NUTRITION REPORTS INTERNATIONAL

NUTRITIVE COMPOSITION OF SMOKE DRY HERRINGS IN GHANA

J. Y. Lu and R. D. Pace
Department of Home Economics
Tuskegee University
Tuskegee, AL
Wayne M. King
Graduate Student
Department of Nutrition and Foods
Florida State University
Tallahasee, FL
W. A. Plahar
Food Research Institute
Accra, Ghana

ABSTRACT

Smoke drying and storage of herring fish did have an effect on nutrient content. Total nitrogen, fat, thiamin and niacin decreased with storage. Contrarily, no changes were observed in amino acids, and fatty acid patterns associated with smoke drying and storage. Acid values increased with storage time indicating rancidity. Although nutrient quality did decrease over time, herrings still appear to be a good source of protein, riboflavin, niacin, calcium, iron and zinc. In addition, smoked dry herrings also contained good quantities of Omega-3 fatty acids.

INTRODUCTION

Fish processing and preservation are major concerns in Ghana because fish is the major food source of protein along the coastal and inland areas. Smoke drying is the most common preservation method for fish and accounts for 65-70% of the total catch (1). Sardinella spp. commonly known as "Herring" is the most frequently consumed fish in Ghana. To prepare smoke dried herrings, the fish are placed single layered in round shape ovens made of clay brick and dried to 10-15% moisture over a smoldering fire for 3-5 days. The smoking temperature may reach 40-60 C. The oven is also used as a storage place and the dried fish are kept there until sold to local stores or shipped to distant markets (2). Because of the high environmental temperature and humidity, the problems associated with smoke dried fish storage are infestation with microoganisms, insects and the development of rancidity. No data on infestation, etc. are available for smoke dried herrings, but post-harvest losses of 30-70% have been reported on unprotected dried fish products during storage (3). Nutrition information on the quality of smoked dried fish is also generally lacking in Ghana. The present study was therefore made to determine nutritive composition of smoke dried herrings stored up to six months.

MATERIALS AND METHODS

Smoke Dried Herring

One hundred fifty pounds of freshly caught Sardinella spp. were purchased at Elmina, a fishing village (west coast of Ghana) in August 1986. Three types of samples were obtained: freshly oven dried (0 month storage), smoked and stored three months and smoked and stored six months. Fish were smoke dried by villagers using traditional methods. Sampling and preparation of fish for chemical analysis were carried out by the scientists at the Food Research Institute, Accra, Ghana. After collecting the fish samples, the edible portion of at least ten or more fish were ground and composite samples were packaged for shipping to the USA. The samples thus prepared were sent to the Food and Nutrition Laboratory. Tuskegee University, Tuskegee Alabama by air (about 24 hours of flight time). The samples were then kept at -60 C until analysis.

Chemical Analyses

Herring samples were analyed for moisture, fat, ash, total nitrogen, riboflavin (a flourometric method) and niacin (a cyanogen bromide method) by standard procedures (4). To determine non-protein nitrogen (NPN), five ml of 5% trichloroacetic acid were added to a 0.5g sample followed by precipitating the protein by centrifugation at 10,000 x g for 15 minutes at 0-4 C. The nitrogen content in the filtrate thus obtained was determined by a semi-micro Kjeldhal method (4). Protein was determined by (total N-NPN) x 6.25. Thiamin was determined by a colorimetic method (5). To determine fatty acids, hexane was first employed to extract the oil. Fatty acids were converted to methyl esters by the BF method then determined by gas chromatography (AOAC, 1980). For amino acid analyses, fish samples were hydrolyzed with 6 N HCl. After removing HCl under vacum, the hydrolysate was properly diluted, then an aliquot of the hydrolysate was injected into an amino acid analyzer. Both fatty acids and amino acids analyses were performed by Medallion Laboratories, Minneapolis, Minnesota. Calcium, iron and zinc were determined by atomic absorption spectrophotometry after wet ashing the samples with concentrated HNO followed by appropriate dilutions with demineralized water (6). Total volatile bases, acid and peroxide values were also determined (7).

