CSIR-FRI/RE/H-OMA/1996/006

GHANA/NETHERLANDS ARTISANAL FISH PROCESSING AND APPLIED RESEARCH PROJECT

RESEARCH PROJECT # AFPP/AR/PH.2/96-006

ASSESSMENT OF STORAGE STABILITY OF SMOKED AND DRIED FISH PACKAGED IN POLYSTYRENE AND VACUUM PAKS.

By

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December 1996

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ACKNOWLEDGEMENT

The authors acknowledge with deep sense of gratitude the financial support provided by the Ghana and Netherlands Governments for the successful implementation and completion of this project.

Special thanks go to the Project Manager, Mrs. Gladys Nerquaye-Tetteh for the effective management of the project and also Dr. W. A. Plahar, the Project Co-ordinator. Deep appreciation go to the supporting technical and secretarial staff of the Food Research Institute for their contribution towards the laboratory studies and secretarial work respectively.

ABSTRACT

Freshly smoked and dried fish were packaged with or without vacuum and in polystyrene. The relative effectiveness of the packaging materials used in preserving the quality of the stored fish was evaluated for physical and biochemical decomposition , microbial load and sensory changes after storage for 8 weeks and over. Vacuum packaging (VP) was found to be the most effective method and provided optimum protection against rancidity, maintaining acceptable microbial and sensory qualities during the storage period. Storage yield of as high as 98% was recorded with corresponding high sensory scores and low microbial load. Proteolytic and lypolytic deterioration was minimal and considered negligible. Storage in polystyrene paks gave the lesser protection, thus resulting in 27% spoilage. However, both packaging methods provided a considerable reduction in microbial population of contaminating microorganisms. Spoilage microorgnisms isolated were predominantly Micrococci, *Bacillus*, *Aspergillus niger* and yeasts. Pathogenic bacteria or mould organisms were absent from the smoked fish before and after storage. Initial moisture content of samples and moisture barrier capacity of the packaging materials were found to be the most critical factors in preserving the quality of the smoked fish. Samples with initial moisture content of between 24-26% stored in both vacuum and polystyrene package became mouldy within 7 days, while those with initial moisture content of less than 10% were preserved for over 24 weeks in vacuum packages. There was a high correlation of flavour and texture quality with moisture absorption which was measured by percent weight gain of the fish in the packages. In a supermarket sales trials, the package appeal to customers/consumers was greater for the vacuum paks than the polystyrene containers.

1. INTRODUCTION

Large quantities of different fish species are landed in Ghana each year especially during the bumper season between July and October. Inspite of the abundance of fish, communities are deprived of the availability of this source of protein due to huge losses as a consequence of minimal levels of preservation and storage techniques. Even to the level that in fishing communities, protein energy malnutrition has been observed (Annan *et al.*, 1995).

The improvement and introduction of proper processing and packaging techniques of fish in order to extend the shelf life for later use of the commodity would be of benefit to consumers and retailers alike. The use of polyethylene, polystyrene and vacuum packaging for fish has not been given prominence in Ghana, whereas in developed countries sale of protein sources like fish and meat have been found to be encouraged in promoting longer shelf life of such commodities.

In Ghana, meat products as compared to fish are more expensive, and therefore fish processing has become a very important aspect in the fish industry as a source of dietary protein to a minority of the population. A major problem, however, associated with such industry is the absence of good packaging techniques for the finished products. Hence the quality of the product is reduced leading to deterioration. Consumer acceptability for the sale of smoked and dried fish in Ghana is hampered by the inappropriate packaging and presentation of the fish. Reusse (1968) estimated that 80% of fish consumed in Ghana are smoked. Such well packaged processed fish are conspicuously absent on the shelves of our supermarkets and shops. They are however found in the open markets, having been transported and displayed in wooden boxes, plastic/metal basins and

baskets, one layer on top of the other resulting in breakages and hence lower consumer acceptance of the product. This is due mainly to the result of poor packaging and handling of the product. In the markets, retailers expose the fish to flies and dust by their display methods in a bid to attract the many consumers who in turn handle and feel the fish before purchasing. this brings about multiple contamination of the fish.

For some of the fish, due to their high lipid content, extended storage may lead to lipid peroxidation as well which may be primary cause of quality loss in such foods. Mud fish (*Clarias* sp.), Sardines (*Sardinella eba*) and Horse mackerel are all fatty fish which are consumed in large quantities due to their comparatively cheaper prices. However, due to their high lipid content, extended storage in the absence of good packaging may lead to lipid peroxidation that may be primarily responsible for quality loss in such foods. This primary mechanism reduces appearance, texture, flavour and nutritional value. In the event of autoxidation of polyunsaturated fatty acids, off-flavours may develop (Gray and Pearson, 1987) or oxidative effects on proteins, peptides and amino acids may result. Traditionally, smoked fish are packaged in brown paper placed in baskets that are covered with jute sacks. Poor packaging and display of processed fish has always been of major concern to consumers and researchers alike, although to varying degrees of concern. One of the major reasons being the lack of the use of appropriate packaging for use in order to reduce contamination, eliminate spoilage and ensure product stability by prolonging shelf life.

Several researchers have used storage of unprocessed fish in modified atmosphere packaging (MAP) to extend shelf life (Brown *et al.*, 1980; Haard and Lee, 1982; Scott *et al.*, 1986). Microbial counts have been reduced and the contents in the packages have remained wholesome for several days. In the air-held samples, high microbial counts have been recorded.

In supermarkets of developed countries like America, Australia and Britain meat is displayed in polystyrene paks with cling wraps. this hygienic packaging method not only eliminates flies, dust and product abuse from direct excessive handling of the food from potential buyers but also affords the individual to view the contents before finally making purchases. In Ghana, where temperatures are high and encourage the growth of mesophilic microorganisms, investigation into appropriate packaging and temperature conditions that will maintain the integrity of such packaged fish will go a long way to afford consumer acceptable and hygienic fish with extended shelf life.

