NUTRITIVE AND ORGANOLEPTIC ASSESSMENT OF THREE FISH SPECIES PROCESSED BY DRYING, SMOKING AND FRYING) FROM AILARA FISHING COMMUNITY, ASA RESERVOIR, KWARA STATE

BY

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A PROJECT IN THE DEPARTMENT OF FISHERIES AND AQUACULTURE, FACULTY OF AGRICULTURE IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF BACHELOR OF FISHERIES AND AQUACULTURE (B. FISHERIES AND AQUACULTURE).

FEDERAL UNIVERSITY OYE-EKITI, EKITI STATE.

NOVEMBER 2017

DECLARATION

I, **OMOWUMI OJO F.** with Matric No. **FAQ/12/0470** of the Department of Fisheries and Aquaculture, Faculty of Agriculture, Federal University, Oye-Ekiti hereby declare that this report is valid and the information was carried out by me. That any falsification will render this report invalid.

CERTIFICATION

This is to certify that this research work was carried out by Omowumi, Ojo F. with Matric No. FAQ/12/0470 of the Department of Fisheries and Aquaculture, Faculty of Agriculture, Federal University, Oye-Ekiti.

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DEDICATION

This study is dedicated to almighty God for His numerous mercies and guidance over me from the inception of the Research work to its completion.

I dedicate this Research work to my Parents Mr & Mrs Ojo who gave me all the moral and Parental support throughout the period of the Research work.

ACKNOWLEDGEMENT

I acknowledge the almighty God for being very faithful to me throughout the course of my study and this research project.

My appreciation goes to my project supervisor, Mrs Joy Ozazuwa for his intellectual support given to me during the course of this study may Almighty God continue to increase your knowledge and your post Amen!

My sincerely profound gratitude goes to the head of department of Fisheries and Aquaculture of Federal University Oye-Ekiti , Dr. Babalola for his intellectual and Fatherly assistance to me during the course of my studies. May God strengthening and boost you with prosperity in all ramifications.

I acknowledge the immeasurable efforts of my great lecturers in Fisheries and Aquaculture, Prof. Nwanna, Dr. Akinsorotan, Dr. Ariyomo, Dr. Okeke, Mr.Omobepade and Mr.Oyawoye Temitope.

I acknowledge the effort and financial support of my Family most especially my parents Mr. and Mrs. Ojo and also my beloved brother in person of Ojo Akinsanmi Anthony and my sisters, Mrs Ibukun Ajakaye, Mrs Oluwatosin Taiwo and Mrs Oluwatoyin Ojo.

Finaly, my appreciation also goes to my Course mates: Akinola Adedapo Michael, Olukayode Toyosi Lawrence, Rabiu Halimat, Odeyemi Kemisola Mary, Ajisodun Abimbola Funmilayo, Ogunmola Temiloluwa Peter, Ogunremi Ismaila Tope, Omisanmi Tosin, and Nuhu Hauwa

May Almighty God bless you all, your contribution in all ramifications is highly appreciated.

ABSTRACT

This study evaluated the nutritive and organoleptic properties of three fish species processed using three methods, sun-drying, smoking and frying in Ailara fishing community of Asa Reservoir in Kwara State. Sun-dried *Oreochromis niloticus, Clarias gariepinus* and *Hydrocynus forskahlii* is on the average more nutritive and better preserved than the others followed by the smoked and the fried. *O. niloticus, C. gariepinus* and *H. forskahlii* are generally liked by the respondents that represent the general populace of Ilorin with the fried *O. niloticus* and *C. gariepinus* being the most liked on the average and the sun-dried the least liked on the average while the smoked *H. forskahlii* is most liked and the sun-dried least liked. It has been observed that though the sundried type of the three fish species studied is the most nutritive and best preserved with the protein content being 70.26%, 68.4% and 73.45% in *Oreochromis niloticus*, *Clarias gariepinus* and *Hydrocynus forskahlii* respectively, it is least liked possibly because of the nature of preparation and lack of information as to the nutritive benefits of the three. Also, since the fried is very much liked, fish processors should be encouraged to venture into more frying in order to increase their sales and hence profitability.

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CHAPTER ONE

INTRODUCTION

The overall total production of fish from capture and aquaculture fisheries in Nigeria is about 800,000 metric tons in 2010 (FAO Fishery Statistics, 2010) thus making fish farming one of the fastest growing agricultural enterprises in Nigeria.

Fish is important as it is the cheapest and most sustainable source of animal protein (Jamin and Ayinla, 2003) to many household considering the fact that fatty acids help in reducing many forms of cancer disease that is most dreadful among Nigerians (Smith, 2015). The consumption of fish is equally not forbidden within religious groups unlike eating Dog and pork (which is forbidden in some religion (Agbelege and Ipinjolu 2001). Study shows that healthy consumption of fish promotes healthy brain tissue and reduces the risk of heart disease through the reduction of probability of clot formation, lowering blood pressure and reducing the cholesterol levels in the blood stream. Nigerians are high fish consumers (Aluko, 2010) as the demand for fish increases rapidly, there will be less fish available per capital annually according to Eyo (1999) due to an increase in human population and with the current demand of 2.66million metric tons/annum.

The Kwara State policy on fisheries is to increase fish production and improve the quality of fish food produce for local consumption and export. With these programmes in place, the fish production in Kwara State has increased from 30,000 metric tons per annual in 2003 to about 120,000 metric tons in 2011(Ilorin Info, 2012).

The potential yield of Nigerian aquaculture has been estimated at over four million tons annually which could conveniently meet the national demand of 2.66million metric tons

and generate considerable export earnings. According to Adekoya and Miller (2004), globally, fish and fish products constitute more than 60% of the total protein intake in adults, especially in the rural areas. Fish has the potential to be considered as a balanced food and can therefore be expected to provide relief from malnutrition (Ogundiran *et al.*, 2014). In recent times, fish has been reported as the cheapest source of protein used to correct protein deficiency in human diets in the tropic region (Akinwumi, 2011). It also contains some bioactive compounds with therapeutic properties that are beneficial to human health (Nnaji *et al*., 2010; Lordan *et al*, 2011).

Fish is an important component in the diets of many Nigerians. It is a good source of Protein; fish constitute the major source of animal protein intake in Nigeria. Fish is also an important source of iron, calcium, iodine, potassium, vitamin A, vitamin B2, vitamin B6, poly-unsaturated fatty acids, other minerals, vitamins, micronutrients (USDA, 2002).

Although fish is a good source of some essential nutrients, processing and processing practices could cause modifications in proximate composition, fatty acids and amino acids as well as changes in the nutritional quality of fish and trace metal composition. Furthermore, the study of the mineral elements present in fish products is of biological importance; since many of such elements take part in human metabolic processes and are known to be indispensable to all living things. A deficiency in these principal nutritional mineral elements induces a lot of malfunctioning; as it reduces productivity and causes diseases such as inability of blood to clot, osteoporosis, anaemia *et cetera*. Also, the measurement of quality is often necessary to ensure that fresh and processed fish meets the requirements of food regulations and commercial specifications.

Hence to ensure the availability of fish throughout the year, especially during the lean season, it is essential to process the fish to preserve it in appreciable quantities in good condition until its use is required (FAO, 2001).

Spoilage set in because fish is susceptible to microbial and enzymatic deterioration and quality reduction occur, if proper steps are not applied to process the fish, (Emokpae, 1985). The fish loses its organoleptic characteristics and becomes progressively more unacceptable for human consumption. There are several ways of accessing quality of fish product, whether smoked, dried, frozen or canned, and these are physical examination, biochemical, microbiological, entomological and sensory methods (Clucas and Sutcliffe, 1981). The process of fish drying involves the removal of moisture from fish flesh; this could be achieved through sun-drying, smoke-drying, application of pressure and use of absorbent pads. Sun drying is presumably the oldest method of fish preservation employing hot heat from sun and atmospheric air (Awoyemi and Eyo, 1998). The demerit of sun drying being the length of time it takes for drying. For better product, sun drying is supplemented with smoke drying. Smoke dried fish, if stored under good conditions can be kept for several months (Tobor, 1984) although Dvorak and Vognarova (1965) reported that smoking caused some decrease in available lysine.

According to Davies and Davies (2009), the problem of high post-harvest losses has been recognized as a major impediment to the realization of the goal of increasing the contribution of fisheries to the Nigerian economy.

The processing and preservation of fish were of utmost importance since fish is highly susceptible to deterioration immediately after harvest and to prevent economic losses (Okonta and Ekelemu, 2005). If fish is not sold fresh, preservation methods should be

applied to extend its shelf –life. These include freezing, smoking, drying according to Davies and Davies (2009).

Agbon *et al.* (2002) and Ayuba and Omeji (2006) reported that insect infestation is the cause of most prominent losses in quality and quantity of stored dried fish in Nigeria.

1.1 STATEMENT OF PROBLEM

In the high ambient temperature of the tropics of which Nigeria is a part, spoilage could occur within 12 to 20 hours depending on the species, method of catch and chemical composition which could be affected by the processing method, while deterioration takes less than 2 days to about 6 days in colder climates (Adejumo, 1997). Fish perishability is due to its high susceptibility to degradable organisms which are present in the slime, gills and intestine and on the surface of the fish. A number of processing techniques are however employed by fish processors in Nigeria such as, smoking, freezing, chilling, salting, drying and fermentation which are aimed at stemming the tide of this spoilage for sustainable usage of these important food resources. Furthermore, due to the lack of a good transport infrastructure for the transportation of fresh fish to remote towns and villages, cured or processed fish is the most convenient form in which fish can be sent to such areas.

One of the constraints to such an attainment aside seasonality of fish food, is the fact that, in general, fish is made up of 70-84 percent water and with this comes its high susceptibility to deterioration without any preservative or processing measures. This is so because immediately a fish dies, quite a number of physiological and microbial deterioration set in and thereby degrade the fish (Davies and Davies, 2009). Agbon et al.

(2002), Ayuba and Omeji (2006) further reported that insect infestation is the cause of most prominent losses in quality and quantity of stored dried fish in Nigeria.

Post-harvest losses usually abound and the nature of the processing method coupled with the nutritive organoleptic acceptability usually determine the extent to which it is marketable or it constitute a loss. The nutritive value is also of utmost importance in ensuring the fish is of optimum benefit to the populace and the utmost nutritional aims and objectives are achieved to the fullest.

Processing methods used by processors of fish caught from the Asa reservoir use the frying, sun-drying and smoking methods (Nzeh, 2012). However, there is no information as to which of these common methods is/ are nutritionally most beneficial and acceptable to the general populace.

1.2 JUSTIFICATION

In this study, *Oreochromis niloticus, Clarias garipienus and Hydrocynus* were chosen due to their good consumer acceptance and economic values (Nadcisa *et al.*, 2001; Chukwu and Shaba, 2009).Therefore the quality of fish processed after the various methods were utilized cannot be the same and hence its subsequent effect on the fish's nutritional properties and consumer acceptance also varies.

Fish being an extremely perishable commodity, spoiling soon after death, due to enzymatic and microbial actions, there is the need for large-scale development of fish preservation and processing machinery and techniques for effective fish handling, harvesting, processing and storage can never be over-emphasized especially now that aquaculture production is on the increase in Nigeria (Davies *et al.*, 2008).

Among the major factors responsible for the non-sustainable utilization of these fish resources is the fact that facilities for processing, storing and distributing are scarce in most cases (Olowe, 2014). There is therefore enormous waste through spoilage of both fresh and processed fish. Although preservation methods for fish and products are often used in order to make the fish safer and to prolong its shelf life to increase the consumability, the determination of some proximate parameters such as moisture, ash, lipid and protein contents in processed fishes such as those from Ailara fishing community are necessary so as to ascertain that they meet the requirements of food regulations and commercial specifications and to determine their relative desirability in terms of their nutritive factors and consumer acceptance.

1.3 OBJECTIVES

The objectives of this study are:

- To know the best preservative method in terms of the nutritional values.
- To investigate the proximate quality changes and nutritional value changes of traditionally smoked, fried and dried fish in Ailara fishing community.
- To determine the organoleptic perception and desirability of local processing methods.
- To establish if there is preference for any of the three preservation methods among people of Ilorin metropolis.

1.4 HYPOTHESES

Hypothesis 1:

H_0 : There is no significant difference in the nutritional values of the three preservative methods.

H_1: There is significant difference in the nutritional values of the three preservative methods.

Hypothesis 2:

H_0: There is no significant proximate quality changes and nutritional value changes of traditionally smoked, fried and dried fish from the fresh in Ailara fishing community.

H_1: There are significant proximate quality changes and nutritional value changes of traditionally smoked, fried and dried fish from the fresh in Ailara fishing community.

Hypothesis 3:

H_0: There is no significant difference in the organoleptic perception and desirability of the three local processing methods.

H_1: There are significant differences in the organoleptic perception and desirability of the three local processing methods.

CHAPTER TWO

LITERATURE REVIEW

2.1 Fish processing in Nigeria

According to George *et al.* (2014), fish processing are the processes associated with fish and fish products between the time in which fish are caught or harvested and the time in which the final product is delivered to the customer.

Eves and Brow (1993) reported that the processing of fish by smoking or drying enhances the nutritive value and promotes digestibility of protein opining that food quality and safety associated with aquaculture products will differ from region to region and habitat to habitat and will vary according to the method of production and harvesting process.

With some of the traditional fish processing methods being associated with contamination which may be injurious to consumers (Ajetomiwa, 2013), Davies (2005) suggested the adoption of appropriate processing technologies that give satisfaction to consumers and equally preserve economical balance. Eyo (1997) reported high level of post-harvest losses in Kainji lake basin, revealing that about 12% of fish is lost post-harvest in the fresh state. For dried fish, 16% is lost before and during processing and 6% from storage prior to sales, bringing the total loss of fish to 35% in the lake totaling a loss of 1000 metric tonnes of fish in Kainji Lake, estimated at about 80 million Naira in 1995. According to Davies and Davies (2009), the problem of high post-harvest losses has been recognized as a major impediment to the realization of the goal of increasing the contribution of fisheries to the Nigerian economy. There is a dearth of information on the exact magnitude of post-harvest losses in fisheries. Such information would be valuable

in developing appropriate technologies and intervention to mitigate the post-harvest fish losses. Eyo (1992) reported different types of preserving methods including drying, smoking, freezing, chilling and brining. The prominent fish preservation method in Ibeju-Lekki, southwest Nigeria is smoke-drying, because not all fishing communities along the coastline have assess to electricity to preserve their catch.

Olokor (1997) analyzed the various advantages of adopting solar energy as a means of drying fish traditionally with Akinola *et al.* (2006) also reporting different types of fish preservation and processing methods. It was observed that the most prominent fish preservation method in Nigeria is smoke drying. This could be as a result of the fact that most of the coastal communities have no access to electricity to preserve and/or process their products. Bolaji (2005) reported that despite the rudimentary nature of traditional processing methods, the lack of control over the drying rate, sometimes results to under- or over-drying and expose fish to wind, dust, dirt, insect infestation and contaminants such as flies. These methods still remain predominant in Nigeria.

Tawari (2006) and Davies and Davies (2009) also reported that most of the fish processing communities in Nigeria employed traditional techniques that have been in existence for many years. In order to reduce post-harvest losses and improve fish product quality, traditional processing technology must be improved by upgrading traditional fish processing technologies, especially by developing increased control over the production processes. Most available modern drying technologies are expensive and not appropriate for developing countries where prerequisites for these technologies, such as electricity are not available.

The term fish processing refers to the processes associated with fish and fish products between the time fish are caught or harvested, and the time the final product is delivered to the customer. Although the term refers specifically to fish, in practice it is extended to cover any aquatic organisms harvested for commercial purposes, whether caught in wild fisheries or harvested from aquaculture or fish farming. Preservation techniques are needed to prevent fish spoilage and lengthen shelf life. They are designed to inhibit the activity of spoilage bacteria and the metabolic changes that result in the loss of fish quality. Spoilage bacteria are the specific bacteria that produce the unpleasant odours and flavours associated with spoiled fish. Fish normally host many bacteria that are not spoilage bacteria, and most of the bacteria present on spoiled fish played no role in the spoilage.To flourish, bacteria need the right temperature, sufficient water and oxygen, and surroundings that are not too acidic. Preservation techniques work by interrupting one or more of these needs.

