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GENERAL LINEAR MODEL (GLM) ANALYSIS OF THE EFFECTS OF PACKAGING MATERIALS AND PRESERVATIVES ON NUTRIENT COMPOSITION OF SMOKED FISH

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Abstract: *This study aimed at assessing the effect of packaging materials and preservatives on nutrient composition of fish was carried out using 864 live Clarias gariepinus with an average weight of 226g acquired from an earthen pond of a fish farm in Omi-Adio, Ibadan, Nigeria. The experiment was conducted using a 4 × 3 × 11 factorial experiment (4 preservatives, 3 packaging materials and 11 storage periods). The protein content of the fish decreased consistently from 77.538 (0days after smoking - $_{DAS}$) till it reaches 51.253 (140_{DAS}). The variance of the protein however increases from 1.051 (for 0_{DAS}) till 25.487 (140_{DAS}). The moisture content of the fish increases consistently from 5.703 (for 0_{DAS}) to 24.976 (for 140_{DAS}). Summary statistics of the packaging materials revealed that mean protein ranged between 59.817±0.94 obtained for the fish packed with basket and 65.897±0.659 (plastics). Highest moisture content of 17.896 (±0.676) was obtained for fish packed with basket while the least moisture content of 13.160 (±0.427) was obtained for fish packed with plastic. All the nutrients returned negative covariates with the protein and the covariates generally ranges between 0.037(cov_{xy} of ash and crude fibre) and 91.206 ($var_{x,x}$ of protein). The general linear model analysis of the fish nutrients revealed that there exist significant difference in the protein, moisture content, ash, fat and crude fiber with $F_{(3, 264:0.05)}$ = 77.40, 460.24, 111.02, 395.77 and 2037.76 respectively.*

Keywords*: Algorithmic, euthanized, eviscerated, therapeutic, deteriorate.*

1. Introduction

Fishery data analysis has two main goals – response prediction and information extraction and there exist two different approaches (data modeling and algorithmic modeling approach) for achieving these goals [1]. General linear model (GLM) falls under the former and it predicts one variable, *response* variable from one or more other independent or explanatory variables [2]. General linear model (GLM) can basically be found useful in testing almost any hypothesis about a numerically measurable dependent variable [3] and there are literally an infinite number of experimental and survey designs that can be analyzed using the GLM. Three statistical tools, analysis of variance, regression analysis and analysis of covariance are subsumed in the term general linear model. This is because all the statistical tools employed to solve data problem has an underlying model attached to it. Fish, a nutritious food and source of high quality protein, is highly susceptible

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to deterioration [4]. Similarly, it was established that the chemical composition of the fish enhances its ease of deterioration [5]. In view of this condition (of ease of deterioration) and importance of fish to food security, there have been concerted research efforts in the post - harvest handling of fish (particularly storage). The knowledge of nutrient composition of smoked fish is essential for consumer acceptability and package presentation for fish optimal market. Indeed, the nutrient composition of packaged products is a requirement for its endorsement by Standard Organization of Nigeria (SON) and other agencies for food control as well as in other countries of the world. Extensive research has been conducted on fish nutrients' composition but regular research in fish nutrient values is justified from the need to constantly monitor variability in fish nutrient composition. A big variation has been reported in the nutrient composition of fish by [6]. Similarly, studies with the approach of the present research (GLM) are scanty or unknown. The relationship between the fish nutrients compositions (response variables) and independent variables like packaging material – x_1, preservatives – x_2 and storage time – x_3 are modeled using the GLM. The present work thus seek to answer the research question – what are the statistical effect of independent variables (like preservatives, packaging materials and period) on the fish quality (which is the response variable)? The objectives of this study were therefore to assess the effect of packaging materials and preservatives on nutrient composition of fish.

