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Chemical Composition, Microbial Content and Sensory Evaluation of Smoked Farmed Catfish *Clarias gariepinus* (Burchell, 1822) Raised Under Different Culture Systems in Ibadan, Nigeria

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Abstract
This paper examined chemical composition, microbial content and sensory evaluation of smoked farmed catfish *Clarias gariepinus* raised in different culture systems with a view to determining its quality and shelf life at ambient temperatures (28 ±2^{o}C) and relative humidity (75% - 85%). Six farms with the two most common fish culture systems (3 concrete tanks (CTs) and 3 earthen pond (EPs) were selected based on frequency of harvest and yield. Fish samples (500±10g) obtained from these farms after 4 months of culture were processed, smoked, packaged and stored for 36 weeks. The values of moisture content, ether extract, crude protein, ash, crude fibre and nitrogen free extract obtained from smoked farmed *C. gariepinus* during storage ranged from 4.67% – 21.69%; 21.00% - 20.79%; 65.02% - 49.35%; 5.51% - 0.03%; 1.00% - 1.37% and 2.81% - 6.60%, respectively. Highest total viable count (TVC) in processed catfish from both systems (1.27x10^{6}±0.01cfu/g) were obtained in the 36th week of storage. Storage time has significant effects ($p<0.05$) on TVC. Smoked fish from local fish processor (LFP) had highest TVC >10^{7}cfu/g. Best sensory scores in processed catfish were 7.0±0.01; 6.5±0.01 and 5.0±0.03 at 24 week of storage for fish from EP, CT and LFP, respectively. All quality and safety indices were within International Commission of Microbiological Specification for Foods acceptable limits.
Keywords: Total viable count, smoked fish, quality changes, protein content, texture

1. Introduction

When fish is alive, its muscle is sterile i.e. free from microorganisms. However, its surface slime, intestinal tracts and gills harbor a host of bacteria depending on the environment from where they are harvested. Once a fish is dead, bacteria will attack the fish flesh from the inside and the outside, multiplying rapidly and leading to its decomposition. As a highly perishable commodity, fish has specific requirements and a significant capacity to withstand processing. The many options for preparing fish allow for a wide range of presentations, making fish a very versatile food commodity. Fish is generally distributed live, fresh, chilled, frozen, heat-treated, fermented, dried smoked, salted, pickled, boiled, fried, freeze-dried, minced, powdered or canned, or as a combination of two or more of these forms (FAO, 2010) among many other methods.

Smoking is a traditional method used to preserve fish in the world, although today, its acceptance in developed countries is primarily based upon the sensory characteristics it imparts on the product. Furthermore, smoking increases the shelf life of fish as a result of the combined effect of dehydration, antimicrobial and antioxidant activities of several smoke constituents mainly: formaldehyde, carboxylic acids and phenols (Doe, 1998). An additional preservative effect is owed to salting which comprises the first step of the fish smoking process. However, smoking is not an absolute preserving method. For this reason, the quality of raw material, the concentration of salt, water activity of the fish, heat through the smoking process, the quantity of smoke, the way of packaging, hygienic circumstances and heat of storage have the most important effects to reduce the risk of deterioration (Serkan *et.al*., 2009).

Fish as foods, like all foodstuffs, runs the risk of causing illness of the consumer if measures are not taken to prevent or eliminate contamination from pathogenic microorganisms, toxin or contaminants. The safety of fish as food is an all important aspect of the need to protect fish consumers and ensure the sustainability of the industry.

Modern food safety and quality assurance systems have as an underlying principle, the need to show that precautions are taken to safeguard the consumer. The broad global acceptance of food safety and quality assurance systems which include Hazard Analysis Critical Control Point (HACCP) principles make these systems currently the systems of choice in food production industries.

The traditional system of marketing and utilization in Africa leaves little opportunity for applying quality assurance programme on fish products entering the domestic market. For traditional products such as fermented, dried, salted and smoked fish, there are no well-developed criteria of quality that can be used in fish quality assurance procedures (Abobarin, 2000). The protection of the interests and health of the population must be a

priority for any government. An effective food safety and quality assurance system is a basic element in protecting both the health of the consumer and the interest of the industry.