In vacuum-packaging, air is eliminated from the package such that unavailability of oxygen hampers the growth of aerobic microorganisms, thus maintaining the quality of the fish and eliminating food spoilage pathogenic organisms that cause health hazards. Such organisms include Salmonella with a minimum infective dose (M.I.D.) of as little as 20 cells (Varnam and Evans, 1991) while other studies have indicated $>10^6$ cells. The use of vacuum packaging may also eliminate organisms like Escherichia coli which have long time survival rate in environments with faecal material especially in cases where the processed fish are handled by many potential buyers. Contamination or unhygienic conditions of food handling are related to E. coli infections (Ahmed, 1991).

Bremner and Statham (1983) combined vacuum-packaging with 0.1% Potassium sorbate-treatment and after 28 days these samples were acceptable, Clostridium botulinum Type E growth or toxin having been completely inhibited.

In fish that contain high levels of lipids (like herrings, mackerel and salmon), rancidity results as microbial spoilage occurs. Sorbic acid, sodium nitrate and nitrite have been used effectively against microbial spoilage. The use of sorbic acid in the form of calcium, sodium or potassium salt as food preservative has been employed, as they act as fungal inhibitors. These compounds are permissible in foods at levels not exceeding

0.2%. Sorbates are effective also against a wide range of bacteria, and is effective in a pH range of between 6.0 and 6.5. Its effectiveness has been shown against *Staphylococcus aureus*. Salmonellae, coliforms, psychrotrophic spoilage bacteria (especially the pseudomonads), and *Vibrio parahaemolyticus* with concentrations as low as 30 ppm have been effective (Sofos, 1989) where shelf life extensions have been obtained by the use of sorbates in vacuum-packaged meats, fish and vegetables. Combinations of sorbates and nitrites have also been used for meat and fish and found to be effective in cured meats against many spoilage bacteria including *Clostridium* and *S. aureus* (Ronning and Frank, 1988). With respect to safety, sorbic acid is metabolized in the body to CO_2 and H_2O in the same manner as fatty acids normally found in foods (Deuel *et al.*, 1954).

So far, no work has been reported on about the use of appropriate packaging of smoked and dried fish meant for sale in our supermarkets aimed at consumer satisfaction and reduction in product abuse through multiple contamination from the numerous potential buyers. For consumer acceptability of the product therefore, processed fish must be presented in an acceptable and safe form that will appeal to the consumer. Proper presentation of packaged smoked and dried fish especially in our supermarkets would not only give the consumer safe products but will also reduce large losses of fish lost annually by curtailing spoilage. This study is aimed at determining the nutritional quality and storage stability of processed fish in polystyrene packages and vacuum sealed bags; and also the acceptability of the packaged fish through a large scale consumer study.

2. MATERIALS AND METHODS

2.1. Raw Materials

Samples of freshly smoked-dried and cooled mud fish (*Clarias lazera*) and *Tilapia* sp. were purchased from identified fish processors from selected processing sites in the Volta Region of Ghana.

2.2. Sample preparation and storage

The smoked fish was purchased in 10 lots of 20 fish, placed in sterile polyethylene bags and labelled according to the treatment to be given. In the laboratory the fish was divided into two equal batches. Representative samples of fish from one lot were vacuum sealed in vacuum bags using a vacuum sealing machine. The second lot were placed in polystyrene containers and wrapped with polyethylene cling wraps. The same number of samples were also further dehydrated and subjected to similar packaging techniques. All the three sets of samples were stored under the same environmental conditions in the laboratory and monitored for a period of 2 to 6 months. After the initial storage of 8 weeks, sample lots found not to have any adverse form of deterioration were further kept for up to 24 weeks .

2.3. Quality assessment of samples

Representative samples were analysed to ascertain the quality at the time of purchase. Quality analyses carried out on the newly packaged samples to be stored were physical, biochemical, microbiological, sensory, nutritional and comparative consumer acceptability tests, using internationally recognised standard methods . At the end of the

storage time, similar analyses were carried out on the same samples selected randomly from the lot.

2.4. Physical and biochemical analysis of fish

The fish samples were individually assessed for any physical damage before packaging and storage. Those found to have bruises, cracks or breakages in any form were removed from the lot.

Biometric measurements including the average weight and length of the fish to be stored were recorded using a balance and a tape measure respectively. The width of the fish at the thickest end was also taken. Fish with averagely similar biometric measurements /parameters were used for uniformity before storage. For biochemical evaluation, analysis included moisture, protein, ash and mineral content following standard methods (AOAC, 1984).

The method of Pearson (1970) was used to determine changes in the total volatile basic nitrogen (TVBN) content of the samples, as an assessment of proteolytic deterioration. Fat and Free Fatty Acids (FFA) content of the samples was determined using the chloroform/methanol extraction technique described by Bligh and Dyer (1959), to serve as an indicator of lipolytic deterioration.

2.5. Sensory Evaluation and Consumer Acceptability Studies

Qualitative descriptive analysis and sensory quality system (Beckley, 1995) were used to evaluate the sensory quality of the smoked fish. This involved a detailed descriptive sensory evaluation of the appearance, colour, aroma, texture, flavour acceptability and overall quality score of the fish.

Preliminary acceptability scores for sensory attributes of the unpackaged, vacuum-packaged and polystyrene-packaged fish were determined by a ten-member trained panel using a 9-point hedonic scale described by Larmond (1977). A triangle difference test was used to determine whether there were any detectable differences between the unpackaged and packaged samples. The fish was also used in light soup preparation and assessed for their palatability. Samples were served at room temperature in porcelain plates and panelists were requested to evaluate the samples by checking the appropriate terms on a graduated scale with anchor words. Panelists were provided with water to clear the mouth between sampling in order to provide an un-adulterated assessment of individual test samples. Responses of panelists were tabulated and subjected to analysis of variance (ANOVA) test for comparison.

A large scale consumer acceptability study was conducted in the Greater Accra and Volta regions of Ghana. A total number of one hundred and twenty respondents comprising 92 females and 28 males were provided with questionnaires requesting them to evaluate the packaged smoked-dried fish for all the sensory attributes and overall acceptability (Appendix 1).