2. Matherials and methods

Eight hundred and sixty four (864) live catfish, *Clarias gariepinus*, with an average weight of 226g were collected using drag net from an earthen pond, Ire Akari fish farm, Omi-Adio, Ibadan Oyo State, Nigeria. The fish were conveyed in plastic bowls to the fish processing unit of the Federal College of Animal Health and Production Technology (FCAH&PT), Moor Plantation Ibadan within 43 minutes. The fish collection was carried out between 07.00 and 09.00 AM to reduce stress. Six kilogram each of dried garlic (*Allium. sativum*) bulb and ginger (*Zingiber officinale*) rhizome bought at Bodija market in Ibadan Oyo state Nigeria were grinded into powder using sterile explosion proof warring blender (New Hartford, CT). Samples from powdered *A. sativum* and *Z. officinale* were also collected and homogenized manually in a ratio 1:1 to give garlic–ginger homogenate. Two hundred and eighty eight (288) transparent plastic (polyethylene terephthalate) and transparent zip-lock nylon bags (polythene) and twelve (12) plastic baskets were purchased from Alesinloye market in Ibadan Oyo state Nigeria. Fish drying was done at the Department of Fisheries Technology of the FCAH&PT, Moor Plantation Ibadan using the NIOMR smoking kiln. Fish samples in plastic container were euthanized [7] by the addition of 20g of table salt/kg and left for 10 minutes. They were thereafter gutted, eviscerated, washed in potable water and were immersed in 15% brine for 5 min [8].

The research was conducted using 4 × 3 × 11 factorial experiment (4 preservatives, 3 packaging materials and 11 storage time). The preservatives are - no preservatives (control); garlic (*A. sativum*); ginger (*Z. officinale*) and mixture of garlic and ginger (*A. sativum* and *Z. officinale*). The three packaging materials were basket, polythene (nylon), and polyethylene terephthalate (plastic) while 11 different storage periods were 0_{DAS}, 14_{DAS}, 28_{DAS}, 42_{DAS}, 56_{DAS}, 70_{DAS}, 84_{DAS}, 98_{DAS}, 112_{DAS},

126_{DAS} and 140_{DAS}. The fish were spiced and packaged following the procedure of [9]. Four preservative groups comprising of 216 pieces each were formed including zero preservative group and three other group of garlic, ginger, and garlic–ginger homogenate at ratio 1:1 for preservatives. The fishes were then smoked and seventy-two (72) samples of each treated smoked catfish were packaged in nylon (polythene) and plastic (polyethylene terephthalate), while others were left unpackaged in basket at ambient temperatures (25–36°C). The samples were thereafter stored for 140 days and sampled at 14 day intervals for organoleptic quality.

The data obtained were analyzed using descriptive statistics (including mean, variance and standard error) using SAS version 9. Correlation Analysis of the variables or nutrients as well as general linear model using 3 degree of freedom (for preservatives), 2df (for packaging materials) and 10 df for storage period. Mean of significantly different sources of variation were partitioned using Duncan Multiple Range Test (DMRT).

3. Results and discussion

3.1. Results

3.1.1. Summary Statistics of the Fish Nutrients

The protein content of the fish decreased consistently from 77.538 (0_{DAS}) till it reaches 51.253 (at 140_{DAS}– Table 1 and figure 1).

Table 1.

Summary Statistics of the Fish Nutrients (g/100g sample) over the storage time

Storage time (DAS)		Protein	MC	Ash	Fat	CF
0_{DAS}	mean± SE	77.538±0.17	5.703±0.10	6.569±0.08	4.949±0.23	5.012±0.43
	Variance	1.051	0.329	0.257	1.894	6.714
14_{DAS}	mean± SE	75.965±0.27	7.094±0.16	6.863±0.08	4.525±0.26	5.553±0.47
	Variance	2.624	0.877	0.228	2.56	7.825
28_{DAS}	mean± SE	72.124±0.32	9.332±0.27	7.291±0.08	5.242±0.25	6.012±0.46
	Variance	3.676	2.551	0.258	2.182	7.777
42_{DAS}	mean± SE	68.4089±0.37	11.747±0.29	7.574±0.11	5.959±0.20	6.317±0.45
	Variance	4.995	3.11	0.427	1.493	7.214
56_{DAS}	mean± SE	64.789±0.38	14.364±0.28	7.972±0.12	6.330±0.22	6.545±0.45
	Variance	5.155	2.802	0.498	1.791	7.317
70_{DAS}	mean± SE	62.300±0.44	15.796±0.30	8.395±0.14	6.796±0.22	6.714±0.45
	Variance	7.107	3.199	0.743	1.772	7.34
84_{DAS}	mean± SE	58.585±0.55	18.101±0.49	8.649±0.17	7.667±0.23	7.003±0.43
	Variance	10.715	8.776	1.044	1.902	6.733
98_{DAS}	mean± SE	56.211±0.62	19.593±0.57	8.913±0.18	8.055±0.22	7.229±0.44
	Variance	13.889	11.724	1.18	1.736	6.928
112_{DAS}	mean± SE	53.559±0.68	21.439±0.65	9.239±0.16	8.336±0.22	7.426±0.44
	Variance	16.478	14.978	0.932	1.699	6.992
126_{DAS}	mean± SE	52.737±0.73	22.880±062	9.082±0.16	8.088±0.21	7.214±0.42
	Variance	19.017	13.862	0.923	1.533	6.268
140_{DAS}	mean± SE	51.253±0.84	24.976±0.75	8.947±0.16	7.720±0.23	7.105±0.41
	Variance	25.487	20.251	0.897	1.915	5.931

