FINAL REPORT

ON

"Evaluation of Indigenous Food Preservation Techniques and Effect on Nutrient Quality of Preserved Foods in Ghana"

Grant No. DAN - 5053 - G - 55 - 5077 - 00

Period: 9/12/85 - 9/30/87

TO

RESEARCH AND UNIVERSITY RELATIONS

BUREAU FOR SCIENCE AND TECHNOLOGY

AGENCY FOR INTERNATIONAL DEVELOPMENT

WASHINGTON, D. C. 20523

BY

Ralphenia D. Pace and

John Y. Lu

Department of Home Economics

School of Agriculture and Home Economics

Tuskegee University

August 29, 1989

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INTRODUCTION

Ghana, a tropical country in Western Africa, may be divided into three climatic zones comprising the coastal savanna, the forest zone, and the northern high savanna zone. In the coastal savanna zone, the major food crops include cassava, maize and vegetables. Fishing, both inland and marine, is also important to this zone. In the forest and marine zone, the major cash corops are cocoa and timber, but food corps such as cassava, yam, cocoyam, sweet potatoes, fruits, vegetables and maize are also produced. In the Northern savanna zone, agriculture is confined to the rearing of livestock and cultivation of some grains and root crops. Production of foods which are highly perishible and semiperishible are mainly concentrated in the coastal savanna zone and to some extent the forest zone. These zones are also the areas where traditional food perservation is widely practiced. Factors contributing to the need for effective food preservation in Ghana are: the seasonality of food, food perishability, and limitations in market and distribution. Most staple foods are highly seasonal and is grown from one season to another. In general, Ghana experiences two seasons, dry and rainy. The rainy season begins in May and ends in October, but the main one is from May thru June, and a susidairy one in October. These are the only times in the year for food crop cultivation in most parts of the country. Although fishing can be done through out the year, the major season is from July to September. Therefore, preservation of excess food during the rainy season and glut fishing season to avoid waste and to ensure a safe food supply during the off-season could impact positively on the nutritional quality of Ghanaian diets. There are a number of food preserva-

tion methods with drying being the oldest and most commonly practiced in Ghana. Some techniques used appear not geared toward preserving nutrient quality of foods. Identification of present food preservation techniques relative to their effect on nutrient quality could provide the knowledge necessary for improved overall nutritional status. The purpose of this project was therefore to identify traditional food preservation techniques and these effect nutrient quality of foods. Specifically the project was to:

1. Identify the main techniques that are being used to preserve foods in Ghana;
2. Identify the method of preservation which affect the biological and nutritional quality of food;
3. Evaluate preservation techniques and make recommendations to improve their effect on nutritive quality of food, and
4. Obtain preserved food samples and evaluate nutrient quality and levels of possible contamination.

PROJECT DESIGN

Host Country Cooperation

Dr. W. A. Plahar of Food Research Institute (FRI), Accra, Ghana served as a consultant to the project and worked closely with the Tuskegee team in planning and implementing experiments, visiting market places and villages in various regions for sampling, preparation and storage of samples and analysis of samples.

Time Phases

The project period was two years which was divided into five phases to achieve the stated objectives.

Phase I. October, 1985-March 1986 was a preparatory stage. During this period, laboratories were equipped to complete chemical analysis procedures examined, contacts made with FRI in Ghana to set our travel schedules, preparation of travel documents, other pertinent materials were gathered related to the project.

Phase II. The first trip was made by two scientists, R. D. Pace and F. Ercanli on March 1, 1986. The following were accomplished by trip: (1) collection of literature (FRI and University of Ghana) concerning food production and traditional methods of food preservation in Ghana. (2) establishment of a close working relationship with FRI scientists and personnel (3) to market places in towns and village in various regions - the Eastern Coastal Region, the Central Coastal Region, the West Coastal region and the Rain Forest region, (4) identification and collection of samples prepared by traditional ways of preservation.

Collected samples were "gari", "kokonte", dry okra, smoked dry herrings, salted dry tilapia, trigger fish, onions and pepper.