Smoked fish as source of foreign exchange is gradually losing ground. This is adduced to the fact that exportation of processed fish to developed countries is becoming increasingly stringent because of the emerging set of Food Safety and Agricultural Health Standard, along with buyers changing their requirements (Ito, 2005 and Oyelese, 2006). Nigeria artisanal fisheries could benefit considerably from increased trade to the ethnic markets in Europe and United States through export of smoked fish and small dried shrimp. However, consignments of smoked fish are regularly detained and often destroyed by Port Health Authorities at Gatwick and Heathrow Airports due to mould growth and insect infestation and other reasons (Ward, 2003). Therefore the objectives of this study are to assess the quality and safety of fresh and smoked farmed *Clarias gariepinus* raised under different culture systems.

2. Materials and methods

Fifty kilogram of fresh samples of *C. gariepinus* were collected from the selected fish farms in Ibadan. The sample was transported to the processing laboratory live in a plastic bucket with water. At the processing laboratory the samples was placed in ice for five hours and the rapid change in temperature led to the death of the fish and also ice preserved it. The preserved fish were then smoked using modified Chorkor oven and under Good Manufacturing Practices (GMP). The smoking time, temperature and ambient conditions were monitored during the smoking operations. The smoking was terminated when the fish were properly dried. The smoked fish was packaged in transparent polythene bags and the packets were then packed in wax coated carton for storage at ambient conditions (28±2^{o}C) for 36 weeks. The fresh and smoked samples obtained from earthen pond system (EPs) and concrete tank systems (CTs) were analyzed for chemical composition, microbial content and sensory evaluation. The proximate composition, microbial analysis and sensory evaluation were determined at 0, 12, 24 and 36 weeks of storage. These were compared with traditionally smoked wild catfish obtained from local fish processor (LFP). Sensory evaluation of the products was also done using standard procedure. Data were analysed using Correlation and ANOVA at $\alpha_{0.05}$

2.1 Proximate Composition Analysis

The smoked catfish samples were finely ground and homogenized for chemical analyses. The percentage proximate composition of the smoked fish samples was determined according to the AOAC (2005) methods. Triplicate determinations were carried out for moisture, protein, lipid, ash, crude fibre and nitrogen free extract. The total protein content was estimated using the Kjeldahl method and crude fat content was determined using the Soxhlet method. The moisture content was determined by oven drying samples overnight at 105^{o}C until constant weight and the ash content was determined by incineration of the samples for 6h at 500^{o}C in a muffle furnace.

2.2 Microbial Analysis: The farmed smoked *Clarias gariepinus* and smoked samples obtained from LFP were assessed for total viable count, Pathogen count, Fungi count and Total Coliform counts during storage. 1.0g of fish sample was ground into powder and mixed with 9ml peptone water to make a stock solution from where serial dilutions were made. 1ml from the stock solution was put into 9ml peptone water till dilution factor 10^{-2}. TVC was plated on Nutrient agar, coliform on Eosine Methylene Blue Agar, Salmonella on Bismult Sulphite Agar and fungi (yeast and mould) on Potato Dextrose Agar. The pour plate method was used. The plate was incubated for 24-48h but for Fungi the result was taken between 5-7 days.

2.3 Sensory Analysis

A five –man panel using subjective methods was put through an eight point hedonic scale (grading sheet) to evaluate changes in colour, odour, texture and taste.

3. Results and Discussions

3.1 Proximate Composition of Fresh *Clarias gariepinus* raised under different culture systems

Fresh *C. gariepinus* raised under different culture systems showed little variation in nutrient composition (Table 1a & b). Moisture content of fresh fish raised in earthen pond (EPs) had a value of 59.35% and 73.55% for fish raised in concrete tank (CTs). Olayemi *et.al* (2011) reported a value of 78.70% moisture for African catfish caught from Fagam farm, Kano State. Ayeloja *et.al.* (2011) also reported value of 78.32% for *C. gariepinus* collected from CTs of a fish farm in Lagos. Moisture content values of 71.70% and 70.35% *C. gariepinus* were also reported by Olopade *et al.,* (2013) and Oladipo and Bankole (2013), respectively. Fresh *C. gariepinus* raised in EPs had the highest value of crude protein with a value of 19.60% in this study. This value is comparable with a value of 19.64% recorded for African catfish from Lekki Lagoon (Osibona, 2011). Olayemi *et al,* (2011) reported values of 7.24% to 16.24% for *C. gariepinus*. Also Ogbonnaya and Ibrahim (2009), Ayeloja *et al.*