2.6. Microbiological Quality Evaluation

2.6.1. Aerobic Bacteria Count (Pour Plate Technique)

Ten grammes of fish powder was weighed into sterile stomacher bags. To this 90 ml of Saline Peptone Solution was added and macerated for 30 s. Serial dilutions of 10^{-1} -10^{-6} were prepared, pippeted into petri dishes of Plate Count Agar and incubated for 72 h at 30^{0}C (Anon, 1986).

2.6.2. Mould and Yeast Count

Employing the Pour Plate Technique, 1.0 ml of 10^{-1} dilution of the fish suspension was pipetted into duplicate sterile petri dishes. This was pour-plated with Malt Extract agar, mixed and incubated at 25 °C for 5 days (Anon, 1987).

2.6.3. Enumeration of Enterobacteriaceae (Coliforms)

One millilitre of 10^{-1} and 10^{-2} dilutions of the fish suspension were pipetted into sterile petri dishes where about 5 ml of Tryptone Soya Agar was added and procedures completed according to Anon (1992a).

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 ^{0}C for 48 h.

2.6.4. Pathogenic Microorganisms

Microorganisms of public health significance investigated were mainly *Salmonella* and *Staphylococcus aureus*.

2.6.4.1. *Salmonella* sp.

Salmonella bacteria organisms was identified by the method of Anon (1991). Four successive stages of identification were employed namely :

a. Pre-enrichment in non selective liquid medium.

b. Enrichment in selective liquid media.

c. Plating out and presumptive recognition of typical *Salmonella* colonies.

d. Confirmatory tests by subculturing and using appropriate biochemical tests as urea, mannitol utilization, ornithine and lysine decarboxylase, Triple Sugar Iron (TSI). Media

used included Rappaport-Vassiliadis (RV) broth, Xylose-lysin-desoxycholate (XLD) agar and Brilliant green-phenol red agar (BGA).

2.6.4.2. *Staphylococcus aureus*

A 5 g sample of fish powder was aseptically weighed and placed in cooked meat medium. A volume of 0.1 ml of the undiluted stock solution was transferred into Baird-Parker's medium. The inoculum was distributed with a sterile angle bent glass rod and incubated at 37 ^{0}C for 24 - 48 h (Anon, 1992b). Confirmatory tests carried out on isolates was the Coagulase test.

2.6.5 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 of the isolates.

2.6.6. Hydrogen Ion Concentration (pH)

The Hydrogen Ion Concentration was measured using Laboratory pH meter PHM 92 (Radiometer Analytical A/S - Denmark). Approximately 5 g of fish powder was weighed into plastic pH cups and mixed with 5 ml of carbon dioxide-free distilled water. Measurements were made with the pH meter previously calibrated using standard buffer solutions of pH 4.0 and 7.0 at 25 ^{0}C.

2.6.7. Statistical Analysis

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

3. RESULTS AND DISCUSSION

3.1. Microbiological quality of unpackaged smoked fish

Microbiological assessment of the smoked fish purchased from the processing plant showed high average bacterial load in all the two kinds of fish samples examined. For *Clarias* species at a pH of 7.0, the average quantitative aerobic bacteria count per gramme of sample recorded was $>300x10^6$ organisms (Table 1). For *Tilapia* species which registered a pH of 6.7, the average load registered was $5.4x10^7$ total viable bacteria organisms. The mould and yeast count for *Clarias* and *Tilapia* were $2.0x10^1$ and $1.0x10^1$ colony forming units per gramme (cfu/g) of fish respectively. The presence of coliforms were detected in as small as 0.1 g of both fish types with values of $5x10^1$ and $5.6x10^2$ organisms per gramme recorded for *Clarias* and *Tilapia* species respectively (Table 1). However, these organisms were found not to be of faecal origin as no *Escherichia coli* was detected in 0.1g of both fish types examined. There was total absence of pathogenic microorganisms such as *Staphylococcus aureus*, *Salmonella*, *Aspergillus flavus* and *Aspergillus parasiticus* from the smoked-dried fish. Dominant microorganisms that were found to contaminate the fish were *Micrococcus*, *Aspergillus niger* and yeasts.

3.1.1. Microbiological quality of polystyrene and vacuum-packaged and stored smoked fish

The smoked fish which were packaged in polystyrene and vacuum paks (Fig. 1a, 1b, 2a and 2b) and stored for a period of 2 months under laboratory conditions had a comparatively low microbial load and a reduced pH environment in the paks (Table 2).

Table 1. Microbiological Quality Evaluation of Unpackaged Smoked Fish

Sample	pH	Total Viable Count /g	Mould and Yeast Count / g	Coliforms in 0.1 g	AFP	Coliform Count /g	E. coli in 0.1g	S. aureus	Salmonella in 25 g	Other
Mudfish	7.0	$> 300 \times 10^6$	2×10^1	Present	Absent	5.0×10^1	Absent	Absent	Absent	*A. nige* Yeasts Microco
Tilapia	6.7	5.4×10^7	1×10^1	Present	Absent	5.6×10^2	Absent	Absent	Absent	*A. nige* Yeasts Microco

