COMPARATIVE COMPOSITION OF FISH DRIED USING DIFFERENT METHODS

BY

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2003/14813EA

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BEING A FINAL YEAR PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG.) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

NOVEMBER, 2008

DECLARATION

I hereby declare that this project is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any University or Institution. Information derived from personal communications, published and unpublished works of others were duly referenced in the text.

Ibrahim Mohammed Shaba

26/11/2008

Date

DEDICATION

This project work is dedicated to the memory of my late father Alhaji Shaba Muhammed.

May his gentle soul rest in perfect peace, amen!

CERTIFICATION

This project entitled "Comparative Compositions of Fish Dried Using Different Methods" by Ibrahim Mohammed Shaba meets the regulations governing the award of the degree of Bachelor of Engineering (B. ENG.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

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In the name of Allah, The most merciful, The most compassionate. Glory is to Almighty Allah the lord of the world, the uncreated creator of the creatures, the ONE, the HOLY, the POWER, and the LIGHT. The ocean of knowledge, may his benediction be upon the seal of prophet, MUHAMMED (S. A.W.).

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ABSTRACT

Some nutritional compositions of two species of cat fish and tilapia fish (*Clarias gariepinus* and *Oreochromis nilotieus*) when fresh and dried were studied. Two methods of drying fish, smoking kiln and electric oven, were to dry the fish. Purchased quantities of both species of fish were shared into two parts: one part was used to determine the proximate compositions of the fish when fresh and the other part was sub-divided into two; a part was dried using smoking kiln and the remaining one was dried using electric oven. The proximate compositions of the dried samples using the two different methods were determined. The results of the analyses showed that fresh fish contains moisture content of 71.90% crude protein content of 19.38%, ash content of 33.08 % lipid content of 4.41% and 4.85 /100g energy value. The proximate compositions of the fish dried using the smoking kiln are; moisture content of 28.92% crude protein content of 53.10% ash content of 3.92% lipid content of 29.60% and 4.41/100g energy value while the proximate compositions of the fish dried using the electric oven are; moisture content of 15.26%, crude protein content of 67.12%, ash content of 3.62%, lipid content of 29.60% and 6.24/100g energy value. From the results it was concluded that, electric method of drying fish is more effective than smoking kiln method of drying fish.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study.

Fish is a very important source of animal protein in the diet of Nigerians for the low and middle level income groups. Fresh fish and dried fish pepper soup are delicacies for the upper class. Smoked or dried fish is a traditional part of the diet of a large section of the world's population. However, the gap between the demand and supply of fish is widening due to increase in population, poor postharvest handling, lack of processing and storage facilities and non-utilization of unconventional fish species. The estimated fish demand in Nigeria in 1994 was put at 1,139,833 tonnes based on the population figure of 94,986,044 and per capita consumption of 12.0kg which was considered globally adequate for normal and healthy growth. However, only 280,307 tonnes were produced, indicating a deficit of 94,705,737 (FAO, 1999).

Fish flesh contains most of the minerals necessary for a balanced diet. In particular, fish is high in iodine. When fish bones are eaten, fish affords a valuable source of calcium and phosphorus (Nettleton, 1985). In general the water and fat content of fish together add up to about 80% of the tissue. This means that in lean fish such as cod, the water content is about 80%, while in fatty fish such as mackerel it may be as low as 50% depending on the season. Generally, the protein content is about 18% but varies markedly between species depending on age and condition (Love, 1990).

The main fibrillar (component of fibre) proteins of fish are actin and myosin, responsible for the contraction and relaxation of muscles. The complex fats which are component of cell membranes are phospholipids and cholesterol, while the depot fats used for energy are usually triglycerides. The depot fat in fish does not contribute to the water activity of the product and the water activity (a_w) must be calculated on water: fat-free solids basis (Doe *et al.*, 1983).

All the vitamins recognized as necessary for human nutrition are found in fish, but their distribution in the various tissues is very uneven. Fish oils are the richest known source of vitamin A and vitamin D. Consumption of fish provides an important nutrient to a large number of people worldwide and thus makes a very significant contribution. Except for the fatty species, fish is relatively unimportant as a source of calories, which are generally obtained from the cereal staples, but is a palatable, convenient, and still moderately priced source of high – quality animal protein, vitamins, minerals, micronutrients and essential fatty acids. The health benefits of fish are being increasingly recognized in western society, which is an important factor in stimulating demand in a large number of developing countries. Fish has always been appreciated as a traditional and culturally acceptable component of diet. Demand from this source is consistent and rising, giving great concern for future availability, in view of the limited nature of the resource (Cruickshank, 1962).

The sequence of changes in fish quality due to a number of causes, such as increases in bacterial number in the wet fish, mould growth due to slow drying, and/or

lengthy storage accompanied by a succession of flies, their larvae and beetles, is well described in James (1983). It is widely known that reducing the water activity (a_w) will result in reduction of microbial activity; at low water activities, other effects such as rancidity become important (Troller and Christian, 1978).

Methods of drying and smoking of fish vary between different countries and within the same country depending on the species of fish used and the type of product desired. The process may use unsalted fish products ranging from less than 2% to over 20%. In addition other curing agents (e.g. nitrate) may be added. The fish may be dehydrated to various degrees with moisture levels in the final product ranging from about 10% to 60%. Processing temperatures may range from less than 5°C to up to 120°C and processing times from half an hour to several months. The fish may be dried only or smoked only or there may be a combination of smoking and drying. In some countries the fish is boiled before being smoked and/or dried. Adding to this complexity, the fish species used as raw material may be fresh water or marine species and may range from very lean to fatty fishes, and its condition from fresh to stale. This variation makes it difficult to arrive at general conclusions regarding processing effects of smoking and drying on protein quality and the nutritional value of the final products. Evidently, the impact of drying and smoking on protein quality may be assessed from known effects of physical/chemical parameters employed in the production such as dehydration, temperature, time, added compounds and oxidation, but only tests on the actual products can provide reliable data on their protein quality (Burt, 1989).

