GHANA/NETHERLANDS ARTISANAL FISH PROCESSING & APPLIED RESEARCH PROJECT

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ON-SITE EVALUATION OF IMPROVED TRADITIONAL SMOKED FISH STORAGE TECHNIQUES IN SELECTED FISH PROCESSING COMMUNITIES.

FINAL REPORT

By

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ABSTRACT

Two sets of improved smoked fish storage structures were constructed and installed at Akplabanya with slight modifications to suit the prevailing conditions in terms of material availability and environmental conditions. Freshly smoked anchovies were stored in the structures for a period of six months with previously programmed temperature and humidity recorders to monitor the environmental changes both inside the structures and in the area during the test storage period. Samples of the freshly smoked and stored anchovies (*Anchoa guineensis*) were taken and analyzed for their physical, chemical, microbiological and sensory characteristics before storage. The improved technique was adequately demonstrated to be effective in preserving smoked anchovies against deterioration under the prevailing rural conditions. A yield of over 93% was realized after six months of storage. A 3% decrease in the moisture content of samples during storage enhanced quality preservation. Proteolytic, lipolytic and microbial deterioration was minimal. Fat acidity increased from 2.05 to a maximum value of 3.11 mg KOH/g while Total Volatile Base Nitrogen increased by about 30% of the original value of 118.5 mg

N/100g. Similar slight increases were also observed in the Non-Protein Nitrogen values which were initially about 2.03g N/100g sample. Increase in protein breakdown products was greater in samples stored in the upper storage boxes than in those stored in the bottom storage boxes. Flavour, aroma and brittleness did not change during storage, but the samples became slightly harder, tougher and darker in colour after six months in storage. Microbial loads in both freshly smoked and stored products were low.

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1. INTRODUCTION

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. In Ghana and many other West African countries fish constitute over 70% of the total animal protein intake; with marine fish accounting for nearly 80% of the fish production (Ghana/Netherlands Project Document, 1988). Large quantities of different species of fish are landed during the season of glut between July and October of each year, and these are preserved by one of several traditional processing techniques to avoid excessive wastage (Okraku-Offei, 1970). The most significant pelagic species of fish landed by Ghanaian canoe fisheries are the sardinellas (*Sardinella aurita* and *Sardinella eba*) and the anchovies (*Anchoa guineensis*).

Among the various traditional processing methods employed in Ghana to preserve fish, smoking and sun drying are the most widely used techniques for anchovies and herring. 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 that the socio-economic significance of smoked anchovy and herring production, and the need for research into their storage problems were identified. The bulk of the smoked fish has to be stored for several months for distribution during the off-season. In a baseline socio-economic study of Tema Manhean, Lokko (1990) discussed the economic significance of smoked anchovies in relation to the social set-up in the area.

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).

In a separate project under phase one of the Ghana/Netherlands artisanal fish processing and applied research Regional project, the most widely used traditional storage techniques for smoked anchovies by artisanal fish processors at Tema Manhean and Akplabanya (in the Greater Accra Region of Ghana) were studied. The structural characteristics established in the study (Nerquaye-Tetteh and Plahar, 1992a; 1992b) were used to construct proto-type anchovy storage structures in the villages to determine their effectiveness. From the results of the study only one storage technique was identified to be highly effective (Nerquaye-Tetteh and Plahar, 1992; Plahar, 1992; Hodari-Okae and Kpodo, 1992; Plahar, et al. 1992a; 1992b; 1993). This was used by some processors at Tema Manhean, but it is not known in the other fish processing areas.

Humidity in the structure was found to decrease steadily from an initial value of 66.7% to as low as 45.5% at the end of the six-month storage period. This situation resulted in the drying of the smoked fish during storage, thus enhancing preservation. The moisture content of samples decreased from 13% to less than 10% resulting in slight increases in sensory attributes such as hardness, brittleness and chewiness. There was only a slight decrease in flavour, but aroma and colour remained the same. Storage yield in terms of overall physical damage was 85%. Proteolytic, lipolytic and microbial deterioration was minimal, occurring mainly in samples at the periphery of the structure. Other structures studied were relatively ineffective and could not adequately preserve the stored fish for three months (Plahar *et al.* 1993a; 1993b).

The improved traditional smoked herring storage technique (Plahar *et al.*, 1991) and the highly effective smoked anchovy storage structure identified in the phase one studies (Plahar *et al.*, 1992) could solve the smoked fish storage problems facing artisanal fish processors if they are widely adopted. There is however the need to first evaluate their effectiveness and possible adoption hindrances in major smoked fish producing areas through on-site studies. The present project was therefore initiated under phase two of the Ghana/netherlands Artisanal Fish processing and Applied Research Project to determine the structural suitability and efficiency of the improved traditional storage techniques for smoked herring for the storage of anchovies at Akplabanya, a fish processing village in the Greater Accra Region of Ghana. The storage conditions were evaluated in terms of physicochemical changes, nutritional losses, and microbial infestation.

2. MATERIALS AND METHODS

2.1. Preparation of Anchovies for storage

Freshly landed anchovies were purchased at Akplabanya and prepared for smoking by washing and surface-drying. Surface-drying was carried out by spreading the fish on the smoking trays. The trays were left in the sun for several hours after which they were arranged on the smoking oven for the smoke-drying process. Earlier reports by the Fish 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 were conveyed in large baskets to the storage site by children who received some token remuneration for their services.

2.2. Construction and set up of Improved Storage Structure

A slightly modified version of the improved smoked fish storage structure designed by Plahar *et al* (1991) was used. The modification consisted of the replacement of the re-smoking unit with a raised wooden platform on which two sets of the storage boxes, comprising two wooden boxes per set, were placed side by side. Each storage box measured 150 x 150 x 50 cm with the bottom end made of wire mesh. The sides of the boxes were provided with several ventilation holes (2 cm diameter) and covered with 0.51 mm wire mesh to keep out insect pests and rodents. The boxes were constructed at the Food Research Institute and conveyed to the storage site at Akplabanya, near Ada in the Greater Accra Region.

The bottom boxes which were constructed without lids, were placed on the raised platform and filled with several baskets of the smoked anchovies to be stored after lining the sides with brown paper. They were then neatly covered with more brown paper. The second box in each set, equipped with a hinged plywood top cover, was then carefully placed on top of the bottom one. The top boxes were also lined with brown paper, filled with more smoked fish and covered with more brown paper before closing them with the plywood covers. These were finally locked with padlocks to prevent pilferage and disturbance. The whole set up was covered with a large sheet of black polyethylene material and securely tied round with a strong rope.

2.3. 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. Two of the recording instruments were placed in rectangular boxes made of framed wire mesh. Each recorder was mounted at the mid section of the fish pile in one bottom and one top storage box. The instruments were earlier programmed to sample temperature and humidity at one minute intervals for 180 days. They were also to record the minimum, average and maximum temperatures and humidities. Arrangements were made with the Ghana Meteorological Department to provide daily temperature and humidity values in the area during the period of the storage trial. This is to facilitate comparison of the environmental conditions inside and outside the storage structure.

2.4. Sampling and sample Preparation

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. A similar procedure was adopted for sampling and sample preparation for the fish after six months in storage. The samples were analyzed for their microbiological, physical, chemical and sensory characteristics.

2.5. 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 and handling.

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.

2.6. 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.

2.7. Chemical Analysis

Samples of milled edible portions as well as whole fish were analyzed 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 analyzed for fat acidity (AACC, 1984, method 02-01).

2.8. Microbiological Quality Evaluation

2.8.1 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 45^0C. 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 30^0C for 72h. The edible portion of the smoked anchovy was treated in the same way to obtain the total viable counts (Harrigan and McCance, 1966).

2.8.2. 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 30^0C for 24 hr.

2.8.3. <u>Enumeration of Enterobacteriaceae (Coliforms)</u>

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 37^0C. 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 37^0C for 48 hr.

2.8.4 <u>Pathogenic Organisms</u>

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 37^0C. The sample was then subcultured onto Mannitol salt agar and incubated for 72 hr at 37^0C for pure culture isolation and identification.

Salmonella sp.

For pre-enrichment, 25g sample of fish was weighed and macerated in 225ml 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 0.1ml of the pre-enrichment broth was transferred to 10ml 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.

2.8.5. 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. Selective identification for *Aspergillus flavus/parasiticus* was performed using a specific medium prepared with Aspergillus Flavus

Parasiticus Agar (AFPA) Base (Oxoid Limited, Hampshire, England).

2.9. 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.

2.10. 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).