Phase III. The second travel was made by scientists, R. D. Pace and J. Y. Lu in November, 1986. they visited three places Ada, the East coastal region, to collect cassava products, Makola, the Central region, to collect dry fish and okra samples, and Elmina, the West coastal region, to collect fresh fish samples. Samples were prepared in powder form at FRI, packaged and analysed, at FRI and Tuskegee University.

Phase IV - V. These two phases were combined. Instead of Scientists from Tuskegee University going to Ghana, Dr. W. A. Plahar of FRI was invited to come to Tuskegee University. the following were accomplished by his visit: (1) brought stored food samples for analysis and (2) pursued further areas of research as follow up to the present research at Tuskegee University. He also presented in seminar to students and faculty of Agriculture and Home Economics information on "The traditional method of food preservation in Ghana".

Nutrient Analysis

Samples collected were cassava products, "Kokonte" and "gari", Okra, smoked dry herrings, tillapia and trigger fish which were stored for six (6) months from various regions. Nutrient analysis included moisture, protein, fat, ash and carbohydrate (by difference) according to AOAC (1) at FRI, Ghana. Minerals, calcium, zinc and iron were determined by atomic absorption spectrometeric method (2) at Tuskegee University. Vitamins, riboflavin, thiamin and niacin were also determined at Tuskegee University (1). Amino acid and fatty acid composition of smoked dry

herring were determined by Medallion Laboratory, Minneapolis, MN.

Microbial Quality

Three types of fish, smoke dried herrings, salt dried trigger and salt dried tillapia, gari and kokonte and dry okra were analyzed for microbiological quality. the analysis were performed at the Food Science Laboratory, Tuskegee University. Samples were properly diluted and plated on plate count agar medium (Difco's) for total count, potato dextrose agar medium (Difco's) for mold and yeast count, Violet Bile Red agar medium for coliform count and anaerobic counts were made by incubating plate count plates in an anaerobic jar with Gas-Pak. The conditions for micobial analysis was described by Dillello (3).

RESULTS AND DISCUSSION

The literature search indicate that only limited information is available on nutrient composition of foodstuffs consumed in Ghana. Most information available are mainly for proximate composition and some minerals as iron, calcium and phosphorous (4). Limited information is available on the effects of preservation methods on nutritive value of preserved foods. In this report, the nutrient composition of reported fresh and processed foods and some data analyzed at Tuskegee University were compared on a dry weight basis. Only those foods which show definite differences are shown in Table 1 (proximate composition, calcium, phosphorus, iron and zinc) and Table 2 (thiamin, riboflavin and niacin).
In comparing preserved fish such as smoked dry herring, trigger fish, tillapia and shrimps, the data showed that protein content was generally reduced after preservation, indicating that lossess of protein might have occurred during processing and storage. Further analysis showed that there were decreases in total nitrogen and protein nitrogen but non-protein nitrogen increased. Increases in non-protein N indicated that active protein degradation occurred during smoked dry processing and storage (Table 3). It was observed that although there was a decrease in protein and increase in non-protein nitrogen, amino acid pattern did not change much before and after storage (Table 4). The smoke dry herring had a well balanced essential amino acid pattern and high in essential amino acids, lysine and mehtionine. Smoked dry herring serves as a good protein supplement to the Ghanaian diet because of their high protein (38-58%) and excellent essential amino acid content. The fat content of tilapia, trigger fish and shrimp was low for processed

products. The decrease in fat could be due to lipolysis to oil which occurred during the preservation process. A similar trend was observed with smoked dry herring analyzed at Tuskegee University (Table 3). Ash content of trigger, herring and tilapia are higher than that of the fresh one because of salting. these fish also had high calcium, phosphorus, iron and zinc, generally, mineral content did not change substantially before and after processing because minerals are stable to processing. It is apparent that in addition to protein, fish are a rich source of calcium.

Snail is considered a delicacy and is available in the marketplaces in Ghana as either fresh or dried. Fat appeared low for dried snail indicating that some lipolysis might have occured during drying. Changes in minerals, Ca, P and Fe seemed insignificant.

