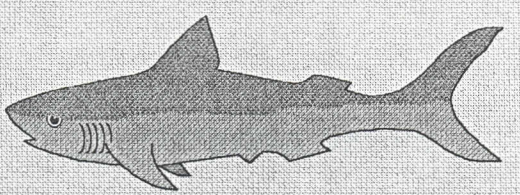
EDITED RESEARCH REPORT #10

FRI/TR/PWA/043

GHANA/NETHERLANDS ARTISANAL FISH PROCESSING & APPLIED RESEARCH PROJECT

★ **RESEARCH PROJECT #AFPP/AR/PH.2/97-003** ★

DEVELOPMENT OF AN INTEGRATED QUALITY ASSURANCE SYSTEM FOR THE TRADITIONAL SUN-DRIED ANCHOVY INDUSTRY IN GHANA



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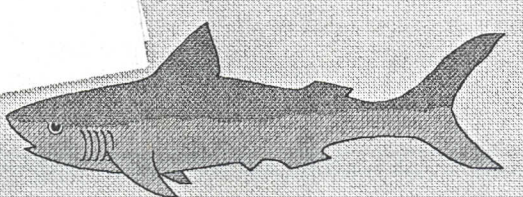
November 1997



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FINAL REPORT

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ACKNOWLEDGEMENT

This project was undertaken with funds provided by the Governments of Ghana and the Netherlands under the second phase of the Ghana-Netherlands Artisanal Fish Processing Project. We are also indebted to the fish processors at *Azizanya* and *Akplabanya* in the Dangme East District, *Nungua* (a suburb of Accra) and *Chorkor*, a fishing village in Accra. We also acknowledge the assistance given by the technicians of the Analysis Division, Food Research Institute, in the analysis of samples.

DEVELOPMENT OF AN INTEGRATED QUALITY ASSURANCE SYSTEM FOR THE TRADITIONAL SUN-DRIED ANCHOVY INDUSTRY IN GHANA

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ABSTRACT

The traditional sun-dried anchovy industry in Ghana was investigated for a critical appraisal of the technological aspects of the process. The physical, chemical, microbiological and sensory quality implications of all the operations involved in handling, drying and storage of the fish were evaluated. The results were used to assess the potential hazards in the traditional sun-dried anchovy production chain and to identify critical control points for the development of an integrated quality assurance system. Operational guidelines recommended were based on pilot scale production and storage trials. Potential safety and spoilage hazards identified in the traditional sun-dried anchovy industry include excess contamination of raw, processed, and stored fish with pathogenic bacteria, spoilage microorganisms and storage insect pests. Both the severity of the safety hazards and the likelihood of provoking diseases were found to be high in most cases. Critical control points identified for the control of the hazards in the sun-dried anchovy delivery chain include raw fish quality and handling from landing to drying site, drying rate and general environmental conditions, storage conditions and hygiene and sanitation procedures. Critical limits have been established for each processing and storage steps to ensure that microbiological, chemical and sensory quality characteristics are satisfied. An effective monitoring procedure has been suggested to include: inspection of raw fish for freshness at both landing and processing sites, ensuring proper drying through visual observation, and frequent inspection of stored fish for insect infestation and mould growth. Sun-dried anchovies for storage should be assessed for dryness by visual observation and hand feel. A few corrective measures have been suggested to be taken when results of monitoring show that a Critical Control Point is not under control.

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1. INTRODUCTION

Apart from smoking sun-drying is the most widely used traditional fish processing method employed in Ghana to preserve the large quantities of fish landed in the season of glut. Anchovies (*Anchoa guineensis*) are mainly sun-dried on beaches, roadside and any open space, for preservation. Methods and general conditions of traditional fish processing, storage and distribution 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). No quality assurance systems are in place in the whole raw material procurement, processing, storage and distribution chain to facilitate prevention of consumer hazards or to produce high quality fish products.

To assure food safety, the latest edition of the Codex Alimentarius International Code of Practice promotes the use of the HACCP system and the European Community Commission has specifically required implementation of HACCP in the general Food Hygiene Directive (Bovee *et al.*, 1995; Codex Alimentarius, 1993; Council of the European Communities, 1993). The Hazard Analysis Critical Control Point (HACCP) system is now generally accepted as an alternative to traditional control options in the food industry. This system is based on a much more systematic and logical approach to avoidance of food hazards, and reflects a much better cost/benefit ratio in comparison with other approaches (Huss, 1989). The HACCP-system consists of the following three steps:

a. An assessment of hazards associated with the product;
b. determination of critical control points (CCP); and
c. establishment of procedures to monitor CCP

When considering hazard analysis, unacceptable levels of both pathogenic and spoilage organisms are of concern while determination of CCP involves both location and/or process, which could lead to contamination, survival or growth of these organisms (Huss, 1989).