RESULTS AND DISCUSSION

Total nitrogen and fat decreased while NPN increased in stored fish samples, indicating that losses of nitrogen compounds and fat occurred (Table I). These changes could be caused either by autolytic enzymes of fish during processing or possibly by microbial enzymes prior to storage. Moisture and ash content appeared not to be affected by smoke drying and storage. Visual observation of the fish samples.

indicated that they had a light color and fine texture. The smoke dry herrings were high in protein but low in fat. The low fat content of fish samples could be due to smaller sizes and younger ages of the fish (8,9).

Table I

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	8.7	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.

The amino acid composition of smoke dried herrings is shown in Table II. The smoke dried herrings had a well balanced essential amino acid pattern. Storage time did not affect the amino acid pattern of smoke dried herrings and these patterns were similar among fish samples regardless of differences in treatment. Smoke dried herrings contained high levels of lysine and methionine, two essential amino acids which are often deficient in legumes and cereals. Smoke dried herrings serve as a good protein supplement to the Ghanaian diet because of their high protein (38-58%) and essential amino acid content.

Table II

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 Acid	10.30	11.30	12.30
Threonine	4.60	4.76	5.70
Serine	4.00	4.14	4.75
Glutamic Acid	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
Phenylalanine	3.38	3.27	3.53
Histidine	1.64	2.05	1.74
Lysine	7.89	8.52	9.82
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/100 g protein

Table III contains data on the fatty acid composition of smoked herrings. The major saturated fatty acid was C_{16} and the major unsaturated fatty acid was $C_{22:6}$. In addition smoked dried herring oil also contained appreciable amounts of (5% or above) C_{14}, $C_{16:1}$ $C_{18:1}$ and $C_{20:5}$. It is interesting to note that two polyunsaturated fatty acids, $C_{22:5}$ and $C_{22:6}$, accounted for 27-30% of the oil. These fatty acids are known as Omega-3 fatty acids. Physiological effects of these fatty acids are related to the etiology of atherosclerosis, coronary heart disease, arthritis and a number of other pathophysiological states involving inflammation have been reported recently (10). The results also shoed that smoke-dried herrings could be a good dietary source of Omega-3 fatty acids. The fatty acid profile of herring oil was also generally not affected by storage time.

Table III

FATTY ACID COMPOSITION OF SMOKED AND STORED HERRINGS

Fatty Acids*	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
18:0 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 Linolenic	0.67	0.36	0.37
18:4	0.80	1.39	1.13
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

Vitamins and minerals of smoke dried herrings are summarized and shown in Table IV. Thiamin was lower for three and six months samples than 0 month samples indicating that losses of thaimin had occurred during smoke drying and storage. Riboflavin unlike thiamin, did not decrease regardless of differences in storage time. Niacin generally decreased with storage time. In spite of the fact that there were some vitamin losses due to smoke drying and storage, smoke dried herrings still appears to be a good source of these vitamins, especially niacin. Minerals are stable therefore, calcium, iron and zinc were generally not affected by storage. Smoked dried herrings contained very high levels of calcium ranging from 1419-2974 mg/100g. Small fine bones present in smoke dried herring flesh contributed to this high calcium value. It appears that smoke dried herrings are an excellent source of minerals, especially calcium.