Nigerian artisans employ various traditional methods to preserve and process fish for consumption and storage. These processing, preservation and storage methods include smoking, drying, salting, frying and fermenting sun-drying, grilling and frying, and various combinations of these (Clucas, 1982).The predominant type of fishery product in any particular country is however, closely related to the food habits and purchasing power of the population. Specific types of fishery products are best suited as the local staple food. Practically all species of fish available in the country can be smoked and it has been estimated that 70-80 percent of the domestic marine and freshwater catch is consumed in smoked form (FAO, 1992, 2001).On the other hand, some traditional processes in food preservation may also destroy or remove some essential nutrients or

decrease their digestibility. It has been observed that different processing methods have different effects on the nutritional compositions of fish. This is because heating, freezing and exposure to high concentration of salt lead to chemical and physical changes and therefore digestibility is increased, due to protein denaturation protein, but the content of thermos-labile compounds and polyunsaturated fatty acids is often reduced.

Fish is highly susceptible to damage once caught and so have become a source of pollution in the environment (Vignesh and Srinivan, 2012). However, processing methods such as salting, boiling, frying, sun drying, roasting and smoking have been used to preserve and increase its availability to consumers (Olayemi *et al*, 2011) with the most common being smoking, sun-drying and frying (Usman *et al.*, 2017)

Most processing methods often times involve removal of the head, viscera and other parts of the fish which may have either negative or positive effect on the total nutritive values of the fish (Saliu, 2008). However, if fish is not sold fresh, preservation methods should be applied to extend its shelf – life. These include freezing, smoking, drying according to Davies and Davies (2009).

2.2 Nutritive properties of processed fish

Previous studies have reported the effects of processing methods on different fish types. For example, Greenfield and Kosulwat (1991) reported that food type and cooking different procedures influence the fat content and other good nutrients. The fat content of raw fish can also influence fat exchanges and interactions between the culinary fat and that of the fish during cooking processing (Sanchez-Muniz *et al.*, 1992). Data on the macronutrient content of fish is only available for raw fish, and there seems to be scarcity of information about processed fish.

Ayinla and Okomoda (1997) reported that majority of processors in the central zone of Nigeria were females, although Anon (1971) had reported that the health of women smokers were at risk Fish were place in open pits containing smoldering wood. Although traditional ovens and kilns produce fish of uneven quality and often pose work-related health risk due to lack of control over temperature and smoke density (Adelowo et al, 1999, Clucas, 1982) mud ovens were most commonly used probably because they are cheap to build, and all materials used in their construction came from local sources. Despite the health risk of smoke and the dull and unattractive color of smoked fish (Eyo, 1985), Kraseman (2005) reported that wood smoke produce microscopic particles which rise as frogs or vapor and these vapours contain volatile oils which are released from the wood and furnish the characteristics textures, flavors and preservative qualities. Also Okoko (1996) reported that smoke drying is employed by remote fishing communities due to traditional preference of the local people for smoke dried fish and lack of sophisticated preservation techniques. Lydia (1977) reported smoking deposits a coating of antimicrobial material or substance on the surface of the fish while at the same time impacting an attractive sheen and pleasant taste which is cherished by the local populace. Stirling (1985) reported that this preservation prevents the growth of bacteria, fungi and micro-organisms as well as retarding fat oxidation which causes rancidity. Jamin and Ayinla (2003) reported that spoilage of fish is slowed down at freezing temperatures, while Adams and Moss (1999) reported that the rate of most chemical reaction are temperature dependent and so as the temperature is lowered, the rate of chemical reaction decreases.

According to previous studies, frying does not always result in an increase in the fat content of seafood (Makinson et al., 1987; Candella et al., 1998). Moreover, Candela *et al.* (1998) had reported that different fish species would have different behavior during the frying process, which should be taken into consideration when determining the total fat intake of a seafood meal (Gardner, 1989). This could therefore account for the seemingly different behavior of the fishes during frying. Also, Oluwaniyi *et al.* (2010) reported that frying reduced the total amino acid contents in four marine fishes commonly consumed in Nigeria (*Clupea harengus*, *Scomber scombrus*, *Trachurus trachurus* and *Urophycis tenuis)* while boiling and roasting increased the total amino acid contents, with the values higher in roasted than boiled samples stating that the percentage of essential amino acids reduced with processing in almost all samples, but the reduction was most pronounced in the fried samples.

2.3 *Clarias gariepinus*

Clarias gariepinus, which is generally considered to be one of the most important tropical catfish species for aquaculture, has an almost Pan-African distribution, ranging from the Nile to West Africa and from Algeria to Southern Africa. They also occur in Asia Minor (Israel, Syria and South of Turkey. It is a very important freshwater fish in Nigeria. It has enjoyed wide acceptability in most parts of the country especially in the North, because of its unique taste, nutrients, flavor and good texture (Adebowale *et al.*, 2008). It is widely distributed and extensively cultivated in ponds with aquacultures have begun to smoke the fish to attract a better price from local and international markets. Smoked *Clarias gariepinus* is a good source of pure protein and would be adequate to

prevent malnutrition in children, and as well desirable for a growing child and adult who feed solely on fish as a main source of protein (IUCN, 2017).

2.4 *Oreochromis niloticus*

Oreochromis niloticus, the Nile Tilapia is predominantly a natural dweller found in West Africa and the Middle East but has been introduced to other parts of the world including Asia and the Americas (Wikipedia, 2017). Alongside other Tilapia, it is the second most produced fish in the world, second only to the carp. It is of great economic benefits especially among the low-income earners of Africa and Asia.

2.5 *Hydrocynus forskahlii*

Hydrocynus forskahlii, the elongate tigerfish is a species of predatory characin from the family Alestidae found in Northern and Western Africa (Wikipedia, 2017). It is a pelagic, potamodromous species of open water, it prefers the well oxygenated surface waters (IUCN, 2017). *Hydrocynus forskahlii* are commonly preserved by salting especially in upper Egyptian Nile, but most are now imported as salted fish from Sudan. Tigerfish are rare in the aquarium trade but this species is the most commonly traded and kept species (Monsterfishkeepers, 2017). Being a commercially important species, it suffers from heavy fishing pressure including threats from dams, water pollution, groundwater extraction and drought.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area

The study area for this study is Ailara fishing community of the Asa reservoir in Kwara State.

3.2 Fish collection

Three species (3 each) of fishes (*Oreochromis niloticus*, *Clarias gariepinus* and *Hydrocynus*) of fresh fish and each processed method was collected from Ailara fishing community of the Asa reservoir in Kwara State between 6 am and 7 am.

3.3 Processing procedure

The processing for the three methods was carried out by the local processors in Ailara fishing community as accustomed.

PLATE 1: (a) Smoked *Oreochromis niloticus* and *Clarias gariepinus* (b) Local smoking kiln used in Ailara fishing community

3.4 Proximate analysis of fresh and processed fish samples

The Proximate analyses were carried out in the chemistry laboratory of the National stored products research institute (NSPRI), Asa dam road, Ilorin, Kwara State. Fresh and processed fish samples were packaged in sterile low-density polyethylene bag and kept for storage at room temperature in readiness for the proximate analyses. All samples were washed thoroughly and homogenized by taking only meat portion (fillet) used in human consumption excluding head and innards. The assessment of proximate composition of each sample was performed in triplicates.

Crude fibre, crude protein content, fat content, moisture content and ash content was determined under proximate analysis with the method of AOAC (2000).

3.4.1 Moisture Determination

Moisture is determined by the loss in weight that occurs when a sample is dried to a constant weight in an oven. About 2g of each processed fish sample was weighed into a silica dish previously dried and weighed. The sample was then dried in an oven for 65^0C for 36 hours, cooled in a desiccator and weighed. The drying and weighing continued until a constant weight was achieved.

$$\%\text{Moisture} = \frac{\text{Wt. of sample + dish before drying} - \text{Wt. of sample + dish after drying}}{\text{Wt. of sample taken}} \times 100$$

3.4.2 Ether Extract (Fat content)

The ether extract of a feed represents the fat and oil in the feed. Soxhlet apparatus is the equipment used for the determination of ether extract. It consist of 3 major components

1. An extractor: comprising the thimble which holds the sample
2. Condenser: for cooling and condensing the ether vapour
3. 250ml flask

Procedure: About 150ml of an anhydrous diethyl ether (petroleum ether) of boiling point of 40 – 60^{0}C was placed in the flask. 2-5g of the sample is weighed into a thimble and the thimble is plugged with cotton wool. The thimble with content was placed into the extractor; the ether in the flask was then heated. As the ether vapour reached the condenser through the side arm of the extractor, it condensed to liquid form and droped back into the sample in the thimble, the ether soluble substances are dissolved and are carried into solution through the siphon tube back into the flask. The extraction continued for at least 4 hrs. The thimble was removed and most of the solvent was distilled from the flask into the extractor. The flask was then disconnected and placed in an oven at 650C for 4 hrs, cooled in desiccator and weighed.

$$\%\text{Ether extract} = \frac{\text{wt. of flask + extract – tare wt. of flask}}{\text{wt of sample}} \times 100$$

3.4.3 Crude Fibre

The organic residue left after sequential extraction of feed with ether was used to determine the crude fibre. This fat-free material was transferred into a flask/beaker and

200ml of pre-heated 1.25% H_2SO_4 was added and the solution was gently boiled for about 30 minutes, maintaining constant volume of acid by the addition of hot water.

The buckner flask funnel fitted with whatman filter was pre-heated by pouring hot water into the funnel. The boiled acid sample mixture was then filtered hot through the funnel under sufficient suction. The residue was then washed several times with boiling water (until the residue was neutral to litmus paper) and transferred back into the beaker. 200mls of pre-heated 1.25% Na_2SO_4 was added and boiled for another 30 minutes, filtered under suction and washed thoroughly with hot water and twice with ethanol. The residue was dried at 65^0C for about 24hrs and weighed. The residue was transferred into a crucible and placed in muffle furnace (400-600^0C) and ash for 4hrs, then cooled in the desiccator and weighed.

3.4.4 Crude Protein

Crude protein is determined by measuring the nitrogen content of the feed and multiplying it by a factor of 6.25. This factor is based on the fact that most protein contains 16% nitrogen. This is the kjeldahl method and it involves digestion, distillation and titration.

i. Digestion: About 2g of the sample was weighed into the Kjeldahl flask with 25mls of concentrated sulphuric acid, 0.5g of copper sulphate, 5g of sodium sulphate and a speck of selenium tablet being added.

Heat was applied in a fume cupboard slowly at first to prevent undue frothing with continued digestion for 45mins until the digesta became clear pale green. It was left until completely cool with 100mls of distilled water being rapidly added. The digestion flask was rinsed 2-3 times and the rinsing was added to the bulk.

ii. Distillation: Markham distillation apparatus was used for distillation. The distillation apparatus was steamed up and about 10ml of the digest added into the apparatus via a funnel and allowed to boil.10mls of sodium hydroxide from the measuring cylinder is added so that ammonia is not lost. This was distilled into 50ml of 2% boric acid containing screened methyl red indicator.

iii Titration: The alkaline ammonium borate formed was titrated directly with 0.1M HCl. The titre value which is the volume of acid used was recorded. The volume of acid used was fitted into the formula below becoming:

$$\%\,N = \frac{14 \times VA \times 0.1 \times w \times 100}{1000 \times 100}$$

VA = volume of acid used

w= weight of sample

% crude protein = %N x 6.25

3.4.5 Ash

Ash is the inorganic residue obtained by burning off the organic matter of feedstuff at 400-600°C in muffle furnace for 4hrs. 2g of the sample was weighed into a pre-heated crucible. The crucible was placed into muffle furnace at 400-600°C for 4hrs or until whitish-grey ash was obtained. The crucible was then placed in the desiccator and weighed.

$$\%\ \text{of ash} = \frac{\text{Weight of fish}}{\text{Weight of sample taken} \times 100}$$

3.5 Organoleptic properties of processed fish

The dried, smoked and fried fish were tested/tasted for taste, odor, color, moistness, tenderness, flavor and texture was determined under organoleptic analysis by 30 trained panelists consisting of individuals within the Ilorin metropolis selected by purposive sampling method between the ages of fifteen (15) and sixty-five (65) who have maintained an interest in taking fish as part of their diet.

The panelists were made to evaluate the effect of smoking, sun-drying and frying on the organoleptic attributes of the three species of fish used in the study. The descriptive 5-point hedonic scale was used for the sensory attributes (taste, texture, aroma, colour, moistness, tenderness and general acceptability) of the samples at 0.05 level of significant. The parameters were assessed using ranking scores like extremely (5), like moderately (4), neither like nor dislike (3), dislike moderately (2) and dislike extremely (1) respectively.

The processed fish from the three processing methods were equally compared for the three species in terms of the most and least desired methods.

3.6 Statistical analysis

Data were analyzed by using SPSS for windows Version 20 statistical programme and Microsoft Excel 2013. Significance was established at $p< 0.05$ using descriptive statistics, clustered bar charts and analysis of variance (ANOVA) test with least significant differences (LSD) method of post-hoc analysis used.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

Table 4.1: Effect of different processing methods on the proximate composition (g/100g) of *Oreochromis niloticus*

Sample	Fresh	Sun-dried	Smoked	Fried
Moisture content	74.20 ± 0.20^{a}	6.50 ± 0.10^{b}	15.40 ± 0.05^{c}	23.45 ± 0.02^{d}
Protein content	$18.52\pm.0.02^{a}$	70.26 ± 0.10^{b}	62.14 ± 0.14^{c}	56.32 ± 1.00^{d}
Fat content	2.23 ± 0.10^{a}	14.52 ± 0.50^{b}	17.85 ± 0.90^{c}	17.75 ± 0.25^{c}
Ash content	1.36 ± 0.04^{a}	6.35 ± 0.10^{b}	1.65 ± 0.03^{c}	1.22 ± 0.05^{d}
Crude fibre	3.18 ± 0.02^{a}	2.08 ± 0.04^{b}	1.22 ± 0.03^{c}	0.75 ± 0.01^{d}

Values are means ± SD of triplicate determinations. Means with different superscripts (across each row) are significantly ($p<0.05$) different

Table 4.2: Effect of different processing methods on the proximate composition (g/100g) of *Clarias gariepinus*

Sample	Fresh	Sun-dried	Smoked	Fried
Moisture content	78.7 ± 0.10^{e}	7.30 ± 0.10^{b}	17.42 ± 0.02^{c}	26.02 ± 0.02^{d}
Protein content	16.24 ± 0.70^{a}	68.4 ± 2.00^{b}	60.52 ± 0.01^{c}	54.24 ± 0.50^{d}
Fat content	0.50 ± 0.10^{a}	12.50 ± 0.20^{b}	16.66 ± 0.02^{c}	17.02 ± 0.50^{c}
Ash content	1.33 ± 0.11^{a}	6.40 ± 0.10^{b}	3.42 ± 0.01^{c}	1.28 ± 0.02^{a}
Crude fibre	2.12 ± 0.02^{a}	1.35 ± 0.01^{b}	1.05 ± 0.03^{c}	0.61 ± 0.04^{d}

Values are means ± SD of triplicate determinations. Means with different superscripts (across each row) are significantly ($p<0.05$) different

Table 4.3: Effect of different processing methods on the proximate composition (g/100g) of *Hydrocynus forskahlii*