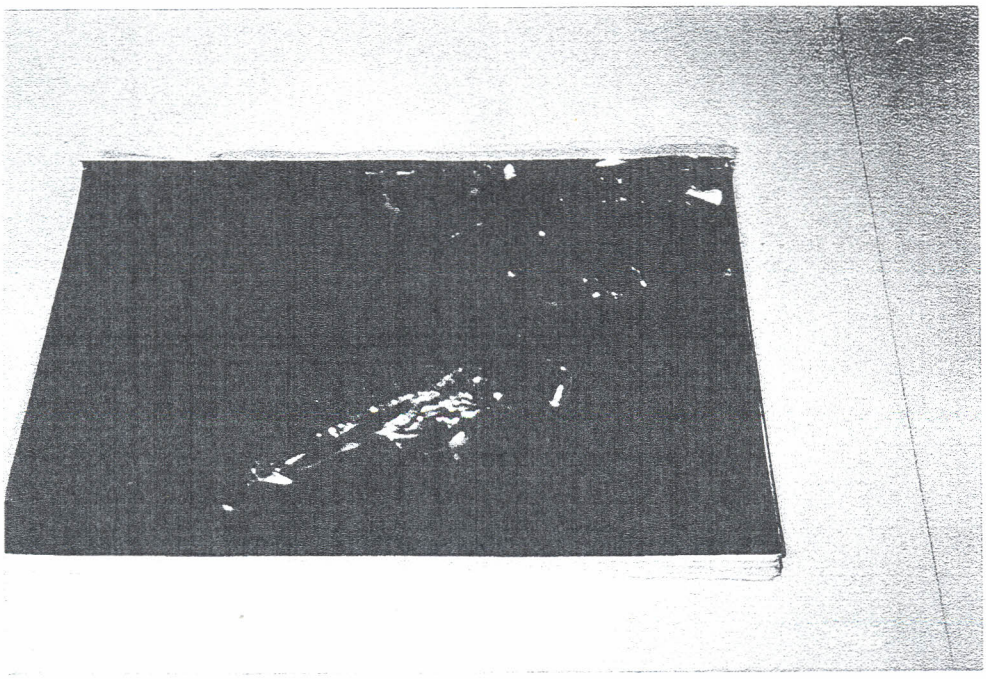

Fig. 1a. Vacuum-packaged *Tilapia* sp.

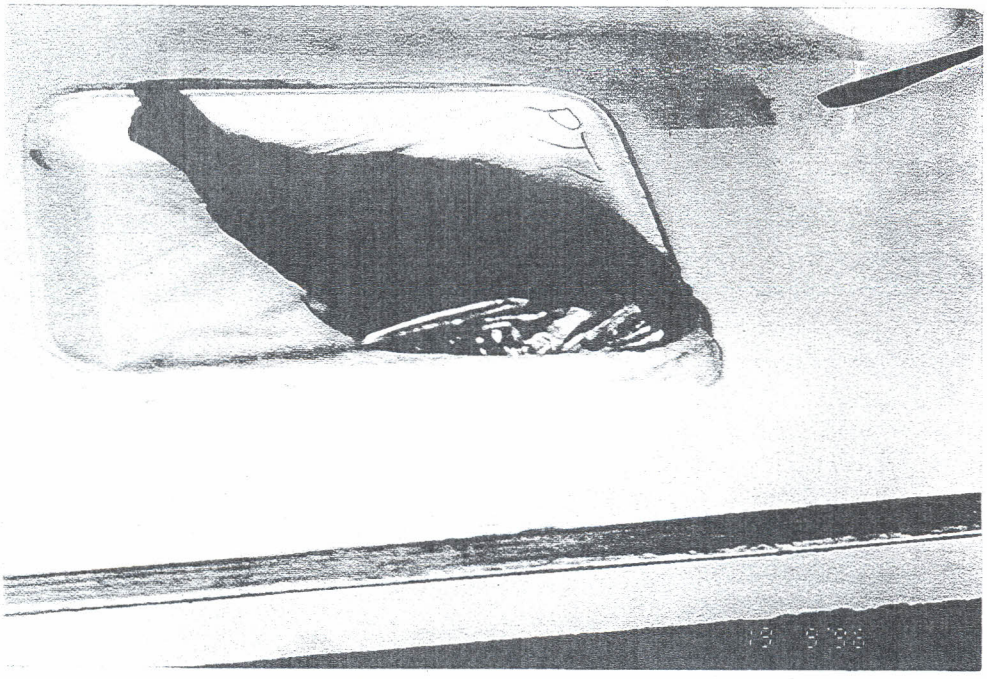

Fig. 1b. Polystyrene-packaged *Tilapia* sp.

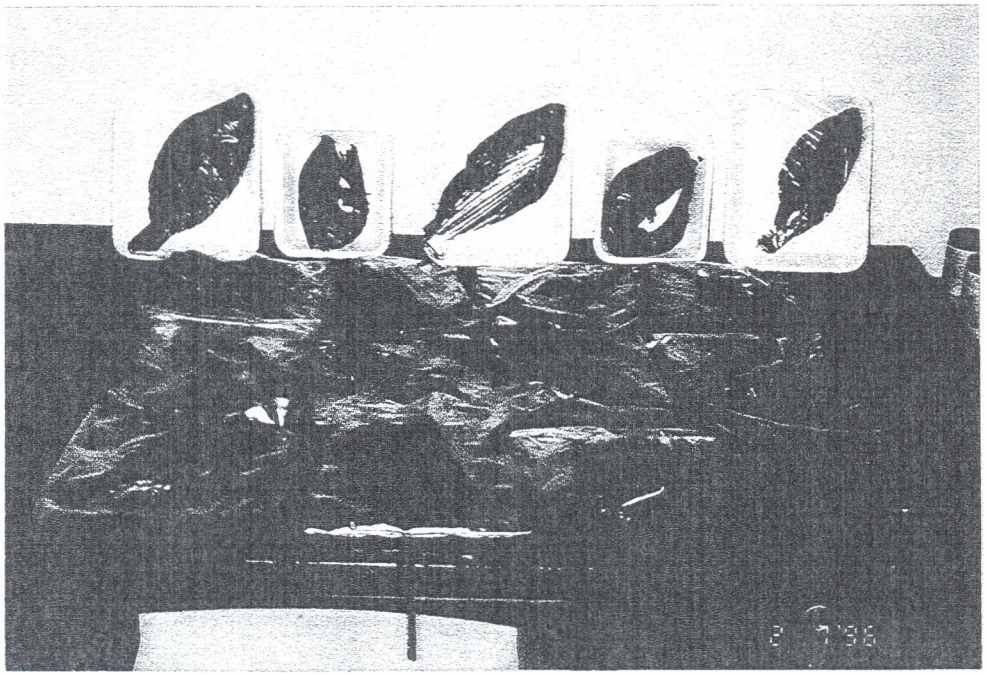

Fig. 2a. Vacuum-packaged *Clarias* sp. (arrowed).

