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EFFECT OF STORAGE ON BIOCHEMICAL COMPOSITION OF SPICED, SMOKED AND DRIED MACKEREL FISH

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ABSTRACT
This research examined the effect of storage on biochemical composition of spiced, smoked and dried mackerel fish. The frozen mackerel fish purchased was allowed to thaw at ambient temperature, eviscerated, dressed, washed and brined in 75% saturated brine, rinsed and drained. A mixture of spices (ginger, turmeric and red pepper) was applied to the surface. The samples were hot smoked for 4 hours and cooled overnight and further subjected to oven drying with varying time corresponding to the various samples. The smoked non dried sample served as the control sample (A), while the remaining 4 batches were drawn after 2, 4, 6, and 8 hours of oven drying. The samples were stored at room temperature for 28 days and samples were drawn after 0, 7, 14, 21 and 28 days for biochemical analysis (moisture content, water activity, peroxide value, and thiobarbituric acid value). Sample (E) which was dried for 8 hours had the lowest values for all the selected biochemical parameters (moisture content: 12.40, water activity: 0.69, peroxide value: 19.36 and thiobarbituric acid: 0.47) followed by other oven dried samples with a significant ($p<0.05$) difference between the oven dried and the control at the end of the storage.
Keywords: Mackerel fish, storage, biochemical composition, and moisture content.

Introduction

Fish is an essential source of protein and essential nutrients for millions of people worldwide, particularly in coastal communities (FAO, 2020). Consumption of fish and fish products is recommended due to good digestibility and the high content of poly unsaturated fatty acids (Oluwaniyi *et al.,* 2010). In most rural areas of Nigeria and other developing countries, fish provides the most affordable source of the much-needed animal protein because it is widely distributed and presented in forms that even low-income people can afford. Mackerel fish is consumed in many parts of the world because of its economic significance and its good nutritional quality such as proteins, essential amino acids, vitamin, minerals, fats, and it is highly digestible. The protein content of fish has immense nutritional importance to pregnant women for proper development of the fetus and it also enhances the proper mental and immunity development against disease among growing children (Isangsdighi *et al.,* 2017). Mackerel fish, a highly prized species, is rich in omega-3 fatty acids, vitamins, and minerals, making it an excellent addition to a healthy diet (Ulbrich *et al.,* 2015). It is widely consumed seafood and most valued fish species in Nigeria known for its rich flavor and nutritional benefits.

Fish is nevertheless highly perishable due to complex processes involving physical, chemical and microbiological activities. It is susceptible to spoilage and degradation due to its high moisture content and enzymatic activity. Fish spoilage is a process of deterioration in the quality of fish, which changes its appearance, odor and taste. The breakdown of bio-molecules like proteins, amino acids and fats in the fish are the factors responsible for fish spoilage. Fish spoilage can occur due to enzymatic degradation, bacterial degradation, chemical decomposition and mechanical damage. This can be characterized by observing the color change, fishy smell, sliminess in the skin and scales, firmness flesh, discoloration of the backbone etc.

Due to its perishable nature various preservation techniques, such as spicing, smoking and drying are employed to extend the shelf life, maintain quality (Ulbrich *et al.,* 2015) and enhance the flavor of mackerel fish. Smoking and drying can effectively reduce the moisture content and inhibit the growth of microorganisms

and enzymes that cause spoilage. Drying in food processing and preservation, which includes smoking and other forms is a common method used for preserving food such as fish, extending its shelf life and enhancing its flavor and texture (Garcia-Segovia *et al .,* 2007). Drying often combined with salting is one of the oldest and simplest methods of fish preservation and drying reduces water activity in fish which inhibits the growth of spoilage microorganisms and enzymatic activities. During drying, heat is applied to accelerate the moisture removal process and several factors influence the impact of drying on the nutritional composition of fish, including temperature duration and initial nutrient profile of the fish. Smoking is a preservation method that involves exposing fish to smoke derived from the combustion of wood or other organic materials. This process of drying can as well be combined with spicing. The use of spice mixture extends beyond flavor enhancement as many spices possess antimicrobial, antioxidant and health promoting properties making them integral to both traditional and modern food system. A common example of spice mixture is the combination of red pepper, turmeric and ginger frequently used in various cuisine and food preservation method. Spices possess antimicrobial activity against food borne pathogens and for the preservation of foods due to their phytochemical content (Gupta *et al.,* 2015). Although they have been employed mainly as flavoring and coloring agents, spices have also exhibited numerous health benefits in preventing and treating a wide variety of diseases such as neurological, cardiovascular and inflammatory diseases. Fish spiced with a mixture of red pepper turmeric and ginger before smoking and drying will have superior sensory qualities and longer shelf life compared to fish preserved using a single method. Some drying processes such as smoking not only impart a distinct flavor to fish but also provide antimicrobial properties. However, it is important to note that smoking process can lead to change in the nutrient composition of fish. The heat and smoke exposure during smoking can cause vitamin degradation, particularly heat sensitive vitamins such as Vitamin C and B-group vitamins (Ghasemzadeh *et al.,* 2017).