While the HACCP system is for the effective identification and control of safety hazards within the food supply chain, it does not address other quality incidents that affect the general product quality and the business. The Quality Assurance Critical Control Points (QACCP) concept, takes care of the other quality 'hazards'. The same HACCP approach is employed here.

The positive role of FAO and other aid organisations such as CIDA, DANIDA, ODA in implementation and improvement of fish quality control programmes in many developing countries has been recognised. Also the work of the *Codex Alimentarius* Commission through the preparation of the Codes of Practice and Product Standards has considerably influenced and assisted developing countries to improve the quality of fish and fishery products to comply with the requirements of major importing countries (Lima dos Santos, *et al.*,1994). According to dos Santos *et al.*, (1994) an increasing number of developing countries are now taking concrete steps to develop and apply the quality assurance innovations. Thailand, Indonesia, Vietnam, India, Sri Lanka, Senegal, Mozambique, Mexico, Nicaragua, Brazil, Chile, Peru, Ecuador, Cuba, Uruguay, etc. were mentioned as having made the application of HACCP concept their main goal in fish safety assurance. The reward is the maintenance of the international markets, the possibility of achieving better prices and opening new markets through better quality and safer products. There is no such quality control system for the artisanal fish sector in Ghana.

In Ghana, an approved research project under the Ghana/ Netherlands artisanal fish processing and applied research project sought to develop quality assurance system for the herring and anchovy smoking industry in Ghana. The results identified a number of critical control points based on which a workable quality assurance system was developed (Plahar *et al.* 1996). The dried anchovy industry in Ghana is even larger than the anchovy smoking industry, with a great deal of export potential. The potential hazard points are however more numerous since no heat treatment is involved. The need to develop an integrated quality assurance system for the dried anchovy industry is therefore quite apparent.

The establishment of an integrated quality assurance system based on both the HACCP and other Quality Assurance Critical Control Points (QACCP) concepts for the artisanal dried anchovy fish industry in Ghana, will not only ensure control of safety hazards, but also other quality incidents

that affect the business. The development and application of these innovations, will ensure good manufacturing practices for enhanced product quality. Hazards will be eliminated, general quality will be improved, production efficiency will be enhanced and export avenues opened for increased productivity, thereby improving on the socio-economic status of the people.

The purpose of this study is to develop an integrated quality assurance system for the traditional sun-dried anchovy industry in Ghana, based on the HACCP/QACCP concepts. While a fully-equipped laboratory is necessary at this stage of developing and introducing the HACCP/QACCP system, the day-to-day quality assurance programme can be effected by the artisanal fish processor without the aid of such laboratory, once the system has been established and the concept adopted.

2. MATERIALS AND METHODS

2.1. Technological Appraisal and Hazard Analysis

A survey was conducted in selected fishing villages to establish the procedures for raw anchovy procurement, handling and drying. Areas covered include *Azizanya* and *Akplabanya* in the Dangme East District and *Nungua* and *Chorkor* in the Ga District. The general conditions at landing and processing sites, transportation of fish, fish preparation for processing and the general procedures involved in traditional sun-drying and storage of anchovies were recorded. Fish samples at various stages of drying or operational steps were collected for freshness assessment as well as the microbiological and chemical quality analyses. The parameters used in the unit operations were also established. From the technological and quality appraisal, the two essential ingredients of hazard analysis were applied. First, the organisms or any disease agent, that could harm the consumer or cause spoilage of the product were identified. The second was an appreciation of how these hazards could arise (Huss, 1994).