NB. DAS = Days after smoking

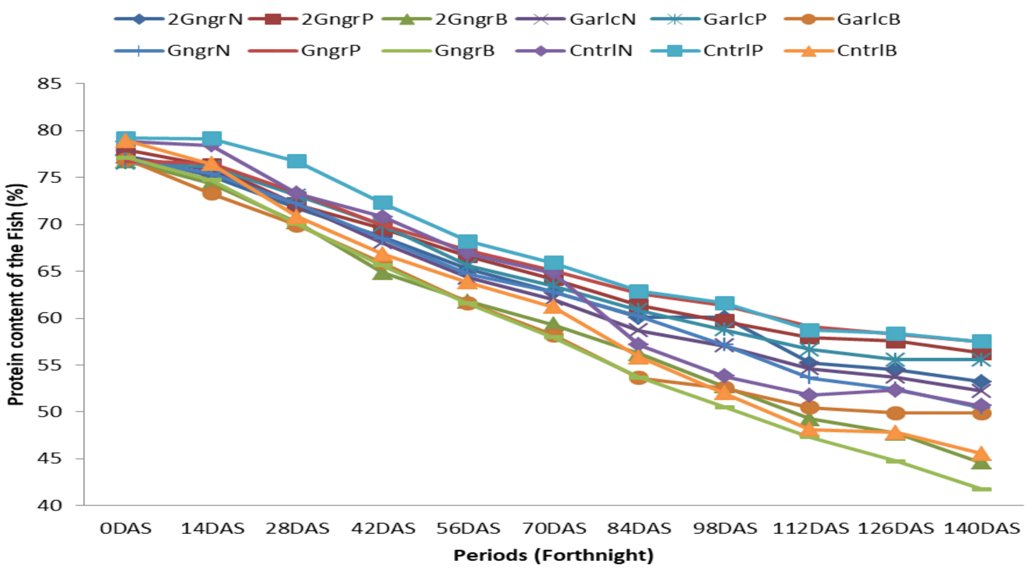

Fig. 1. Protein Content of Fish as affected by both Preservative and Packaging Materials *(DAS = Days after smoking), N=Nylon, P = plastic and B = Basket; Garlc = Garlic, Gngr = Ginger and 2Gngr = Garlic+ginger & Cntrl = Control.*

The decreasing protein index also continues until P_4 (Point 4) when it followed a cyclical pattern. The variance of the protein however increases steadily from 1.051 (for 0 $_{DAS,}$) till 25.487 (140 $_{DAS,}$). The moisture content of the fish unlike the protein content increases steadily from 5.703 (for 0 $_{DAS}$) to 24.976 (for 140 $_{DAS}$ – Table 1). The protein index returned a decreasing trend for the first 4 periods (42$_{DAS}$) while a fluctuating trend was obtained for the remaining period (Figure 2).