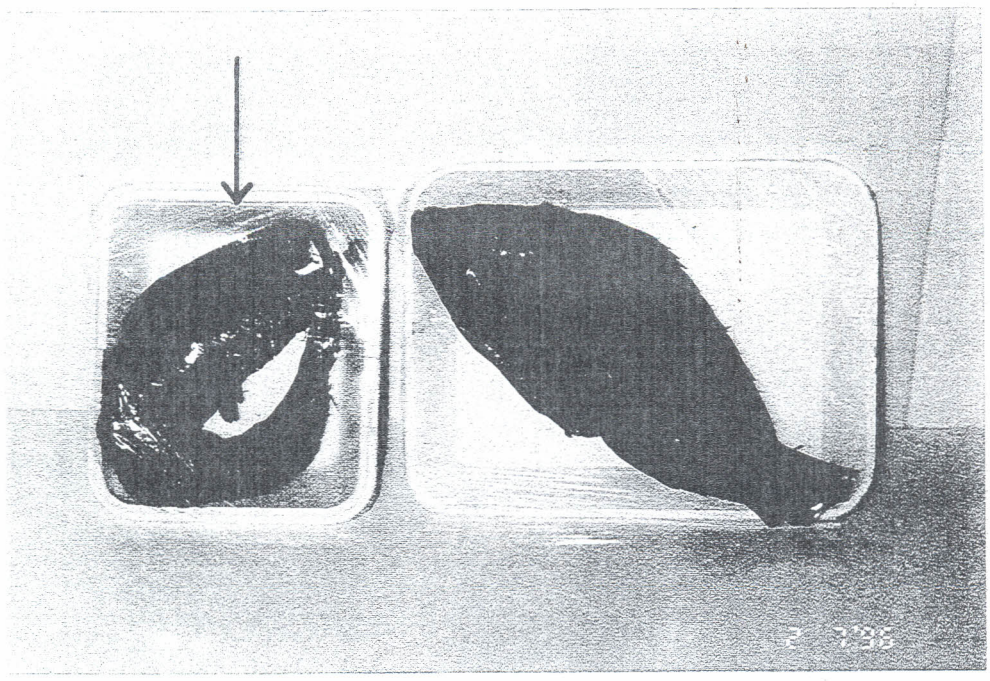

Fig. 2b. Polystyrene-packaged *Clarias* sp. (arrowed).

Table 2. Microbiological Quality Evaluation of Polystyrene- and Vacuum-packaged Smoked Fish

Sample/ Packaging	pH	Total Viable Count /g	Mould and Yeast Count /g	AFP	Coliform Count /g	E. coli in 0.1g	S. aureus	Salmonella in 25 g	Others
Clarias sp. (Polystyrene)	6.4	1.3×10^4	< 10	Absent	< 10	Absent	Absent	Absent	Micrococci
Clarias sp. (Vacuum)	6.3	1.3×10^4	< 10	Absent	< 10	Absent	Absent	Absent	Micrococci
Tilapia sp. (Polystyrene)	6.6	$> 300 \times 10^3$	< 10	Absent	< 10	Absent	Absent	Absent	Micrococci *Bacillus*
Tilapia sp. (Vacuum)	6.5	4.0×10^3	< 10	Absent	< 10	Absent	Absent	Absent	Micrococci *Bacillus*

There was no significant difference in counts between each fish species packaged in polystyrene and in vacuum. In polystyrene packaging, *Clarias* sp. recorded a total viable bacteria count of $1.3x10^4$ organisms/g while in vacuum packaging the counts remained the same in pH environments of 6.4 and 6.3 respectively. *Tilapia* species packaged in polystyrene and in vacuum registered values of $>300x10^3$ and $4.0x10^3$ organisms/g in pH environments of 6.6 and 6.5 respectively. Mould and yeast counts of both fish types packaged in the two types of packaging materials were insignificant. Values registered were all less than 10 colony forming units per gramme (<10 cfu/g) of sample. Coliforms count/g of sample was insignificant and found to have reduced to <10 organisms/g after storage. Faecal coli and pathogenic microorganisms like *E. coli*, *S. aureus*, *Salmonella*, *A. flavus* and *A. parasiticus* were absent in the packaged samples. *Micrococcus* was found to be persistent in all packages containing *Clarias* and *Tilapia* sp. irrespective of whether it was polystyrene or vacuum paks that were used. In packages that contained *Tilapia* sp., there was an appearance of Gram-positive bacilli after they were sampled and examined upon storage. However, *Aspergillus niger* detected in both fish types before packaging and storage was carried out was found to be completely absent from the stored products (Table 2). Fig. 3a and 3b shows high mould infestation in polystyrene-packaged *Clarias* and *Tilapia* sp.

3.2. Sensory assessment of unpackaged and packaged/stored smoked fish

Table 3 shows sensory scores of the two fish types as purchased from the processor. The smoked dried *Tilapia* and *Clarias* spp. had an overall acceptability of 7.42 ± 0.59 and 7.77 ± 0.96; while the quality scores were 9.0 and 8.0 respectively. When used in light soup preparations, overall acceptability of *Clarias* sp. was 7.92 ± 1.57 while for