Baobab leaves and okra are important vegetables in Ghana. After drying protein content was lower and fat content higher for dried leaves than for fresh ones. Fat content decreased for okra after drying. Starch content of Baobab does not seem to be affected by drying.

Cassava is the major staple in West Africa. It is commonly processed into "gari" and "kokonte" because fresh cassava root can't be kept more than 3 days. Protein, fat and ash were lower for "gari" or "kokonte". Drying does not change its role as a source of calories. One advantage of processing cassava into "gari" is the detoxifying effect through hydrolysis of the cyanogenic glucosides.

Tiger nut and groundnut (peanut) are common oil seeds in Ghana. They are simply sun dried or roasted for storage and consumption. Sun drying and roasting treatments do not seem to affect proximate composition. Sun drying and roasting treatments do not seem to affect proximate

composition of these two nuts.

A fermented product of locust bean gum is called "Dawadawa". this product had higher protein and fat but lower carbohydrate than fresh ones. Carbohydrate of "Dawadawa" was low because it was hydrolyzed and lost during fermentation.

Like cassava, maize is an important staple in Ghana. A popular product called "Kenkey" which is slightly fermented during the preparation process is made from maize. Protein and carbohydrate did not differ much, but fat was lower and Ca, P, and Fe were higher in "Kenkey" than fresh maize.

Vitamin data are generally lacking in Ghanaian foods. Table 4 presents the values analyzed at Tuskegee University and the values reported by Watson (4). Smoked dry herring a common preserved fish contained a fair amount of thiamin (0.038 mg) and 0.11 mg riboflavin whereas tilapia had 0.015 mg thiamin and 0.814 mg riboflavin. The results showed that tilapia is an excellent source of riboflavin.

A comparison of cassava and cassava products, "gari" and "kokonte", showed that thiamin, riboflavin and niacin were all low in the processed products. these vitamins might have leached out during washing and fermentation of cassava.

Watson's study (4) on riboflavin content indicated that the riboflavin content was about the same for fresh cassava, cassava dough but lower for "gari" and roasted peanuts. Comparison of maize and maize products showed that riboflavin content was about the same for fresh maize, "banku" and maize dough, but riboflavin content was higher for roasted corn flour and lower for "kenkey" than for the fresh locust bean gum indicating the possibility that some increase in riboflavin

TABLE 1. Proximate and Mineral Composition of Preserved Ghanaian Foods.

Food-stuff	Preserva-tion method	Pro-tein	Fat	Ash	Carbo-hydrate	Ca	P	Fe	Zn
Herring	Fresh	38	5.9		0	477	630	4.1	
	Smoke-dry	34	9.0		0	220	600	6.4	
*Herring	Fresh	78	13.6	8.0		1307	1223	14.8	5.6
	Smoke-dry	74	17.2	7.6		1204	1910	38.8	5.3
*Trigger	Fresh	65.2	8.4	22		1716	1612	14	6.8
	Salting	64.3	5.8	30.6		1875.7	1472	12.2	10.2
*Tilapia	Fresh	64.6	23.9	11.02		1101.6	2555	15.5	3.0
	Salted dried	42.8	20.6	35.6		1195	1195	21.0	4.1
Shrimps	Fresh	63.5	5.7		0	149.6	822	9.1	
	Dried	57	3.8		0	2480	855	12.5	
Snail	Fresh	43	6.4		20	988	357	10.2	
	Dried	44	3.0		25	675	420	14.5	
Baobab Leaves	Fresh	15	1.0		52	353	380	11.0	
	Dried	11	3.7		58	221	235	15.0	
Okra	Fresh	14.4	1.8		50	558	324	16.8	
	Dried	17.5	0.8		53	910	550	26	
Cassava	Fresh	1.3	0.3		80	53.2	114	6.2	
Dough	Fermented								
Flour	Dried	1.4	0.4		82	54	115	3	
Meal	Fermented	1.7	0.1		82	43	60	1.8	