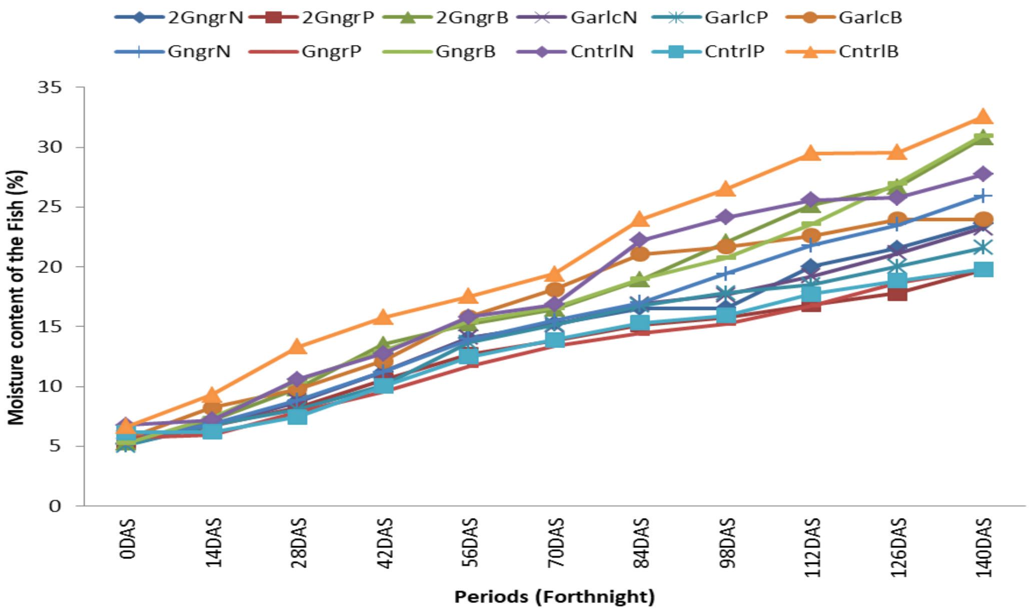

Figure 2. Moisture Content of Fish as affected by both Preservative and Packaging Materials *(DAS = Days after smoking). N=Nylon, P = plastic and B = Basket; Garlc = Garlic, Gngr = Ginger and 2Gngr = Garlic+ginger & Cntrl = Control.*

The implication is that the rate of decrease in protein content is not uniform while the moisture content index returned a randomly increasing trend (Figure 3). The ash content of the fish was found to appreciate from 6.569 ± 0.08 (for 0_{DAS}) until 9.239 ± 0.16 (for 112_{DAS}) and drops till 8.9947 ± 0.16 on 140_{DAS}. Similarly, crude fiber of the fish rose from 4.949 ± 0.23 (for 0_{DAS}) until 8.336 ± 0.22 in the 112_{DAS} after which it decreases to 7.72 ± 0.23 in the 140_{DAS} (Table 1). Mean crude fiber increases with increase in the period and it ranged between 5.012 ± 0.43 (0_{DAS}) and 7.424 ± 0.44 (for 140_{DAS}) after which it reduces to 7.105±0.41. The implication of these results is that the nutrient composition of the fish in terms of the ash content, crude fiber and fat can be guaranteed until 112_{DAS} after the processing and that after this period the nutrient quality would begin to deteriorate.

The summary statistics of the packaging materials revealed that mean protein ranged between 59.817±0.94 obtained for the fish packed with basket and 65.897±0.659 (plastics). Highest moisture content of 17.896 (±0.676) was obtained for fish packed with basket while the least moisture content of 13.160 (±0.427) was obtained for fish packed with plastic (Table 2). Similar results were returned for the fat and crude fiber where the highest of both (6.736 and 6.934) were obtained for fish packed with basket. The least of both fat (6.667) and crude fiber (6.313) were obtained for fish packed with plastic (Table 2).

Table 2.

Descriptive statistics of the Fish Nutrients according to Packages.

			Protein(%)	**MC(%)**	**Ash(%)**	**Fat(%)**	**CF(%)**
Packaging Materials	Nylon	mean± SE	63.412±0.79	15.587±0.57	7.881±0.08	6.688±0.17	6.426±0.24
		Variance	82.275	42.636	0.837	3.584	7.408
	Plastic	mean± SE	65.897±0.659	13.160±0.427	7.970±0.089	6.667±0.181	6.312±0.236
		Variance	57.305	24.046	1.038	4.34	7.319
	Basket	mean± SE	59.817±0.940	17.896±0.676	8.556±0.131	6.736±0.144	6.934±0.235
		Variance	116.599	60.341	2.257	2.749	7.26
Preservatives	Garlic + Ginger	mean± SE	62.982±0.91	14.996±0.66	7.660±0.09	7.202±0.15	7.149±0.11
		Variance	82.628	42.507	0.781	2.173	1.221
	Garlic	mean± SE	62.724±0.89	15.037±0.60	7.924±0.10	5.272±0.19	8.989±0.15
		Variance	78.838	35.455	1.044	3.753	2.212
	Ginger	mean± SE	62.63±0.99	15.093±0.68	8.339±0.16	6.358±0.14	7.560±0.13
		Variance	97.468	42.287	2.658	2.025	1.587
	Control	mean± SE	68.832±1.04	17.064±0.77	8.620±0.09	7.955±0.15	2.530±0.10
		Variance	107.776	58.549	0.849	2.295	0.938

The implication of these results are that the fish packed with plastic materials could be adjudged the best since it had the highest protein content, least moisture content and fat.