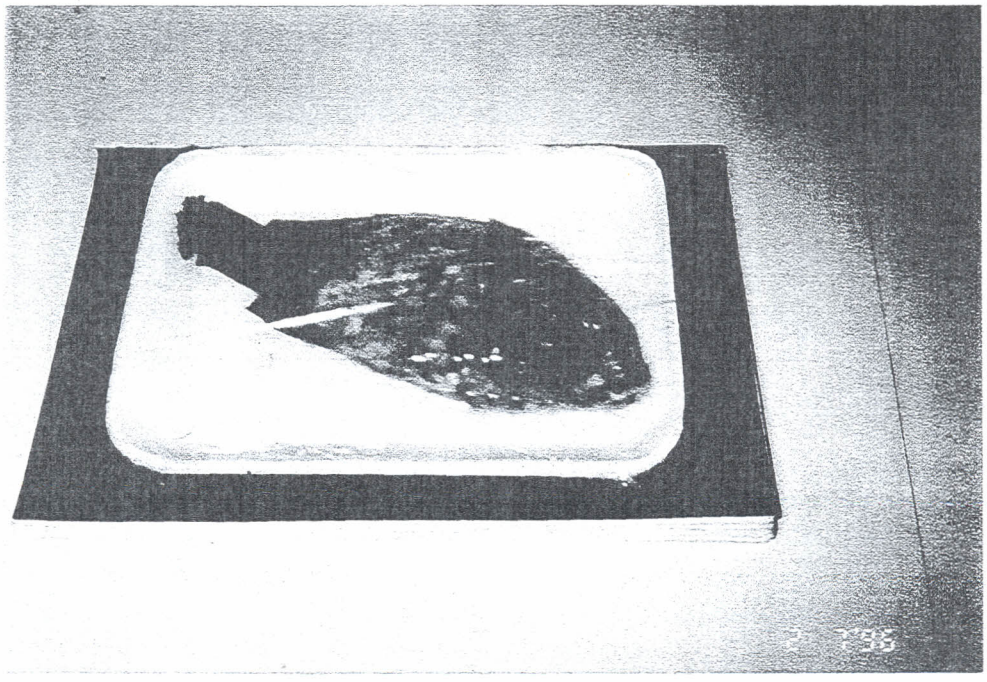

Fig. 3a. Mould infestation of un-dehydrated *Tilapia* sp. packaged in polystyrene.

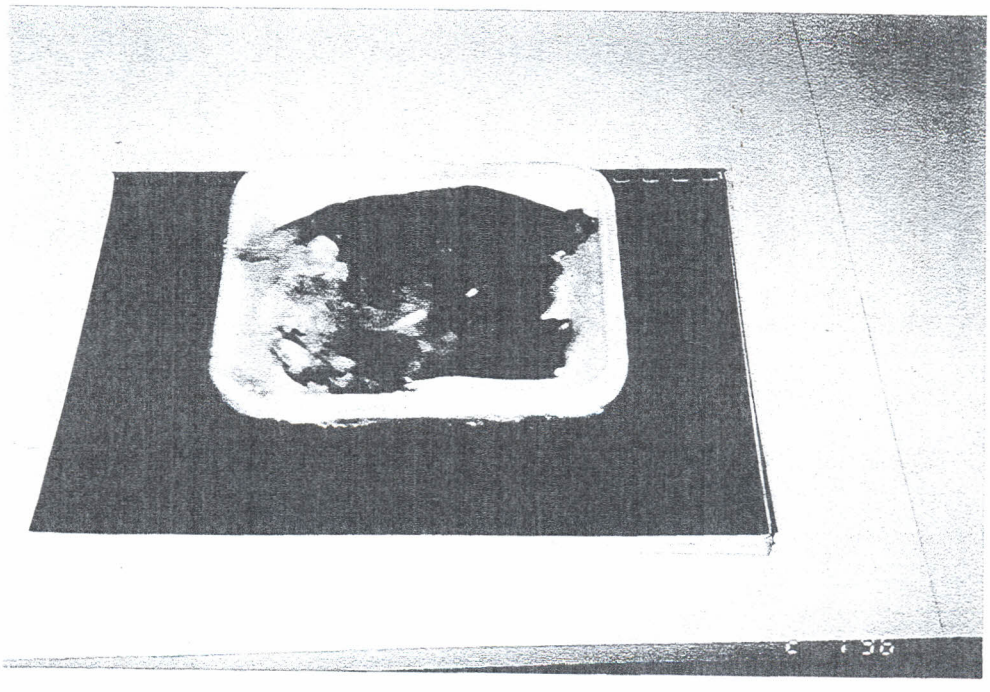

Fig. 3b. Mould infestation of un-dehydrated *Clarias* sp. packaged in polystyrene.

Table 3. Sensory evaluation of unpackaged smoked *Clarias* and *Tilapia* sp.

Sensory Attributes	Smoked Dry Fish		Smoked Fish Light Soup	
	Tilapia sp.	*Clarias* sp.	*Tilapia* sp.	*Clarias* sp.
Appearance	7.02 ± 0.84	7.49 ± 2.07	8.02 ± 1.58	7.48 ± 2.49
Colour	6.55 ± 1.55	7.95 ± 1.40	7.23 ± 1.86	8.12 ± 1.45
Aroma	7.34 ± 0.63	7.33 ± 0.81	8.16 ± 1.07	7.29 ± 2.45
Texture	7.49 ± 0.79	6.33 ± 1.40	7.91 ± 1.31	7.34 ± 2.02
Flavour	7.55 ± 0.69	8.24 ± 1.05	7.73 ± 1.25	6.92 ± 2.83
Overall acceptability	7.42 ± 0.59	7.77 ± 0.96	8.25 ± 0.79	7.92 ± 1.57
Overall quality score	9.0	8.0	8.0	8.0

Tilapia sp. it was 8.25 ± 0.79. There was however no difference between the overall quality score of 8.0 registered for the two fish types. Generally, both types had acceptable sensory attributes since scores exceeding 6 were registered. The fish in light soup had acceptable aroma typical of such fish. In addition, the intensities of sensory attributes were within the acceptable range of 6 to 10, using the Quality Sensory System (Beckley, 1995).

Table 4 shows the mean sensory score of the two fish samples stored for two months. Vacuum-packaged fish was found to have a slightly higher overall acceptability than those in polystyrene packaging, since for all the sensory characteristics investigated, the vacuum-packaged samples scored slightly higher than those in polystyrene. Physical examination indicated by the overall quality scores in Table 4 showed that the stored products were acceptable. The overall quality scores for *Tilapia* sp. packaged in vacuum and polystyrene were 8.16 ± 1.40 and 8.00 ± 1.13 respectively while values for *Clarias* sp. were 6.83 ± 1.99 and 6.50 ± 2.47 respectively. The stored treatments not only extended the shelf life of the fish but also gave good display and attractive products that will increase its marketability (Fig. 2a).

