48.5	60.9	17.5	27.3	44.8
12/17/92	13:05:07	29.2	42.6	60.9	17.3	26.6	44.8
12/18/92	13:05:07	29.2	40.4	60.9	18.9	26.8	44.8
12/19/92	13:05:07	28.8	43.4	60.9	17.5	26.5	46.0
12/20/92	13:05:07	27.3	40.2	60.9	18.1	33.4	45.6
12/21/92	13:05:07	27.4	40.9	60.9	19.1	29.2	46.3
12/22/92	13:05:07	28.8	42.3	60.9	19.1	27.3	46.0
12/23/92	13:05:07	28.8	43.5	60.9	19.1	26.7	41.6
12/24/92	13:05:07	28.8	42.8	60.9	18.9	26.9	41.6
12/25/92	13:05:07	28.8	43.8	60.9	18.9	26.4	40.0
12/26/92	13:05:07	28.8	42.1	60.9	18.3	26.9	38.4
12/27/92	13:05:07	28.8	43.3	60.9	19.0	27.0	40.0
12/28/92	13:05:07	28.8	44.3	60.9	18.9	26.4	38.4
12/29/92	13:05:07	27.4	40.3	60.9	19.1	26.5	40.0
12/30/92	13:05:07	27.4	43.0	60.9	18.3	26.1	45.4
12/31/92	13:05:07	28.8	42.6	60.9	15.9	26.3	45.4
01/01/93	13:05:07	27.4	41.5	60.9	17.5	26.6	41.6
01/02/93	13:05:07	27.4	41.8	60.9	17.5	26.1	38.4
01/03/93	13:05:07	29.2	41.4	60.9	18.2	25.7	44.8
01/04/93	13:05:07	30.6	43.5	60.9	17.5	25.9	44.8
01/05/93	13:05:07	30.6	45.3	60.9	18.2	26.1	44.8
01/06/93	13:05:07	29.2	42.7	60.9	17.5	26.2	44.8
01/07/93	13:05:07	27.4	41.0	60.9	17.5	29.1	44.1
01/08/93	13:05:07	28.8	36.1	60.9	17.5	39.3	42.8
01/09/93	13:05:07	31.0	34.2	40.0	39.3	40.0	40.8
01/10/93	13:05:07	32.3	33.5	35.8	38.9	39.3	39.7
01/11/93	13:05:07	32.2	33.4	35.8	38.8	39.2	39.4
01/12/93	13:05:07	32.2	33.5	35.8	38.8	39.2	39.6
01/13/93	13:05:07	31.0	33.7	40.0	39.1	39.4	39.7
01/14/93	13:05:07	31.0	34.0	40.0	39.3	39.7	40.1
01/15/93	13:05:07	32.8	34.5	40.0	39.7	40.1	40.6
01/16/93	3:05:07"	33.4	34.9	40.0	40.0	40.6	41.2
01/17/93	13:05:07	28.8	36.6	60.9	18.1	38.5	42.8
01/18/93	13:05:07	27.4	38.4	60.9	17.5	34.6	43.2
01/19/93	13:05:07	27.3	40.2	60.9	17.5	31.4	43.2
01/20/93	13:05:07	27.3	40.7	60.9	17.5	29.8	43.2
01/21/93	13:05:07	27.4	39.6	60.9	17.3	28.1	43.6
01/22/93	13:05:07	27.4	40.2	60.9	18.3	27.3	44.0
01/23/93	13:05:07	28.8	39.6	60.9	17.5	27.5	44.8
01/24/93	13:05:07	28.8	40.6	60.9	17.5	29.0	44.8
01/25/93	13:05:07	27.0	40.7	60.9	16.9	29.8	43.6
01/26/93	13:05:07	27.4	40.2	60.9	17.3	30.1	43.4
01/27/93	13:05:07	27.3	39.9	60.9	17.5	29.8	43.1
01/28/93	13:05:07	27.3	41.3	60.9	17.5	29.5	43.2
01/29/93	13:05:07	28.8	39.0	60.9	17.3	28.8	44.8
01/30/93	13:05:07	27.3	41.8	60.9	17.3	25.9	43.7
01/31/93	13:05:07	27.4	43.1	60.9	17.5	25.2	38.4
02/01/93	13:05:07	27.4	40.7	60.9	17.3	25.1	38.4
02/02/93	13:05:07	27.4	39.8	60.9	15.9	25.0	38.4
02/03/93	13:05:07	28.8	41.2	60.9	16.9	25.3	38.4
02/04/93	13:05:07	27.4	40.4	60.9	15.9	24.9	38.4

02/05/93	13:05:07	28.8	41.8	60.9	17.3	25.9	43.3
02/06/93	13:05:07	27.3	41.3	60.9	17.3	29.4	43.1
02/07/93	13:05:07	27.3	41.8	60.9	16.5	29.1	42.8
02/08/93	13:05:07	27.3	39.8	60.9	15.9	30.0	42.4
02/09/93	13:05:07	27.3	41.7	60.9	17.3	28.8	42.6
02/10/93	13:05:07	28.8	41.7	60.9	15.9	25.7	42.8
02/11/93	13:05:07	27.3	41.5	60.9	17.1	24.5	38.4