The summary statistics analysis of the preservatives (Table 2) showed that the control (without any preservatives) maintained the highest of Protein (68.832), MC (17.064), Ash (8.620) and Fat (7.955) while fish preserved with ginger returned closely higher values for MC (15.093) and Ash (8.339). This was followed by garlic + ginger which was second best in both proteins (62.982) and Fat (7.702) – Table 2.

The implication of this result is that addition of the preservatives enhances easy deterioration of the fish nutrients.

The correlation analysis results showed that sixty percent (60%) of the bivariate correlations were positive while 40% were inversely correlated (table 3).

Table 3.

Correlation Analysis of the nutrients

	Protein	MC	Ash	Fat	CF
Protein	91.206	-62.820	-8.843	-11.345	-8.498
MC	-0.971	45.874	6.042	8.247	2.867
Ash	-0.766	0.738	1.460	1.343	0.037
Fat	-0.631	0.647	0.591	3.540	-1.699
CF	-0.328	0.156	0.011	-0.333	7.365

The bivariate correlation value, r_i ranged between 0.011 (relationship between ash contents and crude fibre) and -0.971 (relationship between protein and moisture content). Forty percent of the r_{ij} are greater than 0.5 while the remaining r_{ij} were generally low. The result of the variance-covariance analysis (Table 3) indicated that generally 0.267 of the covariates (cov_{xy}) returned values greater than unity (cov_{xy} >10) while the remaining (0.733) were less than unity. All the nutrients returned negative covariates with the protein and the covariates generally ranges between 0.037(cov_{xy} of ash and crude fibre) and 91.206 which is the variance of the protein while none of the covariates was zero. The implications of these results are that the fish nutrients are not independent and that there exist little or minimal variability among the nutrients.

3.1.2. General Linear Model (GLM) Analysis

The GLM analysis of the fish nutrients revealed that there exist significant difference in the protein, moisture content, Ash, fat and crude fiber returned by different preservatives. The $F_{(3, 264:0.05)}$ = 77.40, 460.24, 111.02, 395.77 and 2037.76 obtained respectively for protein, moisture content, ash, fat and crude fiber were significant (P<0.05- Table 4). In addition, mean protein obtained for the control (63.832) was significantly higher than that obtained for ginger +garlic (62.982- Table 4). Mean protein obtained for ginger (62.630) was the least and was not significantly different from that obtained for garlic (62.724). The mean moisture content of the fish followed the trend
Control (17.064) > Ginger (15.073) > Garlic (15.037) > 2ginger (14.996).
Two classes (the control and other different treatments) were clearly defined from this partition (Table 4). The ash content was grouped into four distinct group/classes. The control had significantly highest Ash content of 8.620 and it was higher than that obtain for Ginger which was 8.339. The least ash content was that of garlic+ginger (7.66) and it is significantly lower than the ash content of Garlic (Table 4). The GLM analysis of the packaging materials used for the smoked fish indicated that significant difference exist between the mean of all the nutrients returned by different packaging materials except Fat. This is because $F_{(2, 264:0.05)}$ = 3218.80, 3359.62, 109.29 and 37.95 obtained for protein, moisture content, ash and crude fiber were significant (P < 0.05 – Table 4).

Table 4.

General Linear Model of the Nutrients composition.

Parameters	Variables	Protein	Moisture content	Ash	Fat	CF
	F-Statistics	77.40**	460.24**	111.02**	395.77**	2032.76**
	Df	3	3	3	3	3
Preservative Materials	Garlic	62.724^{c}	15.037^{b}	7.923^{c}	5.272^{d}	8.989^{a}
	Ginger	62.630^{c}	15.093^{b}	8.339^{b}	6.358^{c}	7.560^{b}
	2Ginger	62.982^{b}	14.996^{b}	7.660^{d}	7.202^{b}	7.149^{c}
	Control	63.832^{a}	17.064^{a}	8.620^{a}	7.955^{a}	2.530^{d}
	F-Statistics	3218.80**	3359.62**	109.29**	0.51	37.95**
	Df	2	2	2	2	2
Packaging Materials	Nylon	63.412^{b}	15.587^{b}	7.881^{b}	6.688^{a}	6.426^{b}
	Basket	59.817^{c}	17.896^{a}	8.556^{a}	6.736^{a}	6.934^{a}
	Plastic	65.897^{a}	13.160^{c}	7.970^{b}	6.667^{a}	6.312^{b}