1.2 Statement of the Problem

It has been observed that not all drying methods are suitable for drying fish. The qualities of fish dried using different methods cannot be the same. Also the shelf life of fish dried in the oven varies from that of smoked over the fire. As a result, it becomes necessary to analyse fish dried using different methods.

1.3 Objectives of the Study

This research is directed toward achieving the following objectives.

1. To determine the nutritional composition of fresh fish and dried fish.
2. To determine the differences in proximate composition of fish dried in the electric oven and smoking kiln.

1.4 Justification of the Study

Fish provides are cheap and affordable sources of nutrition which is high in protein for virtually all classes of society. Fresh fish catch in large quantity cannot be used at a time but rather processed for future use. It is therefore essential to know the proximate composition of fish dried in order to meet the needs of the consumer and sustain its quality.

1.5 Scope of the Study

The scope of this project work is limited to the analysis of the proximate composition of catfish and tilapia fish dried using electrical oven and smoking kiln.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Fish Processing

Given the large diversity of commercially exploited species and the products which can be derived from them, the term 'processing' can encompass operations which range from the very simple to the complex. More over, when it comes to processing, as with most food industries, evidence indicates that the sanitary condition of the sea food processing plant do correlate well with the microbial quality of the finished product (Wentz *et al.*, 1985).

One area of concern, with respect to microbial contamination of finfish during processing is the use of wash tanks. While wash tanks are effective in removing blood and physical debris, they can be a significant source of microbial contamination. A study by Mayer *et al* (1986) revealed that when similar lots of fish were processed at newly processing plants, the microbial load differed greatly depending on the use of wash tanks and high pressure washing. Aerobic plate counts (APCS; 20°C) of dressed Atlantic mackerel, which were passed through a wash tank, were moved than 2.67×10^5 N/m^2 higher than high pressure washed fish. Similar results were also obtained with dressed sea bass and dressed porgy. Additional studies indicated that finfish fillet quality can be best maintained by high pressure washing whole fish, prior to filleting, rather than high pressure washing the fillets themselves. Bluefish which were processed immediately had

a 10 day shelf- life (tray- packed fillets, 0.56°C) while bluefish which were stored whole on ice for periods of 4 and 7 days before processing lasted approximately 11 and 13 days from day of catch.

Kosak and Toledo (1981) also investigated the effects of microbial decontamination on the storage stability of finfish. Chlorine dip was used for microbiological decontamination of the fish prior to packaging. Townley *et al* (1981) looked at the possibility of delayed evacuation. Working with Atlantic croaker and Grey trout, they reported on advantages to delayed processing. In fact, fish eviscerated(remove internal organ) immediately upon landing maintained class 1 quality 7-10 days longer than un- eviscerated (un-remove internal organs) fish or iced fish eviscerated 3 days after harvest. Microbial populations were reported to remain lower in eviscerated fish, for both species, throughout a 2 week storage period (0-1°C with top icing).

2.2 Fish Products

The products of greatest relevance to the poor are dried fish products, usually produced by relatively simple traditional technologies. Throughout the world there is a very wide range of products, some of considerable regional importance in both developed and developing countries. The following products could be included in a list: dried; salted and dried; smoke dried (either salted or not); brine or acid; fermented; and products resulting from a number of combination processes. In addition the product can be presented as whole fish, fillets, fish powder, or hydrolysates, such as fish sauces. Traditional processing technologies have clearly been developed in order to preserve

excess quantities of fresh fish for storage or transport. Usually these technologies are not well documented, particularly in developing countries, and are being lost to the trend of urbanization and convenience food. More effort is required to investigate and collect the processing methods. In developing countries, products of this category are usually made from low-cost materials, but in developed world there is still a considerable demand for products such as dried, or salted and dried cod, where the raw material and final product are of high value. The general importance of dried fish and relatively simple technologies employed in its production has encouraged technologists to look for prospect of industrializing the process. The fact that these efforts, despite involving significant investment, have not succeeded is worthy of further investigation to see if they should be continued (Peter, 1996).

2.3 Nutritional Content of Fish

Proximate composition of fish vary depending on certain factors such as the geographical location, season of the year, the feed intake, the metabolic efficiency of the fish, the energy expended by the fish, sex, species, age and size; it can also vary within the individual fish species.

A typical composition of various fish species is shown in Table 2.1 for marine water fish and Table 2.2 for fresh water fish.

Table 2.1 Chemical Composition of Various Fish Species

Specific Name	Common Name	Water (%)	Lipid (%)	Protein (%)
Marine water				
'Anguilla anguilla	Eel	60-70	8.0-31.0	14.4
Carcharchinus brachyurus	Shark	25-80	0.1	18;9
Clupea harengus	Herring	60-80	0.4-22.0	16.0-19.0
Gadur morhua	Cod	78-83	0.1-0.9	15.0-19.0
Merluccius Capensis	South African hake	80	0.4-1.0	17.8-18.6
Micromesestus poutassou	Blue whiting	79-80	1.9-3.0	13.8-15.9
Nephrops nopregicus	Norway lobster	77	0.6-2.0	19.5
Pleuronectes platersa	Plaice	81	1.1-3.6	15.7-17.8
Sardina pilchardus	Pilchard	60-80	17.0-20.0	1.0-23.6
Scomber Scombrus	Mackerel	56-74	1.0-23.5	16-20
Solea solea	Sole	78	1.8	18.8
Thunnus spp	Tuna	71	4.1	25.2

Source: Murray and Burt, 1977; Afolabi *et al.*, 1984; Eyo. 1998

Table 2.2 Chemical Composition of Various Fish Species

Specific Name	Common Name	Water (%)	Lipid (%)	Protein (%)
Fresh Water				
Citharinus utharus	Moon fish	76-80	1.18	20.04
Clarias gariepinus	Catfish	78.13	4.22	18.63
Cyprinus carpio	Carp	78.80	2.0-2.2	17.5-18.9
Hemichromis fasciatus	Cichlid	74.37	0.25	18.41
Later nilotieus	Nile perch	74.37	1.2-9.9	15.1-22.0
Mormyrus rume	Trunk fish	74.77	4.97	19.36
Oreochromis nilotieus	Tilapia	78.11	4.22	18.41
Salmo salar	Salmo	67.11	0.3-14.0	21.5
Salmo trutta	Trout	70.79	1.2-10.8	18.9-19.1
Sarotherodon galilacus	Tilapia	78.11	3-6	18.62
Tilapia mossambicus	Tilapia	78.20	2.2	18.60
Tilapia zilli	Tilapia	77.50	2.75	18.88