Sample	Fresh	Sun-dried	Smoked	Fried
Moisture content	70.56 ± 0.10^{a}	4.72 ± 0.10^{b}	13.60 ± 0.02^{c}	21.16 ± 0.03^{d}
Protein content	22.20 ± 0.10^{a}	73.45 ± 0.20^{b}	65.05 ± 0.03^{c}	58.55 ± 0.11^{d}
Fat content	1.52 ± 0.11^{a}	13.12 ± 0.20^{b}	16.95 ± 1.00^{c}	18.20 ± 0.60^{d}
Ash content	2.85 ± 0.03^{a}	6.86 ± 0.05^{b}	2.42 ± 0.02^{c}	1.05 ± 0.03^{d}
Crude fibre	2.12 ± 0.02^{a}	1.35 ± 0.01^{b}	1.05 ± 0.03^{c}	0.61 ± 0.04^{d}

Values are means ± SD of triplicate determinations. Means with different superscripts (across each row) are significantly ($p<0.05$) different

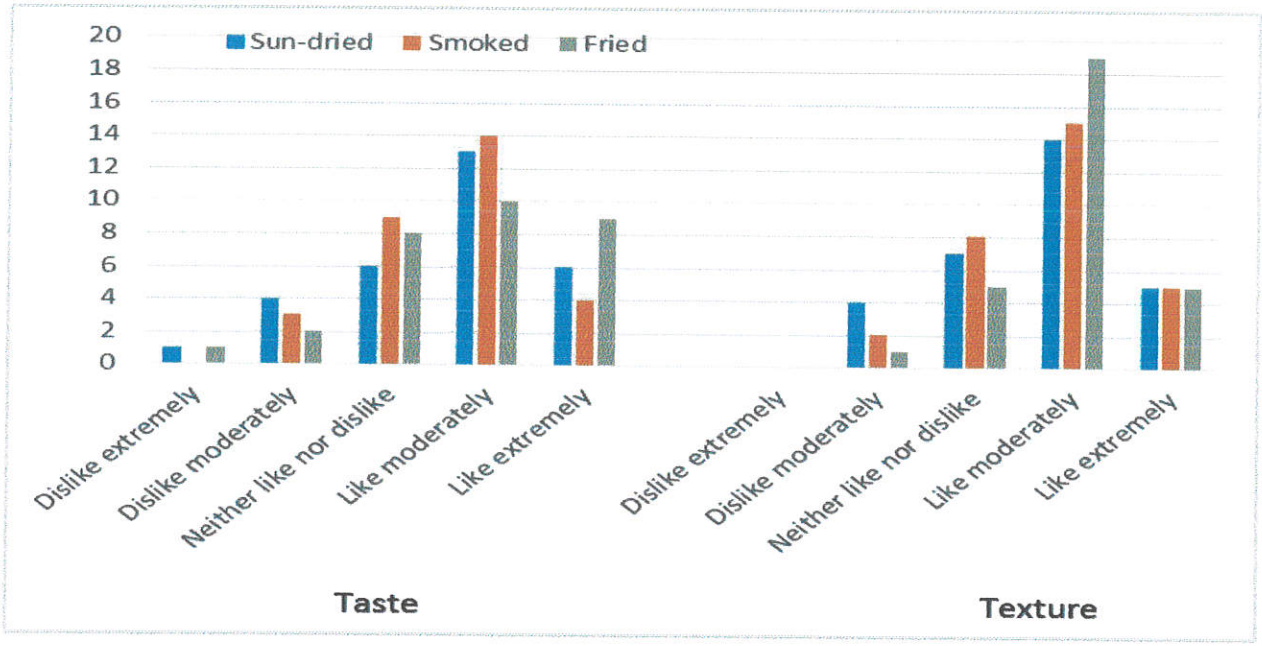

FIGURE 1: Interest levels of respondents to Oreochromis niloticus processed using the three methods based on the fish's taste and texture

Tables 1, 2 and 3 shows the effect of the processing methods Fresh samples on the proximate composition (g/100g) of *Oreochromis niloticus, Clarias gariepinus* and *Hydrocynus forskahlii* with the fresh samples showing the highest values in terms of their moisture content with a range of 78.7% to 70.56%. All three processing methods have a significant effect on the protein content in all three (3) species of fish. Among the processed fishes, the sun-dried have the highest percentage

The smoked and the fried having relatively higher fat content than the others with the fried having slightly higher values than the smoked and all processed treatments showing significant difference in the fat content from the fresh. There are no significant difference in the ash content of fresh *O. niloticus* and fresh *C. gariepinus* together with fried *C. gariepinus*.

FIGURE 1 show the interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's taste and texture with the highest number of respondents liked the fish from the three (3) processing methods moderately.

(a) (b)

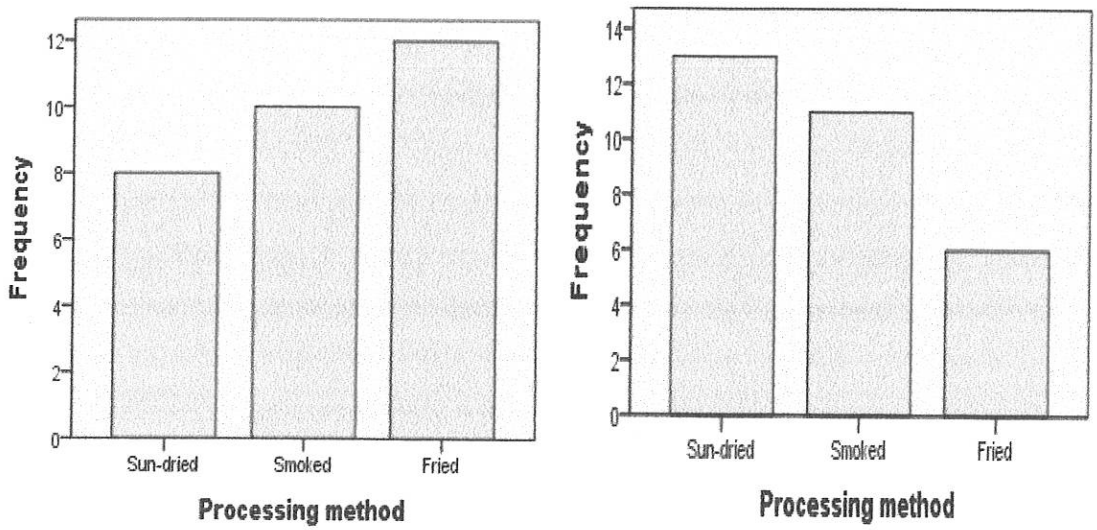

Figure 2: Desired processing method by taste for *Oreochromis niloticus* (a) Most (b) Least

(a) (b)

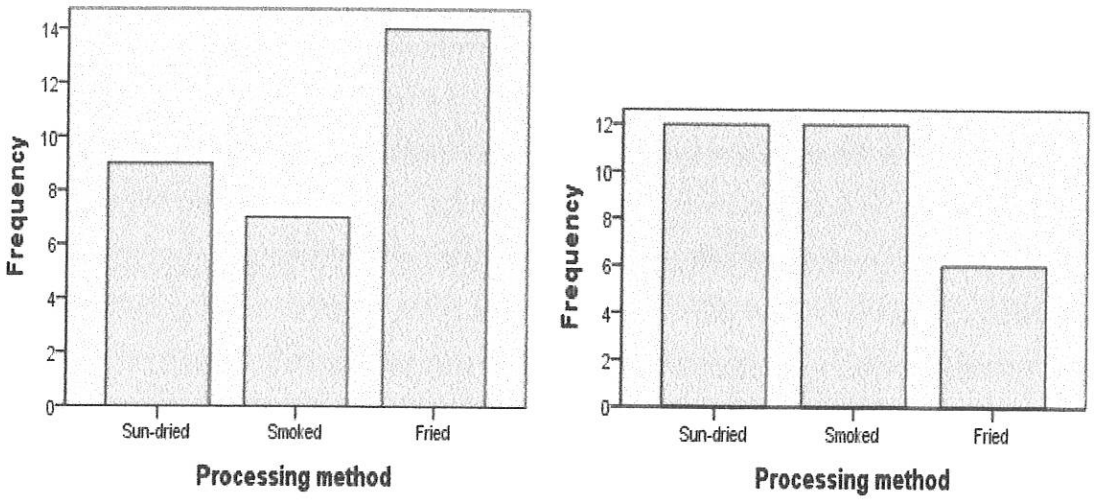

FIGURE 3: Desired processing method by texture for *Oreochromis niloticus* (a) Most (b) Least

(a) (b)

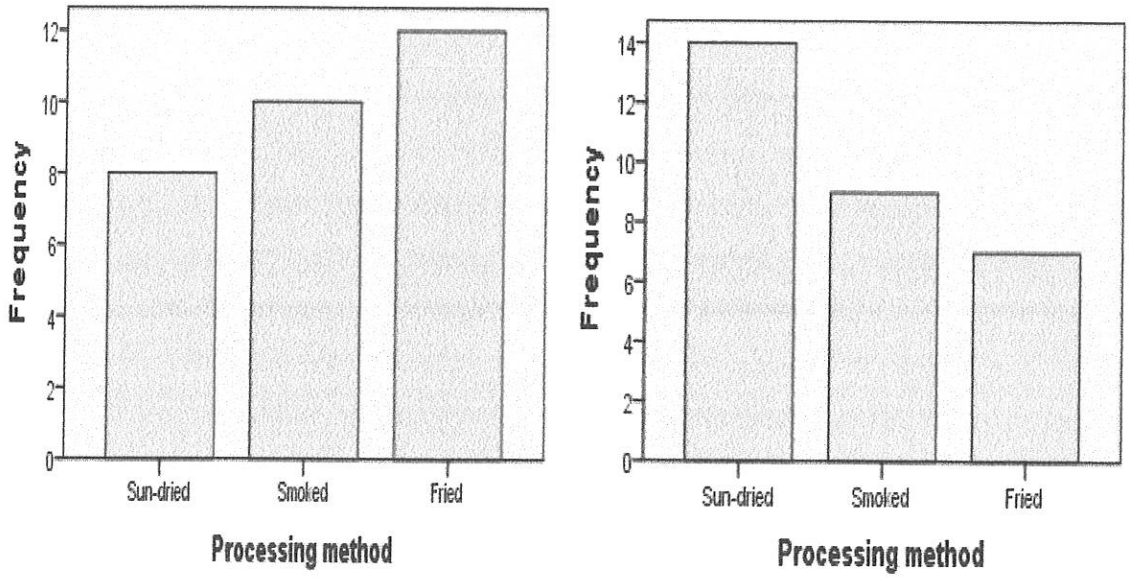

FIGURE 4: Desired processing method by aroma for *Oreochromis niloticus* (a) Most (b) Least

(a) (b)

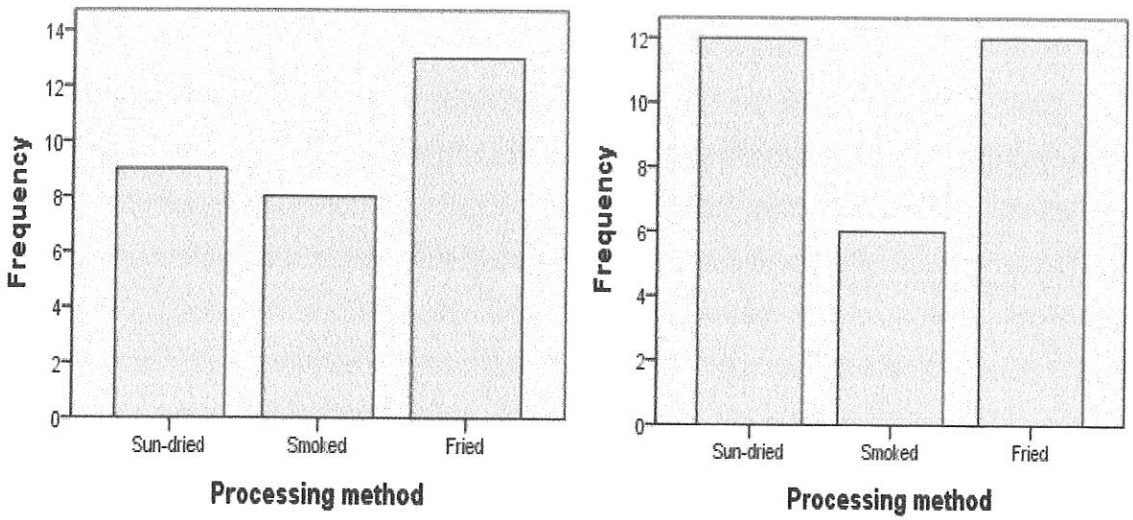

FIGURE 5: Desired processing method by colour for *Oreochromis niloticus* (a) Most (b) Least

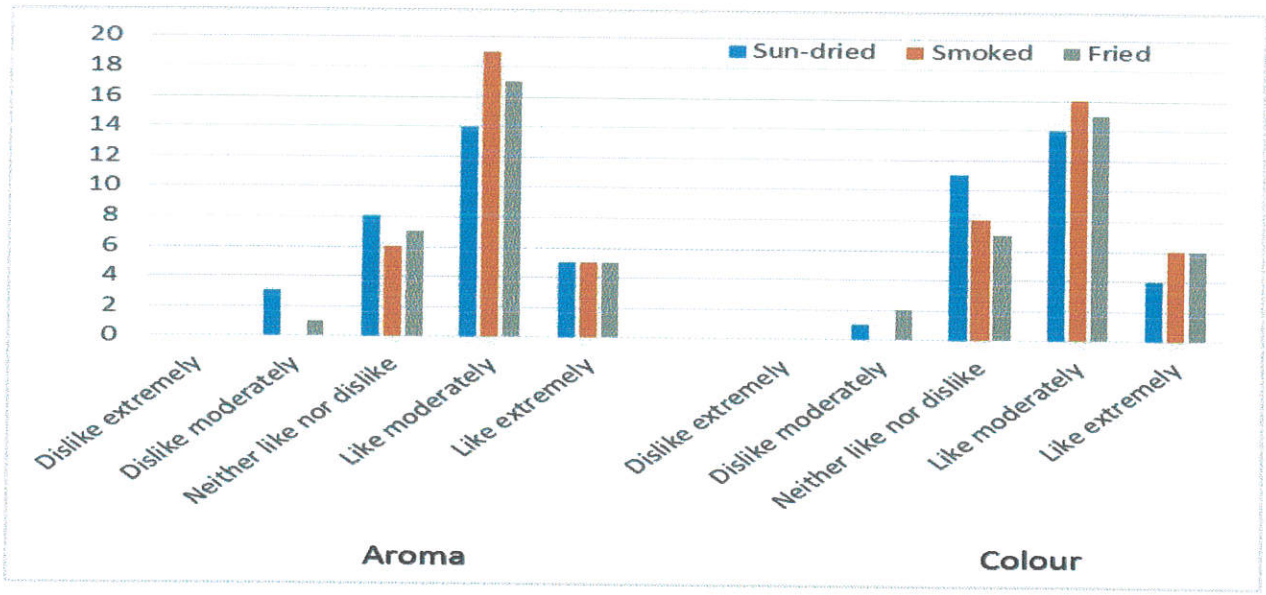

FIGURE 6: Interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's aroma and colour.