Rancidity often becomes a problem for food that contains appreciable amounts of fat especially if the fat contains high levels of polyunsaturated fatty acids. The results Table V show that the acid value increased progressively with storage time indicating that hydrolytic rancidity had proceeded during storage. The lipolytic reaction could be caused by autolytic enzymes in fish or by microorganisms during storage. Acid values of 5.21 and 6.61 may be considered slightly rancid (7). Contrarily, perioxide values were not high for all the samples analyzed. The reason could be that as a result of smoking, some aldehydes and phenols in smoke might have become deposited on the fish, which may have prevented the oxidative reaction of fish oil, therefore, peroxide values were small. Fish protein is known to possess active autolytic enzymes. Decomposition of fish protein often produces volatile bases such as ammonia and amines which may sometimes be employed as an indicator of fish freshness. The total volatile bases value obtained (10.5-12.6 mgN/100g) in this study was not considered high. Total volatile bases decreased slightly with storage time. The reason for low total volatile bases could be that either autolysis of fish was not severe during the preparation of fish or the volatile bases that once formed might have evaporated during drying and storage. For instance, ammonia

Table IV

THIAMIN, RIBOFLAVIN, NIACIN, ZINC AND CALCIUM IN SMOKED AND STORED HERRING IN GHANA

	Thiamin (mg/100g)	Riboflavin* (mg/100g)	Niacin* (mg/100g)	Zinc* (mg/100g)	Iron* (mg/100g)	Calcium* (mg/100g)
Elmina Region						
Dried - no storage time	0.0324	0.4050	46.87	14.82	20.28	2974.18
Smoked - stored 3 months	0.0229	0.4540	-	12.46	20.49	2643.79
Smoked - stored 6 months	0.0226	0.4017	37.48	14.42	20.40	1419.35

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

was smaller for six month than for 0 month and three month stored samples as shown in the amino acid composition analysis (Table II).

Table V

ACID VALUES, PEROXIDE VALUES, AND TOTAL VOLATILE 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 determinations.

The nutritive composition of smoke dried herrings generally appeared good; it was high in protein, had a well balanced essential amino acid pattern, high in methionine and lysine, a good source of Omega-3 fatty acids, thaimin, riboflavin, niacin, zinc, iron and calcium. Some concerns raised with this product were that the fish had slightly high acid values, and also there was nearly a 35% decrease in protein after six months of storage. Further studies are needed to improve handling, processing and storage conditions of the fish to minimize the losses of nutrients as well as to obtain a high hygenic quality fish product.

REFERENCES

1. Kagan, B. Fish Processing in Ghana-Possibilities of Improving Traditional Processing. A FAO report, Rome, Italy (1970).

2. The International Labor Office. Improved Village Technology for Women's Activities - A Manual for West Africa. P-173, Geneva, Switzerland (1984).

3. Nerquaye-Tetteh, G. A. The Traditional Post Harvesting Fish Processing Technology in Ghana. A Report of Food Research Institute, Accra, Ghana (1979).

4. AOAC. Official Methods of Analysis. 13th ed. Association of Official Analytical Chemists, Washington, D.C. (1980).

5. Kramer, A., and Twigg, B. A. Colorimetric Test for Thaimin, from Quality Control for the Food Industry. The AVI Publishing Co., Inc. Westport, Conn., p 488 (973).

6. Annoymous. Analytical Methods of Atomic Absorption Spectrophotometry. Perkin Elmer's Corp., Norfolk, Conn. (1971).

7. Cox, H. E. and Pearson, D. The Chemical Analysis of Foods. Chemical Publishing Co., New York, p 319 (1962).

8. Deng, J. C., Orthoefer, F. T., Dennison, R. A. and Watson, M. Lipids and Fatty Acids in Mullet: Seasonal and Locational Variations. J. Food Sci. 41, 1479 (1976).

9. Kukucz, J. T. Effect of Biological Factors (sex, seasonal races, spawning migrations) on Fat Protein and Water, their Distribution in Sea-Trout. Fish in Nutrition. (E. Heen and R. Kreuzer, editors). Fishing News Ltds., London, p. 76 (962).

10. Kinsella, J. E. Nutritional Implications of Increased Seafood Consumption. A paper presented at the Annual Institute of Food Technology Meeting at Las Vegas, Nevada, June 16-19 (1987).

Accepted for publication: May 11, 1988.