Source: Murray and Burt, 1977; Afolabi *et al.*, 1984; Eyo, 199

2.3.1 Fish Protein

Proteins are complex organic substances occurring naturally and formed from combination of amino acids linked together by peptide bonds, sulfhydyl bond and Vander Waal forces. Proteins are the most important constituents of fish tissues and anatomically

the major constituents of fish body. They are made up of carbon, oxygen, hydrogen and nitrogen, some proteins contain sulphur and phosphorous in addition. The molecular weight of protein is usually in excess of 100,000. Proteins are varied in shape, size, composition of physical properties and functions. Indeed, this diversity gives them such a significance in living system where they act among other things as enzymes, structural elements, receptors, antibodies and hormones. Proteins are present in different forms and in different parts of the animal e.g. globular proteins are found in the blood and tissue fluids, collagemour proteins occur in skin or cell membrane, fibrous proteins are present in the hair, muscle e.t.c. and crystalline proteins are found in the lens of the eye. Most proteins are soluble in water and alcohol. Heating, freezing and exposure to high concentration of salt easily denature protein (Eyo, 2001).

The quantity of animal protein consumption varies from place to place. In developing countries it is about 11kg per capital compared to 54kg in developed countries. In Nigeria, the per capital protein consumption is 7.6kg (FAO, 1999).

2.3.1.1 Nature of Muscle Proteins

Fish muscle can consist of two main types, dark and white depending on the life-cycle of the species concerned. Strong-swimming species, such as tuna and mackerel have a larger proportion of dark muscle than relatively sluggish fish such as cod, haddock and flat fish. The two muscle types are essentially similar in composition but the dark muscle has a higher content of haem pigments such as myoglobin for oxygen transport and more non structural lipids to provide energy; this reflects its role in active strong-

swimming. The actual amino-acid composition of dark and white fish muscle is roughly the same as in terrestrial species such as cattle, although the proportion of different protein types vary- reflecting the environment in which these creatures live. Three groups of proteins can be differentiated and separated by solubility in salt solution of increasing concentration. The sarcoplasmic proteins are water soluble and normally found in the cell plasma where they act as enzymes and oxygen carrier. They will comprise anything from 18-20% of total muscle protein. The largest pore portion of muscle protein, 65-80% of total protein, consists of the myofiberillar proteins, which give the muscle its fibro-like structure and muscular activity. The major components are myosin, actin, tropomyosin and troponin. These proteins can be extracted by the use of salt solution up to 0.3M. The final groups of proteins are those making up the connective tissues, surrounding the muscle fibres and in the skin; they include collagen and elastin. These proteins known as stroma comprise about 3-5% of the total protein (which is much less than in terrestrial animals) are easily solubilised by cooking (Hall, 1992).

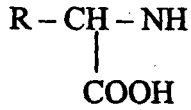
2.3.1.2 Nutritive Value of Protein

The nutritive value of protein is expressed in terms of amino acids present.

Amino Acids

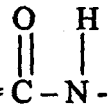
Amino acids are regarded as the building block of protein and 23 amino acids have been isolated from protein.

Amino acid structure is given as:



In glycine R=H. This is simplest amino acid.

In lysine R=NH_2 $(CH_2)_4$



A peptide bond = C – N -

The amino acids are carboxylic acid which contain an amino (-NH_2) group in the molecule. The carboxylic group of one amino acid with the alpha- amino group of another amino acid is bonded by the peptide bonds. These peptide bonds allow many amino acid linkages until a protein is formed. These amino acids, which cannot be synthesized in the body from substances normally available and at the speed required to maintain good health, are known as essential amino acids. Such amino acids must be obtained preformed in the diet. The amino acids essential to man are lysine, methionine, tryptophan, isoleucine, leucine, threonine, valine and phenylalanine. The non- essential amino acids are normally synthesized or interchangeable within the body except under famine conditions. They are alanine, protine, glycine, serine, tyrosine, asparagines, glutamic acid, aspartic acid, hydroxyproline histidine and arginine (Eyo, 2001).

2.3.2 Nutritive Value of Lipids

Lipid is an important source of energy (about 35 kilojoules/g of fat). As a group, it is the major source of concentrated energy available to man. The essential fatty acid

(EFA) cannot be manufactured by man and must be taken with food. They are oleic C 18:1 and acachidonic C 2:4 acids. Moderate amounts are present in fish oil. The major source of essential fatty acid is vegetable oil (Eyo, 2001).

Lipids are made up of the chemical elements carbon, hydrogen and oxygen that are found in carbohydrates. But unlike the latter that the number of hydrogen and oxygen atoms in the molecule are not in the ratio of two to one. Lipids are the most concentrated form of energy stored in the fish, and it is no coincidence that active species such as salmon, tuna or herring carry more lipids than less – actives such as cod or plaice. Lipids occur in fish as two broad groups. The first consists of triacylglycerols (triglycerides) and is the main form in which energy resources are stored. The lipids are often observable as actual globules of oil that have accumulated in the flesh, liver and in some species around the intestine also. The second lipid group, mostly phospholipids and cholesterol, is an essential component of cell walls, mitochondria and other sub cellular structures. Consequently, it cannot be readily drawn to supply energy and in cod at least, its mobilization coincides with the breakdown of actual contractile protein. The lipids in the edible part of fish are important to the food scientist in this respect. Firstly, any oily deposits noticeably influence the sensation of the cooked flesh in the mouth of the eater. Herrings, for instance when well- fed and fat-rich, taste very smooth and succulent (juicy), although the sensation is produced by oil not water. After spawning when the oil is at its lowest level, the main sensation is of dryness or fibrousness, perhaps 'rough' or 'coarse' describes it better- at any rate the taste is disappointing. Secondly, fish lipids, as