The biochemical composition of processed mackerel products is vital for both nutritional value and sensory attributes. Lipid oxidation and other biochemical changes in fish products can result in off flavors, odors and deterioration of nutritional quality as well as formation of potentially harmful compounds in fish products when left for a period of time. This study therefore, aims to investigate the effects of storage on the biochemical composition of spiced, smoked and dried mackerel fish with a focus on understanding changes in moisture content, water activity, peroxide value, thiobarbituric acid (TBA) value and the overall quality of the products during storage so as to contribute to consumer health and safety. By monitoring the biochemical characteristics of fish products during storage, this study can provide insight into products safety and help establish storage protocols that minimize the risk of food borne illness.

Materials and Methods

Procurement of raw materials

Fresh Mackerel fish were bought from Eke market at Afikpo Ebonyi state with precautionary measures taken to ensure the samples were of high quality and representative of the specie.

Length and Weight Measurement

The length and weight measurements of the fish samples were taken in order to get sample of relatively equal and uniform sizes. This was so as to achieve even distribution of various treatments given to the samples. It also resulted in uniform cooking and smoking of the fish at the same time.

Preparation of Fish for Brining and Smoking

The frozen mackerel fish samples were allowed to thaw at ambient temperature and then eviscerated and cleaned by the method elucidated by Roger *et al.* (1970). The eviscerated fish samples were further cleaned using clean water.

Brining of Fish

Brining was carried out by dipping the fish into 75% saturated brine solution made by dissolving 27g of salt (NaCl) in 100ml of water for 2-3, minutes, the fishes were then rinsed with cool clean water for about 1 minute.

Preparation and Application of spice mixture

Three different spices (Red Pepper, Turmeric and Ginger) mixture was used for the work. The spices were thoroughly cleaned, crushed into powder and finally mixed together in the percentage ratio of 50:30:20 for red pepper, turmeric and ginger respectively. The spice mixture was uniformly applied (1%) on the surface of the fish. They were subsequently laid in smoking trays with the split surface upward and allowed to drain and then taken for smoking.

Fish Smoking

Fish Smoking procedures as described by (Ikeme and Gugnani, 1988) were used. The improved traditional kiln (NIOMR Kiln) built in the department was used for the smoking. The firing chamber was filled with hard wood together with sawdust and wood shaving to produce smoking. The kiln was allowed to warm before the introduction of fishes. The fish were introduced into the smoke house and smoked for 4 - 4.5 hours at the temperature of about 75-80°c, the temperature was maintained by either withdrawing or adding the sawdust. The flow of air into the kiln was regulated by opening or partial enclosure of one of the entrance to the firing compartment. The fish were observed at intervals by pressing the fish flesh between the fingertips until a persistent rubbery feel of cooked fish was obtained. At the end of the smoking the smoked fish were allowed to cool in the smoking chamber overnight.

Fish Drying: The spiced and smoked fish samples were further oven dried at a temperature of 60^0C at different intervals of 2hour, 4hours, 6hours and 8hours representing the various samples.

Fish Storage and Sampling

After drying in batches, 5 batches of spiced, smoked, and dried fish samples were kept for storage for weeks under ambient condition. Samples were taken on the 0, 7, 14 and 28 days of storage for the biochemical analysis.

Biochemical Analysis of Fish Samples

Moisture Content of Samples

The fish samples were analyzed in triplicates for moisture content using the approved methods of the Association of Official Analytical Chemists (AOAC, 2010).

Water activity of Samples

The water activity determination described by Lupin (1986) using water activity meter was used.

Thiobarbituric Acid (TBA) and Peroxide Values of Samples

The thiobarbituric (TBA) acid number and peroxide value of the fish samples were determined at 0, 14, and 28 days of the storage using the Association of Official Analytical Chemists (AOAC, 2010).