(2011), Oladipo and Bankole (2013) and Olopade *et al.,* (2011) reported protein values of 19.51% and 18.01%, 17.50% and 18.13%, respectively for *C. gariepinus* collected from fish farms.
The ether extract value for fresh *C. gariepinus* raised in EPs was between 2.7% and 7.7% while *C. gariepinus* raised in CTs had values ranging from 5.22% to 5.78% fat. These values were very close to the 7.80% reported by Fawole *et.al* (2007) for *C. gariepinus.* Values of 8.94% and 6.55% were also reported by Oladipo and Bankole (2013) and Olopade *et.al.* (2011). The values obtained showed that *C. gariepinus* belong to low fat fish species. Olele (2012) reported values of 25.04% to 35.07% for *Gnathonemus tamandua* from river Niger. Adefemi (2010) reported values of 17.16% to 39.03% in *Chrysuchtys nigrodigitatus* and 18.30% to 37.02% in *Tilapia mossambicus.*
The crude fibre of *C. gariepinus* raised in EPs was 0.1% while *C. gariepinus* raised in CTs had values between 1.57% and 2.00% from this study. This concentration is comparable with that reported by Ogbonnaya and Ibrahim (2009) in *C. gariepinus* obtained from a fish market in Minna, Niger State (0.98%). *C. gariepinus* raised in EPs and CTs had ash content values of 1.09% to 1.27% and 1.20% to 2.4%, respectively in this study. Osibona (2011) analyzed *C. gariepinus* from Lekki Lagoon and reported values of 1.23% ash. Ayeloja *et.al* (2011) reported ash value of 1.13% for *Clarias* collected from CTs and Ogbonnaya and Ibrahim reported ash value of 3.06% for *Clarias* collected from a fish market. The variations observed in the nutrient composition of *C. gariepinus* raised in EPs and CTs could be due to feeding in addition to natural nutrients in EPs.

3.2 Proximate Composition of Smoked farmed *Clarias gariepinus* raised in different culture systems

Mean composition of analyzed specimens from different culture systems are shown in Tables 2- 4. The moisture content of the smoked fish samples were 4.67 ± 0.02%, 5.08 ± 0.01% and 11.28 ± 0.01% after hot smoking process for fish obtained from EPs, CTs and LFP, respectively but increased with storage time. At week 0, the crude protein, ether extract, ash, crude fibre and nitrogen free extract were 65.02 ± 0.02%, 62.06 ± 0.01%, 65.03 ± 0.01%; 21.00 ± 0.02%, 20.08 ± 0.01%, 17.72 ± 0.01%; 5.51 ± %, 9.68 ± 0.01% , 0.2 ± 0.00%; 1.00%, 1.01 ± 0.01%, 0.20 ±0.00% and 2.81 ± 0.02%, 2.61 ± 0.01% , 3.13 ± 0.01%, respectively. Linear correlation of proximate composition of smoked fish from CTs with storage time showed that moisture content, ether extract and nitrogen free extract had positive correlation with storage time. A unit increase in storage time led to 0.99, 0.95 and 0.91 increases in the values of moisture content, ether extract and nitrogen free extract respectively. Also crude protein had negative correlation with storage time; a unit increase in storage time led to 0.96 decreases in the value of crude protein. For smoked fish from earthen pond, correlation was significant at 0.01 levels (2-tailed). Comparison of mean of proximate values obtained from smoked fish from local fish processor showed that moisture content, ether extract and nitrogen free extract were significant at 0.05 levels (2-tailed). Moisture content of catfish decreased sharply after the hot smoking process and this decrease was due to loss of water during smoking. Similar findings were reported by Serkan *et al.,* (2009), Omojowo *et al.*, (2009) and Kumolu-Johnson *et.al*, (2010) that the spoilage of fish resulting from the action of bacteria and enzyme activities can be reduced by salting and by reducing moisture content through hot smoking. Olayemi *et al.,* (2011) also reported sharp decrease in moisture content of *C. gariepinus* smoked with Nigerian stored Products Research Institute developed kiln. The moisture content of the processed fish samples was lower than the moisture content of smoked fish obtained from the local fish processor. The moisture content (which is of great importance in storage) of the farmed smoked *C. gariepinus* samples is still at safe level between 4% and 5% which is in between the recommended safe moisture content for dried fish (6 to 8%) (Yanar, 2007). The increase in protein levels in smoked fish samples, when compared with the fresh fish, suggested that protein nitrogen was not lost during hot-smoking. This is also in agreement with the work of Ogbonaya and Ibrahim (2009). There was no significant difference ($p>0.05$) in the moisture content of smoked fish obtained from the EPs and from CTs. The low moisture content of the smoked fish samples extended the shelf life to about 4-6 months. The preliminary investigation of smoked fish purchased from local fish processor showed that there was rapid growth of microorganisms within few days which could be due to poor handling, poor hygiene of the fish handler and environment where the fish was kept and poor packaging. Huda *et. al.,* (2010) reported that nutrient content of fish is influenced by several factors including smoking method and time. The result of the proximate composition generally showed fish as good source of protein higher than those of sheep meat (17.2g/100), cow meat (19.6g/100) and pork (19.4g/100) (Effiong and Fakunle, 2012). Smoked dried fish is the most acceptable form of fish product in Nigeria (Yanar, 2007; Stolyhiro and Sikorski, 2005).