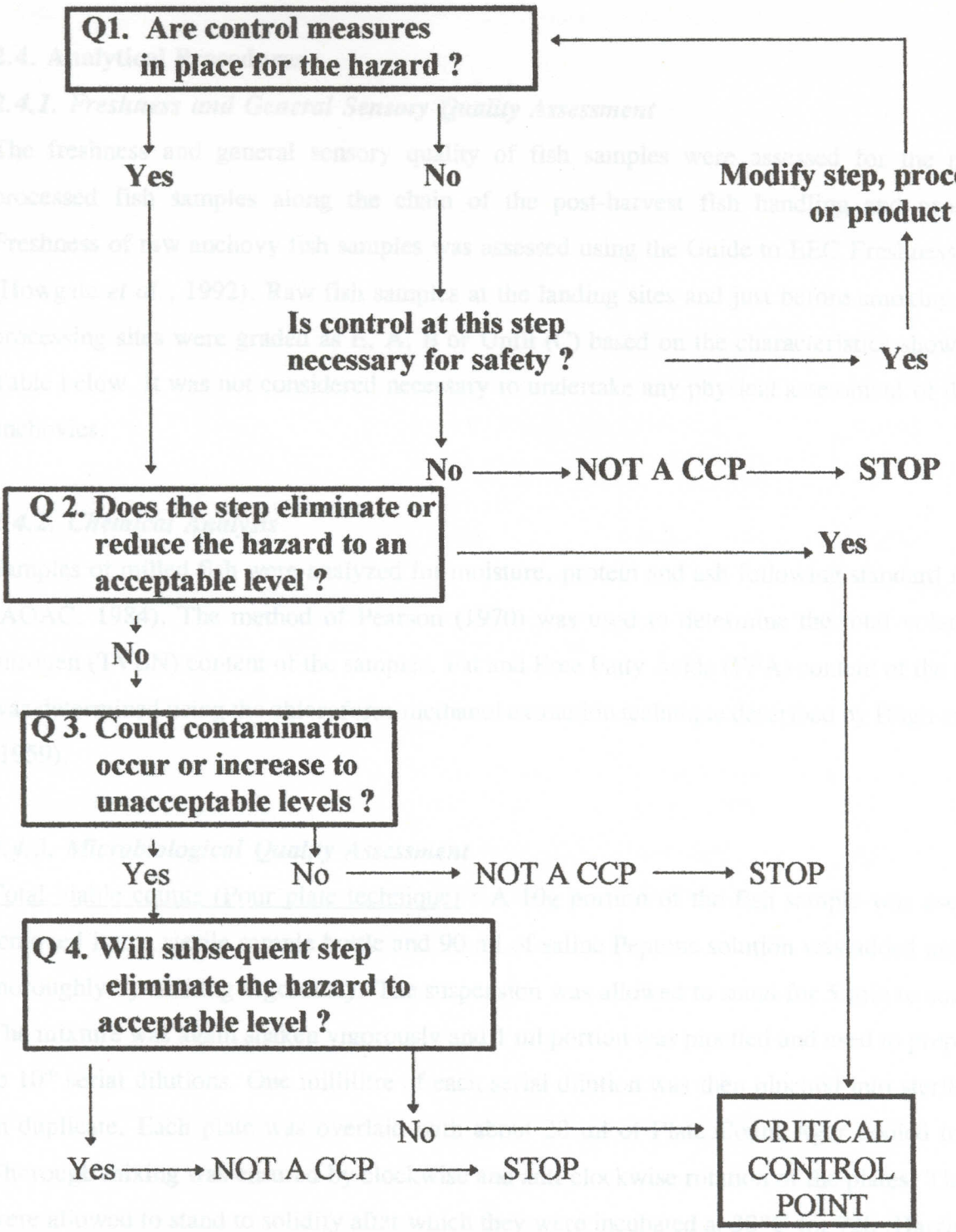
2.2. Determination of Control Points (CPs) and Critical Control Points (CCPs)

A critical analysis of the locations, procedures and processing steps in relation to the hazards identified helped to determine all the possible control points (CPs). From this, the critical control points that will ensure full control of a hazard (CCP-1) or that which will minimize but not assure full control (CCP-2), were identified. To determine if a particular step or point in the process or operation for the production of the smoked herring or anchovies is a CCP, a decision tree, as shown in Figure 1, was used. The major issue of concern here was that a CP is normally only critical within the context of the particular operation; so that an individual processing step may or may not be a CCP depending on the rest of the process. Consideration was given to whether the existing control measure is sufficient to achieve the necessary safety or quality specification.

2.3. Determination of Critical limits

To establish the critical limits which must be met to ensure the control of the Critical Control Points, trial processing and laboratory studies were undertaken. From the results, clear

Fig 1. TYPICAL DECISION TREE



and specific control procedures were developed for each CCP identified. Limits for process parameters to achieve the desired product quality were established.

2.4. Analytical Procedures

2.4.1. Freshness and General Sensory Quality Assessment

The freshness and general sensory quality of fish samples were assessed for the raw and processed fish samples along the chain of the post-harvest fish handling and processing. Freshness of raw anchovy fish samples was assessed using the Guide to EEC Freshness Grades (Howgate *et al.*, 1992). Raw fish samples at the landing sites and just before smoking at the processing sites were graded as E, A, B or Unfit (C) based on the characteristics shown in the Table below. It was not considered necessary to undertake any physical assessment of the dried anchovies.

2.4.2. Chemical Analysis

Samples of milled fish were analyzed for moisture, protein and ash following standard methods (AOAC, 1984). The method of Pearson (1970) was used to determine the total volatile base nitrogen (TVBN) content of the samples. Fat and Free Fatty Acids (FFA) content of the samples was determined using the chloroform/methanol extraction technique described by Bligh and Dyer (1959).

2.4.3. Microbiological Quality Assessment

Total viable counts (Pour plate technique) : A 10g portion of the fish sample was aseptically removed into a sterile sample bottle and 90 ml of saline Peptone solution was added and mixed thoroughly by shaking vigorously. 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 72h (Harrigan and McCance, 1966).