TABLE 1. Continued

(Gari)									
*Cassava	Fresh	2.38	0.95	2.38	94	71	116	6.1	0.78
*Gari	Fermented	2.07	0.32	0.87	96	13	65	3.9	0.22
*Kokonte	Dried	1.54	0.66	1.1	96	11	110	3.8	0.19
Tiger Nut	Fresh	4.2	17.9		51	12.6	273	7.7	
	Dried	4.6	21.5		54	34	265	11.5	
Peanut	Fresh	21.1	50.5		20.6	22	305	4.5	
	Roasting	21.8	50.5		20.2	44	380	4.5	
Locust Bean Gum	Fresh	19.6	11.6		30.4	112	108	14.4	
Dawadawa	Fermented	30.5	30.4		8.7	240	435	27	
Maize	Fresh	3.3	1.4		25.1	3.5	50.7	0.84	
Kenkey	Fermented	3.5	0.6		25	10	105	1.8	

*Analyzed at Tuskegee University, Dry Weight Basis.

Table 2. Vitamin Content of Some Preserved Ghanaian Foods

Foodstuff	Preservation Method	Thiamin	Riboflavin mg/100g	Niacin
*Herring	Fresh	0.035	0.45	0.31
	Smoke-Dry	0.06	0.84	0.67
*Trigger	Fresh			
	Dried	0.038	0.11	
Tilapia	Fresh			
	Dried	0.015	0.814	
*Cassava	Fresh	0.07	0.07	0.30
*Gari	Fermented	0.032	0.01	0.19
*Kokonte	Drying	0.044	0.01	0.25
Cassava				
Dough	Fermented		0.06	
Gari	:		0.03	
Kokonte	Drying		0.21	
Peanut	Fresh		0.24	
	Roasting		0.27	
Maize	Fresh		0.15	
Banku			0.14	
Dough	Fermented		0.14	
Corn Flour	Drying		0.25	

Table 2. Continue

Kenkey	Fermented	0.10
Locust Bean Gum	Fresh	0.51
Dawadawa	Fermented	0.81

*Determined at the Food Science and Nutrition Lab. Tuskegee University, Tuskegee, AL U.S.A.

*Dry Weight Basis

Table 3

PROXIMATE COMPOSITION OF SMOKED AND STORED HERRINGS IN GHANA

	Total Nitrogen* mg/100g	Nonprotein Nitrogen* mg/100g	Protein* %	Fat %	Moisture %	Ash* %
Dried-no storage time	8.1	0.033	54.52	3.89	7.5	10.5
Smoked-stored 3 months	8.0	0.027	51.42	2.86	6.6	11.4
Smoked-stored 6 months	7.3	0.128	43.77	2.13	7.9	8.4

*Data are expressed on a dry weight basis; average of duplicate determinations.

Table 4

AMINO ACID COMPOSITION OF SMOKED AND STORED HERRINGS

Amino Acid*	Dried no storage time Percent	Smoked stored 3 months Percent	Smoked stored 6 months Percent
Aspartic	10.30	11.30	12.30
Threonine	4.60	4.76	5.70
Serine	4.00	4.14	4.75
Glutamic	15.30	16.75	17.67
Proline	2.70	3.33	3.34
Glycine	7.88	7.27	8.36
Alanine	9.39	6.31	10.85
Valine	5.40	5.80	6.49
Methionine	2.34	2.45	2.45
Isoleucine	3.70	3.92	4.14
Leucine	8.49	8.87	9.89
Tyrosine	2.46	2.50	2.43

TABLE 4. Continued

Phenylalanie	3.38	3.27	3.53
Histidine	1.64	2.05	1.74
Lysine	7.89	8.52	9.89
Arginine	5.06	5.42	5.10
Ammonia	1.18	1.14	0.72

*Data are expressed on a dry weight basis; g amino acid/100g protein.

might have occurred as a result of fermentation. Drying, salting and fermentation are the most common methods used in Ghana for preservation of foods. As far as thiamin, riboflavin and niacin are concerned, these traditional methods generally do not affect the vitamin content.