3.3 Microbiological Analysis of Fresh and Smoked *Clarias gariepinus*

The result of microbiological analysis of fresh *C. gariepinus* is presented in Table 5 and change in the microbial load of smoked *C. gariepinus* from EPs, CTs and LFP during storage are presented in Tables 6, 7 and 8 respectively. The highest total viable count (TVC) (1.27×10^6) in processed catfish from both culture systems was obtained in the 36^{th} week of storage. Ayeloja *et al,* 2013 reported TVC value of 2.6×10^2cfu/g for smoked *C. gariepinus*. Fungal growth was observed at 24^{th} week with a value of 2×10^0cfu/g. Salmonella and coliform were

not detected in the samples throughout the storage period. Total viable count, coliform and pathogens were highest in smoked fish obtained from LFP. Analysis of Variance (ANOVA) (Table 9) revealed that storage time, culture systems and season of the year did not have significant effect ($p>0.05$) on the growth of coliform, salmonella, fungi and pathogen. Storage time however had significant effect ($p<0.05$) on the total viable count (TVC) which increased with storage time. The result of microbial analysis obtained in this study is within the International Commission of Microbiological Specification for Foods acceptable limits. According to Mazorra-Manzano *et al,* (2000), microbial activity is the main factor limiting the shelf life of fresh fish. However, at 0^oC freshness of fish is lost before bacterial counts increase significantly. Smoked fish samples obtained from local fish processor showed high microbial content which could be due to exposure of the fish to contamination from the handler and the atmosphere (i.e. poor hygiene). Olayemi *et al,* (2012) reported mean total bacteria of 2.0 x 10^3 for catfish smoked with Nigerian Stored Products Research Institute. Oladipo and Bankole (2013) and Daniel *et al.,(*2013) reported values of 2.0 x 10^4cfu/g and 1.24 x 10^6cfu/g for smoked *C. gariepinus*, respectively. Adeosun *et al.* (2014) reported TVC value of 2.7 x 10^5cfu/g for fresh pond-raised *C. gariepinus*. The result also indicated that there was no contamination with enteric organisms by handler during smoking as there was no coliform found after smoking.

3.4 Sensory Evaluation of smoked *C. gariepinus* stored at ambient conditions

The mean sensory scores for smoked *Clarias gariepinus* are presented in Figures 1-3. Smoked fish was assessed on the basis of odour, taste and texture characteristics. The results showed high level of acceptability of the processed products and this was attributed to the strict sanitary condition under which the product was handled at all stages. However, overall acceptability decreased with storage time. The experimental smoked fish samples had very good quality up to 24weeks. The samples were no longer acceptable after 24th week of storage. Fish from local fish processor could not be stored for a long period of time. The panelists response was based on hedonic scale (Ihekoroye and Ngoddy, 1985) where 8 = excellent, 7= very good, 6 = good, 5 = fair, 4= fairly poor, 3 = poor, 2 = very poor and1= extremely poor.

3.5 Packaging

Microbial load of smoked fish from the local fish processor was higher experimental samples. This was due to strict compliance with good manufacturing practices and also the use of packaging material. This led to improved quality of the experimental fish and longer storage life than fish samples obtained from local fish processor. The packaging materials used to package the experimental samples also prevented the samples from insect infestation. Throughout the storage period of 36 weeks there was no insect infestation of the samples. Therefore, hygienic processing, proper packaging and storage will improve the quality and safety of smoked fish.