is now widely recognized, are very beneficial to the health of the consumer. In cases of myocardrial infants, patients put on a diet of fatty fish appear to have a greatly reduced likelihood of a recurrence, and atherosclerosis (coronary artery disease) is reduced. When Eskimos and Japanese used fish as the main part of their food intake, they almost never suffered from heart attacks. Many other diseases, such as rheumatoid arthritis and even cancer, appear to be alleviated eating fish oils. The beneficial substances in fish oil are the polyunsaturated fatty acids, especially eicospentaenoic acid, which has 20 carbon atoms in the chain and 5 double-bonds (20:5) and also the fatty acid dodecahexaenoic acid (22:6). Both acids belong to the n- 3 series, that is, with the fish unsaturated linkage at the third carbon atom along the carbon chain from the methyl group. Finally, flesh lipid contributes to the flavour of the fish. The lipids themselves have slight taste, but of greater importance is their propensity to develop an off-flavour in the frozen state. This is caused by atmospheric oxidation, especially of the unsaturated phospholipids. Each of these aspects will now be considered in turn (Hall, 1992).

i **Oiliness of the Flesh in Relation to the Spawning Cycle.**

The oiliness of the flesh of fatty species as linked to the time of spawning varies in a regular annual cycle. Lipids are deposited during a feeding period when the gonads are inactive, and still continue to be deposited as they start to develop. There appears to be further depletion for a while after spawning is completed (Hall, 1992).

ii Fish Lipid and Human Health.

The extent to which polyunsaturated fatty acids can be synthesized by the fish from less unsaturated fatty acids in the diet varies with the species Chinook salmon (*Oncorhynchus oshawytscha*) grows very slowly on fat-free diet but recovers a normal growth rate complete when fed only fatty acid 18: 2. The elongation (addition of carbon to the chain) and desaturation (increase in the number of double bonds) of 18:3 fatty acid administered to another marine teleost and the cod (*Gauus morhua)* were both slight where fish are cultured for human consumption, therefore, it is to ensure that fish marine oils are used as basis of dietary lipids, and that they are not admixed with vegetable oils which are defiant in the n-3 series of polyunsaturated (Ross, 1977)

iii Development of Rancidity in Frozen Fish

Fish that are frozen and cold-stored gradually develops an off- flavour and off-odour which have been likened to boiled clothes, wet cardboard and cold tea e.t.c. in the case of very oily fish such as herring or mackerel, the eater, unless experienced in tasting cold- stored fatty fish, does not immediately think that what he or she is eating is rancid. More usually, fish simply tastes oily than usual and oiliness subtly unpleasant (Hall, 1992).

2.3.3 Minerals

The mineral content of fish is another reason of interest that makes fish unavoidable in the diet. Fish is a source of different minerals that contribute greatly to good health. These minerals include sodium which is present in body fluids, iron in the

blood haemoglobin, magnesium, phosphorous and calcium are present in the bones and potassium found in cell fluids. The absence or low level of mineral in certain parts of the body will cause disease. For example calcium is needed for the development of bone and teeth, coagulation of blood and aids in the functioning of muscles. Its deficiency leads to soft, deformed and calcified bones which are also associated with vitamin D deficiency; potassium is needed in the body for cellular functions and for the maintenance of the alkalinity of bile. Fish is the richest source of fluorine and iodine, which are needed for the development of strong teeth and the prevention of goitre or enlargement of the thyroid gland stunted in the neck. Key sources and functions of minerals are presented in Table 2.3.

Table 2.3 Sources and Functions of Minerals

Minerals	Best Source	Deficiency	Function
Calcium	Fish, Milk, Snail.	Malformation of bone and teeth.	Assists in the absorption of iron and healing of wounds.
Phosphorus	Fish, Milk, Kidney.	Rickets	Required for the formation of bones and teeth.
Iodine	Fish, Milk, Crabs, Water plants.	Stunted growth and goiter enlargement of the thyroid gland.	Component of the thyroxin which functions in the regulation of metabolic rate, iodine salt can be used to prevent deficiency.
Fluorine	Fish	Dental carrier	Assists in the formation of bones and teeth.
Potassium	Fish, Milk, Eggs, Fruits.	Disfunctioning of heart and respiratory system.	Essential in the functioning of cell and in the alkalinity of bile and blood.

Source: Eyo, 2001

A diet low in minerals is recommended for patients with heart trouble, therefore the minerals present in the edible parts of fish are of great interest. The total mineral contents of the flesh of marine and fresh water fish are not markedly different, although

trace elements such as boron, bromine and lithium are more plentiful in the former. Since connective tissue is much richer in sodium than in contractile muscle, the concentration of sodium at the tail end of cod is twice that of the head end, containing as it does many more of connective tissue septa per unit length (Hall, 1992).

2.3.4 Vitamins

Fish also contains appreciable quantity of vitamins. Vitamins are accessory food substance required in minute quantities, which are necessary for the maintenance of good health. Fish contains all the fat soluble vitamins known as vitamin A, D, E and K. These vitamins perform useful functions in the body. Vitamin A is important in vision and its deficiency leads to night blindness. Fish liver oil is the most important source of vitamin A. The vitamin A contents of liver varies with species, age, size, sex, nutritional condition and spawning stage of the fish as well as geographical location and season of catch (Karrick, 1969). Vitamin D (calciferol) enables the body to metabolize calcium in milk and foods and build strong teeth and bones in young people. Its deficiency leads to rickets in the young where the bone become bent and osteomalacia or brittle bone in the aged. Fish are the richest source of vitamin E (Tocopherol). The vitamin E content in fish flesh is related to fat content, geographical location, sexual maturity and seasonal factors, which include diet and temperature (Syvaoja *et al.*, 1985).