Statistical analysis

All the data obtained were subjected to Analysis of Variance (ANOVA) by using Statistical Package for Social Sciences (SPSS) version 20. Duncan New Multiple Range Test (DNMRT) was used to determine significant differences and to separate means at $p<0.05$ using SPSS version 20.

Results and Discussion

Effect of Storage on Moisture Content of Fish Samples

The results of the moisture content of fish samples as shown in table 1 revealed significant ($p<0.05$) effect of smoking and subsequent drying on the moisture content of the fish samples. The moisture content of fish samples decreased progressively during the 28 days storage period at ambient temperature. The untreated sample (control) had the lowest rate of decrease while sample (E) which was oven-dried for 8 hours had the lowest moisture content.

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Table 1: Changes in Moisture Content (%) of Fish Samples during Storage

Sample	0 DAY	DAY 7	DAY 14	DAY 21	DAY 28
A	50.90^{a}±0.07	45.30a±0.37	38.27^{a}±0.01	26.31^{a}±0.38	20.01^{a}±0.06
B	38.25^{b}±0.20	36.16^{b}±0.28	32.18^{b}±0.22	24.24^{b}±0.20	18.17^{b}±0.07
C	37.33^{c}±0.01	33.27^{c}±0.01	29.07^{c}±0.12	22.15^{c}±0.07	15.26^{c}±0.28
D	34.47^{d}±0.28	29.10^{d}±0.28	25.27^{d}±0.14	21.25^{d}±0.21	14.56d±0.14
E	29.20^{e}±0.02	24.40^{e}±0.17	21.18^{e}±0.42	19.17^{e}±0.02	12.40^{e}±0.27

Values are means of 3 replicates ± standard deviation.

Means with different superscripts are significantly different (p<0.05).

AAA = Spiced and smoked fish sample (control); BBB = Spiced, smoked + 2hour dried fish sample; CCC = Spiced, smoked + 4hours dried fish sample; DDD = Spiced, smoked + 6hours dried fish sample; EEE = Spiced, smoked + 8hours dried fish sample.

The reduction in moisture content during storage can be attributed to protein denaturation and consequent loss of water holding capacity of the proteins of the fish samples. Also, protein cross linkage which occurred during prolonged storage must have led to further moisture loss eventually resulting in the extended shelf-life of the spiced, smoked and dried fish samples.

Changes in Water Activity of Fish Samples during Storage

The table 2 shows the changes in water activity of the spiced, smoked and dried mackerel fish samples during the 28 days of storage. The characteristic of dried food products that makes them shelf stable is their low water activity.

Table 2: Changes in water activity of spiced, smoked and dried fish samples

Samples	0 DAY	DAY 7	DAY 14	DAY 21	DAY 28
A	0.93^{a}±0.24	0.91^{a}±0.30	0.88^{a}±0.01	0.83^{a}±0.01	0.78^{a}±0.01
B	0.90^{b}±0.32	0.89^{b}±0.05	0.85^{b}±0.04	0.79^{b}±0.01	0.78^{a}±0.02
C	0.89^{c}±0.61	0.86^{c}±0.05	0.83^{c}±0.01	0.78^{c}±0.41	0.72^{b}±0.01
D	0.86^{d}±0.40	0.85^{d}±0.01	0.81^{d}±0.01	0.76^{d}±0.03	0.71^{c}±0.01
E	0.85^{e}±0.31	0.80^{e}±0.02	0.78^{e}±0.02	0.75^{e}±0.01	0.69^{d}±0.02

Values are means of 3 replicates ± standard deviation.

Means with different superscripts are significantly different (p<0.05).

AAA = Spiced and smoked fish sample (control); BBB = Spiced, smoked + 2hour dried fish sample; CCC = Spiced, smoked + 4hours dried fish sample; DDD = Spiced, smoked + 6hours dried fish sample; EEE = Spiced, smoked + 8hours dried fish sample.

It is recommended by the FDA to scientifically establish a drying process that reduces the water activity (a_w) to 0.85 or below if the product is to store and be distributed unrefrigerated (Hazard and Control Guidance, FDA, 2001). From the result, the water activity mean value of the fish samples varies significantly ($p<0.05$) from 0.69 to 0.93 with the highest value being the control sample that was not further dried after smoking. There was a steady decline in water activity of all the treatments. The water activity level dropped progressively with increase in drying period and with the storage. This could be attributed to changes in moisture content. The batch dried for 8 hours had the lowest water activity of 0.69 whereas the control sample had the highest of 0.93 though it gradually decreased 0.78 as the storage progressed. As the drying time increased, the water activity of the fish samples decreased, hence the fish samples (D) and (E) dried for 6 and 8 hours respectively had the water activity values significantly ($p<0.05$) lower than those of samples (B) and (C) dried for 2 and 4 hours respectively before storage. The decrease in water activity consequently results in

decrease in microbial activity, however, at low water activity, other effects such as rancidity becomes important (Olley *et al.,* 1988).