4. Conclusion

The smoking process reduced the microbial load on the fresh fish and the reduction in moisture content of the experimental samples made the smoked samples shell stable. Packaging also plays an important role in safeguarding the health of consumers by protecting and preserving the food product during its anticipated shelf-life. The packaging of fish products should ensure attractive presentation among other food products without contaminating them. The packaging also prevented re-contamination and reduced breakage. There was no insect infestation throughout the experimental period. Therefore, hygienic processing, proper packaging and storage will improve the quality and safety of smoked fish. Local fish processors should also be trained in good manufacturing practices so that quality fish products will be available for consumers.

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Table 1a: Proximate composition of fresh *Clarias gariepinus* raised in earthen pond before processing

Age of fish (Month)	Moisture Content %	Ether Extract %	Crude Protein %	ASH %	Crude Fibre %	Dry Matter %	Nitrogen Free Extract %
1	59.35±0.02	7.70±0.02	27.8±0.08	1.22±0.01	0.10±0.01	40.65±0.02	3.83±0.05
5	72.82±0.02	2.70±0.02	19.6±0.09	1.09±0.01	0.01±0.01	27.18±0.02	3.78±0.07
6	73.55±0.02	4.71±0.02	19.6±0.05	1.27±0.01	0.10±0.01	26.45±0.02	1.32±0.05
LFP	58.90±0.01	11.1±0.01	27.3±0.01	2.30±0.02	0.01±0.01	41.10±0.01	0.40±0.01

Values are mean of triplicate determinations

Table 1b: Proximate composition of fresh *Clarias gariepinus* raised in concrete tank before processing

Age of fish (Month)	Moisture Content %	Ether Extract %	Crude Protein %	ASH %	Crude Fibre %	Dry Matter %	Nitrogen Free Extract %
1	71.00±0.01	5.30±0.01	18.50±0.01	1.20±0.01	2.00±0.02	29.00±0.02	2.00±0.01
5	72.50±0.02	5.78±0.02	18.57±0.02	2.22±0.01	1.93±0.01	27.50±0.02	1.00±0.00
6	73.90±0.01	5.22±0.02	16.12±0.01	2.40±0.01	1.57±0.01	26.10±0.02	0.79±0.00
LFP	58.90±0.01	11.1±0.01	27.30±0.01	2.30±0.02	0.01±0.01	41.1±0.01	0.40±0.01

Values are mean of triplicate determinations

Table 2: Proximate composition of smoked farmed *Clarias gariepinus* raised in earthen pond

Storage Time (weeks)	Moisture Content %	Ether Extract %	Crude Protein %	ASH %	Crude Fibre %	Dry Matter %	Nitrogen Free Extract %
0	4.67±0.02	21.00±0.02	65.02±0.02	5.51±0.02	1.00±0.00	95.33±0.02	2.81±0.02
12	6.33±0.01	20.61±0.01	61.20±0.01	8.48±0.01	1.37±0.01	93.67±0.01	2.01±0.01
24	10.98±0.01	18.02±0.01	62.96±0.01	3.56±0.01	0.18±0.00	89.01±0.01	4.30±0.01
36	13.64±0.01	16.90±0.01	61.00±0.01	3.90±0.01	0.03±0.00	86.35±0.01	4.53±0.01

Values are mean of triplicate determinations

Table 3: Proximate composition of smoked farmed *Clarias gariepinus* raised in concrete tank

Storage Time (weeks)	Moisture Content %	Ether Extract %	Crude Protein %	ASH %	Crude Fibre %	Dry Matter %	Nitrogen Free Extract %
0	5.08±0.01	20.08±0.01	62.06±0.01	9.68±0.01	1.01±0.01	94.92±0.02	2.61±0.01
12	11.44±0.01	20.08±0.01	60.78±0.01	4.43±0.01	0.02±0.00	88.56±0.01	2.26±0.01
24	15.95±0.01	20.61±0.01	52.85±0.01	3.71±0.01	1.53±0.01	84.05±0.01	5.69±0.01
36	21.69±0.01	20.79±0.01	49.35±0.01	0.03±0.00	1.37±0.01	78.31±0.01	6.60±0.01

Values are mean of triplicate determinations

Table 4: Proximate composition of smoked farmed *Clarias gariepinus* from local fish processor (LFP)