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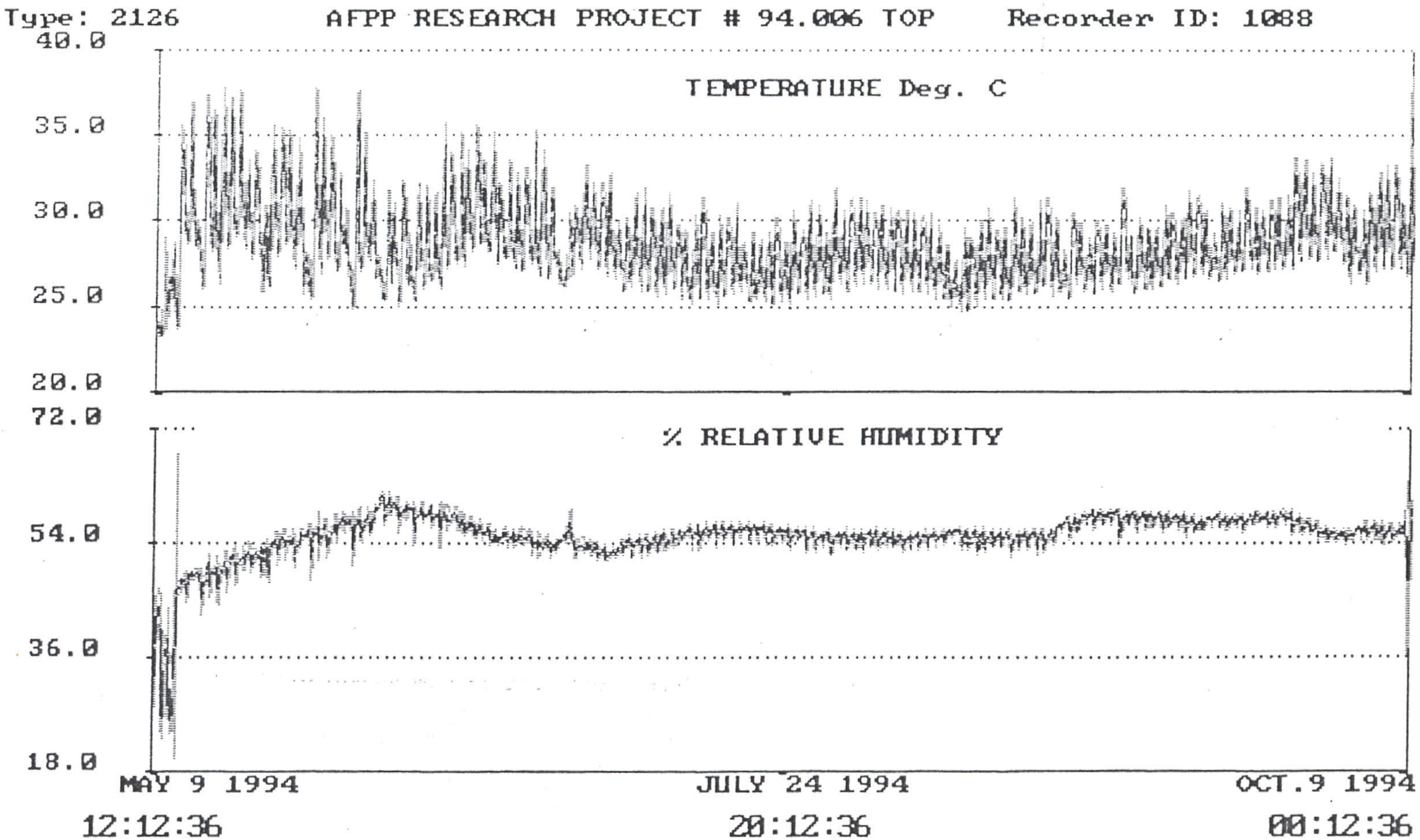
3. RESULTS AND DISCUSSION

3.1. Changes in the Temperature and Humidity Conditions During Storage

The temperature and humidity recordings in the top and bottom storage structures during the six-month period are shown in Figures 1 and 2 respectively. In general there was a gradual increase in the storage temperatures in both storage boxes during the first two months (between May and June) after which the temperature dropped to about 27°C and remained fairly constant between the months of July and September. A gradual rise in temperatures was again observed during the final month of storage. The lowering of temperatures during the major part of the storage period could be attributed to the season. Similar to the temperature changes, humidity also rose slightly in the structures during the first month and then dropped to about 54% and remained fairly constant at low value throughout the six-month period.

In earlier studies using similar structures for smoked herring storage, Plahar *et al* (1992) observed a similar situation where the humidity fell slightly to about 65% after rising from an initial average value of 60% to about 70% within the first month. It then maintained an average value of between 68% and 70% throughout the period of storage. In recent studies on the traditional bulk storage of smoked anchovies in Ghana, Plahar *et al* (1992b) found that the storage structure maintained its own micro-environment which could not be easily influenced by the temperature and humidity changes outside.



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35.0
30.0
25.0
20.0
% RELATIVE HUMIDITY
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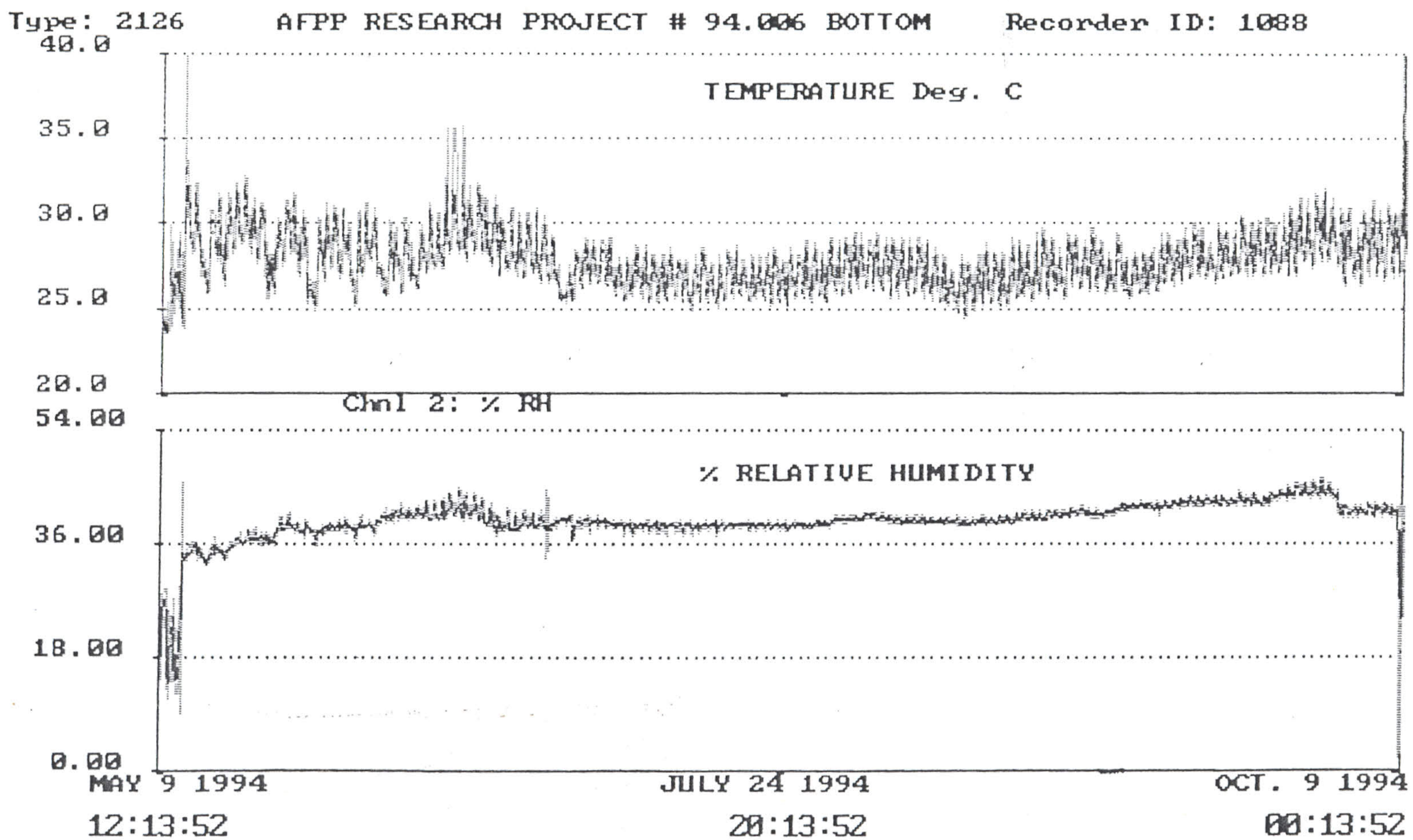
54.0
36.0
18.0
MAY 9 1994
12:12:36
JULY 24 1994
20:12:36
OCT.9 1994
00:12:36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Recorder ID: 1088
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35.0
30.0
25.0
20.0
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Chnl 2: % RH
54.00
36.00
18.00
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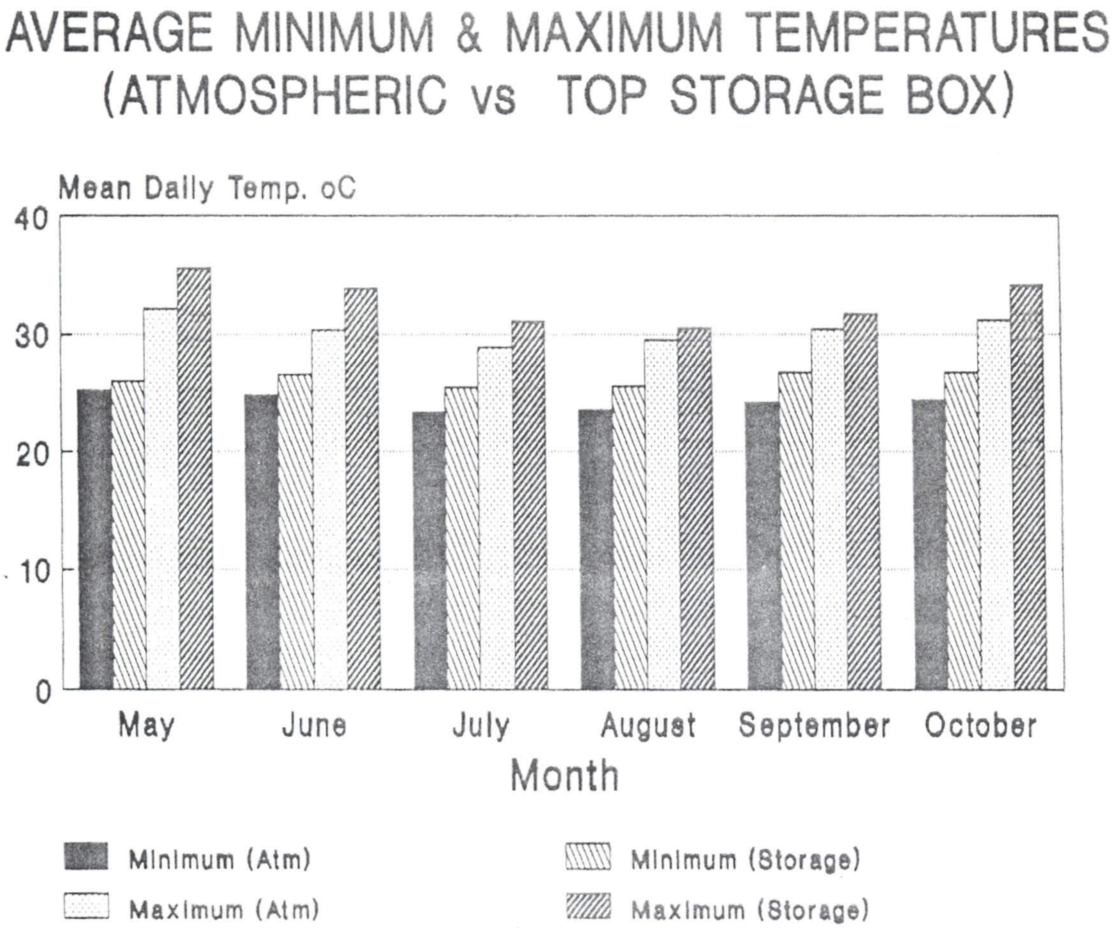