High quality animal proteins such as milk and meat are limited in availability in Ghana because of high cost. High quality animal protein available in market places is fish either fresh or preserved. The most common preserved fish is smoked dry herring. In the traditional way of preservation, after smoked drying, fish are kept in the same smoke oven outdoors for several months or until fish are sold out. It was reported the losses of fish may reach 50-70% after several months (5). The loss of fish during storage appears to be a serious problem due to heavy infestation with worms and the presence of mold.

Fish oil is characterized by a multiplicity of polyunsaturated fatty acids. Table 5 shows that smoked dry herring oil had more than 20 fatty acids present. The major saturated fatty acid was C_{16}, and the major unsaturated fatty acid was $C_{22:6}$. Other fatty acids presented in appreciable amounts were C14, C16:1, C18:5 and C20:5. It was noted that two polyunsaturated fatty acids, C22:5, and C22:6, accounted for 27-30% of the oil. These fatty acids are know as omega fatty acid which was reported to reduce incidence of atheroscleosis, coronary heart disease, arthritis and a number of other pathophysiologic states (6). The fatty acid profile of smoked dry herring stored at different periods of time indicated that they were similar and not affected much by the storage period. The results indicate that smoked dry herring is a good source of omega fatty acids.

Rancidity often becomes a problem for food that contains a high

Table 5

FATTY ACID COMPOSITION OF SMOKED AND STORED HERRINGS

Amino Acid*	Dried no storage time Percent	Smoked stored 3 months Percent	Smoked stored 6 months Percent
10:0 Capric		0.70	
12:0 Lauric	0.20	0.22	1.36
14:0 Myristic	5.86	8.07	6.37
15:0 Pentadecanoic	1.26	0.75	0.740
16:0 Palmitic	29.20	26.63	27.940
16:1 Palmitoleic	5.09	11.60	7.720
18:1 Stearic	8.92	6.89	7.940
18:1 Oleic	10:64	11.54	10.78
18:2 Linoleic	1.43	2.09	2.42
18:3	0.67	0.36	0.37
20:0 Arachidic	0.56	0.25	/
20:1 Gadoleic	0.57	0.50	1.05
20:2 Eicosadienoic	0.32	0.19	0.21
20:3 Eicosatrienoic	0.20	0.30	0.27
20:4	2.22	2.17	2.27
22:5	7.68	10.95	9.41
22:0 Behenic	0.30	/	/
22:1 Erucic	/	0.17	0.67
22:5	1.14	1.39	1.20
22:6	22.36	14.19	18.11
24:0	00:30	00.27	/
24:1	00.45	/	/

*% fatty acid in oil

Table 6

ACID VALUES, PEROXIDE VALUES, AND TOTAL VALATILE BASES OF SMOKED AND STORED HERRINGS IN GHANA

	Acid Value*	Peroxide Value* (ml N/500) (thiosulfate/g)	Total Volatile Bases* (mg N/100g)
Elmina Region			
Dried - no storage time	3.59	1.0	12.6
Smoked - stored 3 months	5.21	1.1	11.2
Smoked - stored 6 months	6.61	0.8	10.5

*Date are expressed on a dry weight basis: average of duplicate determination.

proportion of fat especially when the fat contains high levels of poly-unsaturated fatty acids. The rancidity problem of smoke dry herring was investigated and the results are shown in Table 6. Acid value increased with storage time indicating active lipolysis had occurred during storage. The acid values of 5.21 and 6.61 may be considered slightly rancid. the peroxide value of fish samples stored at different times were low and did not vary much. The reason could be that aldehydes, ketones, and phenols formed as a result of smoking of wood may have deposited on the fish during smoking which may have prevented oxidation therefore, low peroxide values. Fish protein is known to posses active autolytic enzymes. Decomposition of fish protein often produces volatile bases. The volatile bases obtained (10.5 - 12.6 mg/100g) in this study was not considered high. In fact, total volatile bases decreased slightly with storage time. The reason for low total volatile bases value could be that either autolysis of fish was not severe during smoke drying or the volatile bases that once formed might have evaporated during the storage period.