Storage Time (weeks)	Moisture Content %	Ether Extract %	Crude Protein %	ASH %	Crude Fibre %	Dry Matter %	Nitrogen Free Extract %
0	11.28±0.01	17.72±0.01	65.03±0.01	2.67±0.01	0.20±0.00	88.72±0.01	3.13±0.01
12	22.02±0.01	18.48±0.01	51.35±0.01	3.44±0.01	1.37±0.01	77.98±0.01	3.41±0.01
24	26.75±0.01	16.99±0.01	45.45±0.01	7.51±0.01	0.73±0.00	73.25±0.01	2.57±0.01
36	35.49±0.01	17.00±0.01	34.36±0.01	9.38±0.02	1.30±0.01	64.51±0.01	2.48±0.01

Values are mean of triplicate determinations

Table 5: Microbial analysis of Fresh *Clarias gariepinus* raised in different culture systems before processing

	Total Viable Count cfu/g	Salmonella Count cfu/g	Coliform Count cfu/g	Fungi Count cfu/g
Earthen pond	3.11×10^3	0.00	0.00	0.00
Concrete tank	2.56×10^5	1.28×10^2	0.00	0.00
Fish from LFP	ND	ND	ND	ND

ND = Not Determined

Table 6: Microbial analysis of stored smoked *Clarias gariepinus* obtained from earthen pond

Storage time (weeks)	Total Viable Count (cfu/g)	Pathogen Count (cfu/g)	Salmonella Count (cfu/g)	Fungi Count (cfu/g)	Total Coliforms (cfu/g)
0	NG	NG	NG	NG	NG
12	NG	NG	NG	NG	NG
24	4×10^2	ND	NG	2×10^0	ND
36	1.27×10^6	NG	NG	2×10^1	NG

Note: NG = No Growth; ND = Not Determined

Table 7: Microbial analysis of stored smoked *Clarias gariepinus* obtained from concrete tank

Storage time (Months)	Total Viable Count (cfu/g)	Pathogen count (cfu/g)	Salmonella Count (cfu/g)	Fungi count (cfu/g)	Total coliforms (cfu/g)
0	NG	NG	NG	NG	NG
12	NG	NG	NG	NG	NG
24	3×10^2	ND	NG	$2X10^0$	ND
36	$1.27X10^6$	NG	NG	$2X10^1$	NG

Note: NG = No Growth; ND = Not Determined

Table 8: Microbial analysis of stored smoked *Clarias gariepinus* obtained from local fish processor

Storage time (Months)	Total Viable Count (cfu/g)	Pathogen count (cfu/g)	Salmonella Count (cfu/g)	Fungi count (cfu/g)	Total coliforms (cfu/g)
0	14×10^2	60×10^0	ND	ND	$31 X 10^0$
12	26×10^4	TNC	NG	31	36×10^2
24	TNC> 10^7	ND	ND	TNC>10^7	4.15×10^6
36	TNC > 10^7	TNC >10^7	TNC >10^7	TNC >10^7	TNC >10^7

Note: NG = No Growth; ND = Not Determined; TNC = Too Numerous to Count

Table 9: Summary of ANOVA for Microbial Analysis of Smoked *Clarias gariepinus* stored at ambient temperature

	Variables	Df	MS	F	p-level
1.	Total Viable Count				
	Culture system	2	$707290x10^7$	0.7390	0.5165*
	Storage time (months)	3**	$786580x10^8$	8.2184	0.0151**
	Error	6	$957100x10^7$		
2.	*Salmonella* Count				
	Culture system	2	$280502x10^8$	2.7454	0.1424*
	Storage time	3	$168002x10^8$	1.6443	0.2763*
	Error	6	$102169x10^8$		
3.	Fungi Count				
	Culture system	2	$25x10^{12}$	1.8000	0.2441*
	Storage time	3	$305556x10^8$	2.2000	0.1889 *
	Error	6	$138889x10^8$		
4.	Total coliform count				
	Culture system	2	$123897x10^8$	2.3470	0.1766*
	Storage time	3	$158287x10^8$	2.9984	0.1171*
	Error	6	$527900x10^7$		
5.	Pathogen count				
	Culture system	2	$253322x10^8$	2.1098	0.2024*
	Storage time	3	$253564x10^8$	2.1118	0.2001*
	Error	6	$120070x10^8$		

**, * denote significance at 1% and 10% respectively

Table 9b: LSD test for Storage Time

Storage time	Mean	1	2
12 (2)	700.0^a	xxxx	
0 (1)	86667.0^a	xxxx	
24 (3)	3333333.0^a	xxxx	
36 (4)	$109x10^{5\,b}$		xxxx