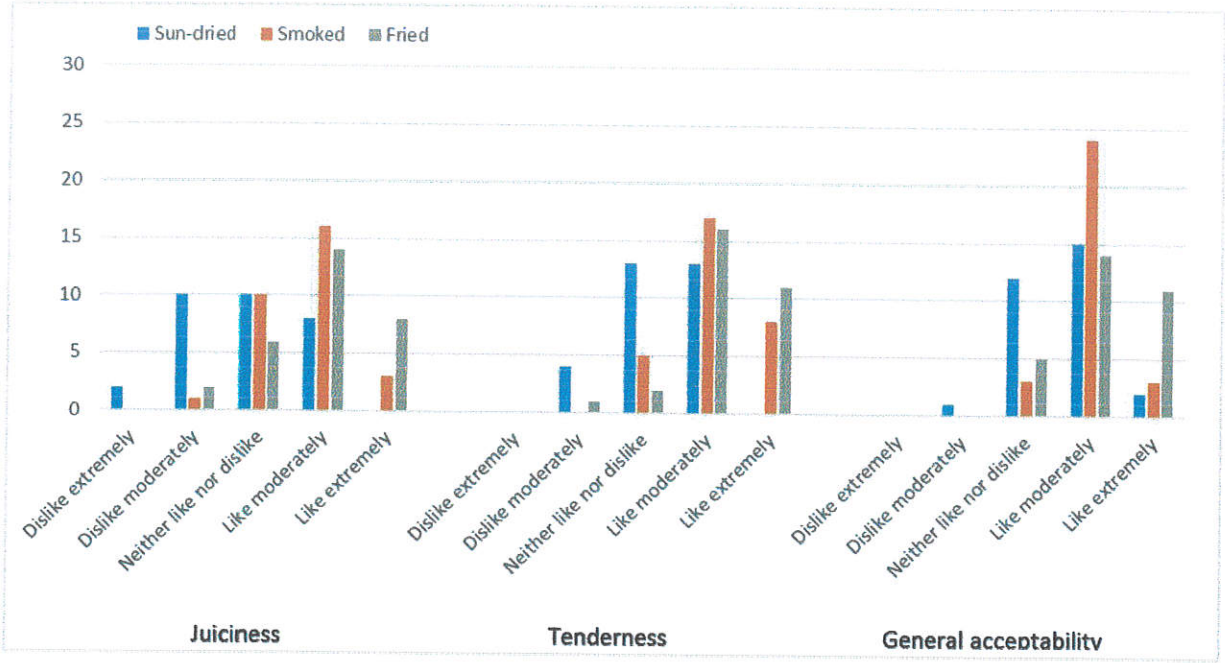

FIGURE 7: Interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's moistness (juiciness), tenderness and general acceptability.

FIGURE 6 show the interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's aroma and colour with the highest number of respondents liking the fish from the three (3) processing methods moderately in both cases. FIGURE 7 show the interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's moistness with the highest number of respondents liking the smoked and fried fish moderately while the highest number either disliked moderately or neither like nor dislike sun-dried *O. niloticus*

FIGURE 7 equally show the interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's tenderness with the highest number of respondents liking the smoked and fried fish moderately and the highest number either liking moderately or neither liking nor disliking the sun-dried *O. niloticus*.

Furthermore, FIGURE 7 show the interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's geneal acceptability with the highest number of respondents liking the fish from the three (3) processing methods moderately

(a) (b)

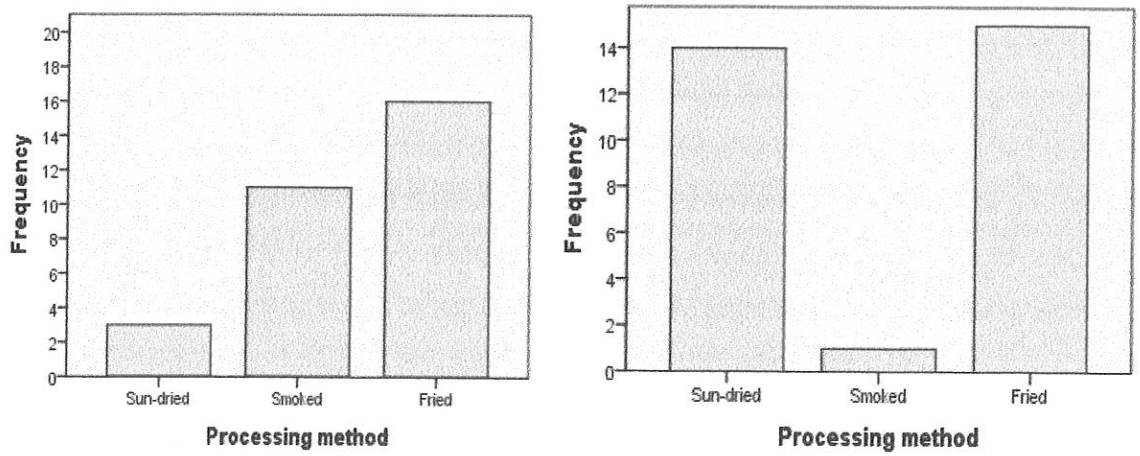

FIGURE 8: Desired processing method by moistness for *Oreochromis niloticus* (a) Most (b) Least

(a) (b)

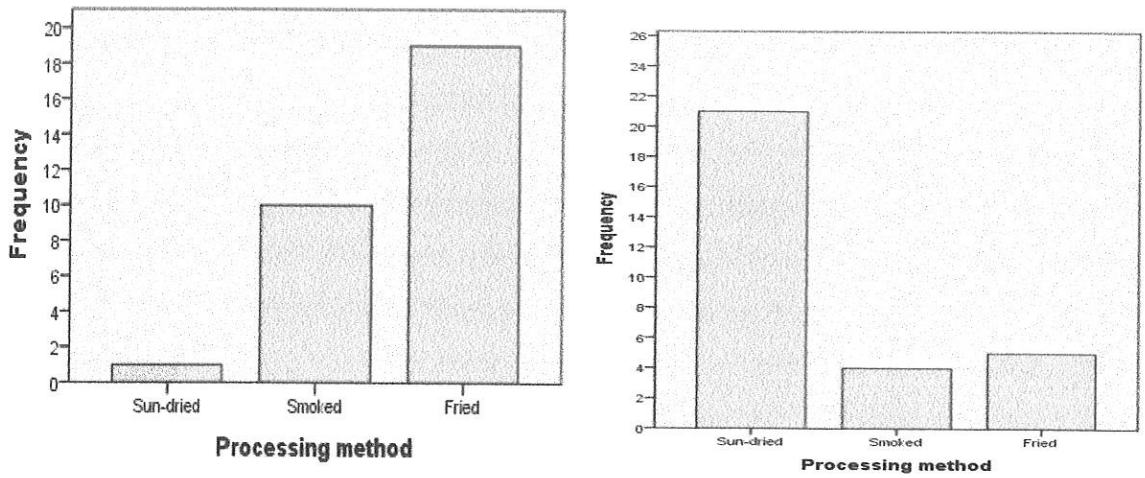

FIGURE 9: Desired processing method by tenderness for *Oreochromis niloticus* (a) Most (b) Least

(a) (b)

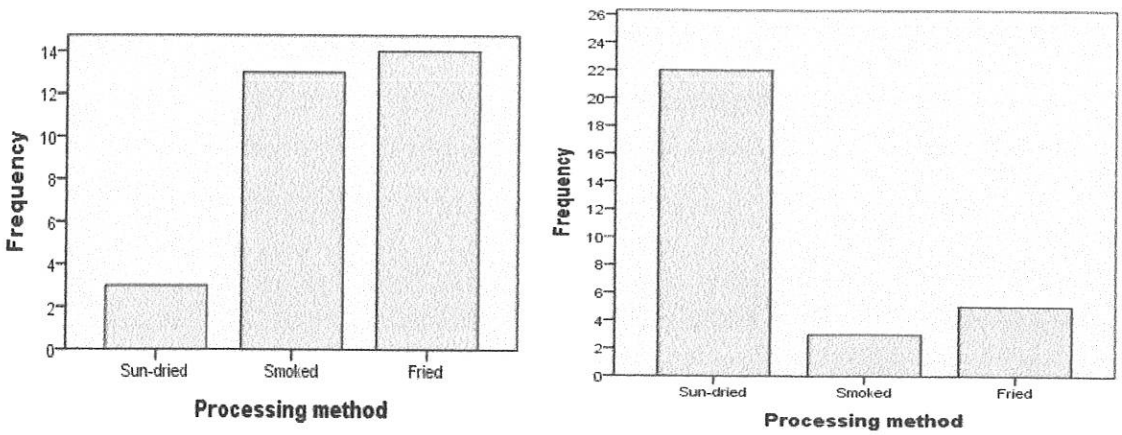

FIGURE 10: Desired processing method by general acceptability for *Oreochromis niloticus* (a) Most (b) Least

Table 4.4: Interest levels of respondents in the 3 processing methods of *Oreochromis niloticus* based on the fish's organoleptic properties

Organoleptic property	Sun-dried	Smoked	Fried	Significance
Taste	3.63± 1.07[a]	3.63± 0.85[a]	3.80± 1.06[a]	0.757
Texture	3.67± 0.92[a]	3.77± 0.82[a]	3.93± 0.69[a]	0.445
Aroma	3.70± 0.87[a]	3.97± 0.62[a]	3.87± 0.73[a]	0.382
Colour	3.70± 0.75[a]	3.93± 0.69[a]	3.83± 0.83[a]	0.494
Moistness	2.80± 0.93[a]	3.70± 0.70[b]	3.93± 0.87[b]	0.000*
Tenderness	3.30± 0.70[a]	4.10± 0.66[b]	4.23± 0.73[b]	0.000*
General Acceptability	3.60± 0.68[a]	4.00± 0.46[b]	4.20± 0.71[b]	0.001*

- Values are means of interest levels; where 0- 1.00 represents "dislike extremely", 1.01-2.00 represents "dislike moderately", 2.01-3.00 represents "neither like nor dislike", 3.01-4.00 represents "like moderately" and 4.01-5.00 represents "like extremely".
- Means with different superscripts within each rows are significantly different at ($p<0.05$)
- Asterisk (*) indicate significant difference among the group of means (in each row).

From the table above, the fried fish shows the highest interest level in terms of their taste. The smoked is highest in terms of its aroma, colour and general acceptability. All four properties being not significantly different in terms of their processing methods.

Texture, moistness and tenderness are significantly different from each other. The fried fish have the highest interest level in all three (liked extremely in texture and only liked moderately in tenderness and moistness) while the sun-dried have the least of all the organoleptic properties.

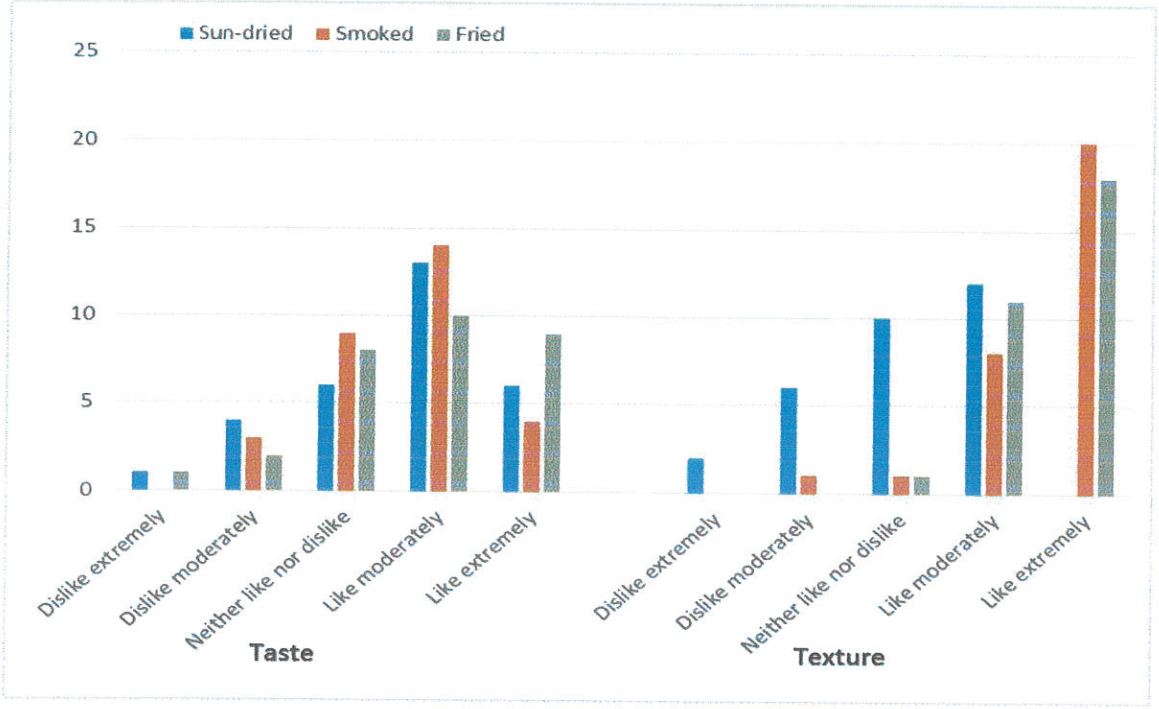

FIGURE 11: Interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's taste and texture.

FIGURE 11 shows the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's taste with the highest number of respondents liking the fish from the three (3) processing methods moderately.

(a) (b)

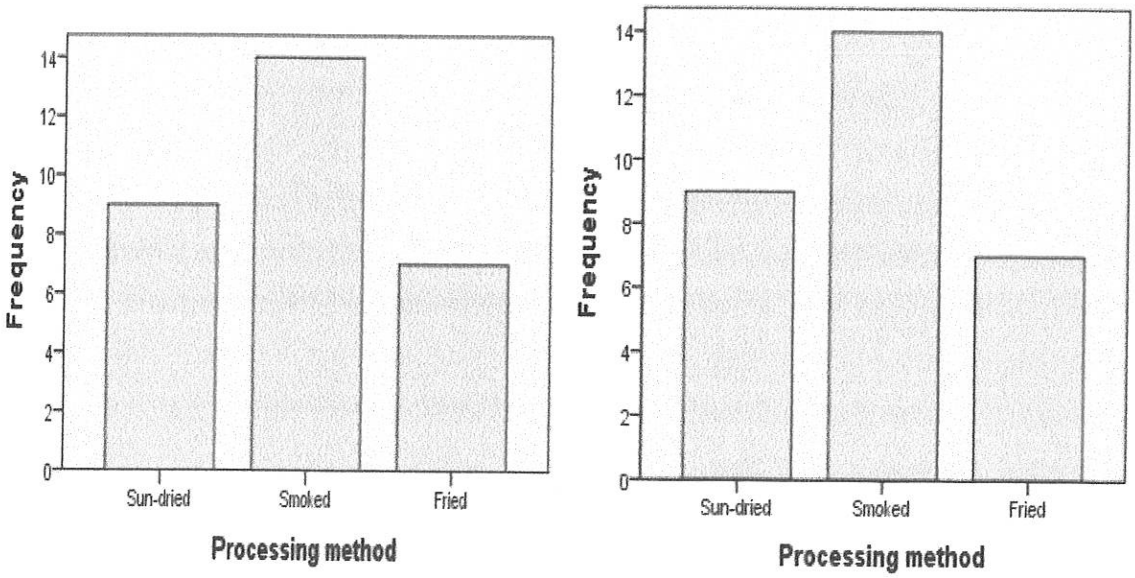

FIGURE 12: Desired processing method by taste for *Clarias gariepinus* (a) Most (b) Least

(a) (b)

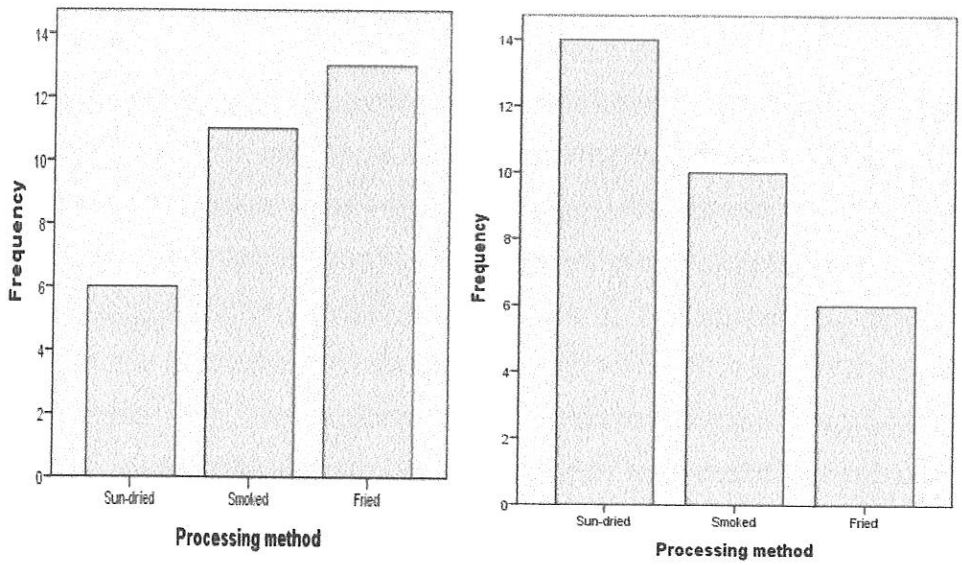

FIGURE 13: Desired processing method by texture for *Clarias gariepinus* (a) Most (b) Least