Effect of Storage on Peroxide Value of Fish Samples

Peroxide value measures the degree of lipid oxidation in fats and oils though not necessarily their stability. It is a measure of the formation of peroxide or hydroperoxide groups that are the initial products of lipid oxidation. Peroxide value is normally used as an indicator of deterioration of fat as it represents the most common test of lipid oxidation. Peroxides are formed when the double bonds of unsaturated fatty acid are oxidized by atmospheric air. The peroxides break down to produce secondary products which indicate rancidity in fish samples.

Table 3: Changes in peroxide value of spiced, smoked and dried fish samples

Samples	0 DAY	DAY 14	DAY 28
A	13.02^{a}±0.06	26.80^{a}±0.47	24.90^{a}±0.36
B	12.04^{b}±0.52	25.40^{b}±0.47	23.86b±0.17
C	11.08^{c}±0.32	24.30^{c}±0.49	23.50^{c}±0.30
D	8.60^{d}±0.36	22.50^{d}±0.30	21.40^{d}±0.45
E	7.50^{e}±0.02	20.84^{e}±0.02	19.36^{e}±0.31

Values are means of 3 replicates ± standard deviation.

Means with different superscripts are significantly different (p<0.05).

AAA = Spiced and smoked fish sample (control); BBB = Spiced, smoked + 2hour dried fish sample; CCC = Spiced, smoked + 4hours dried fish sample; DDD = Spiced, smoked + 6hours dried fish sample; EEE = Spiced, smoked + 8hours dried fish sample.

From the results in table 3, there was a significant (p<0.05) difference between the peroxide value of the sample (E) which had the lowest value and the rest of the samples though its values increased from 7.50 to a maximum of 19.36 at the end of the storage period. The lowest value as seen in sample (E) could be attributed low water activity of the sample. Oxidation is minimized at a very low water activity probably because of the concentration of metal catalyst (Burt *et al.,* 1988). The batches samples (D) and (E) which were dried for 6 and 8 hours respectively had the lowest peroxide values while the sample (B) that was dried for 2 hours had a very high peroxide value similar to that of the control sample (A) at ambient storage, portraying the preservative potentials of drying. This is agreement with the reports of Pratt and Watts, (1964) and Lec *et al.* (1986) who opined that drying has a role to play in retarding oxidative rancidity.

Effect of Storage on Thiobarbituric Acid (TBA) Value of Spiced, Smoked and Dried Mackerel Fish Samples

The thiobarbituric acid (TBA) value is a measure of the deterioration of lipid. It measures the secondary product of lipid oxidation, malonaldehyde. The TBA test correlates better with sensory evaluation of rancidity than does peroxide value, but it still measures a transient product of oxidation. The TBA values of the fish samples as displayed on table 4 revealed that the TBA values changed according to the extent of the treatment (drying) and duration of storage.

Table 4: Changes in thiobarbituric acid (TBA) value of spiced, smoked and dried fish samples

Samples	0 DAY	DAY 14	DAY 28
A	0.29^{a}±0.01	0.47^{a}±0.02	0.79^{a}±0.01
B	0.25^{b}±0.01	0.40^{b}±0.01	0.68^{b}±0.01
C	0.22^{c}±0.01	0.37^{c}±0.01	0.59^{c}±0.01
D	0.20^{d}±0.01	0.32^{d}±0.01	0.52^{d}±0.02
E	0.16^{e}±0.01	0.28^{e}±0.01	0.47^{e}±0.01

Values are means of 3 replicates ± standard deviation.
Means with different superscripts are significantly different (p<0.05).
AAA = Spiced and smoked fish sample (control); BBB = Spiced, smoked + 2hour dried fish sample; CCC = Spiced, smoked + 4hours dried fish sample; DDD = Spiced, smoked + 6hours dried fish sample; EEE = Spiced, smoked + 8hours dried fish sample.