FIGURE 3

Both minimum and maximum monthly average temperatures were higher in the top storage structures than outside atmospheric temperatures in the area (Fig. 3). The outside temperatures ranged between an average minimum of 23°C and an average maximum of 31°C, while temperatures in the top storage boxes were between 25°C minimum to 35.5°C maximum for the six-month period of study. The

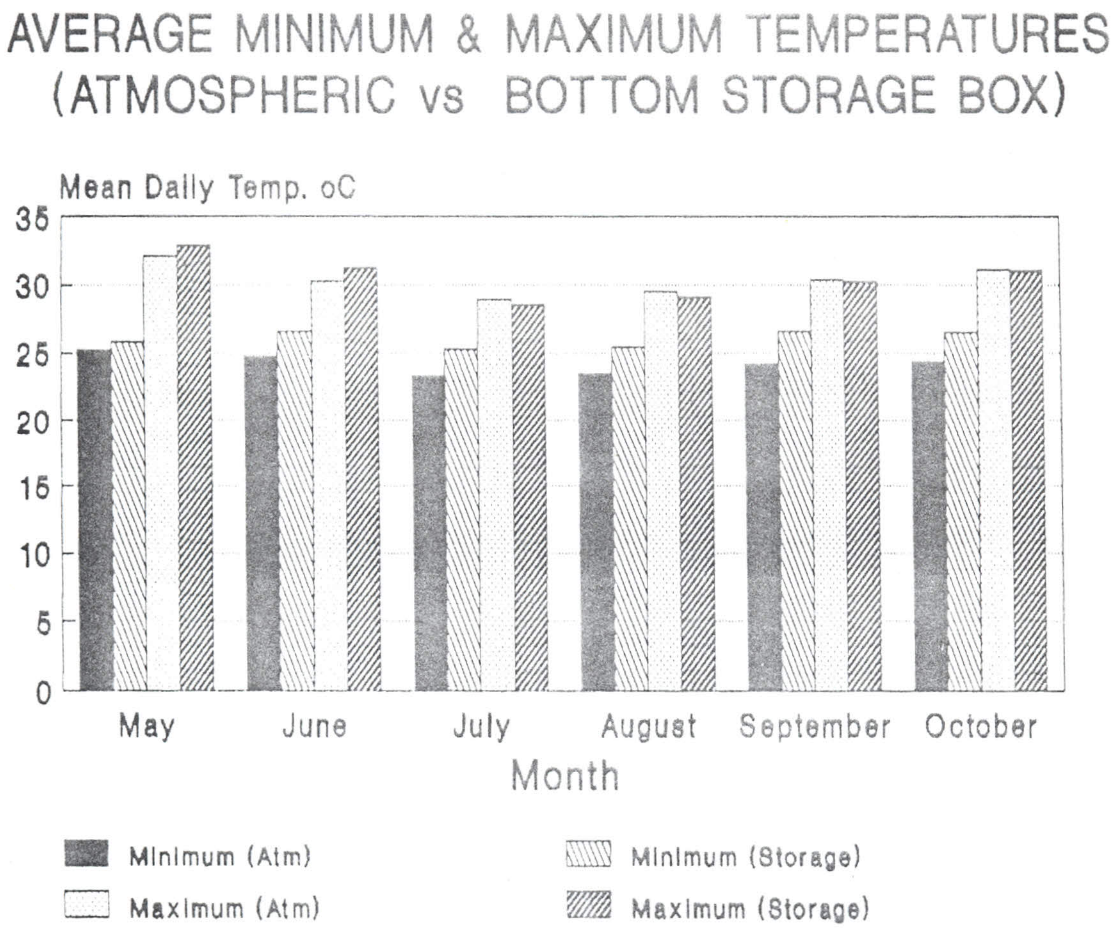

FIGURE 4

minimum temperatures in the bottom storage boxes were also higher than atmospheric; but the maximum temperatures recorded were found to be similar to the atmospheric temperatures (Fig. 4).

Highest environmental temperatures were recorded in the months of May and June and between September and October. July and August were found to be colder. These changes in the outside temperatures

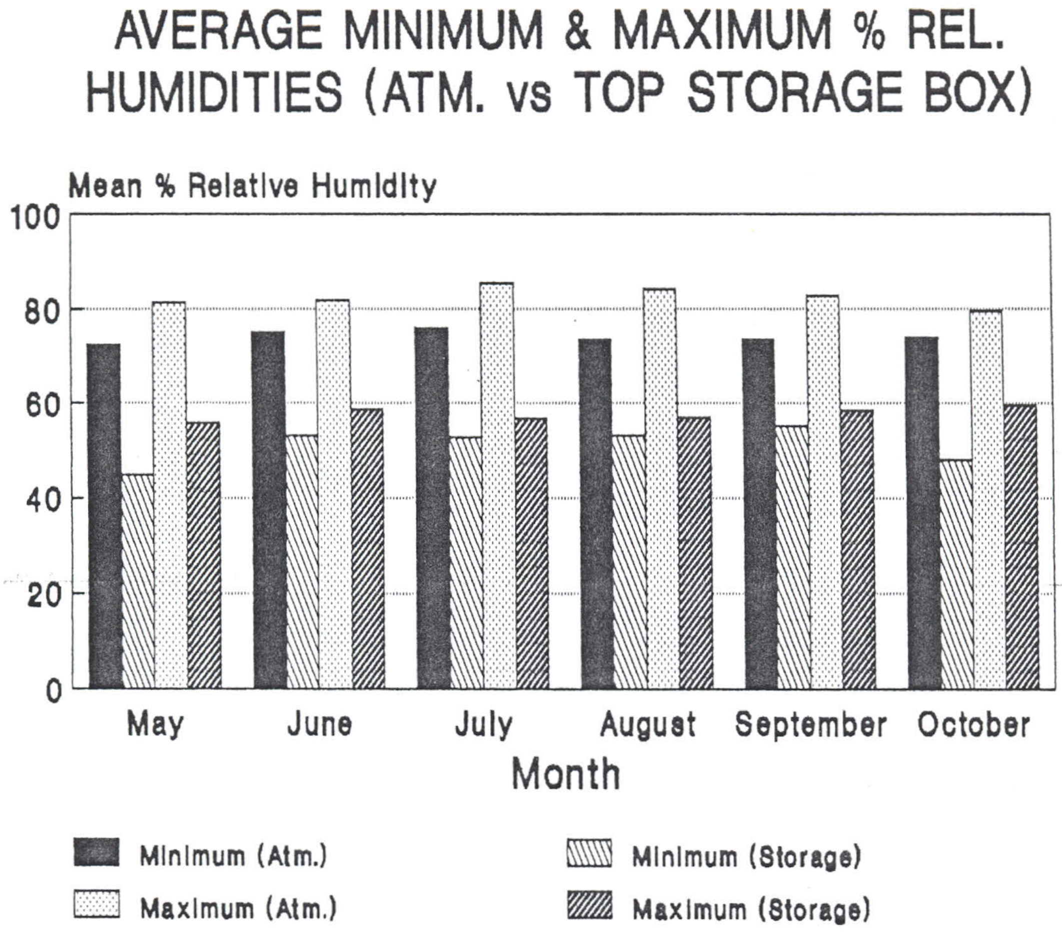

FIGURE 5

were not however reflected in the temperatures inside the storage structures. The temperatures in the structures were fairly similar throughout the period with no significant influence from the changes in the atmospheric temperatures.