*** Significant @ 0.01 probability levels (P < 0.01), * Significant @ 0.05 probability levels (P < 0.05)*

Mean fat content ($F_{2,\ 264:0.05} = 0.51$) obtained for the packaging materials was however not significant ($P < 0.05$). DMRT partitioned the mean of both protein and moisture content into 3 significantly different packaging classes. The mean protein obtained for the fish packed with plastic (65.897) was significantly higher than that of the nylon (63.412). The least mean protein (59.817) was obtained for the fish packed with basket and was significantly different from others (Table 4). The DMRT partitioning of the mean moisture content however reversed the partitioning trend of the protein for the moisture content. Mean moisture content for the plastic packed fish was the least (13.160) and was significantly less than the moisture content obtained for the fish packed with nylon (15.587). The mean moisture content obtained for fish packed with basket was the highest (17.896 – Table 4).

DMRT however partitioned both the mean ash and mean crude fibre into two significantly different classes of similar trends. Mean ash obtained for fish packed with basket was significantly higher (8.556) than the mean ash content obtained for fish with plastic (7.970) and nylon (7.881). Similarly, mean crude fiber obtained for fish packed with basket (6.934) was significantly higher than those obtained for both nylon (6.426) and plastic (6.312) which falls within the same class (Table 4). The GLM analysis of the effects of the storage periods on fish nutrients quality (Table 5) showed that there exist significant difference in the mean crude protein, moisture content, ash, fat content and crude fiber obtained for different storage periods. The $F_{(10,\ 264:0.05)} = 8394.09$, 6194.90, 195.65, 206.38 and 55.82 obtained for crude protein, moisture content, ash, crude fat and crude fiber respectively were significant ($p < 0.05$).

DMRT partitioned mean crude protein and mean moisture content into 11 significantly different classes. Mean crude protein obtained for the 0_{DAS} was significantly the highest (77.538) while mean crude protein obtained for the 140_{DAS} was significantly the least - 51.253 (Table 5). DMRT however partitioned mean moisture content in a reverse order when compared to crude protein. Mean moisture content obtained for the fish at the 0_{DAS} was significantly the least (5.703) while mean moisture content obtained for the 140_{DAS} was significantly the highest (24.976). Mean ash content were however partitioned into nine significantly different classes using DMRT. The partition was of the order $0_{DAS}(6.569) < 14_{DAS}(6.863) < 28_{DAS}() < .... < 112_{DAS}(9.239)$. The mean ash for the 126_{DAS} (9.082) formed an intermediary class between 126_{DAS} and 98_{DAS} (Table 5). Similarly, mean fat was partitioned into eight significantly different classes. Mean fat obtained for the 112_{DAS} (8.336), 126_{DAS} (8.088) and 98_{DAS} (8.055) formed the highest significantly different class. This was followed by the mean fat returned for the 140_{DAS} (7.720) and the mean fat obtained for the 42_{DAS} remained the least - 4.525 (Table 5). Mean crude fibers were partitioned into seven significantly different classes. Mean crude fiber returned for the 112_{DAS} was the highest but not significantly different from the crude fiber obtained for both 98_{DAS} (7.229) and 126_{DAS} (7.214). Crude fiber obtained for the 0_{DAS} (5.012) was significantly the least (Table 5).

Table 5.

General linear model (GLM) analysis of the effects of storage period on Fish nutrients

Parameters	Protein	Moisture	Ash	Fat	Crude fiber
$F_{(10, 264:0.05)}$	8394.09	6194.90	195.65	206.38	55.82
Df	10	10	10	10	10
0_{DAS}	77.538^{a}	5.703^{k}	6.569^{i}	4.949^{g}	5.012^{g}
14_{DAS}	75.965^{b}	7.094^{j}	6.863^{h}	4.525^{h}	5.553^{f}
28_{DAS}	72.124^{c}	9.332^{i}	7.291^{g}	5.242^{f}	6.012^{e}
42_{DAS}	68.403^{d}	11.747^{h}	7.574^{f}	5.959^{e}	6.317^{d}
56_{DAS}	64.789^{e}	14.364^{g}	7.972^{e}	6.330^{d}	6.545^{cd}
70_{DAS}	62.299^{f}	15.796^{f}	8.395^{d}	6.796^{c}	6.714^{c}
84_{DAS}	58.585^{g}	18.101^{e}	8.649^{c}	7.667^{b}	7.003^{b}
98_{DAS}	56.211^{h}	19.593^{d}	8.913^{b}	8.055^{a}	7.229^{ab}
112_{DAS}	53.559^{i}	21.439^{c}	9.239^{a}	8.336^{a}	7.426^{a}
126_{DAS}	52.737^{j}	22.880^{b}	9.082^{ab}	8.088^{a}	7.214^{ab}
140_{DAS}	51.253^{k}	24.976^{a}	8.947^{b}	7.720^{b}	7.105^{b}