	E	A	B	Unfit (C)
Skin	full bloom; bright; shining; iridescent; clean.	slight dullness and loss of bloom	definite dullness and loss of bloom	dull; no bloom
Outer slime	transparent or water white	milky; slight browning	brownish	brown
Gill covers	silvery	silvery; slight browning; slight bright red blood stain	some browning and blood staining	very brown and blood stained
Eyes	convex	plane	slightly concave	concave; sunken
Firmness	very stiff and firm	fairly stiff and firm	stiffness nearly absent, fairly soft	soft or very soft
Gill odours	fresh seaweedy	less fresh seaweedy, slight oily.	slight stale seaweedy; definite oily; trace of slight H_2S (sulphide), 'salt cured' or rancid oil	definite H_2S (sulphide); rancid oil; amines; faecal; sour.

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 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 24h.

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 72h 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 48h.

Pathogenic Organisms :

Staphylococcus sp.: A 5g sample of fish powder was aseptically weighed and placed in cooked meat medium with 10% salt added. It was mixed thoroughly and incubated for 12 - 18h at 37°C. The sample was then subcultured onto Mannitol salt agar and incubated for 72h at 37°C for pure culture isolation and identification.

Salmonella sp.: For pre-enrichment, 25g sample of fish was weighed and macerated in 225 ml of Buffered Peptone Water using a stomacher. This was incubated at 37°C for 16-24h. The contents were mixed thoroughly by shaking, upon removal from the incubator; and 0.1 ml of the pre-enrichment broth was transferred to 10 ml Rappaport-Vassiliadis (RV) broth which had been pre-warmed to 42°C. This was then incubated at the same temperature for 24h.

Using a loop, sample from the enrichment broth was inoculated onto the surface of Xylose-lysin-desoxycholate (XLD) agar and Brilliant green-phenol red agar (BGA). The plates were incubated in inverted position at 37°C for 18-24h. Presumptive colonies were then picked for biochemical verification. From each agar plate, at least two typical or presumptive colonies were picked and inoculated onto a suitable non-selective plates, so that well isolated colonies develop. The plates were incubated at 37°C for 18-24h. For the biochemical confirmation, tests carried out include urea, mannitol utilization, ornithine decarboxylase, lysin decarboxylase and Triple sugar iron (TSI) agar test.

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).

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.

3. RESULTS AND DISCUSSION

3.1. Technological Aspects and Hazard Analysis of Sun-dried Anchovy Production

3.1.1. Traditional production and storage of sun-dried anchovy

Raw fish procurement and handling:

Between the months of August and October, large catches of anchovy are landed along the beaches of the Greater Accra, Central and Volta Regions of Ghana. Anchovy is caught throughout the year with poli nets, purse seines, beach seines and sometimes trawl nets (Abbey, 1996). The raw fish is purchased directly from fishermen or through fresh fish mongers at the beach. Anchovies (*Anchoa guineensis*) are landed without chilling by the artisanal fisheries sector which accounts for most of the anchovy landings. There are no facilities for chilling the anchovy catches in spite of the high temperatures. The fish is exposed to the sun and all environmental contaminants during the discharge and sale. Irrespective of the highly unsatisfactory sanitary conditions at the landing beaches, the measured fish is placed direct on the beach sand in the open under the harsh tropical conditions with temperatures as high as 32°C. The processors then pack and convey the fish in aluminium bowls or baskets from the beach to the drying site by carrying them as open headloads.

The drying process:

The traditional drying of fish is a simple process. Raw anchovies (*Anchoa guineensis*) are spread out on the hot beach sand, on the ground in any open space in the village compound, or on the hot laterite or tarred walk ways by the road side. Drying surface temperatures on hot sunny days have been determined as follows:-

Tarred walk way: 48°C - 53°C,
Laterite walk way: 45°C - 50°C,
Village compound grounds: 40°C - 45°C,
and Sandy beach: 47°C - 55°C.

Wherever the drying of anchovies is taking place, very little or no particular attention is paid

to maintain any hygienic conditions. Pedestrian trample the fish under feet in the walkways, animals walk and feed on them in the village compound, while at the road sides vehicular traffic mash those too close to the road side.

The drying period varies between two and three days depending on the weather conditions. Collection of the drying fish in the evenings or when the weather is threatening leaves much to be desired. The anchovies are swept with a broom and gathered in small heaps in a manner similar to the normal domestic garbage. Depending on where the material is being dried, a great deal of rubbish is collected with the fish. In most cases, livestock or poultry faecal matter is included.