2.3.5 Fish Carbohydrates

Fish contains negligible amount of carbohydrates, therefore, inclusion of generous portion of fish in he diet is important in controlling body weight (Eyo, 1998)

2.3.6 Moisture Content

Moisture content is frequently used to determine the degree of dehydration of fish and fish product. The procedure involves accurate weighing the material in a petro-dish nickel and oven drying the content to a constant weight at a specific temperature usually 105°C. The moisture content is calculated from the weight loss of the sample. The water content varies with the season and the method of handling and storage. Usually the water content increases and protein content decreases as spawning time approaches. Fish stored in melting ice tends to gain water whereas fish frozen and thawed tends to lose water. Typically water content of cartilaginous fishes e.g. state, ray or shark is in the range of 70-80%. In most other species, the sum of the water and fat content at any given time is approximately 80 % (Love, 1970).

2.3.7 Ash Content

The ash content is the inorganic matter which remains after the organic matter has burnt. Determination of the ash content indicates the mineral matter present in the fish. The procedure is to fish char a known weight of the first sample and transfer to the furnace to ash at 550^{0}C to 570°C for one hour after until weight of the sample is constant and no black particles remained in the evaporating dish (FAO, 1999)

2.4 Fish Preservation Methods

2.4.1 Fish Chilling

Fresh fish spoils very quickly after catch and the rate of spoilage is influenced to a large extent by temperature. Consumers generally demand and pay more for good quality

fresh fish. Fish intended for smoking, drying or salting fetches a lower price on a fresh weight basis, constituting an economic loss to fishermen and fish traders. Because of the hot humid climate prevalent in African bacterial multiply very rapidly on dead fish. The rate at which bacteria grows is significantly reduced at low temperature. One of the simplest ways of lowering fish temperature thereby retarding bacterial growth is to ice the fish.

Ice is used extensively in the fishing industry as a cooling medium for fresh fish medium for fresh fish in order to preserves its quality and prolong its storage life (Curran *et al.*, 1981).

2.4.1.1 Merits of Icing

As soon as fish is iced, heat is transferred from the fish to the ice causing the ice to melt. This continues until an equilibrium temperature is reached between the ice and fish. This temperature would be a little above 0°C if sufficient quantity of ice is used. At this temperature the activities of micro- organisms and enzymes are reduced and the storage life of fish is prolonged. As the ice melts the flowing molten water washes away bacteria, slime, blood and other debris from the fish. It also keeps the fish moist and prevents it from dehydration. As soon as spoilage sets in, the melt water carries away metabolic products of bacteria. This is probably one of the main reasons why fish on ice keeps a few days better than fish kept at temperatures of 0°C. Many factors are known to affect the rate of spoilage of fresh fish on ice. There are discussed as follows:

i **Size, shape and fish type**

The size of the fish affects the speed at which the fish is chilled. A fish weighing 3kg at an initial temperature of 20°C will reach 0°C throughout in about 8 hours small fish becomes chilled faster then large fish and rate of spoilage of the small fish on ice is faster. Also it has been demonstrated that small tropical fish species showed significantly shorter maximum storage lives on ice (Poulter and Nicolaides, 1985)

ii **Delay in icing**

Studies with marine and fresh water species have shown that the longer the delays before fish are chilled after death, the faster will bacterial and enzymic spoilage occur hence the shorter the storage life on ice. For example tilapia, stored for 26 days when it was iced immediately after harvesting. When icing was delayed for 4, 8 and 12 hours the fish had shelf lives of 20, 16 and 1 day respectively. However, when trench sardine (*Amblygaster sirm)*, obtained under semi-commercial condition were iced immediately (0 hour) or 5 hours at ambient condition, it was observed that the sensory, chemical and microbiological parameter were not significantly different 24 hours after landing. But when icing delayed by 10 hours after the fish was caught, even though iced, was unsuitable for further processing (Chinavasagam and Vidanapathirana, 1985).

iii Type **of Environment from which Fish are Caught**

Many workers have found a relationship between the storage lives of fish on ice and the environment from which the fish are caught. Fresh water fish have been reported to keep longer in ice than marine fish although their patterns of spoilage are similar. One

explanation for this difference is that fresh water fish contains antimicrobial substance in their surface slime which are absent in marine species. It is known that fresh water fish have little or no trimethylamine oxide (TMAO) which is present in marine fish. During storage TMAO undergoes a breakdown to produce ammonia-like odour and flavour. Fresh water fish does not produce ammonia-like odour during ice storage, therefore, they may be considered of better quality than marine fish after the same length of storage under the same conditions.

iv **Method of Capture**

The iced storage life of fish may be affected not only by the method of capture but by how long the fish have remained entangled in net line. Caught fish keep longer than trawled asphyxiated fish associated with a slower development of rigour mortis; besides trawled fish from polluted areas or warm tropical water have been known to carry bacterial loads 100,000 times greater than line caught fish. High bacterial load are quite often associated with spoilage. In artisanal fisheries some of the catches entangled overnight in gillnet may spoil before they are landed.

v **Method of Icing**

Icing is most effective if the full surface of the fish is in contact with ice. Therefore, the smaller the ice the better and the coarser the ice the slower is the chilling rate. If ice is improperly applied on fish, then it will take a much longer time for the temperature of the fish to attain 0°C. This could have the same effect on delayed icing.

vi **Fat Content of Fish**

Studies so far have shown that lean fish keep longer on ice than fatty fish. Fish with a high fat content deteriotiate rapidly due to the onset of rancidity, which is faster at low temperature than in bacterial spoilage. It has been suggested that the higher the fat content of fish, the softer and more delicate is the texture and structure of the fish. For this reason fatty fish tend to break down physically much more quickly than non-fatty fish during storage. The small size and fatty nature of sardine should be the reason for their short shelf life of nearly one-week in ice storage (Clucas, 1985).

2.4.2 Fish Drying

Drying or dehydration is used to describe any process involving the removal of water from fish or fish product by evaporation. Salting application of pressure and using absorbent pad are other method of fish preservation.