(a) (b)

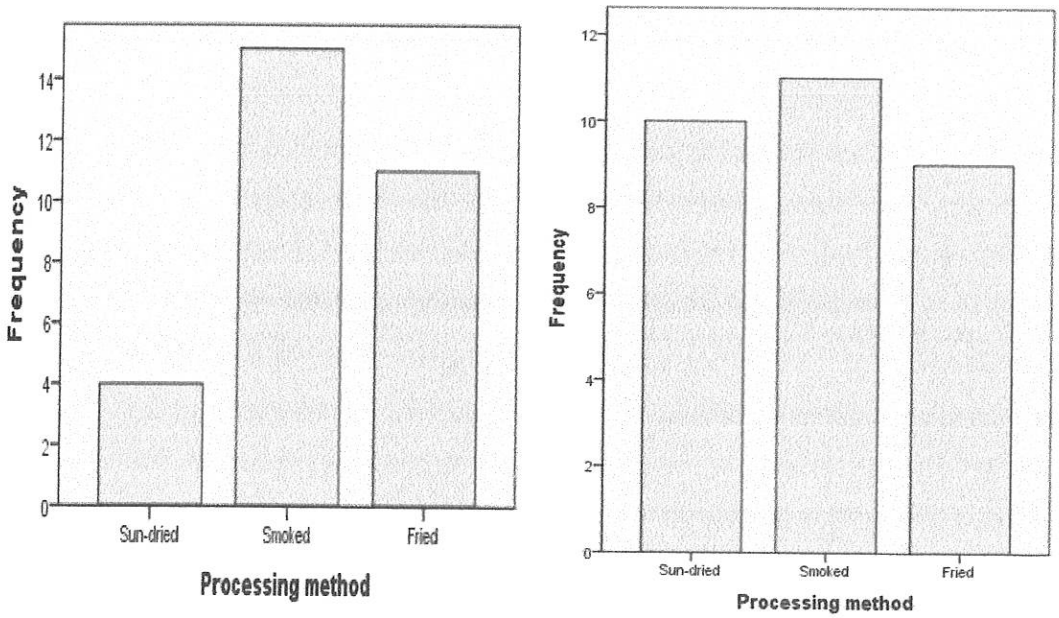

FIGURE 14: Desired processing method by aroma for *Clarias gariepinus* (a) Most (b) Least

(a) (b)

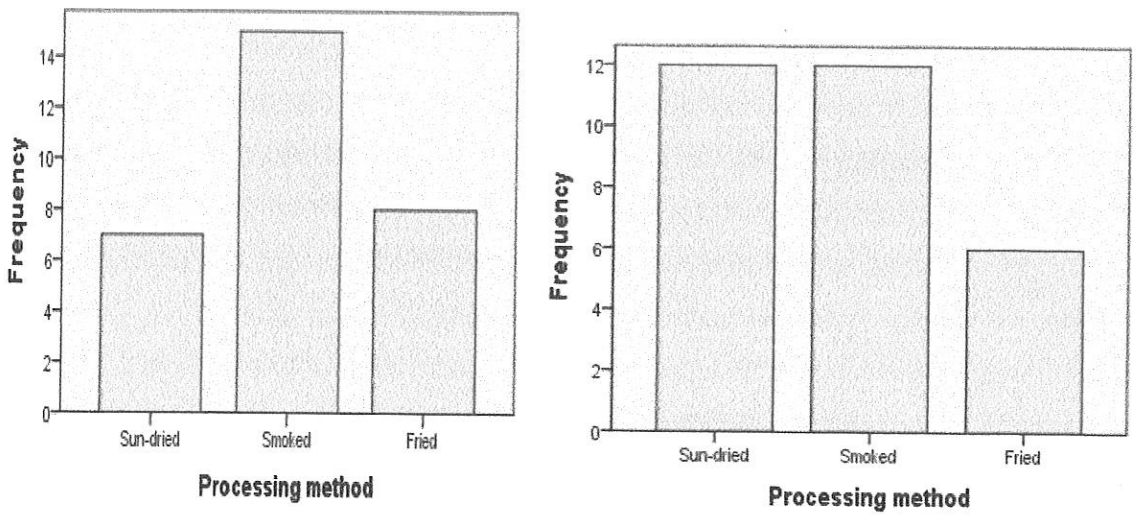

FIGURE 15: Desired processing method by colour for *Clarias gariepinus* (a) Most (b) Least

(a) (b)

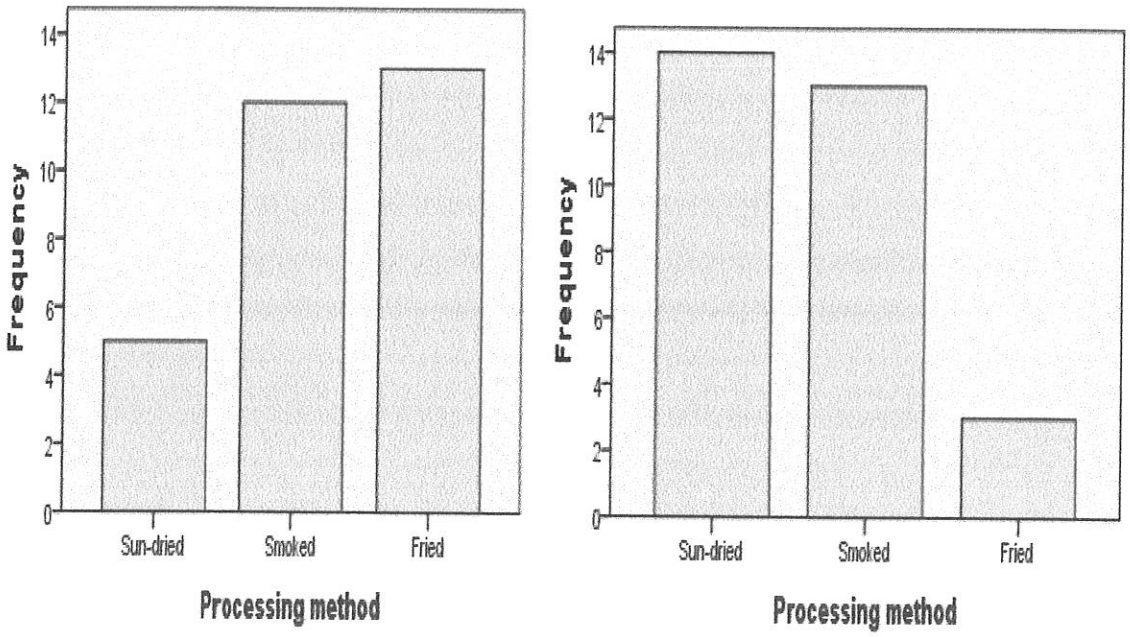

FIGURE 16: Desired processing method by moistness for *Clarias gariepinus* (a) Most (b) Least

(a) (b)

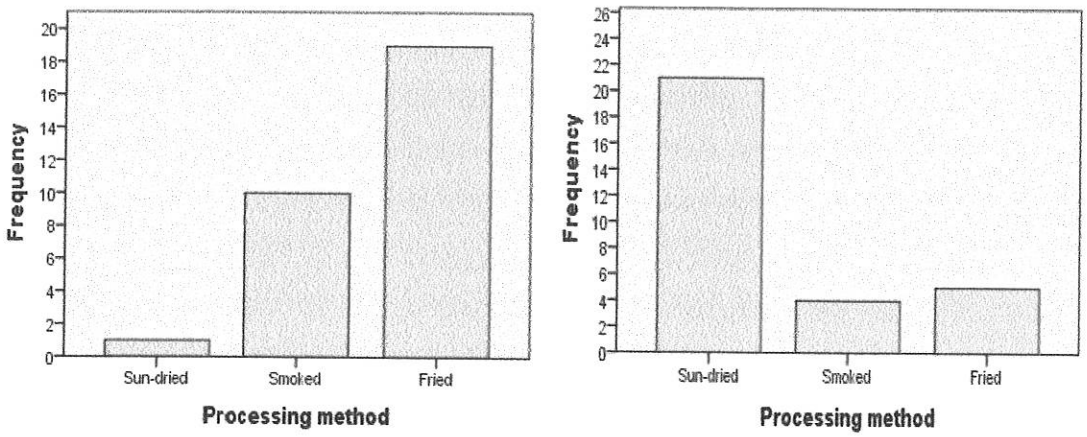

FIGURE 17: Desired processing method by tenderness for *Clarias gariepinus* (a) Most (b) Least

(a) (b)

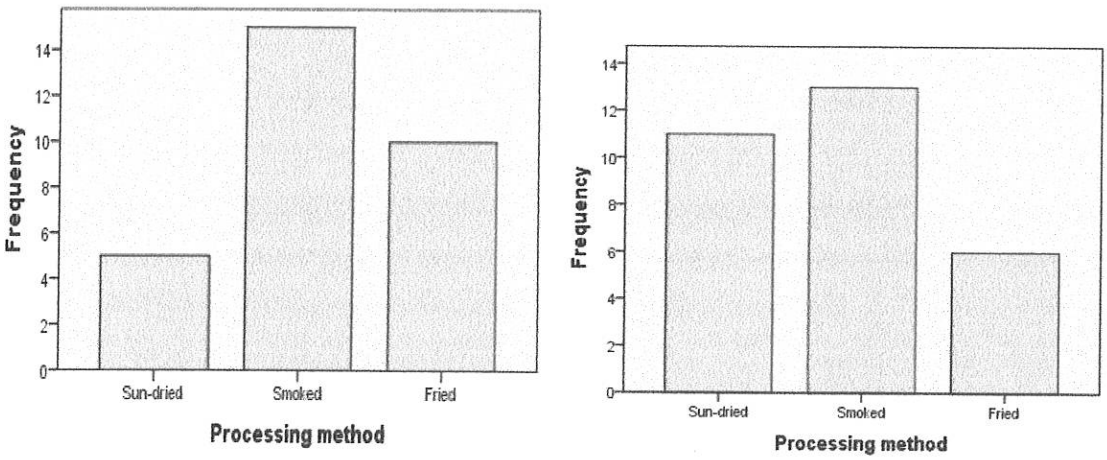

FIGURE 18: Desired processing method by general acceptability for *Clarias gariepinus* (a) Most (b) Least

Table 4.5: Interest levels of respondents in the 3 processing methods of *Clarias gariepinus* based on the fish's organoleptic properties

Organoleptic property	Sun-dried	Smoked	Fried	Significance
Taste	3.40± 1.35[a]	3.53± 1.20[a]	3.63± 1.33[a]	0.783
Texture	3.07± 0.94[a]	4.57± 0.73[b]	4.57± 0.57[b]	0.000*
Aroma	3.37± 1.25[a]	3.90± 1.06[a]	3.77± 1.22[a]	0.196
Colour	3.67± 1.12[a]	3.83± 1.12[a]	3.73± 1.08[a]	0.842
Moistness	2.87± 1.46[a]	3.57± 1.14[b]	3.83± 1.09[b]	0.010*
Tenderness	3.30± 1.21[a]	3.93± 1.02[b]	4.17± 0.95[b]	0.007*
General Acceptability	3.60± 1.19[a]	3.97± 1.03[a]	3.90± 1.03[a]	0.384

- Values are means of interest levels; where 0- 1.00 represents "dislike extremely", 1.01-2.00 represents "dislike moderately", 2.01-3.00 represents "neither like nor dislike", 3.01-4.00 represents "like moderately" and 4.01-5.00 represents "like extremely".
- Means with different superscripts within each roware significantly different at ($p<0.05$)
- Asterisk (*) indicate significant difference among the group of means.

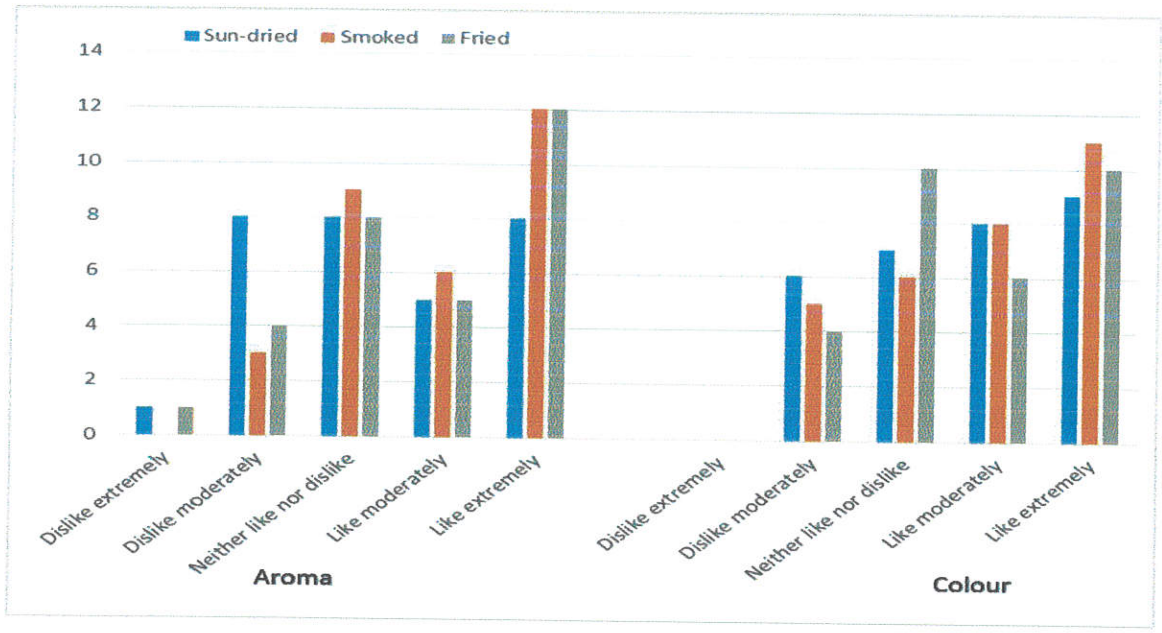

FIGURE 19: Interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's aroma and colour.

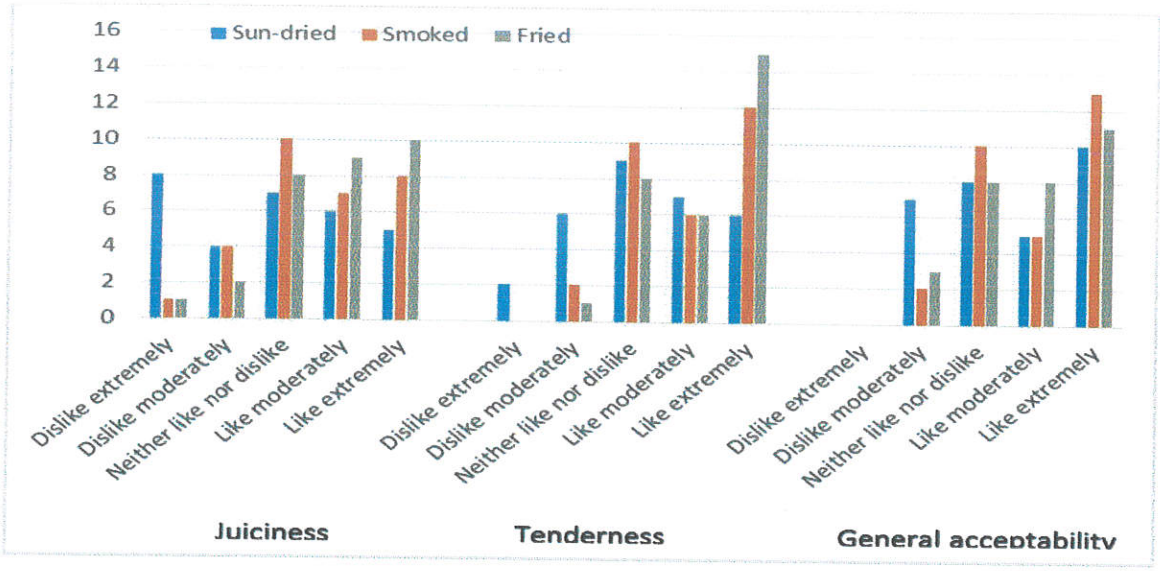

FIGURE 20: Interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's moistness (juiciness), tenderness and general acceptability.