Traditional storage of sun-dried anchovies

Unlike the storage of smoked anchovies for which elaborate structures are constructed, the traditional storage of sun-dried anchovies is very simple. Depending on the intended period for storage, the sun-dried anchovies are either dumped in a fence yard and covered with sacks and polyethylene sheets, or packaged in large baskets lined with brown paper. In some areas, the traditional round smoking oven is used for sun-dried anchovy storage. The fish is packed in the oven, about 0.6m above the combustion level, and covered with polyethylene sheets and jute sacks for protection.

Packing sun-dried fish for distribution

Sun-dried anchovy is usually packed tightly in baskets lined with brown paper, then covered with more paper which are firmly sewn to the rim of the basket. The basket loads are transported in trucks to large markets for sale to wholesalers in the interior of the country, or sometimes to far away neighbouring countries.

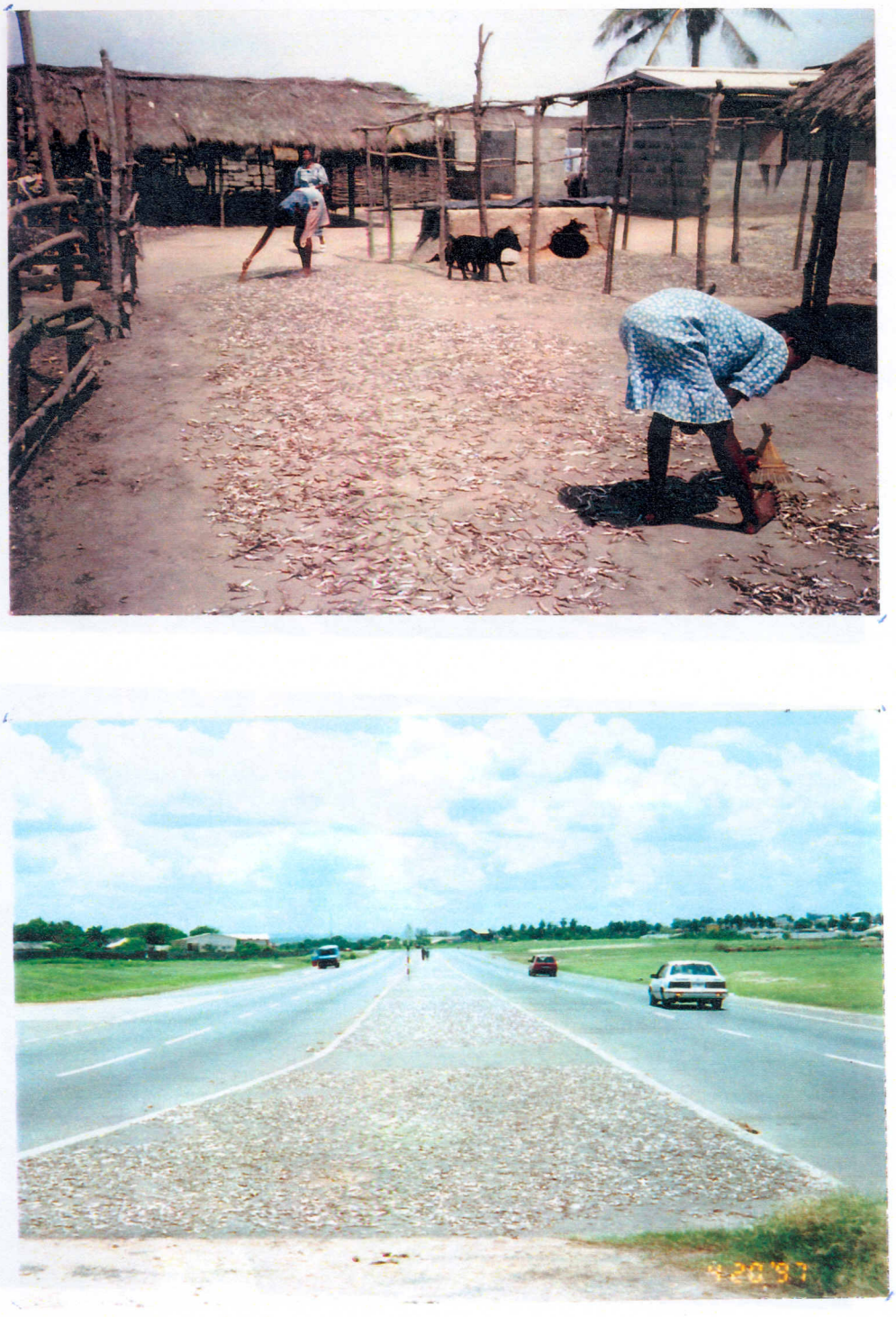


Fig 1. Traditional sun-drying of anchovy.

Fig 2. Traditional storage and packaging of sun-dried anchovy.