2.4.2.1 Principles of Fish Drying

Preservation by drying is effected by lowering the water vapour pressure of the fish to a level which micro-organism can no longer grow. The ratio between the water vapour pressure of a substance and the vapour pressure of pure water at the same temperature is called water activity (a_w). The ratio also expresses the relative humidity of air with which the substance is in equilibrium. Most micro-organism can grow at water activity (a_W) of 0.95 and above. Below this water activity (a_w) growth of some micro-organisms are affected. Fresh fish has water activity (a_w) of above 0.95, that is, fish is easily prone to microbial proliferation. Most spoilage bacteria are reported to have a

minimum water activity (a_w) of 0.91 while yeast and moulds can reproduce at a minimum water activity (a_w) of 0.88 and 0.80 respectively. Some micro-organism can tolerate water activity (a_w) while is lower than the minimum reported for micro-organisms of that class. For example halophilic bacteria can grow at water activity (a_w) of 0.75 while metabolic processes have been observed in xerophilic mould and osmophilic yeast at water activity 0.65 and 0.61 respectively. In order to destroy the micro-organisms enough heat must be applied on fish to reduce the water activity in the milieu. Heating not only reduces the water activity of the fish but also desiccates the micro-organism causing them to die out. Thermophilic (high temperature loving) micro-organisms may still survive in dried fish after heating hence dried fish should not be considered as being sterile. The destruction of micro-organism during the drying process depends not only on the nature and level of infestation, but also on environmental factors such as relative humidity and speed of air flow and particularly on the changes in temperature and water content of the product. There are two stages in the fish drying process; removing moisture on the surface and removing moisture within the fish. These distinct phases of drying are termed constant rate and falling rate drying respectively,

i Constant Rate Drying

The drying rate in the constant rate drying depends on the temperature, the speed of air movement and the relative humidity of the air. The drying rate and the constant rate period can be calculated using the following equation.

$$e = h_m A (P_s - Pa) \qquad (2.1)$$

Where:

e = Drying rate (Kg/s).

h_m = mass transfer coefficient (Kg/sm^2p_a).

A = surface area of the fish (m^2).

P_S = partial pressure of water vapour in the air at the fish surface.

P_a = partial pressure of water vapour in the air stream.

Thus, the drying rate can be increased by increasing the air temperature and by reducing the air relative humidity. High ambient temperature and opening the fish up thereby increasing the surface area of the fish as filleting hasten the drying process (Janson, 1958).

ii. Falling Rate Drying

Once the ice water has been removed from the surface of the fish, water then begins to migrate from the fish flesh to the surface. As the rate of migration becomes slower the drying rate declines. This is known as the falling rate. The moisture content of the point when the constant rates stop and the falling rate begins is known as the critical moisture content. The falling rate can be expressed by the Fourier's equation:

$$\frac{dc}{dt} = D_x \frac{d^2c}{dx^2} + D_y \frac{d^2c}{dy^2} + D_z \frac{d^2c}{dz^2} \qquad (2.2)$$

Where:

c = moisture concentration (kgH_2O/m^2 of Fish).

Dx, Dy, Dz = Diffusivities of water vapour in fish in three direction x, y and z (m^2/s)

t= time (s)

iii **Fish Drying Process**

During fish drying, moisture migrates to the surface of fish fillets and then evaporates. Such water carries with it soluble substances such as sugar, phosphates and amino acid which are deposited on the surface of the product, thus retarding the rate of evaporation and setting a higher required heat input to effect evaporation. This results in thermal denaturation as water migrates to the surface and evaporated, the moisture content within the product as well as the rate falls. The falling moisture content within the product results in concentration of solution and a lowering of pH value. A combination results in extensive protein denaturation which limits the re-hydration proportion of the product and causes toughening in the re- hydrated products (Janson, 1958).

2.4.2.2 Factors Affecting Fish Drying Rate

i Size of Fish

The drying rate of thin fish or piece of fish is faster than a thick fish of the same weight because a thin fish has a proportionately greater surface area and diffusion path to the surface is shorter.

ii. Fatness of the Fish

The lower the content of the fish the faster the water diffuses to the surface of the fish hence the faster the drying rate. If during the early drying stage, the fish is dried at high temperature (more than 40^0C), or when the relative humidity is too low, the outer layers become cooked or altered so as to be almost impervious to water. This effect is known as case hardening (Lupin, 1983).

iii. Temperature

The higher the temperature, the faster the water diffuses to the surface of the fish and faster the water evaporates on the surface.

iv. Air Speed

The higher the speed of the air flowing over the fish, the faster the water evaporates from the surface of the fish being dried.

v. Saltiness of the Fish

The greater the amount of salt added the more slowly that water diffuses to the surface. Thus drying time is increased in the presence of salt. Heavily salted fish is in equilibrium moisture in the air at relative humidity of 76%; drying is slow when the relative humidity reaches above70%. (Lupin, 1983).

2.4.2.3 Sun Drying

Exposure of freshly caught fish to heat from sunlight is the simplest method of fish preservation in the arid regions of the tropics where wood for smoking is scarce and heat energy from sunlight is of considerable intensity and duration to dehydrate the fish before the onset of spoilage. In some artisanal fishery, sun drying is preformed traditionally by simply placing gutted or pen gutted fish in the open. Also cemented floor, or polythene sheets or similar materials placed on the ground may be used. Alternatively fish may be laid on a bed of grasses along the beach, on rocks or sand, dust and crawling insects. The fish may be at various degrees of spoilage before or during sun drying (Eyo, 2001).

2.4.2.4 Oven Drying

(From www.i4at.org) Either build trays as described for sun drying or convert oven racks to drying racks by stretching muslin or cheesecloth across the oven rack. Secure with toothpicks or long sewn stitches. Alternate trays in the oven periodically to assure even drying. Set oven control at its lowest setting, but not below 140-150% if using an electric oven; wedge a potholder between oven and door to allow an opening. Moisture from the drying food will vent through this opening. Close the door on a gas oven, so that the vent will permit moisture to escape.

2.4.2.5 Dehydrator

(From www. i4at.org) There are two types of dehydrators; solar and electric. For each type of dehydrator, prepare food and place on racks. If using a solar dehydrator, adjust the position of the food throughout daylight hours to keep in direct sunlight.