Contrary to the observations in the temperature conditions, humidity in the structures were far lower than atmospheric (Figs.

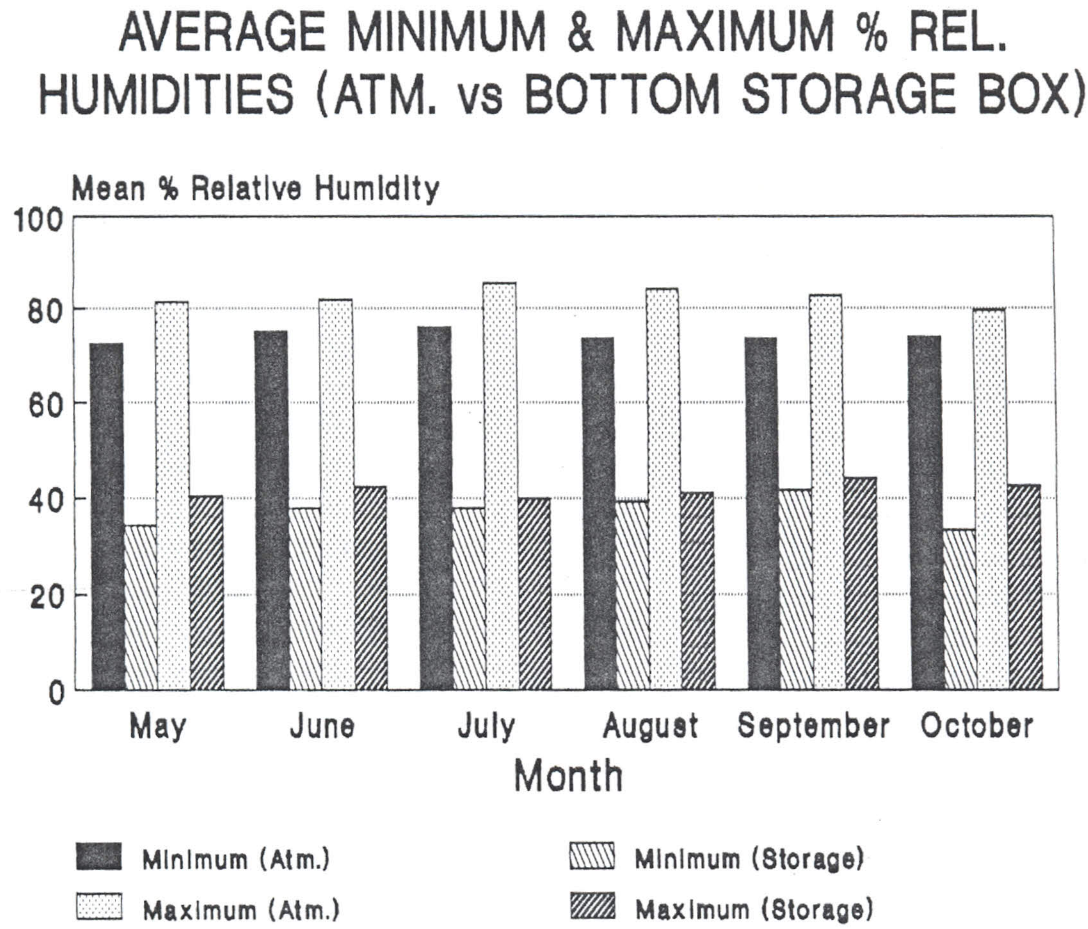

FIGURE 6

5 and 6). Storage humidities ranged between 34% and 59% while the atmospheric humidities were found to range between 72.5% and 85.5% during the test period. The ability of the storage structures to maintain such low humidities without adverse influences from the atmospheric humidity fluctuations is quite a desirable characteristic that would retard deterioration of the fish.

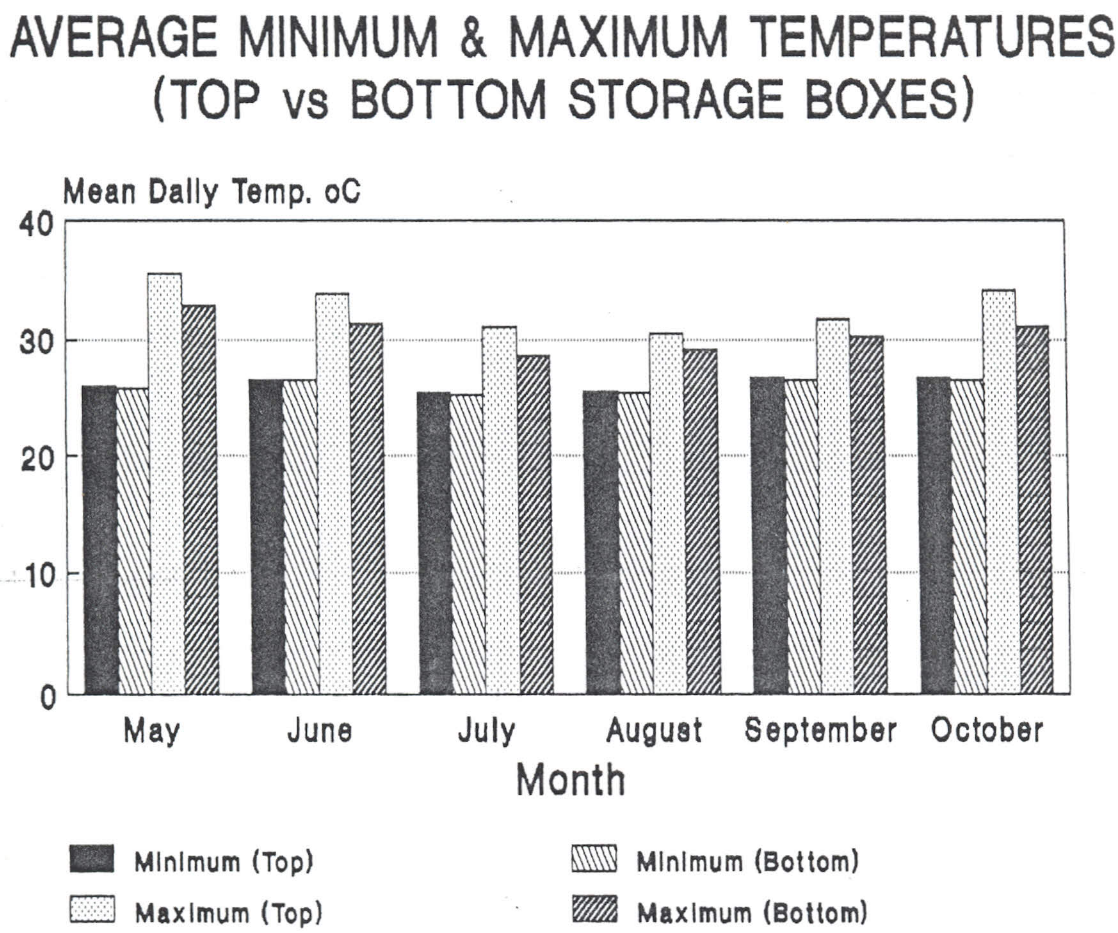

FIGURE 7

Comparing the storage conditions in the relative positioning of the storage boxes (Figs. 7 and 8), it was observed that the minimum temperatures recorded were similar in both the top and bottom boxes throughout the period. A slight but significantly higher maximum initial temperatures were however recorded in the top boxes.