The major cause of food spoilage is microoganisms. The presence of great numbers of microorganisms in food is therefore generally not desirable. High temperatures (70-90°F) and high humidity (60-85%) favors growth of microoganisms in food which is not properly stored or preserve-ed. Only limited data are available on the microbial quality of pre-served foods in Ghana. The results are shown in Table 7. Comparison of dry fish products indicated that the microbial counts were greater for smoked dry herrings than for salt dried tilapia and trigger fish. The smoke dried herrings were positive to both anaerobic and coliform counts whereas salt dried tilapia had low anaerobic count and salt dried trigger

fish had low coliform counts. It appears that microbial counts are generally low in salted dried fish. The use of salt at high concentrations and dehydration might have prevented the growth of anaerobes and coliforms which are not salt tolerant. Anaerobic count may include anaerobes as well as facultative anaerobes such as lactic acid bacteria and E. Coli. The effect of storage time on microbial count of dry fish were not clear. Only aerobic counts of smoke driet herrings decreased after storage of six months.

Microbial counts of cassava products especially that of gari were low. Both anaerobic and coliform counts were lower than that of kokonte. The development of acidity as a result of fermentation might have dicouraged the growth of anaerobes and coliforms. Gari samples analyzed in this study appeard to have a low microbial population. The microbial counts were slightly greater for kokonte than Gari. The kokonte samples were also positive to coliforms. The effect of storage time was not clear. The storage time difference between three and four and a half months may not be long enough to exhibit significant difference among kokonte and gari samples.

Among the samples analyzed in this study, okra had the highest number of microogranisms indicating a poor microbial quality of this product. The reason may be that okra contains high levels of pectin and other polysaccharides that make it viscous, sticky and hard to dry. Okra which is exposed to the outdoor environment during drying might become highly contaminated because of the longer drying time required Coliform count is used to determine lactose fermenting bacteria such as E. Coli and Enterobacter aerogenes. It is not clear why "kokonte" and okra had a relatively high coliform count while their anaerobic plate

count was low. It may be that the samples analyzed contained larger numbers of other lactose fermenting bacteria which do not grow well under anaerobic conditions. In order to reduce the microbial load, drying conditions should be improved. Higher temperatures or better ventilation may reduce drying time. Use of screens during drying will prevent insects such as flies from gathering on okra as well as fish products and prevent contamination.

In this study only mold colonies were counted becaused few yeast colonies were found in all the samples analyzed. Predominant types of molds were Aspergillus and Penicillium species. Generally mold counts were not high for cassava and fish products. They did not show any definite correlation with location and storage time for all the samples analyzed. The reason may be that foods prepared at villiages are not aseptically packaged. They are usually kept in baskets, tin cans or in paper bags loosely covered with tree leaves or newspaper and stored under an open environment, therefore foods are unprotected from mold spores in the air.

Smoked dried herrings are one of the most popular food items in Ghana. The results of this preliminary study showed that it had relatively high levels of anaerobic and coliform counts. Further study is needed to determine the presence of Clostridium botulium type E and other pathogenic bacteria. The former is often implicated in the outbreak of botulism in seafoods (7).