There was an increase in the TBA value of all samples during the storage with the control sample (A) and the sample (B) which was dried for 2 hours having the highest TBA values of 0.29 and 0.25 respectively while the sample (E) dried for 8 hours had the lowest TBA value of 0.16 as the storage progressed. The result is in agreement with the report of Beltran and Moran (1991) which stated that high TBA values are correlated with the degree of oxidation of fats in smoked fish. Beharjo and Sofos (1993) also elucidated that TBA value is routinely used as an index of lipid oxidation in meat product in store and that rancid flavor is initially detected in meat product between TBA value of 0.05 and 2.0.

Conclusion

The application of spices and drying treatments to fish samples has a great role to play in preserving and extending the shelf stability of the fish. The present study buttresses the fact that spices, smoking with subsequent drying treatments contributed to a large extent in enhancing the keeping quality of the mackerel fish samples. The results obtained from this work showed that drying enhanced the reduction of moisture content of the fish samples which also reflected in the water activity even during the storage. The sample (E) dried for 8 hours had the lowest water activity and moisture content than the rest of the samples (B, C, and D) however they all decreased gradually with storage. There were also significant changes ($p<0.05$) in the peroxide and TBA values of the fish samples. These findings can inform the development of evidence-based guidelines for storage and handling of dried fish products, ultimately contributing to improve food safety and security.

References

AOAC. (2010). Official Methods of Analysis, 18th ed. Association of official Analytical chemists Washington, D.C. USA.

Beltran, A. and Moral, A. (1991). Changes in Fatty Acid Composition of Fresh and Frozen Sardine during Smoking. Food Chemistry 42:99-100.

Olawunmi, O.O., Dosumu, O.O. and Awolala, G.V. (2010). Effect of local processing methods on the amino acid composition of four marine fishes commonly consumed in Nigeria. Food Chemistry, 123(4), 1000-1006

Duncan, D.B. (1995). Multiple range and Multiple f-tests. Biometrics, 11:1-42.

FAO (2020). Uniform Fishery Statistics, in Food and Agriculture Organization of the United Nations, Yearbook, Roma, 82:187-188

Fernandiz-segovia, I., Eschriche, I., Serra, J. A., and Garcia, S. P. (2018). Influence of brining on the quality and shelf life of fish. *Journal of food control* 84, 325-332.

Garcia-Segovia, P., Andres, Bello, A., Martinez-Mozo, J., and Fuentes, A. (2007). Quality characteristics of Mediterranean Anchovy (engraulis encrasicolus) salted with different methods. *Journal of food science 72(1) S055-S062.*

Ghasemzadeh, A., Jaafar, H. Z. E. and Rahmat, A. (2016). Antioxidant activities total phenolics and flavonoids content in two varieties of Malaysia young Ginger (zingiber officinate Roscoe) molecules 21(6), 653.

Ghosh, R., Chattopadhyay, P., and Chatterjee, R. (2015). Role of spices in fish preservation. *Journal of food science and technology, 52(9), 5894-592*

ISSN: 2992-3727 Published 25th May, 2025

Gupta, S. C., Sung, B., Kim, J. H., Prasad, S.L.S., and Agarwal, B.B. (2015). Multi targeting by turmeric the golden spice from kitchen to clinic molecular nutrition and Food research 57(9), 1510-1528.

Gomez-Esta, J., Lopez de Lacey, A., Gabellero, M. E., and Gomez-Guillen, M. C. (2014) Biodegradable gelatine chitosan films incorporated with essential oils as antimicrobial agents for fish preservation. Food science and technology international. 20(8) 661-668.

Gupta, S., Patchua, S., and Aggarwal, B. B. (2013). Therapeutic Roles of Curcumin lessons learned from clinical trials. *The AAPS Journal.15 (1), 195-128.*

Ikeme, A.I. and Gugnani, H.C. (1988). Effect of Smoking Time on Product Quality of Hot- smoked Mackerel. FAO Expert Consultation on Fish Technology. Food and Agriculture Organization, Rome 124-130.

Isangsdighi I. Ofonmbuk O., Ofonime U., Gift D. Comparative Study of the nutrient content of Cultured and wide African Catfish (Clarias gariepinus, Burchell1822) *Int. J. Agric Environ . Biotechnol. 2017;2 (5):363-371.*

Lupin, H.M. (1986). Water Activity in preserved product in cured fish products in the tropics. Proc. of a Workshop on the Production of cured fish. University of Philipines Visayas, Diliman, Quezon City Phillipines, 16:14-25

Ulbricht, T. L. V., Southgate, D. A. T., and Coronel, P. (2015). Influence of f storage temperature and duration on the biochemical composition of spiced mackerel fish. *Food Research International, 70, 83-89.*