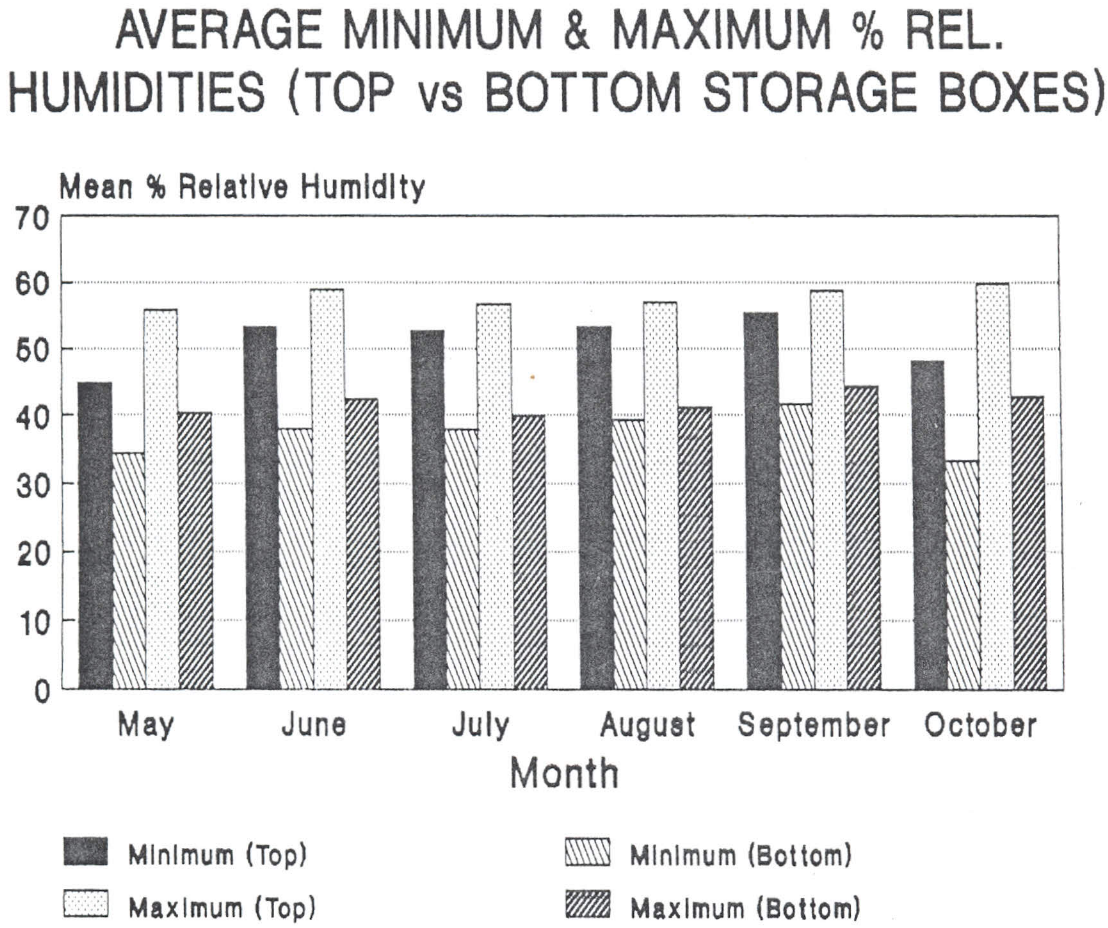
AVERAGE MINIMUM & MAXIMUM % REL.
HUMIDITIES (TOP vs BOTTOM STORAGE BOXES)
Mean % Relative Humidity
70
60
50
40
30
20
10
0
May
June
July
August
September
October
Month
Minimum (Top)
Minimum (Bottom)
Maximum (Top)
Maximum (Bottom)

FIGURE 8

3.2. Physical and Sensory characteristics of smoked anchovies

Almost 95% of the fish prepared for storage in the improved structures were physically sound and whole (Table 1). There were no visible mouldiness or insect infestation in any of the samples examined. As observed in previous studies, the few broken pieces observed could be the direct result of handling during packaging and storage, but not due to physical deterioration.

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

The results of the six-month storage showed a storage yield of over 93% physically sound product in the lower storage boxes (Table 1). The upper storage boxes had slightly lower storage yields than the lower ones. This was due mainly to higher mouldiness and insect infestation in the upper boxes. The remaining 7% or less was made up of physically damaged samples such as broken pieces, insect infestation, visible mouldiness etc. which in actual fact could be used for animal feed. They were not complete losses as such.

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

Physical characteristics		Lower storage box		Upper storage box	
		0 mo.	6 mo	0 mo.	6 mo.
Total examined	(g)	801.80	790.50	801.80	810.40
	(%)	100.00	100.00	100.00	100.00
Whole unbroken	(g)	766.60	741.49	766.60	767.45
	(%)	95.60	93.80	95.60	94.70
Broken pieces	(g)	35.20	49.01	35.20	42.95
	(%)	4.40	6.20	4.40	5.30
Visibly mouldy	(g)	0.00	22.13	0.00	46.19
	(%)	0.00	2.80	0.00	5.70
Insect Infested	(g)	0.00	11.86	0.00	19.45
	(%)	0.00	1.50	0.00	2.40
Overall physical damage	(g)	35.20	83.00	35.20	108.59
	(%)	4.40	10.50	4.40	13.40
Storage damages	(g)	-	47.80	-	73.39
	(%)	-	6.00	-	9.06
Storage yield	(g)	-	742.70	-	737.01
	(%)	-	93.95	-	90.94

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 fish stored in the improved structures. This analysis is very useful in characterising the sensory properties of the samples quantitatively for reliable comparisons to be made. Typical of freshly smoked fish (Plahar *et al.*, 1991), the smoked anchovies studied scored very highly for flavour, aroma and colour in relation to the expected freshness

Table 2. Quantitative descriptive analysis of smoked anchovies (*Anchoa guineensis*) stored in improved structures.

Sensory characteristic	Initial fresh sample	Mean scores for stored samples (6 mo.)	
		Lower box	Upper box
Hardness	6.6 (firm to hard)	7.1 (firm to hard)	6.9 (firm to hard)
Brittleness	6.5 (neither crumbly nor brittle)	6.6 (neither crumbly nor brittle)	6.8 (neither crumbly nor brittle)
Chewiness	6.0 (chewy)	8.1 (chewy to tough)	7.8 (chewy to tough)
Flavour	9.4 (freshly smoked)	9.3 (freshly smoked)	9.2 (freshly smoked)
Aroma	9.8 (fresh smoky)	9.0 (fresh smoky)	8.7 (fresh smoky)
Colour	9.6 (light brown)	9.0 (light brown)	8.8 (light brown)

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 fish.
Aroma : 0=mouldy or rancid, 10=fresh smoky aroma
Colour : 0=black, 10=light brown

values. The freshly smoked samples possessed the characteristic fresh smoky aroma with typical freshly-smoked fish flavour. Other quantitative descriptive scores also characterized the samples as firm to hard, chewy as well as being neither brittle nor crumbly.

These are some of the typical quality attributes that are expected to be preserved by the storage techniques employed in order to enhance product safety and consumer acceptability.

After six months in storage, the samples became slightly harder and tougher. There was also a slight darkening in the colour. Flavour, aroma and brittleness did not change significantly. The slight changes observed could be attributed to the low humidity and high temperatures in the structures. No significant differences were observed in the sensory attributes of samples stored in the lower and upper storage boxes.

3.3. Changes in the proximate composition and chemical properties

Both the fat and moisture contents were low enough to present little deterioration problems during storage (Table 3). High-fat smoked fish samples develop rancidity problems within a short period of storage. With moisture, earlier work by Okoso-Amaa *et al.* also indicated that the shelf-life of smoked *Sardinella* spp. varied according to the moisture content. 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. During the six months in storage the most significant change in the proximate composition of the fish samples was in the moisture content. There was a reduction in the moisture content of the smoked fish samples from the initial value of about 13% to about 11% by the end of the six-month storage period. This situation helped a great deal in the

Table 3. Effect of improved storage on the proximate composition and mineral content of smoked anchovies (*Anchoa guineensis*).

Component	Whole fish		Edible portion	
	0 mo.	6 mo.	0 mo.	6 mo.
Lower storage box:				
Moisture (%)	12.95	10.77	13.21	11.01
Protein (%)	61.54	60.48	65.00	62.95
Fat (%)	6.62	6.43	5.82	5.80
Ash (%)	15.40	15.31	10.55	10.70
Calcium (%)	2.85	2.91	1.51	1.48
Phosphorus (%)	2.88	2.79	2.90	2.77
Iron (%)	0.01	0.01	0.01	0.01
Upper storage box:				
Moisture (%)	12.95	11.07	13.21	11.44
Protein (%)	61.54	61.23	65.00	63.79
Fat (%)	6.62	6.57	5.82	5.22
Ash (%)	15.40	15.44	10.55	10.49
Calcium (%)	2.85	2.88	1.51	1.73
Phosphorus (%)	2.88	2.82	2.90	2.84
Iron (%)	0.01	0.01	0.01	0.01

[1]Values are means of triplicate determination

preservation of the fish in terms of proteolytic and lipolytic deterioration as well as microbial and mycotoxicological quality.