2.4.3 Fish Smoking;

The use of smoke from smoldering wood for the preservation of perishable food dates back to civilization. The method might have been developed in the ancient time by hanging perishable food over a fire, which was used for heating purposes. Among the raw materials cured in this way, fish and fish products were the most vulnerable to deterioration. The bacteriostatic, bactericidal and antioxidant functions of smoke and the dehydration effect of the process were used inadvertently by the early fish processors in the preservation of fish. Although traditional fish smoking is still being practiced especially in the tropics, however, in this modern time, in most of the technologically

developed countries smoking is often at low temperature to produce a desirable colour and flavour while canning and freezing are relied upon for preservation. When these modern preservative methods are not readily available, smoking is still a major method of preserving fish and in such area, hot smoking that also cooks the fish is usually practised (Clifford *et al.*, 1980).

2.4.3.1 Types of Fish Smoking Processes

In fish smoking there are two types of processes commonly in use. The 'cold' smoking process in which the temperature of the smoke does not exceed 30°C and hot smoking during which the fish is properly cooked with the temperature reaching 120°C or so while the centre of the fish may be at 60°C. Cold smoking is practiced in places where alternative means of preserving the fish such as refrigeration are available. Cold smoking is primarily to improve the flavour of the fish and retain its nutritive value. Cold smoked fish is not well cooked, has shorter shelf life and is easily infested by micro-organisms such as bacteria and mould if not properly stored in a refrigerator. Moisture retention is usually high and may be in the order of 35-45%. Hot smoking is the traditional method of fish smoking in the tropics. Fish is smoked until cooked in order to obtain a product with extended shelf-life since alternative preservation methods such as refrigeration are absent in remote fishing villages where most fish processing takes place. The primary aim of hot smoking is to preserve the product, flavour and colour arising as a result of the preservation function (Foster and Simpson, 1961).

2.4.3.2 Method of Fish Smoking

Fish smoking is conducted in the tropics in smoking houses, ovens and kilns. The design for the smoking equipments varies from place to place. The various smoking types can be classified into traditional methods which include:

i **Traditional Smoke House**

This is simply a one room apartment of variable dimensions with thatched and mud wall. Inside the house are smoking platforms of wire meshing 5-10 m long, 2m wide and 1-2m high supported by bamboo sticks. The number of shelves determines the capacity of the smoke house. Fish are laid on the racks and fire burning wood below. The excess smoke leaves smoke house through the thatched roof. The smoke is found in place where the volume of catching fish is high. In particular this is the commonest smoking equipment for bonga (*Ethmalosa spp.*) fish along the Atlantic coast.

ii **Pit Oven**

This consists of shallow pit of about 0.5m covered with a tray of chicken wire or iron rods. Fish is placed on the tray and fire is set on fire wood arranged inside the pit. The method requires close supervision to prevent fish charring or burning during smoking.

iii **Mud- Type of Smoking Kiln**

Traditionally the mud-type of fish kiln is made of clay wall which may be conical or rectangular in shape. The conical type may vary in height from 1 to 1.5m with a diameter of 0.5 to 1.5m. Only one stoke hole is available for burning fire wood in the

oven. The rectangular mud-type smoking kilns is used extensively by commercial fish processors in the tropics, are built in chains with clay and could vary 1m to 10m, 15m wide and1m high with stoke- hole spaced out at 1-2m interval. Each smoking chamber contains a single support of chicken wire reinforced by expanded metal or hardwood frames, which are embedded in the opposite of the oven.

iv Drum- type- Smoking Kiln with A Single Smoking Rack

This drum-type-smoking kiln with a single smoking rack could be fabricated from a 44-gallon drum. Simply, opening the top end of the drum completely and passing the iron rods at about 20cm below the top could do this. Smoking racks of wire mesh are placed on the iron rods at the opposite end of the drum and a 30cm square opening is created to form stokehole. Fish are placed on the smoking rack and fired from below; the fish is covered with iron sheet to conserve the heat in the drum (Eyo, 2001).

Merits of the Traditional Smoking Kiln

i It is relatively cheap and easy to construct.

ii The drum-type is portable and could be used in swampy area

Demerits of the Traditional Smoking Kiln

i It is difficult to control the smoke and heat production; occasionally the fire may burst which may cook the fish or char the product. The products become dirty due to exposure to soot.

ii The process is labour intensive, a great deal of labour is needed to fetch the fire wood and supervise operation.

iii Traditional smoking seldom gives a uniform standard product since the type of product depends on the amount of fire and the length of exposure to the smoke.

iv There is often wastage and financial losses from cooked fish that falls on the fire and burnt.

v Smoking is dependent on convection current and the vagaries of the weather. The distance of the smoke from the fire depends on the air coming in (Eyo, 2001).

2.4.3.3 Effects of Smoking on Nutritive Value

Although consumers are generally attracted by the flavour of smoked fish, its nutritive value is of paramount importance since every consumer would want to obtain good quality protein from fish consumption. Most of the works on the nutritional value of smoked fish have centred on lysine- an essential amino acid which is limiting in cereals and root crops which are the staple food of most inhabitants of tropical countries. Lysine is the most sensitive basic amino acid to heat damage- the loss of lysine being proportional to the temperature and duration of smoking. The loss of water increases the concentration of nutrients and the denaturation effect of smoking increase the digestibility of protein and hence availability of some essential amino acids. Compared to smoking, traditional sun drying results in an insignificant loss in available lysine (Eves and Brown, 1993).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials and Preparation of Samples

Two pair of fresh Cat fish (*Clarias gariepinus*) and Tilapia fish (*Oreochromis nilotieus*) were bought at the back of mobile filling station in Minna, Niger State. The fresh cat fish and tilapia fish samples were taken to Fisheries Laboratory Department of Federal University of Technology, Minna, Niger State to analyse their proximate compositions. A cat fish and tilapia fish were dried using electric oven and the remaining cat fish and tilapia fish were also dried using smoking kiln at temperature range of 60^0C to 70°C for 24 hours. The dried fish were then taken back to Fisheries Laboratory for the final determination of their proximate compositions.

i Cat fish (*Clarias gariepinus*).

ii Tilapia fish (*Oreochromis nilotieus*).

iii Electric oven.

iv Smoking kin.