FIGURE 20 equally shows the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's texture with the highest number of

respondents liking the smoked and fried fish extremely while the sun-dried fish was liked moderately by the most respondents.

FIGURE 18 shows the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's aroma with the highest number of respondents liking the smoked and fried fish extremely and the sun-dried fish has its highest number of respondents shared equally amongst those who liked it extremely, disliked moderately and neither like nor dislike.

FIGURE 18 equally shows the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's colour with the highest number of respondents liking the smoked and sun-dried fish extremely while the fried fish has its highest number of respondents shared equally amongst those who liked it extremely and those who neither like nor dislike.

FIGURE 19 shows the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's moistness with the highest number of respondents liking the fried fish extremely, the smoked fish highest respondents neither liked nor disliked it while the highest for sun-dried disliked it extremely.

FIGURE 19 equally shows the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's tenderness showed that the highest number of respondents liked the smoked and fried fish extremely, the highest respondents for the sun-dried fish neither liked nor disliked it while the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's general

acceptability has the highest number of respondents liking the smoked and fried fish extremely and the highest respondents for the sun-dried fish neither liked nor disliked it.

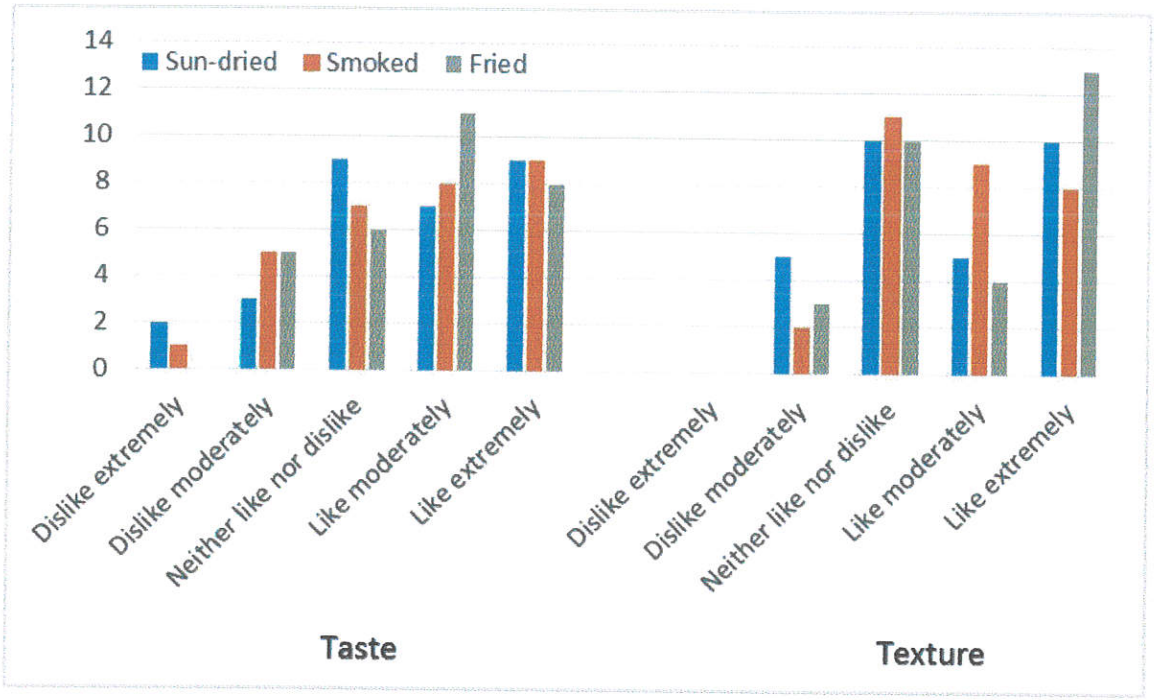

FIGURE 21: Interest levels of respondents to *Hydrocynus forskahlii* processed using the three methods based on the fish's taste and texture.

(a) (b)

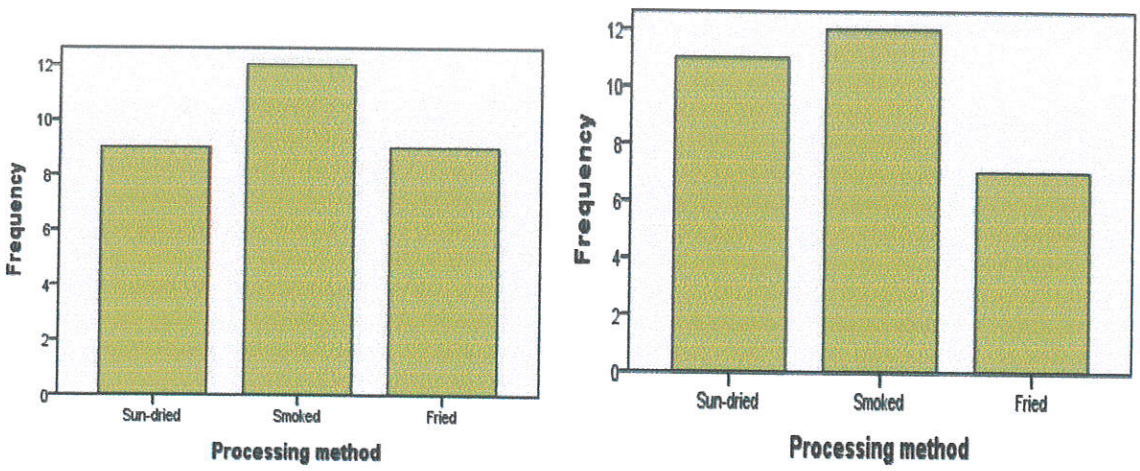

FIGURE 22: Desired processing method by taste for *Hydrocynus forskalii* (a) Most (b) Least

(a) (b)

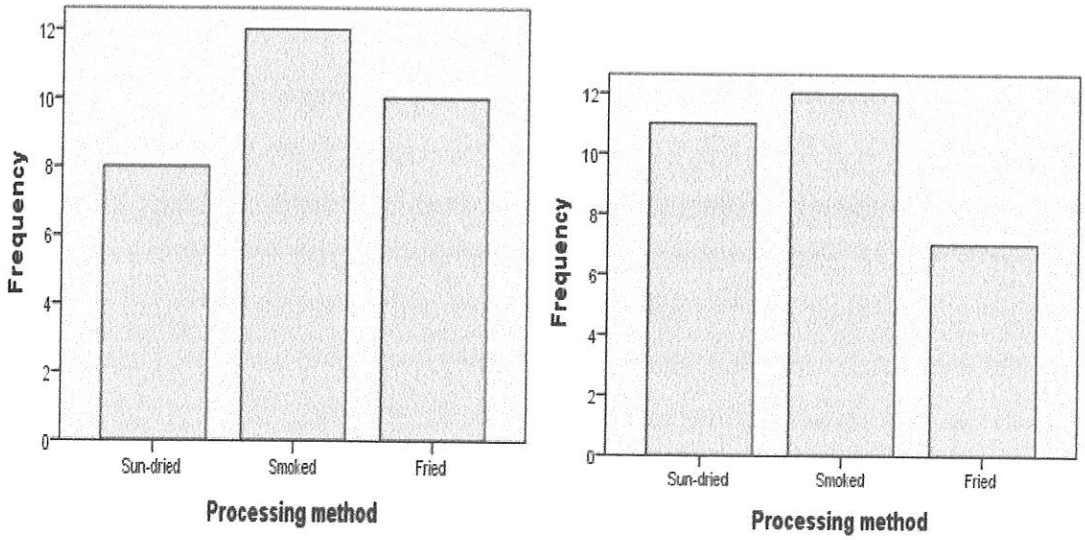

FIGURE 23: Desired processing method by texture for *Hydrocynus forskalii* (a) Most (b) Least

(a) (b)

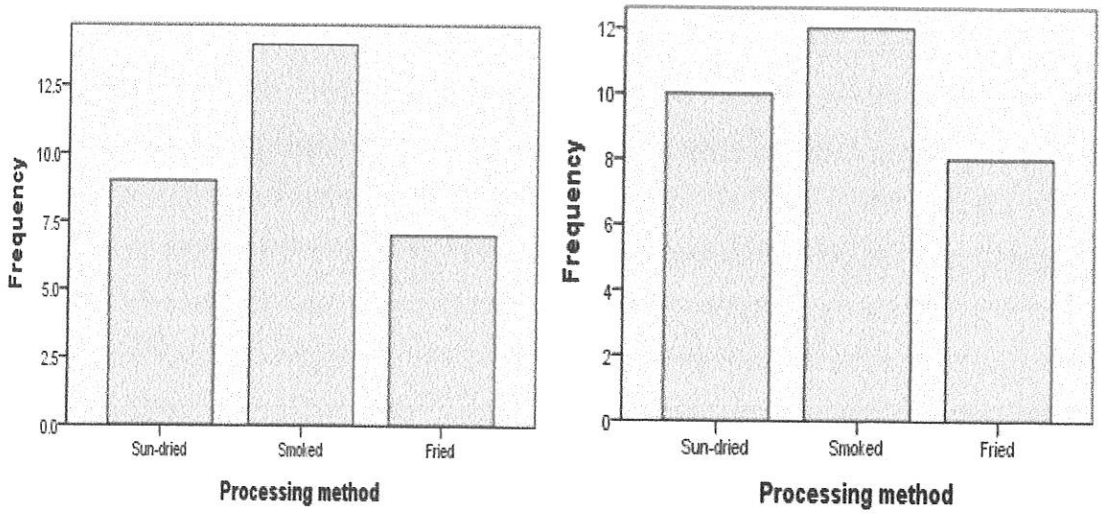

FIGURE 24: Desired processing method by aroma for *Hydrocynus forskalii* (a) Most (b) Least

(a) (b)

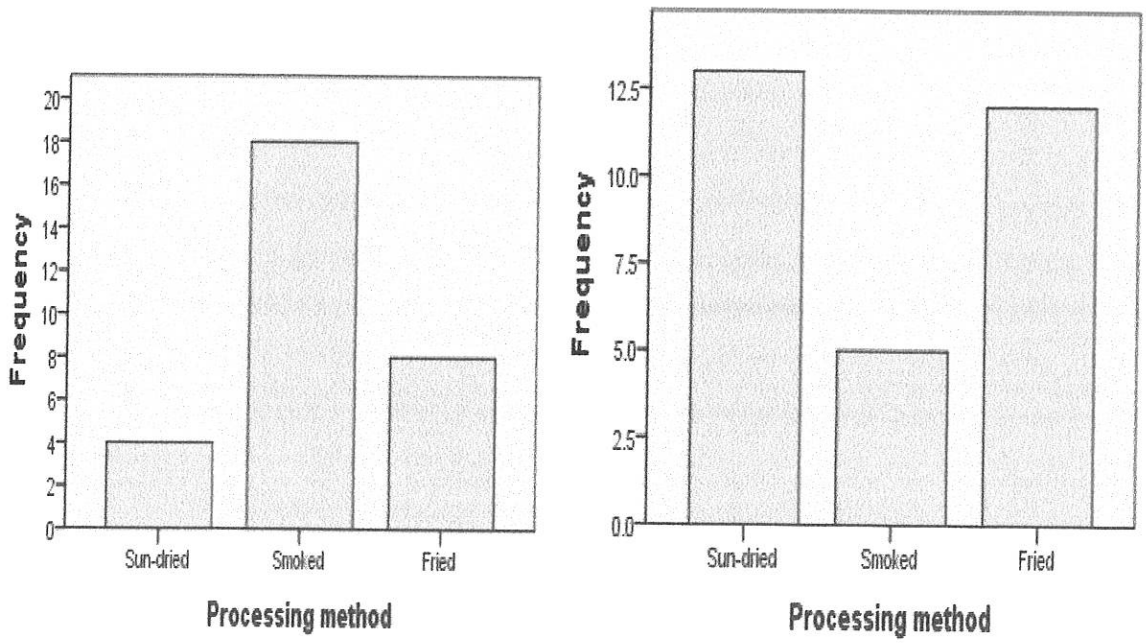

FIGURE 25: Desired processing method by colour for *Hydrocynus forskalii* (a) Most (b) Least

(a) (b)

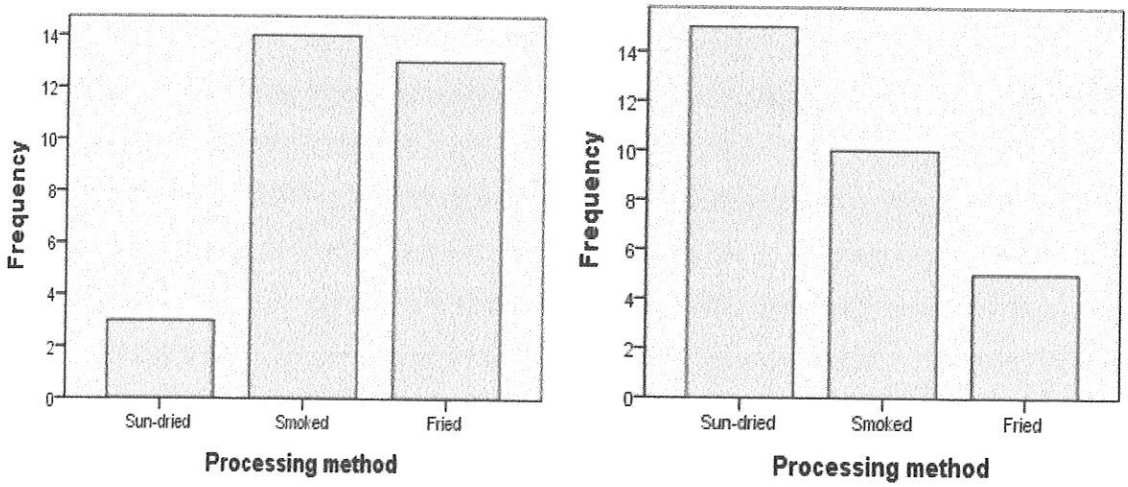

FIGURE 26: Desired processing method by moistness for *Hydrocynus forskalii* (a) Most (b) Least.

(a) (b)

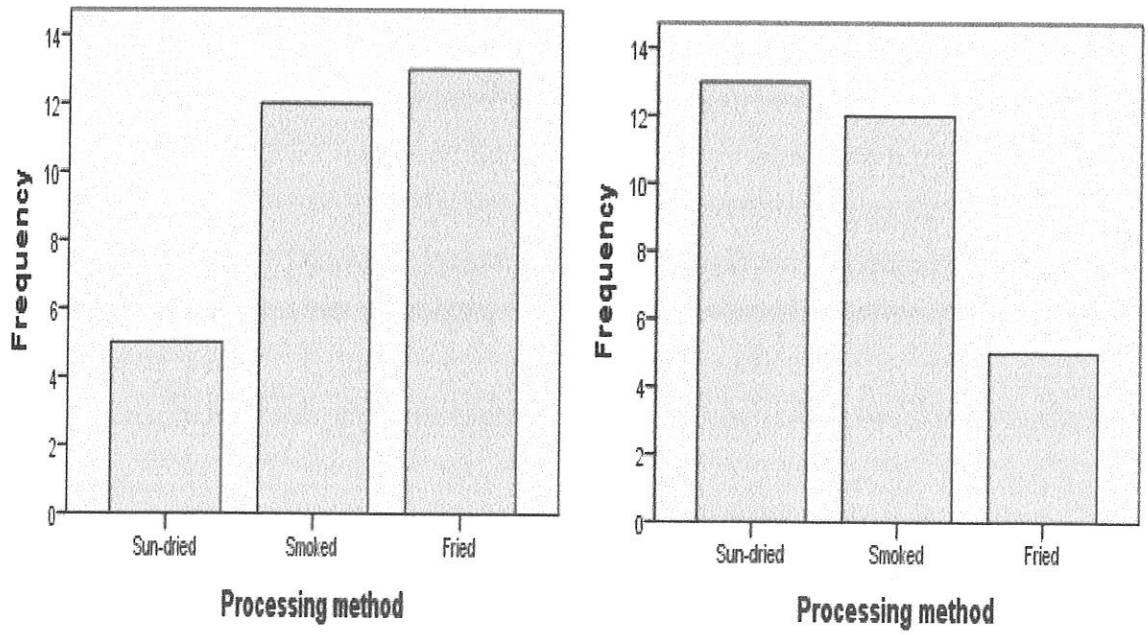

FIGURE 27: Desired processing method by tenderness for *Hydrocynus forskalii* (a) Most (b) Least.