As observed in previous studies, 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 the freshly smoked anchovy samples (Table 4). The TVBN values obtained in this study ranged between 100 and 119 mg N/100 g sample. Farber (1965) reported a suggested upper limit of 60 mg N/100 g for marine fish. Based on about 80% moisture for fresh marine fish, this upper limit value is about 300 mg N/100 g sample. The samples prepared for storage were therefore far below the limit suggested for TVBN content. In a recent study, Hodari-Okae *et al.* (1991) obtained TVBN values of between 18 - 22 mg N/100 g fresh fish for some species of marine fish purchased from some fish markets in Ghana. On dry weight basis, these values are also between 90 - 110 mg N/100 g sample. Plahar (1992) also observed a range of 103 - 116 mg N/100g sample for smoked anchovies.

In the present study, fat acidity was also found to be low and there were only traces of peroxides present. 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.

During storage TVBN concentration of the fish samples increased slightly but significantly ($P < 0.05$). Increases recorded in samples from the upper storage boxes were greater than for samples from the lower storage boxes. Removal of non-edible portions of the fish further reduced the TVBN content. Previous studies on storage of smoked herring showed decreases in the TVBN content of samples stored by traditional and modified (improved) techniques (Plahar *et al.* 1991). Both techniques involved re-smoking of the samples. In a recent study on the traditional storage of smoked anchovy however, Plahar *et al.* (1992) observed that TVBN increased by about 50% of the original value after the six-month storage period. The traditional storage of smoked

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

Chemical	Storage period (mo)	Fat acidity (mg KOH/g)	TVBN (mg N/100g)	NPN (g N/100g)
Whole fish				
Lower box	0	2.05	118.47	2.03
	6	3.11	133.80	2.13
Upper box	0	2.05	118.47	2.03
	6	3.74	168.70	2.22
Edible portion				
Lower box	0	2.34	100.80	1.47
	6	2.67	101.45	1.63
Upper box	0	2.34	100.80	1.47
	6	2.93	145.00	2.10

anchovy, and the conditions of the present study did not involve any re-smoking operations. The occasional re-smoking of stored smoked herring could therefore be responsible for the decreases in the TVBN content reported in the previous studies. The relatively volatile bases could easily be driven off by the hot smoke. A similar decreasing trend was observed in the NPN values of the smoked herring, perhaps due to loss of the TVBN component.

Fat acidity was also low. The initial value of about 2 mg KOH/g sample almost doubled after six months of storage. Hodari-Okae *et al.*(1991) observed a possible relationship between fat acidity and marine fish freshness.

3.4. Microbiological Quality of stored fish

Total aerobic viable counts/g for both whole and edible portions of the fresh samples were low, being 6.0×10^3 and 5.1×10^3 organisms respectively (Table 5). Mould and yeast counts recorded were very low for the fish samples. Cocci and Micrococci were the only bacterial organisms recorded and in very small amounts. There was absence of coliforms and faecal coli as well as any pathogenic microorganisms. The fish was found to be microbiologically sound and safe for consumption. Absence of faecal organisms also indicated proper hygienic handling of the fish during processing and storage.

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, the edible portions of the freshly smoked fish had very low and acceptable bacterial and fungal loads.

Only slight increases were observed in the levels of aerobic bacterial count during storage, with pH decreasing from 6.2 to 5.9. The initial temperature and humidity conditions in the structure were quite ideal for the rapid proliferation of the few bacteria present in the freshly smoked samples. Mould growth was however, not favoured. During storage, fairly anaerobic conditions and low humidity existed in the structures. This situation could cause a drastic reduction in the rate of proliferation of the aerobic

Table 5. Microbiological quality of whole and edible portions of freshly smoked anchovies (*Anchoa guineensis*)

Test	Initial fresh sample	Stored for six months	
		Lower box	Upper box
Physical appearance	Dark-brown meal	Dark-brown meal	Dark-brown meal
Viable organisms			
Aerobic bacterial count per gram	6.0×10^3	275×10^3	300×10^3
Mould count per gram	$< 10^1$	$< 10^1$	$< 10^1$
pH	6.3	5.9	5.7
Culture	Gm +ve cocci and Micrococci	Gm +ve cocci and Micrococci	Gm +ve cocci and Micrococci
Coliforms (in 0.1 g)	Absent	Absent	Absent
Faecal coli (in 0.1g)	Absent	Absent	Absent
Pathogens			
Salmonella in 25g sample	Absent	Absent	Absent
Staphylococcus	Absent	Absent	Absent

organisms, giving a final product with microbiological quality similar to that of the original samples stored.

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APPENDICES

TEMPERATURE AND HUMIDITY RECORDINGS IN TOP STORAGE STRUCTURES

Output compressed by a factor of 12

Date	Time	Ch1	Min	Avg	Max	Ch2	Min	Avg	Max
"05/09/94"	"12:12:36"		23.2	25.0	29.1		23.2	35.2	46.9
"05/11/94"	"12:12:36"		23.7	28.8	35.6		20.0	39.9	68.2
"05/13/94"	"12:12:36"		26.0	29.9	37.0		42.7	48.3	50.2
"05/15/94"	"12:12:36"		26.3	31.3	37.4		43.1	48.7	52.3
"05/17/94"	"12:12:36"		28.3	32.4	37.8		44.2	49.9	53.7
"05/19/94"	"12:12:36"		27.7	31.3	37.7		47.5	51.2	54.4
"05/21/94"	"12:12:36"		25.8	29.3	34.2		48.4	51.9	54.8
"05/23/94"	"12:12:36"		27.9	31.4	35.7		47.8	53.4	56.3
"05/25/94"	"12:12:36"		25.7	30.1	35.3		50.2	53.9	56.4
"05/27/94"	"12:12:36"		25.4	29.5	37.8		48.2	54.7	59.1
"05/29/94"	"12:12:36"		27.0	30.7	36.1		51.7	55.3	58.8
"05/31/94"	"12:12:36"		24.9	28.5	32.9		50.7	56.9	59.0
"06/02/94"	"12:12:36"		27.0	30.7	37.7		50.5	56.6	60.0
"06/04/94"	"12:12:36"		25.3	27.6	32.4		55.3	58.9	62.1
"06/06/94"	"12:12:36"		25.0	28.2	31.8		55.7	59.6	62.1
"06/08/94"	"12:12:36"		25.2	27.8	32.4		53.6	59.0	60.8
"06/10/94"	"12:12:36"		26.0	28.7	32.3		54.1	58.4	60.8
"06/12/94"	"12:12:36"		26.0	29.6	35.8		53.1	57.7	60.7
"06/14/94"	"12:12:36"		27.3	30.5	35.1		55.6	57.7	60.2
"06/16/94"	"12:12:36"		28.2	31.0	35.7		54.8	56.4	58.6
"06/18/94"	"12:12:36"		27.4	30.4	35.1		53.5	55.4	57.5
"06/20/94"	"12:12:36"		27.2	29.7	33.6		53.4	54.9	56.6
"06/22/94"	"12:12:36"		27.0	29.8	33.3		52.2	54.7	56.8
"06/24/94"	"12:12:36"		26.6	29.9	35.3		51.5	53.8	55.8

"06/26/94""12:12:36"	26.1	27.9	32.0	51.8	53.8	55.6
"06/28/94""12:12:36"	26.8	28.8	31.2	51.7	54.8	59.5
"06/30/94""12:12:36"	27.2	29.6	33.3	52.1	53.4	55.3
"07/02/94""12:12:36"	26.6	29.2	32.9	51.2	52.5	54.0
"07/04/94""12:12:36"	25.8	27.8	30.2	51.8	53.6	55.4
"07/06/94""12:12:36"	25.8	28.5	32.0	51.5	53.8	55.7
"07/08/94""12:12:36"	25.6	27.8	30.8	52.2	54.3	56.4
"07/10/94""12:12:36"	25.4	27.9	31.7	52.7	54.9	56.5
"07/12/94""12:12:36"	25.1	27.1	30.3	52.8	55.6	57.3
"07/14/94""12:12:36"	25.1	27.4	31.4	53.0	55.8	57.6
"07/16/94""12:12:36"	25.6	27.6	30.3	53.3	55.9	57.7
"07/18/94""12:12:36"	25.2	27.4	31.1	53.5	55.9	57.4
"07/20/94""12:12:36"	25.2	26.9	29.3	54.0	56.0	57.5
"07/22/94""12:12:36"	25.0	27.1	30.2	53.6	55.6	57.3
"07/24/94""12:12:36"	24.8	27.2	30.7	52.9	55.4	57.1
"07/26/94""12:12:36"	25.4	27.6	31.2	52.4	55.2	56.8
"07/28/94""12:12:36"	25.3	27.5	31.0	52.3	54.8	56.5
"07/30/94""12:12:36"	25.8	28.3	32.0	51.9	54.7	56.6
"08/01/94""12:12:36"	26.1	28.4	31.4	52.7	54.7	56.4
"08/03/94""12:12:36"	26.0	28.2	31.2	52.6	55.0	56.6
"08/05/94""12:12:36"	25.8	28.1	30.9	53.0	54.9	56.5
"08/07/94""12:12:36"	25.7	27.9	30.7	52.5	54.6	56.1
"08/09/94""12:12:36"	25.7	27.8	30.4	52.7	54.7	56.4
"08/11/94""12:12:36"	25.3	27.4	30.4	52.8	54.8	56.2
"08/13/94""12:12:36"	24.7	26.3	28.7	53.5	55.5	56.9
"08/15/94""12:12:36"	24.7	26.8	29.7	53.0	55.1	56.7