Table 4. Sensory evaluation of polystyrene- and vacuum-packaged smoked fish

Sensory Attributes	*Tilapia* sp.		*Clarias* sp.	
	Vacuum	Polystyrene	Vacuum	Polystyrene
Appearance	8.40 ± 0.99	7.98 ± 1.36	7.68 ± 1.78	7.26 ± 1.47
Colour	8.12 ± 0.99	7.91 ± 1.04	7.79 ± 1.22	7.88 ± 1.56
Texture	7.94 ± 1.33	7.39 ± 1.67	7.34 ± 1.52	6.79 ± 2.11
Flavour	8.00 ± 0.77	7.98 ± 1.06	7.88 ± 1.24	7.59 ± 0.81
Overall acceptability	8.53 ± 0.81	7.93 ± 1.08	7.76 ± 1.39	7.43 ± 1.31
Overall quality score	8.16 ± 1.40	8.00 ± 1.13	6.83 ± 1.99	6.50 ± 2.47

3.3. Biochemical quality of stored polystyrene and vacuum-packaged smoked fish

The chemical composition of freshly smoked, dehydrated and stored samples of *Tilapia* and *Clarias* sp. are given in Tables 5 and 6. The results show that smoked fish samples purchased at the processing sites contain too much moisture to be packaged for storage and sale. The moisture content of between 24 and 26 % obtained for the two fish species in this study was too high for storage of these products without the onset of rapid microbiological and biochemical deterioration occurring. The shelf life of smoked fish has been shown to vary according to the moisture content (Okoso-Amaa *et al.* 1978). Stored dry-smoked fish samples with moisture content of less than 13% have been observed to last for over six months, provided storage conditions were such as would give maximum protection against environmental humidity influences (Plahar *et al.*, 1992). In the present study, the samples were dried to moisture levels below 10%; which was ideal for long storage life. The vacuum packaging protected the samples and maintained the low moisture throughout the six months period of storage. The polystyrene packaging, on the other hand, could not prevent moisture diffusion and slight increases in the moisture content of the samples occurred during storage.

Table 5. Effect of storage in polystyrene and vacuum packaging on the chemical quality of smoked *Tilapia* sp.

Chemical component	Freshly smoked	Dehydrated for storage	Stored samples (6 months) Polystyrene	Vacuum paks
Proximate composition				
Moisture (%)	26.2	7.6	9.2	7.9
Protein (%)	59.3	73.5	72.2	72.8
Fat (%)	8.8	10.9	10.6	10.8
Ash (%)	3.3	4.1	4.0	4.2
Mineral content				
Calcium (mg/100g)	608.0	753.9	738.8	748.9
Phosphorus (mg/100g)	767.0	951.1	932.0	941.5
Iron (mg/100g)	6.3	7.4	7.3	7.3
Decomposition products				
FFA (% as oleic)	6.8	8.4	9.6	8.9
TVBN (mg N/100g)	80.9	98.4	110.8	100.7

[1]Values are given on *as-is* basis for triplicate composite samples.

Table 6. Effect of storage in polystyrene and vacuum packaging on the chemical quality of *Clarias* sp.

Chemical component	Freshly smoked	Dehydrated for storage	Stored samples (6 months)	
			Polystyrene	Vacuum paks
Proximate composition				
Moisture (%)	24.4	9.0	11.4	9.7
Protein (%)	46.8	56.2	54.5	55.2
Fat (%)	23.2	27.8	27.2	27.6
Ash (%)	4.3	5.2	5.0	5.0
Mineral content				
Calcium (mg/100g)	554.0	664.8	644.8	658.9
Phosphorus (mg/100g)	1,165.0	1,390.0	1,350.3	1,400.0
Iron (mg/100g)	9.0	10.8	10.1	9.6
Decomposition products				
FFA (% as oleic)	6.8	8.6	12.3	9.1
TVBN (mg N/100g)	105.3	116.4	150.4	112.5

[1]Values are given on as-is basis for triplicate composite samples.

In terms of quality deterioration, both the Free Fatty Acids (FFA) and Total Volatile Base Nitrogen (TVBN) content of the fish samples increased slightly but significantly in samples packaged in polystyrene. There was no significant deterioration in samples packaged in vacuum paks. In all cases however, the FFA values for the samples were not up to the concentration required to produce noticeable rancidity to the palate. According to Pearson 1970, most oils produce noticeable acidity to the palate when the FFA value calculated as oleic acid is about 0.5 to 1.5%. High levels of free fatty acids in fish samples is an indication of onset of oxidative rancidity, and can thus serve as an indicator to assess the storage stability of a food product. With regards to protein decomposition, the total volatile base nitrogen (TVBN) values obtained clearly demonstrated a higher degree of decomposition in the dry-smoked *Clarias* sp. than in the *Tilapia* sp. The value for dehydrated *Clarias* sp. was about 116 mg N/100 before storage, and this increased by about 30% during storage. Farber (1965) reported a suggested upper TVBN limit of 60 mg N/100g fresh fish sample. This value, when converted on the basis of 10% moisture level gave about 270 mg N/100g sample, which was about twice the values obtained in the stored *Clarias* sp.

4. CONCLUSION AND RECOMMENDATIONS

The study has been able to demonstrate the suitability of vacuum paks as effective packaging materials against microbiological and chemical deterioration for storage and sale of smoked *Tilapia* sp. and *Clarias* sp. As a result of its relatively lower moisture barrier, the polystyrene packaging encouraged a slight increase in moisture content of the stored product and consequent deterioration over a long period of storage. However, over a storage period of six months, the deteriorative changes occurring in the samples packaged in polystyrene, though significant, did not render the samples unacceptable.

Consumers have shown a high preference for the packaged fish samples. It is therefore recommended that a large scale education of the Ghanaian public be conducted to publicise the benefits of appropriate packaging for processed fish.

5. REFERENCES

Ahmed, F. E. 1991. Seafood safety. **In: Assurance of seafood quality**. Huss ed. 1994. FAO. Fish Tech. Paper 334 p. 21-22.

Annan, N. T., Plahar, W. A. and Hodari-Okae, M. A. 1995. Pilot scale production and consumer acceptability of anchovy fish powder in weaning foods. Ghana/Netherlands Artisanal Fish Processing and Applied Research Project. Food Research Institute, Accra, Ghana.

Anon, 1986. Aerobic Microorganisms: Enumeration at 30^0C in Meat and Meat Products. Nordic Committee on Food Analysis, NMKL No. **86** : 2nd edition.