TABLE 7. Microbial counts[1] of foods from Ghana

Sample	Storage[2] month		Aerobic count	Anaerobic count	Mold count	Coliform count
Smoked herrings	3	Range	$2-10 \times 10^4$	$0-26 \times 10^2$	$1-63 \times 10^2$	$0-90 \times 10^2$
		Mean	4×10^4	9×10^2	16×10^2	25×10^2
	6	Range	$2-60 \times 10^2$	$0-25 \times 10^2$	$1-52 \times 10^2$	$1-6 \times 10^2$
		Mean	22×10^2	7×10^2	15×10^2	2×10^2
Salted Dry trigger fish	3	Range	$10-59 \times 10^2$	10^2	$2-66 \times 10^2$	10^2
		Mean	3×10^2	10^2	28×10^2	10^2
	6	Range	$30-59 \times 10^2$	$0-1 \times 10^2$	$2-56 \times 10^2$	10^2
		Mean	44×10^2	$0-5 \times 10^2$	22×10^2	10^2
Salted Dry tilapia	3	Range	$22-37 \times 10^2$	10^2	$1-3 \times 10^2$	$0-1 \times 10^2$
		Mean	3×10^2	10^2	2×10^2	0.5×10^2
	6	Range	$20-98 \times 10^2$	10^2	$1-2 \times 10^2$	$0-1 \times 10^2$
		Mean	44×10^2	10^2	1.5×10^2	0.5×10^2
Gari	3	Range	$2-8 \times 10^3$	10^2	$1-8 \times 10^2$	10^2
		Mean	3.4×10^3	10^2	4×10^2	10^2
	4	Range	$2-5 \times 10^2$	$0-2 \times 10^2$	$0-2 \times 10^2$	10^2
Kokonte	3	Range	$12-30 \times 10^4$	10^2	$2-10 \times 10^3$	$4-22 \times 10^2$
		Mean	16×10^4	10^2	6.5×10^3	11×10^2
	4	Range	$13-25 \times 10^4$	10^2	$6-22 \times 10^2$	$10-69 \times 10^2$
		Mean	20×10^4	10^2	11×10^2	29×10^2
Okra	3	Range	$36-55 \times 10^6$	10^2	$32-53 \times 10^2$	4--55 $\times 10^2$
		Mean	41×10^6	10^2	39×10^2	47×10^2
	6	Range	$36-52 \times 10^6$	10^2	$30-56 \times 10^3$	$22-47 \times 10^2$
		Mean	42×10^6	10^2	39×10^3	31×10^2

[1] No. of organism/g sample.

[2] Time fo storage under local condition at processor's place.

CONCLUSION

1. The main food preservation technique used in Ghana is sun drying. Preservation of food is carried out mainly in villiages. The use of refrigeration or other modern technology is limited.
2. Commonly preserved foods are "kokonte" and "gari" from cassava, and many varieties of dried fish; the most common one being smoked dry herring. the other plant foods preserved by drying are okra, pepper, legumes and peanut.
3. Fish is the most important source of high quality protein available in the diets of Ghanaian.
4. Protein content decreased and lopolysis proceeded in smoked dry herring during storage. Also substantial quantity of fish was lost during storage because of infestation by microorganisms and insects.
5. Microbial studies indicated that smoked dry herring and higher aerobic, anaerobic and coliform counts than salted dry fish. Sanitary quality of smoked dry herring needs further evaluation.

RECOMMENDATION

The most important preserved food item in Ghana is smoke dried herring for the following reasons: it is the most popular type of fish consumed in large quantity, therefore, it is economically important; secondly, fish is an important source of high quality protein for Ghanaian people. There are problems associated with the traditional way of preservation by which village people used to prepare smoke dried herring. The most serious one is the loss of fish after storage which sometimes was reported to reach as high as 50-70%. Apparently, the method of storage must be improved to prevent huge losses which occur as a result of contamination by microorganisms and or by infestation of insects. There may be some nutritional as well as health problems associated with consuming somewhat rancid smoked dry fish. High anaerobic count and coliform count of smoked dry herring are not desirable and there is need to determine the possibility of the presence of pathogenic bacteria such as Clostridium botulinum type E, Staphylococcus aurens and others which may cause outbreaks of food borne disease.

1. Modify smoke dry oven and make it more efficient in smoke drying and also prevent infestation by insects.
2. Store smoked dry fish in sealed pouches or bag kept inside to prevent exposure of the fish product to high temperature, sun, light, high humidity and dust during storage.
3. Make a nutrition study of smoke dry herring to determine if there is any health hazzard problems associated with consuming smoked dry fish stored for several months.

4. To determine if there is the presence of pathogenic bacteria such as Clostirium botulinum, Staphyococcus aureus and other pathogens present in smoked dry herring. The process must be improved if these types of pathogens are present.

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