Note: DAS = Days after storage

The least square mean analysis of the protein content of the fish decreases with storage period with the control (packaged with basket) maintaining the highest. Fish seasoned with ginger and garlic as well as packaged with plastic maintained higher protein content after the control (Figure 2). The least fish in term of protein content retention at the end of the experiment was the one packaged with basket and seasoned with ginger. The implication of this is that both the preservatives and the packaging materials have specific impact on the fish quality. Also, analysis of the least square mean showed that moisture content on the other hand increases with increase in the period of the research. Fish packaged with plastic and no preservatives had the highest moisture content while fish packaged with basket had the least. The least significant mean (LSM) analysis of the Nitrogen returned a constant Nitrogen values for each of the packaging materials by the preservatives over the research period (Table 6). LSM for the Nitrogen ranged between 12.24 for fish spiced with ginger and packaged with plastic and 13.04 (for fish spiced with ginger and packed with nylon. Ash content showed a disparate trend from the Nitrogen. The LSM analysis showed an increasing mean ash content over the period. The fish packaged with basket and spiced with ginger had the highest ash content of 11.24 at the end of the research (140_{DAS}). It was however observed that the rate of increase differ from one treatment to another.

Table 6.

Least Significant Means of the Fish Nutrient content.

Nutrients		2Gngr			Garlic			Ginger			Control		
	Period	Nylon	Plastic	Basket	Nylon	Plastic	Basket	Nylon	Plastic	Basket	Nylon	Plastic	Basket
	0_{DAS}	6.38	6.14	6.18	6.19	6.26	6.54	6.34	6.60	6.23	7.36	7.26	7.34
	14_{DAS}	6.72	6.54	6.54	6.53	6.69	7.15	6.39	6.67	6.89	7.46	7.26	7.53
	28_{DAS}	6.99	7.39	6.92	7.07	6.95	7.85	6.82	6.84	7.37	7.73	7.48	8.08
	42_{DAS}	7.08	7.53	6.95	7.14	7.12	8.09	7.22	7.31	8.13	7.84	8.13	8.35
	56_{DAS}	7.43	7.80	7.36	7.42	7.22	8.56	8.08	7.58	8.94	7.97	8.51	8.79
	70_{DAS}	7.93	8.37	7.73	7.87	7.40	8.99	8.14	7.82	10.44	8.48	8.76	8.81
	84_{DAS}	8.13	8.54	7.66	8.13	7.56	9.30	8.50	8.03	11.10	8.67	9.20	8.97
	98_{DAS}	8.13	8.87	7.74	8.41	7.66	9.31	8.41	8.40	11.57	9.24	9.36	9.52
	112_{DAS}	8.58	9.09	7.90	8.74	8.69	9.78	8.66	8.72	11.59	9.51	9.90	9.73
Ash	126_{DAS}	8.43	8.94	7.87	8.57	8.60	9.48	8.43	8.41	11.47	9.31	9.78	9.68
	140_{DAS}	8.14	8.75	7.71	8.34	8.38	9.48	8.41	8.45	11.24	9.13	9.72	9.60
	0_{DAS}	5.19	4.93	4.82	2.29	6.38	4.29	4.59	5.59	3.31	5.96	6.39	5.65
	14_{DAS}	5.63	4.78	4.77	2.29	1.29	4.70	4.51	5.59	3.32	5.86	6.39	5.16
	28_{DAS}	6.28	6.07	5.51	2.99	2.36	5.13	5.01	6.12	3.97	6.78	6.74	5.94
	42_{DAS}	6.63	6.16	6.71	4.62	3.16	5.99	5.71	6.75	5.00	6.88	7.18	6.71
	56_{DAS}	6.72	6.51	7.20	4.84	3.53	6.10	5.75	7.09	5.44	7.26	8.30	8.79
	70_{DAS}	7.24	7.02	7.73	5.44	3.93	6.52	5.97	7.27	6.20	7.66	8.70	7.87
	84_{DAS}	8.24	8.10	8.47	6.66	4.54	7.60	6.56	8.04	7.11	9.13	9.36	8.20
Fat	98_{DAS}	8.24	8.68	8.60	7.04	5.16	7.77	7.08	8.14	7.42	9.88	9.62	8.70
	112_{DAS}	8.73	8.99	8.66	7.41	5.36	7.94	7.72	8.34	7.68	10.12	10.04	9.05
	126_{DAS}	8.40	8.88	8.66	7.13	5.29	7.50	7.70	7.75	7.49	9.66	9.45	9.14
	140_{DAS}	8.13	8.53	8.15	7.01	4.21	7.50	7.38	7.40	6.81	9.61	9.23	8.67
	0_{DAS}	7.20	5.53	6.98	8.61	6.02	4.57	6.62	5.32	7.42	1.08	1.03	1.42
	14_{DAS}	5.83	5.72	7.15	8.62	9.10	6.67	6.82	5.32	7.69	1.08	1.03	1.60
	28_{DAS}	6.27	6.20	7.52	9.06	9.54	7.32	7.13	5.85	8.19	1.58	1.61	1.88
	42_{DAS}	6.46	6.27	7.97	8.91	9.54	7.92	7.37	6.42	8.29	1.71	2.39	2.33
	56_{DAS}	7.20	6.40	8.40	9.33	10.02	7.92	7.59	6.42	8.64	2.07	2.54	2.63
	70_{DAS}	6.78	6.56	8.79	9.56	10.06	8.19	7.62	6.45	8.81	2.24	2.76	2.74
Crude fiber	84_{DAS}	7.04	6.88	8.77	9.66	10.30	8.41	7.62	6.87	9.17	2.90	3.27	3.01
	98_{DAS}	7.29	7.01	8.92	9.84	10.61	8.74	7.94	6.87	9.75	2.93	3.53	3.27
	112_{DAS}	7.50	7.12	9.07	10.02	10.80	9.25	8.20	7.05	9.85	2.99	3.63	3.64
	126_{DAS}	7.07	6.85	9.07	9.48	10.50	9.19	7.88	6.90	9.29	2.94	3.56	3.83
	140_{DAS}	6.92	6.70	8.77	9.20	10.26	9.19	7.87	6.86	9.21	2.88	3.56	3.62