Anon, 1987. Moulds: Determination in Foods. Nordic Committee on Food Analysis, NMKL No. **98** : 2nd edition.

Anon, 1991. *Salmonella* Bacteria: Detection in Foods. Nordic Committee on Food Analysis, NMKL No. **71** : 2nd edition.

Anon, 1992a. Enterobacteriaceae: Determination in Foods. Nordic Committee on Food Analysis, NMKL No. **144** : 2nd edition.

Anon, 1992b. *Staphylococcus aureus*: Determination in Foods. Nordic Committee on Food Analysis, NMKL No. **66** : 2nd edition.

AOAC. 1984. Official Methods of Analysis (13th edn). *Association of Official Analytical Chemists*, Washington, DC.

Beckley, J. P. and Kroll, D. R. 1995. Searching for Sensory Research Excellence. Food Technol. **50** (2) : 61-64.

Bligh, E. G. and Dyer, W. J. 1959. A rapid method of total lipid extraction and purification. Can. J. Biochem. Physiol. **237** : 911-917.

Bremner, H. A. and Statham, J. A. 1983. Effect of potassium sorbate on refrigerated storage of vacuum packaged scallops. J. Food Sci. **48** : 1042-1047.

Brown, W. D.; Albright, M.; Watts, D. A.; Heyer, B.; Spruce B. and Price, R. J. 1980. Modified atmosphere storage of rockfish (*Sebastes miniatus*) and silver salmon (*Oncorhynchus kisutch*). J. Food Sci. **45** : 93-96.

Deuel, H .J.; Calbert, C. E.; Anisfeld, H.; McKeehan, H. and Blunden, H. D. 1954. Sorbic acid as a fungistatic agent for foods. II. Metabolism of α , β -unsaturated fatty acids with emphasis on sorbic acid. Food Res. **19** : 13-19.

Farber, L. 1965. Freshness tests. *Fish as Food*. Vol. IV. (Borgstrom, G., Ed). Academic Press, New York and London.

Gray, J. I. and Pearson, A. M. 1987. Cured meat flavour. Adv. Food Res. **29** : 1-86.

Haard, N. F. and Lee, Y. Z. 1982. Hypobaric storage of Atlantic salmon in a carbon dioxide atmosphere. Can. Inst. Food Sci. Technol. J. **15** : 68-71.

Larmond, E. 1977. Method of sensory testing. **In : Laboratory Methods for Sensory evaluation of Food**. Canada Dept. of Agric. Publication 1637, Ottawa, Canada..

Okoso-Amaa, K.; Eyeson, K. K.; Bonsu, L.; Nerquaye-Tetteh, G. A. 1978. Report on the activities of the processing sub-committee. GH/IDRC Fishery Research and Devêlopment Project. Food Research Institute, Accra, Ghana.

Pearson, D. 1970. **The Chemical Analysis of Foods**. (6th edn). J. & A. Churchill, 104 Gloucester Place, London.

Plahar, W. A.; Nerquaye-Tetteh, G. A.; Hodari-Okae, M. A. and Kpodo, K. A. 1992. Studies on the storage of anchovies in Ghana: Effect of traditional storage on the quality of smoked anchovies (*Anchoa guineensis*) at Tema Manhean. A Project Report submitted under the Ghana/Netherlands Artisanal Fish Processing and Applied Research Project. Food Research Institute, Accra, Ghana.

Reusse, E. 1968. Ghana food industries. *UNDP Special Fund Project in Ghana Report EA/SC/GHA/68*. UNDP, Accra.

Ronning, I. E. and Frank, H. A. 1988. Growth response of putrefactive anaerobe 3679 to combinations of potassium sorbate and some common curing ingredients (sucrose, salt and nitrite), and to non-inhibitory levels of sorbic acid. J. Food Protect. **51** : 651-654.

Scott, D N.; Fletcher, G. C. and Hogg, M.G. 1986. Storage of snapper fillets in modified atmosphere at -1^{0}C. Food Technol. Aust. **38** : 234-238.

Sofos, J. N. 1989. Sorbate Food Preservatives. Boca Raton. CRC Press.

Steel R.G. D. and Torrie, J. H. 1980. Multiple comparison. Principles and Procedures of Statistics (2nd ed.). McGraw Hill Book Co., New York, p. 72.

Varnam, A. H. and Evans, M. G. 1991. Food-borne Pathogens. Wolfe Publishing Ltd.

6. APPENDIX 1

CONSUMER PREFERENCE TEST

Biodata **Questionnaire No :**

Date :

Location :

1. **Name of respondent :**
2. **Sex :**
3. **Age :**
4. **Marital status :**
5. **Number of children :**
6. **Occupation :**
7. **Level of education** :
   a. No formal education
   b. Primary school
   c. Middle school / JSS
   d. Secondary school / SSS
   e. Other (specify)
8. The smoked dry fish have been packaged in vacuum paks and with polystyrene cling wrap. Please assign numbers to indicate your preference for each fish.

a. Scoring Scale (Vacuum paks) **Clarias sp.** **Tilapia sp.**

Very highly acceptable (desirable).....10

Highly acceptable.....9

Moderately acceptable.....8

Slightly acceptable.....7

Neither acceptable nor unacceptable.....6

Slightly undesirable.....5

Strongly undesirable.....4

Poor.....3

Very poor.....2

Extremely unacceptable.....1

How do you compare this packaged product to that on the open market?

b. Scoring Scale (Polystyrene with cling wrap) **Clarias sp.** **Tilapia sp.**

Very highly acceptable (desirable).....10

Highly acceptable.....9

Moderately acceptable.....8

Slightly acceptable.....7

Neither acceptable nor unacceptable.....6

Slightly undesirable.....5

Strongly undesirable.....4

Poor.....3

Very poor.....2

Extremely unacceptable.....1

How do you compare this packaged product to that on the open market?

9. Would you prefer smoked fish sealed in :

   a. Vacuum paks?

   b. Polystyrene cling wrap?

   c. Exposed (unpackaged)?

   d. No comment.

State the order of preference and your reasons.

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