3.1.2. Potential hazards and quality characteristics of sun-dried anchovy production and storage

Freshness quality of raw anchovy for sun-drying

The freshness quality of raw samples of anchovy obtained from landing beaches and drying sites is presented in Table 1. A great deal of deterioration in freshness was found to occur between the time of landing and sun-drying. Samples classified as grade A or B deteriorate to grade B or C before they are ready for sun-drying. As stated in an earlier report on smoked anchovies, the normal handling practices from the point of purchase through preparations for drying are such as would subject the raw fish samples to high temperatures for long hours, at the same time exposing them to a variety of spoilage organisms. Discharge of fish from the canoes is done manually and may last for some time depending on the amount landed. The discharging and subsequent sale of the fish expose them to the sun and other environmental factors like sand, flies and man. This situation is quite ideal for rapid autolytic and microbial spoilage. In some cases where attempts are made at sea to ice the fish, post-landing handling negates the effort of the fishermen at sea.

Chemical quality characteristics of fresh, sun-dried and stored anchovy

The chemical characteristics of the fresh, sun-dried and stored anchovy samples are presented in Table 2. As observed in previous studies with smoked anchovy samples (Plahar *et al.*, 1996), sun-dried anchovy samples prepared for storage were found to be a very good source of protein and minerals (Table 2). The fat content of the sun-dried product was low enough to present little deterioration problems if storage conditions are properly controlled. The moisture content was however a little too high for maximum storage stability. High-fat processed fish samples develop rancidity problems within a short period of storage. With moisture, earlier work by Okoso-Amaa *et al.* (1978) indicated that the shelf-life of smoked *Sardinella* spp. varied according to the moisture content. During storage, there was no significant reduction in the moisture content of the dried fish samples from the initial value of about 15%. At this sustained level of moisture, a great deal of proteolytic and lipolytic deterioration as well as microbial proliferation will be favoured. Protein decomposition, as measured by non-protein nitrogen (NPN) and total volatile base nitrogen (TVBN) content was low in the raw anchovy samples. During drying, both TVNB

Table 1. Freshness quality of raw Anchovy at various stages of handling

		Sampling Location	
		Landing site	Drying site
Skin	Best	slight dullness and loss of bloom	definite dullness and loss of bloom
	Worst	definite dullness and loss of bloom	dull; no bloom
Gills	Best	silvery; slight browning; slight bright red blood stain	some browning and blood staining
	Worst	some browning and blood staining	very brown and blood stained
Eyes	Best	plane	slightly concave
	Worst	slightly concave	concave; sunken
Odour	Best	less fresh seaweedy, slight oily	slight stale seaweedy
	Worst	slight stale seaweedy; trace of slight H_2S (sulphide).	definite H_2S (sulphide); rancid oil; amines; faecal; sour.
Texture	Best	fairly stiff and firm	stiffness nearly absent, fairly soft
	Worst	stiffness nearly absent, fairly soft	soft or very soft
Grade	Best	A	B
	Worst	B	C

[1]Based on the EEC freshness grading system (Howgate *et al.* 1992)

Table 2. Mean chemical quality characteristics of fresh, sun-dried and stored anchovy

	Raw fish	Freshly sun-dried	Stored (3 mo.)
Moisture (%)	70.9	14.9	14.4
Protein (%)	21.2	74.8	74.5
Fat (%)	1.7	4.6	4.4
Ash (%)	7.2	17.6	18.0
Calcium (mg/100g)	770.0	2,663.5	2,650.8
Phosphorus (mg/100g)	876.0	383.4	320.7
Iron (mg/100g)	7.4	16.6	19.7
TVB N (mg/100g)	20.6	47.2	184.8
NPN (g/100g)	0.4	0.8	1.2
FFA (% as oleic)	1.3	4.2	7.8

and NPN values more than doubled. Traditional sun-drying of anchovies is very slow, and the warm drying temperature is quite ideal for deteriorative activities during the process. The TVBN value obtained in this study was 21 mg N/100g raw fish and 47 mg N/100g freshly sun-dried 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 dry sample. The freshly sun-dried 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 for some species of marine fish purchased from some fish markets in Ghana. On dry weight basis, these values are also between 90 -110 mg N/100g sample.

During storage TVBN concentration of the sun-dried anchovies increased considerably to over three times the original value. Initial fat acidity of raw samples was low, but increased with drying and storage. There was a six-fold increase in the initial free fatty acids after only three months of storage. Lipolytic activity and oxidative rancidity could therefore be a major problem in the prolonged storage of sun-dried anchovies.

Microbiological quality of fresh, sun-dried and stored anchovy

Table 3 shows the results of microbiological analysis of raw, sun-dried and stored anchovy samples. 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 the present study, the initial microbial types and viable numbers increased during drying. Microbial loads increased again under the traditional post-processing handling and storage conditions. The nature of traditional storage of sun-dried anchovy did not provide this protective advantage, as was also observed in previous studies with smoked samples.