(a) (b)

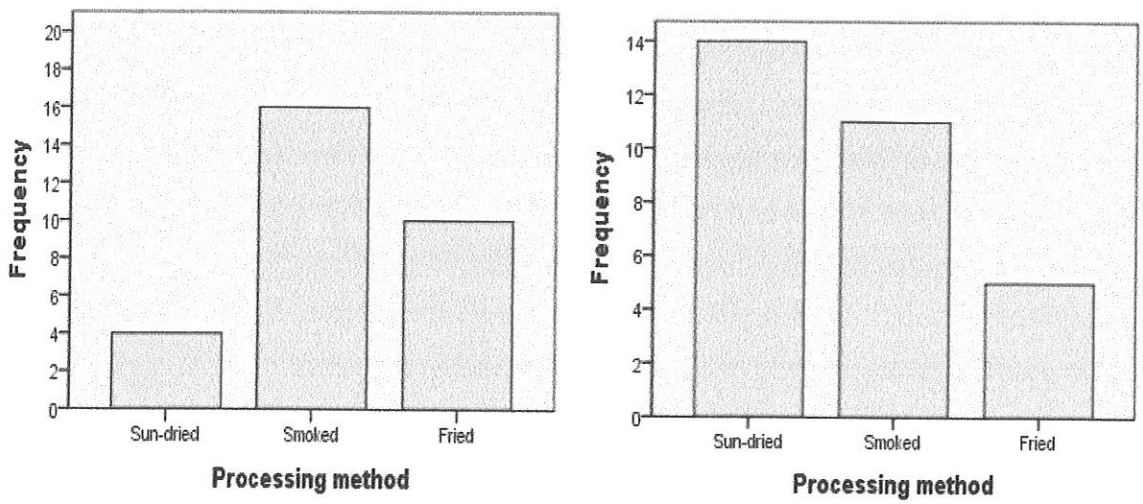

FIGURE 28: Desired processing method by general acceptability for *Hydrocynus forskalii* (a) Most (b) Least.

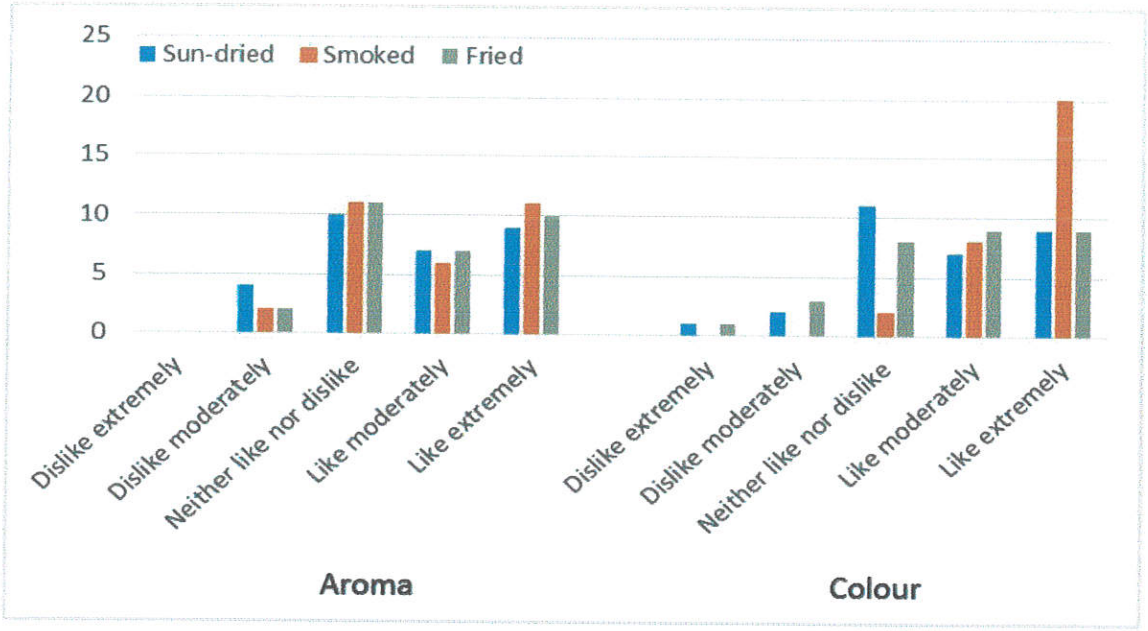

FIGURE 29: Interest levels of respondents to *Hydrocynus forskahlii* processed using the three methods based on the fish's aroma and colour.

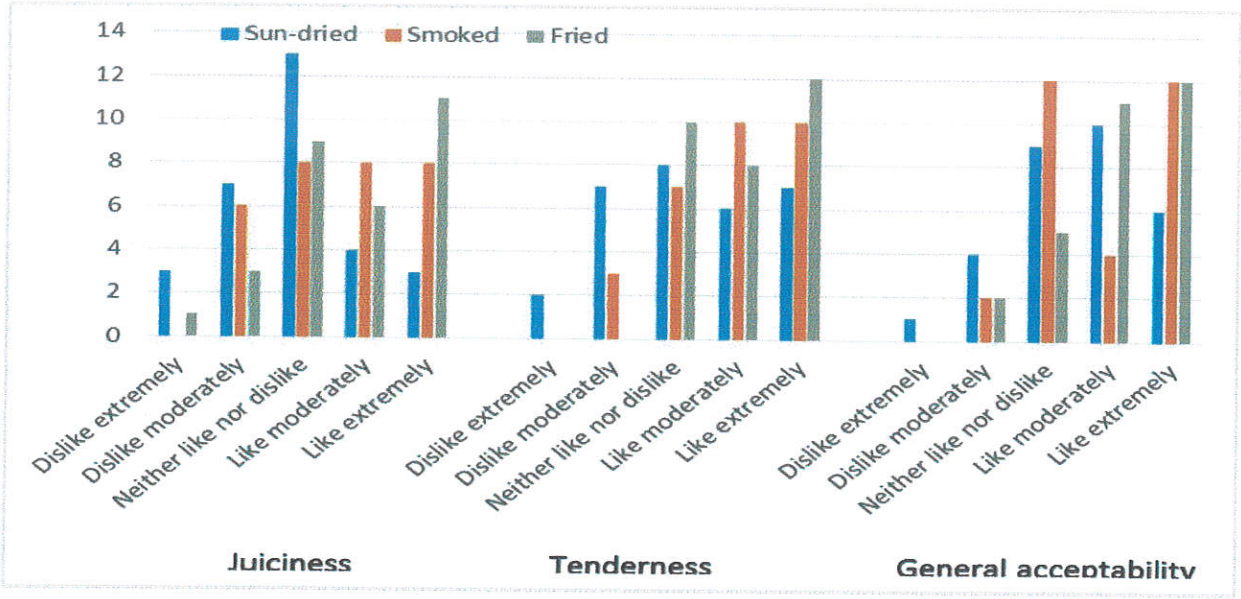

FIGURE 30: Interest levels of respondents to *Hydrocynus forskahlii* processed using the three methods based on the fish's moistness, tenderness and general acceptability.

FIGURE 29 show the interest levels of respondents to *Hydrocynus forskahlii* processed using the three methods based on the fish's taste with the fried fish being liked moderately by most respondents, liked extremely by most for smoked fish and liked extremely and neither liked nor disliked equally by most respondents for sun-dried fish.

FIGURE 29 equally shows the interest levels of respondents to *Hydrocynus forskahlii* processed using the three methods based on the fish's texture with the fried fish being liked extremely by most respondents, smoked fish neither liked nor disliked by most respondents while the sun-dried fish is neither liked nor disliked and liked extremely equally by the most respondents.

FIGURE 28 show the interest levels of respondents to *Hydrocynus forskahlii* processed using the three methods based on the fish's aroma with the fried fish being neither liked nor disliked by most respondents, the smoked fish neither liked nor disliked and liked extremely by most respondents nor the sun-dried fish neither liked nor disliked by the most respondents.

FIGURE 28 equally shows the interest levels of respondents to *Hydrocynus forskahlii* processed using the three methods based on the fish's colour with the fried fish being liked extremely and moderately by most respondents, smoked fish liked extremely by most respondents and the sun-dried fish neither liked nor disliked by the most respondents.

FIGURE 29 equally shows the interest levels of respondents to *Hydrocynus forskahlii* processed using the three methods based on the fish's moistness with the fried fish being liked extremely by most respondents, smoked fish liked extremely, moderately and neither liked nor disliked equally by most respondents while the sun-dried fish neither

liked nor disliked by the most respondents. FIGURE 29 equally show the interest levels of respondents to *Hydrocynus forskalii* processed using the three methods based on the fish's tenderness with the fried fish being liked extremely by most respondents, smoked fish liked extremely and moderately equally by most respondents and the sun-dried fish neither liked nor disliked by the most respondents.

Furthermore, FIGURE 29 also shows the interest levels of respondents to *Hydrocynus forskalii* processed using the three methods based on the fish's general acceptability with the fried fish being liked extremely by most respondents, smoked fish liked extremely and neither liked nor disliked equally by most respondents while the sun-dried fish liked moderately by the most respondents.

Table 4.6: Interest levels of respondents in the 3 processing methods of *Hydrocynus forskalii* based on the fish's organoleptic properties.

Organoleptic property	Sun-dried	Smoked	Fried	Significance
Taste	3.60± 1.22[a]	3.63± 1.19[a]	3.73± 1.05[a]	0.897
Texture	3.67± 1.12[a]	3.77± 0.94[a]	3.90± 1.09[a]	0.692
Aroma	3.70± 1.06[a]	3.87± 1.01[a]	3.83± 0.99[a]	0.798
Colour	3.70± 1.09[a]	4.60± 0.62[b]	3.73± 1.11[a]	0.000*
Moistness	2.90± 1.09[a]	3.60± 1.10[b]	3.77± 1.17[b]	0.008*
Tenderness	3.30± 1.26[a]	3.90± 1.00[b]	4.07± 0.87[b]	0.015*

General Acceptability	3.53 ± 1.07^{a}	$3.87 \pm 1.04^{a,b}$	4.10 ± 0.92^{b}	0.100

- Values are means of interest levels; where 1.00-1.49 represents "dislike extremely", 1.50-2.49 represents "dislike moderately", 2.50-3.49 represents "neither like nor dislike", 3.50-4.49 represents "like moderately" and 4.49-5.00 represents "like extremely".
- Means with different superscripts within each roware significantly different at ($p<0.05$)
- Asterisk (*) indicate significant difference among the group of means.

In table 6 above, fried fish shows the highest interest level (liked moderately) in terms of their taste, texture and general acceptability while the smoked is highest in terms of its aroma (liked moderately) with all four properties being not significantly different in terms of their processing methods.

Colour, moistness and tenderness are however significantly different from each other with the fried fish having the highest interest level in terms of moistness and tenderness (liked moderately) and the smoked having the highest in terms of colour (liked extremely) while the sun-dried fish showed the lowest in terms of all characters and is significantly different from the others in terms of moistness and tenderness (neither liked nor disliked) while the sun-dried fish and fried fish (liked moderately) are different from smoked fish (like extremely) in terms of colour.

4.2 Discussion

Tables 1, 2 and 3 show the effect of different processing methods on the proximate content of the three species of fish with the fresh and unprocessed samples showing the highest moisture values with a range of 78.7% to 70.56%. These high values confer on these samples their vulnerability to spoilage as indicated in Brown *et al.* (2014). Among the processed samples, the sun-dried ones show the lowest moisture content possibly due to the greater intensity of the drying brought about by the sun and making it possibly the best fit in terms of durability. The smoked fish closely follows with the fried the highest by moisture content among the processed samples possibly down to their liquid drying method which makes more moisture to be retained than the others. All treatments for moisture content are statistically different from each other indicating their different moisture level hence vulnerability to spoilage. These results obtained were similar to those found for boiled and fried common *Silver barb,* Nile tilapia, walking catfish, boiled striped catfish, and fried Spanish fish (García-Arias et al., 2003).

The effect of different processing methods on the protein content of three species of fish indicates that all three processing methods have a significant effect on the protein content in all three (3) species of fish. Among the processed fishes, the sun-dried have the highest percentage in terms of the protein content and thus possibly the most nutritious by virtue of their protein content. All twelve treatments are equally statistically different from each other indicating their different nutritious level by protein. The fried samples generally have the lowest protein content values possibly due to the effect of frying the fish in oil thus reducing the protein content as observed in Kashim *et al.* (2015).

The effect of different processing methods on the fat content of three species of fish with the smoked and the fried having relatively higher fat content than the others and the fried having slightly higher values than the smoked possibly due to the absorption of fat from the processing medium. All processed treatments show a significant difference in the fat content values from the unprocessed values indicating more available energy to be gotten including the fried which is showing the highest nutritive values in terms of the fat content. This is consistent with García-Arias *et al.* (2003) that shows that frying resulted in more lipid gain than the other cooking methods mainly due to the absorption of the fat by the fish during frying.

There is also no significant difference between the fat content of smoked *C. gariepinus* and *H. forskahlii* and that of fried *O. niloticus* and fried *C. gariepinus* showing no significant difference in the fat content of these two species thus showing similarities in their nutrition levels.

The effect of different processing methods on the ash content of three species of fish shows the highest levels in sun-dried samples and the lowest in both fresh and fried samples. There are no significant difference in the ash content of fresh *O. niloticus* and fresh *C. gariepinus* together with fried *C. gariepinus*. Also, sun-dried *O. niloticus* and *C. gariepinus* show no significant difference while fried *O. niloticus* and *C. gariepinus* show no significant difference as well. While sun-dried *H. forskahlii* has the highest value, fried *H. forskahlii* has the lowest value indicating the varying levels of their mineral content. All values are also in accordance with previous studies for other fish types (Adeyeye and Adamu, 2005; Aremu and Ekunode, 2008).

The effect of different processing methods on the crude fibre of three species of fish with fresh *O. niloticus* shows the highest value while fried *O. niloticus* show the lowest value. Among the processed samples, sun-dried shows the highest value for their crude fibre content while fried samples for the three species generally show the lowest indicating the levels of carbohydrate content in the processed food with the processed samples generally showing reduced values and thus a slightly lower energy content but of course increased shelf-life.

FIGURE 1 shows the interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's taste with the highest number of respondents liking the fish from the three (3) processing methods moderately.

FIGURE 1 equally shows the interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's texture with the highest number of respondents also liking the fish from the three (3) processing methods moderately.

FIGURE 2 shows the desired processing method by taste for *Oreochromis niloticus* in terms of the most desired and the least desired with the fried fish being most desired and the sun-dried fish least desired.

FIGURE 3 shows the desired processing method by texture for *Oreochromis niloticus* in terms of the most desired and the least desired with the fried fish being most desired here as well and the sun-dried and smoked fish being equally least desired by the same number of respondents.

FIGURE 4 shows the desired processing method by aroma for *Oreochromis niloticus* in terms of the most desired and the least desired with the fried fish being most desired and the sun-dried fish least desired.