Note – DAS – Days after storage

3.2. Discussion.

The essence of fish smoking is not only for presentation but preservation in case it is more than what can be consumed within acceptable quality guaranty period and for profit maximization. The goal of the present study has been the determination of shelf life of fish and nutrient quality of such fish using general linear model approach. It is noteworthy that crude protein and moisture content as well as other investigated nutrients of the fish are inversely related. Also, the increasing trends of the moisture content of the fish can be hinged on the ability of smoked fish to absolve water or moisture from the surroundings and it is in agreement with [10]. Similarly, the progressive increase in moisture content of the fish can sufficiently cause decay and deterioration of the fish condition [11]. This increasing trend of the moisture content of the fish however, conflict with the [12]. Fish smoked at different temperature (50^0C, 60^0C and 70^0C) were found to have declining moisture content when observed for 15 hours. The disparity in [12] and current study might be hinged on the length of storage or observation (140_{DAS} against less than 1 day). The moisture content of the fish in our present study is far above 10 – 15% established by [13] and the fish still maintained its quality.

Declining crude protein as established in this present study is in line with [10], [14] and [15]. However, the declining rate of crude protein in [15] and the present study differ from each other. The difference could be hinged on differences in the species used in both cases. Rana and Chakraborty (2016) [15[uses *Neotropius atherinoides* while the present study uses *Clarias gariepinus*. Smoke-dried baim fish (6 month) was established to have better shelf-life than smoke-dried chapila (4 month) and kaika (4 month) fish [16].

The assumptions associated with the use of GLM [17] include but not limited to;

1. Response variable (which are the fish nutrients composition in our present study) is a continuous variable.
2. The error, ℓ_{ijk} are normally distributed with mean zero.
3. Equality of variance (though the variance are unequal but are minimal in our present study) for all values of *i*, *j* and *k*.
4. Individual observations are independent.

The data for the present study fulfilled some of these assumptions (continuous nature of the data, independent of observation and normal distribution of the error).

4. Conclusion

It can thus be concluded from the present study that baring any therapeutic, *C. Gariepinus* can maintain its quality for 126 days after which its quality begin to deteriorate. Although deterioration is an inevitable phenomenon in fish and fishery processing, the choice of appropriate packaging materials and preservatives would however enhance a longer shelve life. It is therefore recommended that the present study be extended to incorporate the effects of species on the shelf life of smoked fish.

5. References

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