Microorganisms isolated from the raw samples were Micrococci, *Corynebacterium*, *Bacillus* spp. and *Aeromonas* while the freshly sun-dried samples showed presence of *Bacillus* spp., *Penicillium*, *Mucor*, Coliforms and *Aspergillus* spp. (Table 4). With the stored samples, the

Table 3. Microbiological quality of fresh, sun-dried and stored anchovy

	Raw fish	Freshly sun-dried	Stored (3 mo.)
Microbiological			
Total viable count/g (log)	5.4	8.92	9.83
Coliforms[1] in 0.1g	AP	AP	AP
Faecal coli[1]	A	AP	AP
Salmonella	Nil	Nil	Nil
Staphylococci	Nil	Nil	Nil

[1] A = Absent, P = Present, AP = Present in some samples.

Table 4. Microbiological culture of fresh, sun-dried and stored anchovy

Sample	Culture
Fresh anchovy	Micrococci, *Corynebacterium*, *Bacillus* spp. *Aeromonas*.
Freshly sun-dried	Micrococci, *Bacillus* spp., *Penicillium*, *Aspergillus* sp. Gm.+ve cocci
Stored	Micrococci, Coliform, *Corynebacterium*, *Penicillium*, *Mucor*, *Rhizopus*, *Aspergillus*.

major organisms were *Micrococcus*, Coliform, *Corynebacterium*, *Penicillium*, *Rhizopus*, and *Aspergillus*. The presence of coliforms in some of the samples before and after storage indicates the possibility of human and animal sources of contamination during drying and storage. Pathogenic organisms such as Salmonella and Staphylococci were absent in samples analyzed. Coliforms, other than *E. coli* are a good indicator of unsatisfactory processing or sanitation.

Identified hazards in the production and storage of sun-dried anchovy

Based on the critical appraisal of the various locations, stages of the drying and storage process, as well as the quality characteristics of intermediate and final products, the potential hazards involved were identified. Potential safety and quality (spoilage) hazards identified in the traditional anchovy drying industry include excess contamination of raw, dried, and stored fish with pathogenic bacteria, spoilage microorganisms, and storage insect pests. The potential hazards along the product flow line may be summarized as follows:

1. Raw fish:
Improper handling and lack of temperature control of raw fish catch will result in the growth of indigenous pathogenic bacteria. The detection of *Aeromonas* spp. in the raw fish samples is an indication of the possible pathogenic contamination. Additional contamination with pathogenic and spoilage organisms from human/animal sources occurs to a large extent during sale, transportation to the drying site, and preparation for drying under the prevailing unhygienic conditions and lack of temperature control. There are high chances of spoilage and loss of sensory quality. The severity of the safety and spoilage hazards related to the handling of the raw fish is high in all cases.

2. Fish drying:
Fish is dried without salting and, in most cases, without washing. The drying temperature is not high enough to effect complete sterilization of the product. Strict time, temperature controls as well as general hygiene are required to ensure avoiding a moisture content that is too high. Further, it is necessary to prevent environmental contamination of the fish as a result of exposure to unhygienic surroundings. Fast drying away from human, animal, and dust is necessary to achieve an acceptable and safe product

3. Post-drying handling, storage and distribution:
Environmental contamination and contamination from human sources occur during handling of the dried fish in preparation for storage. Under favourable conditions in

storage, the contaminating organisms may grow and present both health and spoilage problems. Since storage is done at ambient temperatures, low product moisture content is an important factor for prolonging its shelf-life. Development of a variety of mould species can be a health hazard if storage conditions are favourable for their growth and biotoxin production. Proliferation of spoilage organisms and insect infestation in storage have also been identified as a major hazard in terms of physical deterioration. This is a high risk with regards to economic loss, but low severity of the safety hazard since no lives are endangered. The traditional methods of distribution expose the product to contamination from various sources - human, air, soil, insects etc. Since sun-dried fish can be incorporated in animal feed meals without any heat-treatment, the hazard to the poultry and livestock industry may be severe and the risk fairly high.

3.2. Critical Control Points

The identified Critical Control Points (CCPs) in the product flow, and the degree of control are summarized in Table 5. The CCPs were chosen on the basis of the risk and severity of the hazard to be controlled. The controls are aimed at minimizing or preventing the risk by taking the specific preventive measures suggested. The hazards associated with pathogenic and spoilage contamination and growth during raw fish handling before drying should be controlled at the time of catch before landing, during discharge and sale at the landing beaches, and during transportation and preparation for drying. Hygienic handling and proper sanitation are important. Time lapse between procurement and drying must be short, if handled at ambient temperatures.