"08/17/94""12:12:36"	25.3	27.5	30.8	52.1	54.8	56.6
"08/19/94""12:12:36"	25.3	27.1	29.7	53.1	54.8	56.2
"08/21/94""12:12:36"	25.7	27.8	31.3	51.8	54.6	56.2
"08/23/94""12:12:36"	25.7	27.8	31.2	52.2	54.8	56.4
"08/25/94""12:12:36"	25.6	27.8	31.3	52.4	55.3	57.2
"08/27/94""12:12:36"	25.3	27.4	30.6	54.4	57.0	58.5
"08/29/94""12:12:36"	25.7	27.4	29.9	55.5	57.9	59.4
"08/31/94""12:12:36"	25.9	27.7	30.0	56.1	58.2	59.3
"09/02/94""12:12:36"	26.2	28.2	32.0	54.5	57.9	59.5
"09/04/94""12:12:36"	25.8	27.5	30.2	55.6	58.0	59.2
"09/06/94""12:12:36"	26.0	27.7	29.7	56.0	57.9	59.2
"09/08/94""12:12:36"	26.3	28.2	30.9	55.4	57.6	59.0
"09/10/94""12:12:36"	26.6	28.6	31.8	54.9	57.4	59.0
"09/12/94""12:12:36"	26.6	28.5	31.6	55.4	57.1	58.4
"09/14/94""12:12:36"	26.4	28.2	31.1	56.1	57.5	58.9
"09/16/94""12:12:36"	26.9	28.5	30.8	56.0	57.5	58.8
"09/18/94""12:12:36"	26.9	28.8	32.0	55.6	57.7	59.2
"09/20/94""12:12:36"	27.0	28.7	31.2	56.3	57.9	59.2
"09/22/94""12:12:36"	27.2	28.9	31.6	55.6	58.0	59.6
"09/24/94""12:12:36"	27.6	30.2	33.8	55.1	56.8	58.8
"09/26/94""12:12:36"	27.6	30.2	33.4	54.0	55.8	57.6
"09/28/94""12:12:36"	27.4	30.0	33.8	53.9	55.1	56.4
"09/30/94""12:12:36"	26.3	28.5	31.6	53.7	55.3	56.9
"10/02/94""12:12:36"	26.3	28.7	31.7	54.2	56.0	57.6
"10/04/94""12:12:36"	27.1	29.7	33.2	53.6	55.6	57.6
"10/06/94""12:12:36"	26.8	29.6	37.4	36.3	55.2	63.9

TEMPERATURE AND HUMIDITY RECORDINGS IN BOTTOM STORAGE STRUCTURES

Output compressed by a factor of 12

Date	Time	Ch1	Min	Avg	Max	Ch2	Min	Avg	Max
"05/09/94"	"12:13:52"		23.4	25.4	29.9		11.2	20.7	29.0
"05/11/94"	"12:13:52"		23.8	28.4	48.0		9.0	26.6	45.8
"05/13/94"	"12:13:52"		25.8	28.4	32.4		32.8	34.7	36.5
"05/15/94"	"12:13:52"		26.2	29.1	31.9		32.5	34.8	37.1
"05/17/94"	"12:13:52"		28.2	30.3	32.4		33.2	35.5	37.9
"05/19/94"	"12:13:52"		27.6	30.0	32.8		35.7	36.8	38.9
"05/21/94"	"12:13:52"		25.6	28.0	31.2		35.6	36.8	38.0
"05/23/94"	"12:13:52"		27.4	29.4	31.4		35.7	38.6	41.2
"05/25/94"	"12:13:52"		25.2	28.6	31.8		36.8	38.4	39.7
"05/27/94"	"12:13:52"		24.9	27.4	30.3		35.5	37.9	40.0
"05/29/94"	"12:13:52"		26.8	29.1	31.2		37.0	38.5	40.1
"05/31/94"	"12:13:52"		25.1	28.0	31.0		37.2	38.8	40.3
"06/02/94"	"12:13:52"		26.9	28.9	31.2		36.4	38.7	40.6
"06/04/94"	"12:13:52"		25.7	27.6	31.0		37.3	39.3	41.9
"06/06/94"	"12:13:52"		25.8	27.9	30.2		39.3	40.5	42.5
"06/08/94"	"12:13:52"		26.1	27.6	30.3		39.4	40.7	42.0
"06/10/94"	"12:13:52"		27.0	28.7	31.2		39.6	40.9	43.2
"06/12/94"	"12:13:52"		27.3	29.5	35.6		39.6	41.3	44.2
"06/14/94"	"12:13:52"		27.8	30.0	35.8		39.7	41.9	45.0
"06/16/94"	"12:13:52"		28.2	29.9	32.4		39.6	41.4	44.2
"06/18/94"	"12:13:52"		26.9	29.1	31.7		37.3	39.9	43.4
"06/20/94"	"12:13:52"		26.9	28.6	31.0		37.8	39.0	41.7
"06/22/94"	"12:13:52"		26.7	28.5	30.7		38.0	39.4	41.6
"06/24/94"	"12:13:52"		26.4	28.3	31.0		33.8	39.4	44.8

"06/26/94""12:13:52"	25.2	26.6	29.3	37.7	39.3	40.4
"06/28/94""12:13:52"	25.3	26.8	28.4	36.4	39.3	40.8
"06/30/94""12:13:52"	26.4	27.5	29.2	37.5	39.5	40.8
"07/02/94""12:13:52"	25.7	27.4	29.2	38.2	39.4	40.4
"07/04/94""12:13:52"	25.4	26.7	28.0	37.3	39.0	39.8
"07/06/94""12:13:52"	25.3	27.0	28.8	37.3	38.9	39.8
"07/08/94""12:13:52"	25.2	26.6	28.1	37.5	38.9	40.0
"07/10/94""12:13:52"	25,3	26.7	28.6	37.3	39.0	39.9
"07/12/94""12:13:52"	24.9	26.3	28.1	37.2	38.8	40.0
"07/14/94""12:13:52"	25.0	26.4	28.6	37.6	38.9	39.8
"07/16/94""12:13:52"	25.3	26.7	28.4	37.3	38.8	39.8
"07/18/94""12:13:52"	25.3	26.7	28.8	38.3	39.1	39.9
"07/20/94""12:13:52"	25.3	26.6	28.2	37.9	39.0	39.7
"07/22/94""12:13:52"	25.1	26.6	28.6	37.9	38.9	39.8
"07/24/94""12:13:52"	25.1	26.6	28.6	38.0	39.0	40.0
"07/26/94""12:13:52"	25.3	26.9	29.0	38.4	39.1	39.7
"07/28/94""12:13:52"	25.3	26.8	28.9	38.4	39.2	40.0
"07/30/94""12:13:52"	25.7	27.3	29.2	38.5	39.7	40.8
"08/01/94""12:13:52"	25.8	27.5	29.4	39.2	40.0	40.8
"08/03/94""12:13:52"	26.0	27.4	29.4	39.6	40.3	41.2
"08/05/94""12:13:52"	25.6	27.4	29.4	39.3	40.2	41.2
"08/07/94""12:13:52"	25.6	27.2	29.2	39.0	39.7	40.8
"08/09/94""12:13:52"	25.6	27.3	29.2	39.2	39.8	40.8
"08/11/94""12:13:52"	25.3	26.8	29.0	39.0	39.6	40.4
"08/13/94""12:13:52"	24.7	26.2	28.1	38.9	39.6	40.5
"08/15/94""12:13:52"	24.4	26.1	28.2	38.8	39.4	40.4