NB: Means of the same letter are not significantly different

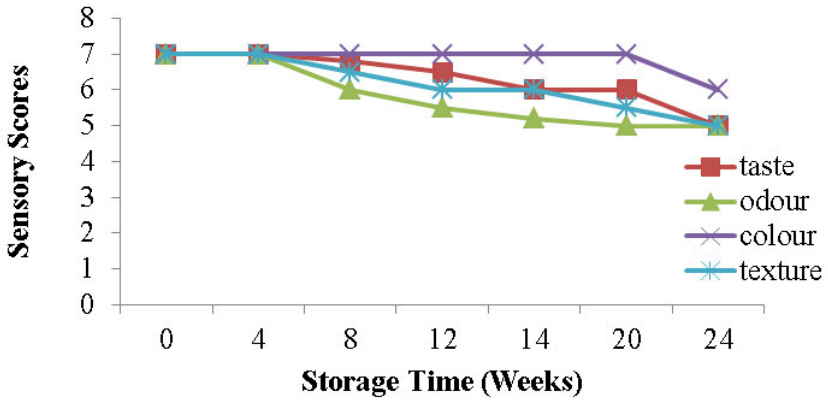

Figure 1: Mean sensory score of farmed smoked *Clarias gariepinus* from earthen pond stored at ambient temperature

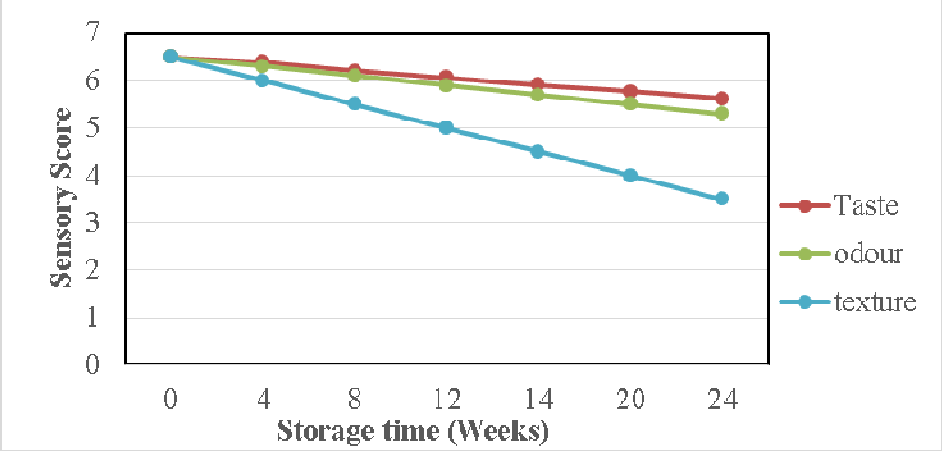

Fig. 2: Mean sensory score of farmed smoked *Clarias gariepinus* from concrete tank stored at ambient temperature

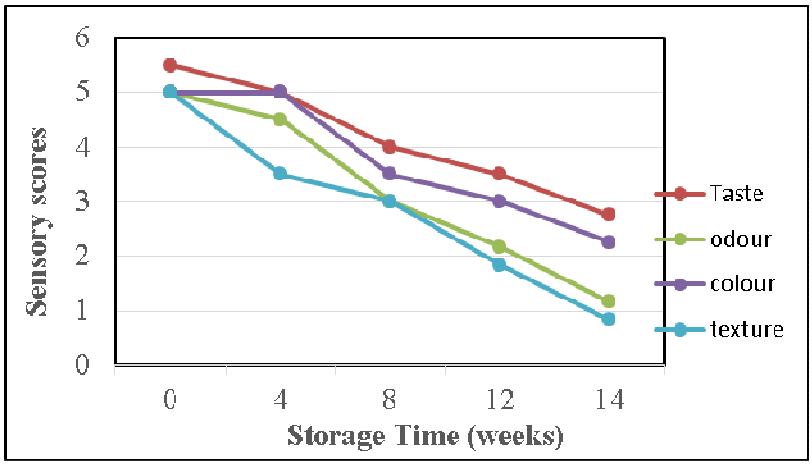

Fig. 3: Mean sensory score of smoked *Clarias gariepinus* from local fish processor (LFP)