The drying operation is quite critical to the production of safe product in terms of reduction of microbial loads, and drying to a desirable moisture to enhance the keeping quality of the product. All unit operations involved in the process are to be critically controlled to eliminate or minimize the hazard by good house keeping, adequate hygiene and proper temperatures and time controls.

Storage conditions are also critical to the safety and prolonged shelf-life of the sun-dried anchovies. The hazards involved at this stage of the sun-dried anchovy delivery system have been associated with growth and toxin production of existing organisms, contamination with pathogenic and spoilage bacteria and insect infestation. Hygienic handling, adequate protection from insect pests and maintenance of low humidities in the storage structure are the main

Table 5 Hazards and Control Points in the traditional production of sun-dried anchovy

Product flow	Safety and Quality Hazard	Preventive Measure	Degree of Control
Raw fish catch and pre-landing handling	Growth of indigenous bacteria	Time and temperature control	CCP-1
Purchase and transportation to drying site	Excess contamination and/or growth of bacteria	Time and temperature control	CCP-1
		Hygienic handling	CP
		Sanitation	CP
Washing	Contamination with pathogenic & spoilage bacteria	Use clean portable water	CCP-2
Sun-drying	Exposure to dust and pathogenic, and spoilage bacteria.	Use solar tent dryer or raised platform	CCP-2
	Too high moisture content	Time and temperature control	CCP-1
All unit operations	Growth of bacteria	Time and temperature control	CCP-1
	Contamination	Hygiene at processing site	CP
Storage and distribution	Growth of bacteria	Avoid high humidities	CCP-1
	Contamination	Hygienic handling when packing in storage	CCP-2
	Insect infestation	Adequate protection	CP

preventive measures to be applied to minimize the hazard.

3.3. Critical Limits and Control Procedures

From the pilot studies undertaken, the critical limits that will ensure that the traditional sun-dried fish satisfy the microbiological and sensory quality were determined as follows:

- Raw fish should not be kept for long periods at ambient temperatures before initiating the drying process.
- Fish should be washed before drying, and the water for washing and for all cleaning operations should be portable
- Initial drying temperatures using the solar-tent dryers or a raised platform should be able to effect over 60% of the drying within the first 12 - 15 h.
- Fish should be dried to about 8% moisture content before storage.
- Stored products should be protected and maintained at relative humidities below 50%.
- The rule of thumb in the management of all operations should be good housekeeping and maintenance of personal hygiene and good manufacturing practices.

3.4. Monitoring System and Procedures

The monitoring procedure to ensure that the critical limits are maintained in order to control the identified CCPs are based mainly on visual observations since the traditional operations in the sun-dried anchovy industry cannot include any elaborate chemical and microbiological procedures. With the raw fish, visual inspection to ascertain freshness before purchase should be undertaken. Weather conditions should be monitored carefully for fast drying. Proper drying can be monitored by visual observation and product dryness can be assessed by hand feel. Frequent inspection of stored fish should be undertaken for signs of insect infestation.

3.5. Corrective Actions

Activities undertaken in raw fish procurement, drying and storage have been targetted for possible corrective action to be taken when the results of monitoring indicate that a CCP is

not under control. The following corrective measures are suggested:

- Raw fish supplies that do not satisfy the requirements for freshness should not be dried for storage and human consumption. Freshly landed fish should be dried immediately.

- If dried fish that is ready for storage is found to contain too much moisture, it should be re-dried immediately.

- If storage environment is found to be too damp, either the structure was not constructed well or the dried fish was not dry enough. Two alternatives are available for corrective action. When the situation is not very serious, the fish should be spread out on hot sunny days and restored. The second alternative that may be followed even if any of the other corrective measure has been undertaken is to shorten the storage duration.

- If insect infestation and/or mould growth is detected in storage, the storage should be terminated immediately and the product sold. Re-drying may be undertaken to minimize the hazard.

4. CONCLUSIONS

In conclusion, the study has established the potential hazards associated with the traditional fish drying and storage processes in Ghana, involving the various locations, stages of procurement, transportation, drying and storage. The potential safety and spoilage hazards include excess contamination of raw, dried and stored fish with pathogenic bacteria, spoilage microorganisms, and storage insect pests. The severity of the safety hazards are high and the likelihood of provoking diseases are also high. Spoilage microorganisms and insect infestation also constitute a high risk in terms of product loss, but low severity of the hazard since no lives may be endangered. Critical control points identified for the control of the hazards in the dried anchovy delivery chain include raw fish quality and handling at landing and drying sites, conditions and duration of drying, storage conditions and hygiene and sanitation procedures. Critical limits have been established for each drying and storage steps to ensure that microbiological, chemical and sensory quality characteristics are satisfied. An effective monitoring procedure suggested to include inspection of raw fish for freshness at landing site, ensuring proper drying through visual observation, and frequent inspection of stored fish for insect infestation.

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