"08/17/94""12:13:52"	25.1	26.6	28.9	38.9	39.6	40.8
"08/19/94""12:13:52"	25.1	26.5	28.3	39.0	39.7	40.8
"08/21/94""12:13:52"	25.6	27.0	29.2	39.0	39.9	41.2
"08/23/94""12:13:52"	25.4	27.1	29.4	39.6	40.3	41.6
"08/25/94""12:13:52"	25.6	27.3	29.8	39.5	40.3	41.6
"08/27/94""12:13:52"	25.6	27.3	29.4	40.0	40.7	42.0
"08/29/94""12:13:52"	26.0	27.5	29.3	40.2	41.1	42.4
"08/31/94""12:13:52"	25.9	27.4	29.8	40.0	40.7	42.0
"09/02/94""12:13:52"	26.0	27.2	29.4	40.4	41.4	42.8
"09/04/94""12:13:52"	25.6	26.7	28.3	41.2	41.9	43.2
"09/06/94""12:13:52"	25.8	27.0	28.6	41.2	42.0	43.2
"09/08/94""12:13:52"	26.3	27.6	29.4	40.4	42.0	43.2
"09/10/94""12:13:52"	26.4	27.9	29.8	41.6	42.6	43.8
"09/12/94""12:13:52"	26.7	28.0	30.1	41.9	42.7	44.0
"09/14/94""12:13:52"	26.4	27.9	30.0	41.8	42.8	44.0
"09/16/94""12:13:52"	26.9	28.1	29.7	41.7	42.8	44.4
"09/18/94""12:13:52"	26.9	28.2	30.6	42.0	42.9	44.8
"09/20/94""12:13:52"	26.9	28.3	30.3	41.8	42.8	44.4
"09/22/94""12:13:52"	26.9	28.3	30.7	42.8	43.8	45.2
"09/24/94""12:13:52"	26.9	29.0	31.6	43.1	44.3	45.8
"09/26/94""12:13:52"	27.3	29.4	31.8	43.2	44.5	46.4
"09/28/94""12:13:52"	27.4	29.4	32.1	42.0	44.2	46.4
"09/30/94""12:13:52"	26.3	28.4	31.0	39.8	41.1	42.8
"10/02/94""12:13:52"	26.3	28.3	30.8	40.1	41.3	42.8
"10/04/94""12:13:52"	26.6	28.7	31.3	39.8	41.3	42.8
"10/06/94""12:13:52"	26.7	29.4	30.9	2.0	40.2	42.4

TEMP/HUM RECORDINGS -AKPLABANYA 1994

MAY
TEMP.

MINIMUM	MAXIMUM	AVERAGE
23	33	28
25	29	27
26	31	28.5
23	33	28
26	33	29.5
27	33	30
27	33	30
28	33	30.5
23	31	27
23	32	27.5
26	33	29.5
26	33	29.5
25	33	29
23	29	26
27	32	29.5
24	33	28.5
27	32	29.5
28	33	30.5
28	33	30.5
24	32	28
22	34	28
24	30	27
27	32	29.5
28	33	30.5
26	33	29.5
22	32	27
23	29	26
24	32	28
26	32	29
23	33	28
28	32	30
25.22580	32.12903	28.67741
1.931800	1.268412	1.600106

JUNE
TEMP.

MINIMUM	MAXIMUM	AVERAGE
28	29	28.5
21	31	26
26	32	29
24	32	28
25	28	26.5
24	31	27.5
26	31	28.5
24	31	27.5
26	28	27
23	29	26
25	32	28.5
26	30	28
24	31	27.5
26	31	28.5
26	32	29
26	31	28.5
23	32	27.5
26	31	28.5
26	30	28
25	30	27.5
22	31	26.5
25	30	27.5
25	31	28
25	31	28
25	31	28
24	31	27.5
25	26	25.5
22	27	24.5
24	30	27
25	30	27.5
24.73333	30.33333	27.53333
1.459071	1.468181	1.463626

JULY
TEMP.

MINIMUM	MAXIMUM	AVERAGE
25	31	28
25	31	28
25	30	27.5
24	30	27
24	29	26.5
24	29	26.5
23	29	26
23	29	26
23	29	26
23	29	26
23	29	26
23	29	26
23	29	26
23	29	26
23	29	26
23	29	26
23	28	25.5
23	29	26
23	29	26
23	27	25
23	28	25.5
23	29	26
23	29	26
23	26	24.5
23	29	26
23	28	25.5
23	29	26
23	29	26
23	29	26
23	29	26
23	29	26
23.29032	28.93548	26.11290
0.632126	0.913535	0.772831

AUGUST
TEMP.

MINIMUM	MAXIMUM	AVERAGE
24	30	27
24	30	27
24	30	27
24	30	27
24	30	27
24	30	27
24	30	27
24	30	27
24	30	27
24	30	27
24	30	27
24	29	26.5
23	29	26
23	28	25.5
23	28	25.5
22	28	25
23	28	25.5
23	29	26
23	30	26.5
23	29	26
23	29	26
23	29	26
23	29	26
23	29	26
23	31	27
24	30	27
24	29	26.5
23	30	26.5
24	31	27.5
24	30	27
23	30	26.5
23.48387	29.51612	26.5
0.560585	0.798020	0.679302

SEPTEMBER
TEMP.

MINIMUM	MAXIMUM	AVERAGE
23	30	26.5
23	30	26.5
23	30	26.5
23	30	26.5
23	29	26
24	30	27
24	30	27
24	31	27.5
24	30	27
24	30	27
24	30	27
24	30	27
24	30	27
24	29	26.5
24	31	27.5
24	30	27
25	31	28
25	32	28.5
25	31	28
24	32	28
24	30	27
25	30	27.5
25	31	28
24	30	27
24	31	27.5
25	31	28
25	31	28
25	29	27
25	30	27.5
25	32	28.5
24.16666	30.36666	27.26666
0.687184	0.795124	0.741154

OCTOBER
TEMP.

MINIMUM	MAXIMUM	AVERAGE
26	31	28.5
25	30	27.5
24	32	28
25	31	28
24	32	28
22	32	27
25	32	28.5
25	32	28.5
24	30	27
23	31	27
26	32	29
23	29	26
24	31	27.5
23	31	27
26	32	29
25	29	27
24	32	28
24.35294	31.11764	27.73529
1.134547	1.022243	1.078395

MAY
HUMIDITY

MINIMUM	MAXIMUM	AVERAGE
70	89	79.5
71	81	76
75	77	76
69	83	76
69	85	77
70	75	72.5
71	76	73.5
80	87	83.5
73	80	76.5
71	78	74.5
75	79	77
75	87	81
81	92	86.5
77	81	79
73	80	76.5
69	79	74
69	75	72
72	78	75
70	89	79.5
71	80	75.5
72	95	83.5
69	78	73.5
71	74	72.5
70	75	72.5
70	81	75.5
77	95	86
68	77	72.5
70	79	74.5
72	78	75
75	76	75.5
84	88	86
72.54838	81.51612	77.03225
3.842367	5.857837	4.850102

JUNE
HUMIDITY

MINIMUM	MAXIMUM	AVERAGE
84	88	86
70	85	77.5
67	89	78
70	76	73
94	98	96
73	80	76.5
74	79	76.5
72	76	74
84	85	84.5
82	84	83
77	82	79.5
76	80	78
69	73	71
72	83	77.5
74	88	81
70	76	73
70	73	71.5
69	78	73.5
70	75	72.5
74	76	75
66	76	71
70	80	75
72	79	75.5
80	82	81
79	81	80
67	85	76
89	91	90
91	94	92.5
73	85	79
73	79	76
75.03333	81.86666	78.45
7.171626	6.026238	6.598932

JULY
HUMIDITY

MINIMUM	MAXIMUM	AVERAGE
72	83	77.5
72	79	75.5
72	76	74
71	79	75
75	85	80
76	88	82
74	91	82.5
78	88	83
77	88	82.5
78	87	82.5
76	83	79.5
75	82	78.5
67	80	73.5
75	86	80.5
76	87	81.5
72	87	79.5
85	86	85.5
76	87	81.5
76	85	80.5
83	87	85
78	86	82
75	86	80.5
75	85	80
83	85	84
75	88	81.5
78	87	82.5
74	91	82.5
72	82	77
79	86	82.5
83	91	87
79	89	84
76.03225	85.48387	80.75806
3.864510	3.527504	3.696007

AUGUST
HUMIDITY

MINIMUM	MAXIMUM	AVERAGE
73	93	83
72	85	78.5
72	80	76
80	86	83
75	81	78
72	81	76.5
72	79	75.5
70	84	77
75	83	79
73	85	79
72	84	78
74	82	78
71	86	78.5
79	85	82
71	85	78
78	86	82
75	94	84.5
72	83	77.5
74	79	76.5
72	85	78.5
78	84	81
73	79	76
72	90	81
73	86	79.5
72	78	75
77	83	80
75	88	81.5
72	83	77.5
74	86	80
70	83	76.5
73	80	76.5
73.58064	84.06451	78.82258
2.511575	3.715143	3.113359

SEPTEMBER
HUMIDITY

MINIMUM	MAXIMUM	AVERAGE
71	80	75.5
72	94	83
75	75	75
80	90	85
81	87	84
70	85	77.5
74	92	83
70	82	76
71	83	77
72	93	82.5
73	78	75.5
79	90	84.5
78	79	78.5
72	77	74.5
71	76	73.5
74	79	76.5
74	77	75.5
76	79	77.5
69	85	77
68	77	72.5
75	92	83.5
75	83	79
77	93	85
76	90	83
72	76	74
70	75	72.5
72	76	74
71	77	74
76	82	79
72	81	76.5
73.53333	82.76666	78.15
3.232474	6.216554	4.724514

OCTOBER
HUMIDITY

MINIMUM	MAXIMUM	AVERAGE
72	74	73
75	85	80
71	77	74
77	79	78
72	78	75
71	79	75
72	73	72.5
73	75	74
77	92	84.5
73	75	74
75	79	77
81	82	81.5
72	79	75.5
71	83	77
73	74	73.5
77	89	83
75	80	77.5
73.94117	79.58823	76.76470
2.710992	5.134185	3.922589