FIGURE 5 shows the desired processing method by colour for *Oreochromis niloticus* in terms of the most desired and the least desired with the fried fish being most desired and the sun-dried and fried fish being equally least desired. This probably indicates that by colour, fried fish is just as most desired as it is least desired among the processing methods for the respondents.

FIGURE 6 show the interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's aroma with the highest number of respondents equally liking the fish from the three (3) processing methods moderately.

FIGURE 6 equally shows the interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's colour with the highest number of respondents equally liking the fish from the three (3) processing methods moderately.

FIGURE 7 show the interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's moistness with the highest number of respondents liking the smoked and fried fish moderately while the highest number either disliked moderately or neither like nor dislike sun-dried *O. niloticus*.

FIGURE 8 shows the desired processing method by moistness for *Oreochromis niloticus* in terms of the most desired and the least desired with the fried fish being most desired and fried fish being equally least desired. This probably indicates that by

moistness also, fried fish is just as most desired as it is least desired among the processing methods for the respondents.

FIGURE 7 equally show the interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's tenderness with the highest number of respondents liking the smoked and fried fish moderately while the highest number either liked moderately or neither like nor dislike sun-dried *O. niloticus*.

FIGURE 9 shows the desired processing method by tenderness for *Oreochromis niloticus* in terms of the most desired and the least desired with the fried fish being most desired and sun-dried fish being least desired.

FIGURE 7 show the interest levels of respondents to *Oreochromis niloticus* processed using the three methods based on the fish's general acceptability with the highest number of respondents liking the fish from the three (3) processing methods moderately.

FIGURE 10 shows the desired processing method by general acceptability for *Oreochromis niloticus* in terms of the most desired and the least desired with the fried fish being most desired and sun-dried fish being least desired.

Table 4 show the interest levels of respondents in the 3 processing methods of *Oreochromis niloticus* based on the fish's organoleptic properties with the fried fish showing the highest interest level in terms of their taste and texture while the smoked fish showed the highest interest level in terms of their aroma and colour. All three processing methods showed no significant difference in their interest levels for this fish species in terms of these afore-mentioned organoleptic characters.

In terms of moistness, tenderness and general acceptability, there are significant differences among the three processed samples based on the interest levels of the respondents with highest interest level being in the fried fish and the sundried fish being the lowest in all three fishes and being significantly different from the others. In terms of the tenderness and the general acceptability, the fried fish is liked extremely while in terms of other organoleptic properties, it is liked moderately

FIGURE 11 shows the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's taste with the highest number of respondents equally liking the fish from the three (3) processing methods moderately.

FIGURE 12 shows the desired processing method by general taste for *Clarias gariepinus* in terms of the most desired and the least desired with the smoked fish being most desired and the smoked fish being equally least desired by the most respondents.

FIGURE 11 equally shows the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's texture with the highest number of respondents equally liking the smoked and fried fish extremely while the sun-dried fish was liked moderately by the most respondents.

FIGURE 13 shows the desired processing method by texture for *Clarias gariepinus* in terms of the most desired and the least desired with the fried fish being most desired and the sun-dried fish being least desired by the most respondents.

FIGURE 18 shows the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's aroma with the highest number of respondents liking the smoked and fried fish extremely while the sun-dried fish has its

highest number of respondents shared equally amongst those who liked it extremely, disliked moderately and neither like nor dislike.

FIGURE 14 shows the desired processing method by aroma for *Clarias gariepinus* in terms of the most desired and the least desired with the smoked fish being most desired and the smoked fish being equally least desired by the most respondents.

FIGURE 18 equally shows the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's colour with the highest number of respondents liking the smoked and sun-dried fish extremely while the fried fish has its highest number of respondents shared equally amongst those who liked it extremely and those who neither like nor dislike.

FIGURE 15 shows the desired processing method by colour for *Clarias gariepinus* in terms of the most desired and the least desired with the smoked fish being most desired and the smoked and sun-dried fish being least desired by the most respondents.

FIGURE 10 shows the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's moistness with the highest number of respondents liking the fried fish extremely. The smoked fish highest respondents neither liked nor disliked it while the highest for sun-dried disliked it extremely.

FIGURE 16 shows the desired processing method by moistness for *Clarias gariepinus* in terms of the most desired and the least desired with the fried fish being most desired and the sun-dried fish being least desired by the most respondents.

FIGURE 18 shows the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's tenderness with the highest number

of respondents liking the smoked and fried fish extremely while highest respondents for the sun-dried fish neither liked nor disliked it.

FIGURE 19 shows the desired processing method by tenderness for *Clarias gariepinus* in terms of the most desired and the least desired with the fried fish being most desired and the sun-dried fish being least desired by the most respondents.

FIGURE 20 shows the interest levels of respondents to *Clarias gariepinus* processed using the three methods based on the fish's general acceptability with the highest number of respondents liking the smoked and fried fish extremely while highest respondents for the sun-dried fish neither liked nor disliked it.

FIGURE 21 shows the desired processing method by general acceptability for *Clarias gariepinus* in terms of the most desired and the least desired with the smoked fish being most desired and the smoked fish being equally least desired by the most respondents.

Table 5 show the interest levels of respondents in the 3 processing methods of *Oreochromis niloticus* based on the fish's organoleptic properties with the fried fish showing the highest interest level in terms of their taste and the smoked being highest in terms of its aroma, colour and general acceptability with all three properties being not significantly different in terms of their processing methods. Texture, moistness and tenderness are however significantly different from each other with the fried fish having the highest interest level in all three (liked extremely in texture and tenderness and only liked moderately in moistness) and the sun-dried having the least.

FIGURE 22 shows the interest levels of respondents to *Hydrocynus forskalii* processed using the three methods based on the fish's taste with fried fish being liked

moderately by most respondents, liked extremely by most for smoked fish and liked extremely and neither liked nor disliked equally by most respondents for sun-dried fish.

FIGURE 23 shows the desired processing method by taste for *Hydrocynus forskahlii* in terms of the most desired and the least desired with the smoked fish being most desired and the smoked fish being least desired by the most respondents.

FIGURE 24 shows the interest levels of respondents to *Hydrocynus forskahlii* processed using the three methods based on the fish's texture with fried fish being liked extremely by most respondents, smoked fish neither liked nor disliked by most respondents and sun-dried fish neither liked nor disliked and liked extremely equally by the most respondents.

FIGURE 25 shows the desired processing method by texture for *Clarias gariepinus* in terms of the most desired and the least desired with the smoked fish being most desired and the smoked fish being least desired by the most respondents.

FIGURE 26 shows the interest levels of respondents to *Hydrocynus forskalii* processed using the three methods based on the fish's aroma with fried fish being neither liked nor disliked by most respondents, smoked fish neither liked nor disliked and liked extremely by most respondents and sun-dried fish neither liked nor disliked by the most respondents.

FIGURE 27 shows the desired processing method by aroma for *Clarias gariepinus* in terms of the most desired and the least desired with the smoked fish being most desired and the smoked fish being least desired by the most respondents.

FIGURE 28 shows the interest levels of respondents to *Hydrocynus forskahlii* processed using the three methods based on the fish's colour with fried fish being liked

extremely and moderately by most respondents, smoked fish extremely by most respondents and sun-dried fish neither liked nor disliked by the most respondents.

FIGURE 29 shows the desired processing method by colour for *Clarias gariepinus* in terms of the most desired and the least desired with the smoked fish being most desired and the sun-dried fish being least desired by the most respondents.

FIGURE 30 shows the interest levels of respondents to *Hydrocynus forskahlii* processed using the three methods based on the fish's moistness with fried fish being liked extremely by most respondents, smoked fish liked extremely, moderately and neither liked nor disliked equally by most respondents and sun-dried fish neither liked nor disliked by the most respondents.

Table 6 show the interest levels of respondents in the 3 processing methods of *Oreochromis niloticus* based on the fish's organoleptic properties with the fried fish showing the highest interest level (liked moderately) in terms of their taste, texture and general acceptability and the smoked being highest in terms of its aroma (liked moderately) with all three properties being not significantly different in terms of their processing methods.

Colour, moistness and tenderness are however significantly different from each other with the fried fish having the highest interest level in terms of moistness (liked moderately) and tenderness (liked extremely) and only liked moderately in moistness) and the smoked having the highest in terms of colour (liked extremely). The sun-dried fish showed the lowest in terms of all characters and is significantly different from the others in terms of moistness and tenderness (neither liked nor disliked) while sun-dried

fish and fried fish (liked moderately) are together different from smoked fish (like extremely) in terms of their interest level.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

Sun-dried *Oreochromis niloticus, Clarias gariepinus* and *Hydrocynus forskahlii* is on the average more nutritive and better preserved than the others followed by the smoked and the fried.

O. niloticus, C. gariepinus and *H. forskahlii* are generally liked by the respondents that represent the general populace of Ilorin with the fried *O. niloticus* and *C. gariepinus* being the most liked on the average and the sun-dried the least liked on the average while the smoked *H. forskahlii* is most liked and the sun-dried least liked.

It has been observed that though the sundried type of the three fish species studied is the most nutritive and best preserved, it is least liked possibly because of the nature of preparation and lack of information as to the nutritive benefits of the three. Also, since the fried is very much liked, fish processors should be encouraged to venture into more frying in order to increase their sales and hence profitability.

REFERENCES

Ademola, B.B. and Miller J.W. (2004) Fish cage culture potential in Nigeria-An Overview, National cultures. *Agricultural Focus* 1:5-10

Afolabi, O.A., O.A. Arawomo and O.L. Oke, (1984). Quantity Changes of Nigeria Traditional Processed Freshwater Species I: Nutritive and Organoleptic Changes. Journal on Food Technology19: 333-340.

Agbelege O O and J K Ipinjolu 92001) An Assessment of the Exploitation and Management Techniques of the Fisheries Resources in the Nigeria portion of the Lake Chad, *Journal of Arid Zone fisheries I 89-98*

AOAC (2000) *Official methods of analysis* (14th ed.). Arlington: AOAC.

Chukwu O., and Shaba I. M., (2009). Effects of Drying Methods on Proximate Compositions of Catfish (*Clarias gariepinus*) *World Journal of Agricultural Sciences* 5 (1): 114-116

Clucas J. I. (1982) Fish Handling, Preservation and Processing in the Tropics, part 2 *Report of the tropical Development and Research Institute* G. 145 p. 18

Emokpae, A. O. (1985). Organoleptic Assessment of Quality of Fresh Fish. *Nigerian Institute of Marine Research Paper* 27: 1 – 30.

Eyo, A.A. (1997) Post-harvest losses in the fisheries of Kainji Lake. *Technical Report Series 5, Nigerian-German (GTZ) Kainji Lake Fisheries Promotion Project, New Bussa, Nigeria, March 1997* pp: 1-75.

Eves, A. and Brow R. (1993) Effect of tradition al drying process on the nutritional value of fish. *Tropical Science* 33: 183-189.

Farzana B. F., Gulshan A. L., Mosarrat N. N. and Mohajira Begum (2014) Effect of Sun-drying on proximate composition and pH of Shoalfish (*C. striatus*; Bloch, 1801) treated with Salt and Salt-turmeric storage at Room Temperature (27^0 - 30^0C)

George F.O.A., Ogbolu A.O., Olaoye O.J., Obasa S.O., Idowu A.A. and Odulate D.O. (2014) Fish Processing Technologies in Nigeria: A Case Study of Ibeju-Lekki Local Government Area, Lagos State. *American Journal of Food Technology 9: 302-310.*

Graves, T.D.D. 1970. Body composition changes during growing in young sockeye (*Oncorhynchus nerka*) in fresh water. *Bangladesh Journal of fish research* 27, 929-942.

IUCN (2017) *"Hydrocynus forskahlii". The IUCN Red List of Threatened Species. International Union for Conservation of Nature and Natural Resources.* Available at: http://www.iucnredlist.org/details/182366/0

Jamin D M amd Ayinla A O (2003) Potential for the Development of Aquaculture in Africa *Naga* 26 (3) 7-13

Kumolu-Johnson, C. A., Aladetohun N. F and Ndimele P.E., (2010). The effects of smoking on the nutritional qualities and shelf-life of *Clarias gariepinus*. *African Journal of Biotechnology* 9 (1): 073-076.

Monsterfishkeepers (2017) *"African Tiger Fish (Hydrocynus) ID and Care Guide 2.3". Monsterfishkeepers.com.* Available at: https://www.monsterfishkeepers.com/forums/threads/african-tiger-fish-hydrocynus-id-and-care-guide-2-3.521170/#post6237136

Niimi, A.J. 1972.Changes in the proximate body composition of large mouth (*Micropterus salmoides*) under starvation. *Journal of Zoology* 50, 815-819.

Ogundiran, M.A., Adewoye, S.O., Ayandiran, T.A. and Dahunsi S.O. (2014) Heavy metal, proximate and microbial profile of some selected commercial marine fish collected from two markets in south western Nigeria *African Journal of Biotechnology* 13 (10)

Okonta, A A. and Ekelemu J K., (2005). A preliminary study of Micro- Organisms associated with fish spoilage in Asaba, Southern Nigeria. Proceedings of the 20th Annual conference of fisheries society of Nigeria (FISON), PortHarcourt 14th-18th November pp 557-560

Olayemi F.F., Adedayo M. R., Bamishaiye E. I. and Awagu E. F. (2011) Proximate Composition OfCatfish (*Clariasgariepinus)* Smoked in Nigerian Stored Products Research Institute (NSPRI): Developed kiln. *International Journal of Fisheries and Aquaculture*. 3(5): 96-98

Oluwaniyi O.O., Dosumu O.O. and Awolola G.V. (2010) Effect of local processing methods (boiling, frying and roasting) on the amino acid composition of four marine fishes commonly consumed in Nigeria 123, Issue 4 pp 22-31

Osibona Adesola Olayinka, 2011. Comparative study of proximate composition, amino and fatty acids of some economically important fish species in Lagos, Nigeria. *African Journal of Food Science. 5 (10): 581– 588*

Parker, R.R. and Vanstin, W.E. (1966) Changes in the chemical composition of central British Colombia pink salmon during early sea life. *Bangladesh Journal of Fisheries Research*. 23, 1353-1384.

Saliu, J.K. (2008) Effect of Smoking and Frozen Storage onthe Nutrient Composition of someAfrican Fish. *Adv. Nat. Appl. Sci.* 2 (1): 16-20.

Usman, I. S., Abdullahi, A. and Waziri, U. M. (2017) Analysis of traditional fish processing methods among women in Lau Local Government Area of Taraba State, Nigeria Journal of Agricultural Science and Practice 2: 42-46.

Wikipedia (2017) *Hydrocynus forskahlii* Wikipedia Available at http://en.wikipedia.org/hydrocynus_forskahlii

APPENDIX A

QUESTIONNAIRE

Respondents are to evaluate the effect of smoking, sun-drying and frying on the organoleptic attributes of three species of fish used in a research study. The parameters are to be scored 5 if the property is liked extremely, 4 if liked moderately, 3 if you neither like nor dislike, 2 if disliked moderately and 1 if disliked extremely. The processed fish from the three processing methods will also be compared for the three species.

Name

Age:

Oreochromis niloticus

Organoleptic property	Processing method			Desirability	
	Sun-dried (SD)	Smoked (SM)	Fried (F)	Most desired	Least desired
Taste					
Texture					
Aroma					
Colour					
Moistness					
Tenderness					
General acceptability					

Clarias gariepinus

Organoleptic property	Processing method			Desirability	
				Most desired	Least desired
	Sun-dried (SD)	Smoked (SM)	Fried (F)		
Taste					
Texture					
Aroma					
Colour					
Moistness					
Tenderness					
General acceptability					

Hydrocynus

Organoleptic property	Processing method			Desirability	
	Sun-dried (SD)	Smoked (SM)	Fried (F)	Most desired	Least desired
Taste					
Texture					
Aroma					
Colour					
Moistness					
Tenderness					
General acceptability					