3.2 Reagents and Instruments

In the course of the practical work carried out on the project, the reagents and instruments used as listed below

3.2.1 Reagents

Tetraoxosulphate (VI) acid (H_2SO_4) Sodium hydroxide (NaOH)

Methyl orange indicator	Petroleum ether
Methyl red	Bromo cresol green
Selenium tablets	Hydrochloric acid

3.2.2 Instruments/Equipment

Soxhlet extractor	Muffle furnace
Conical flask	Petri dish
Crucible	Oven
Electric oven	Smoking kiln
Desiccators	Electric weighing balance (± 0.01g)
Digestion tube	Pipette
Maikhais distiller	Volumetric flask
Kjeldahl flask	Electric heater (180W)
Flame Photometer	Spectrophotometer $20D^{+}$

3.3 Experimental procedures

The AOAC (1981) guidelines for determining nutritional parameters were followed.

3.3.1 Determination of Moisture Content.

The AOAC is one of the most important and widely used measurements in samples that absorb and retain water. Air or vacuum oven method is used on weight loss as a result of drying the samples of fish to acceptable weight in an air or vacuum oven at a specific temperature and time.

Procedure:

Four Petri dishes were put in an oven at 80°C for 30 minutes, cooled in a desiccator and weighed (W_1). 20g of the samples (samples 1: *clarias gariepinus* cat fish) and (samples: 2 tilapia fish) were put in each of the Petri dishes and then weighed (W_2). The dishes and samples were then put in an oven to dry at 105°Cfor about 24 hours. The dishes were removed from the oven, cooled in desiccators and reweighed (W_3). The loss of weight is the moisture content of the samples. The same experiment was also carried out on dried samples:

$$\% \text{ Moisture Content} \frac{\text{Loss in weight}}{\text{weight of sample before drying}} X\ 100$$

$$= \frac{W_2 - W_3}{W_2 - W_1} X\ 100$$

3.3.2 Determination of Crude Protein

The protein content was determined by the micro-kjeldahl method. 0.5g of the samples (both cat fish and tilapia fish) was weighed into a clean dry 10ml kjeldahl flask. About one gram of mixed catalyst (160g anhydrous K_2SO_4 10g or $CUSO_4$, $5H_2O$, 3g setenium powder mixed well in a mortar) was added followed by 6ml of concentrated sulphuric acid and few glass beads, it was then carefully digested over an electric heater in the hood (fume chamber) initially with low flame until frothing subsided and then at higher temperature until content became clear greenish colour. Digestion was then

continued for more 60mimues, the heater was put off and the flasks were allowed to cool. The content was transferred quantitatively to 100ml volumetric flask containing the digested samples and was then made up to the marked volume with distilled water and mixed thoroughly.10ml of the digest was then pipetted into marked distiller and 10ml of 40% sodium hydroxide solution was added to the digest. The steam distilled ammonia liberated was collected into 10ml boric acid solution containing 4 drops of mixed indicator (Bromo oresol green 99mg, methyl red 66mg, and thymol blue 11mg) in the conical flask. After the indicator turned green the distillation was removed and titrated with standard hydrochloric acid, the end point being reached when the indicator changed from green through grey to definite pink-the amount of acid used (titre) was recorded (V_1ml) A blank containing 6ml concentrated sulphuric acid, 1g of mixed catalyst without any samples was prepared and the above procedure was carried out in the burette where reading was recorded (V_2ml). The same experiment was also carried out on dried samples.

% Nitrogen content is given by the formula:

$$\% \text{ Nitrogen} = \frac{\text{corrected titre } (V_2 - V_1) X\ 14\ X\ 5\ X\ 100}{1000\ X\ 70\ X\ \text{Sample weight (g)}}$$

$$= \frac{\text{corrected titre (ml)}}{10\ X\ \text{sample weight(g)}}$$

The percentage protein was calculated by multiplying percentage nitrogen by a factor of 6.25 % protein = % Nitrogen X 6.25

3.3.3 Determination of Ash Content

The ash content of the samples was determined by AOAC (1981) guidelines. The crucibles and the lipid were dried in the oven at 105°C until a constant weight was obtained, cooled in a desiccator and weighed (W_1). 4g of the samples (fresh cat fish and tilapia fish) was weighed into the crucibles and the weights of the crucibles were taken (W_2). The samples in the crucibles were then heated on a hot plate until smoking ceased. They were then transferred to the muffle furnace and then heated at 550°C for 12 hours until the ashes were white. The crucibles were then cooled in the desiccators and their weights after ashing were taken (W_3). The same experiment was repeated for dried samples.

$$\% \text{ Ash Content} = \left(\frac{W_3 - W_1}{W_2 - W_1}\right) X\ 100$$

3.3.4 Determination of Lipid Content

Soxhlet extraction was carried out to determine the percentage of lipid contents. The methods were followed in order to calculate the percentage lipid extracted. The method used is AOAC (1981). 3g of the sample (fresh cat fish and tilapia fish) were weighed into three whatman filter paper that has been filtered and staple at the end.

The filter paper was previously dried to a constant weight (W_1). After the sample was added in to filter paper, the filter paper was folded and stapled at the other end and its weight was taken (W_2). This was placed in the extractor. Petroleum ether (40-60°C) was poured into the round bottom flask on a heating mantle set at 60°C until petroleum ether

just boiled. The extraction was continued for 6 hours after which the heating was stopped and dismantled, the defatted sample and filter paper were then dried in the oven at 60°C. This was cooled in the desiccators of filter paper and the samples were taken (W_3), this is known as thimble method. This experiment was also carried on dried samples.

$$\% \text{ Lipid Content} = \left(\frac{W_2 - W_3}{W_2 - W_1}\right) X\ 100$$

3.3.5 Determination of Crude Fibre

Two containers (conical flasks) were weighed (W_1). 2g of each of the samples were put in the conical flask and weighed (W_2) H_2SO_4 and NaOH were added to the conical flask with sample, which were then put in an oven at 50°C for 6 hours. They were then removed from the oven, cooled in the desiccator and reweighed (W_3). Crude fibre is lost during incineration. This experiment was also carried on the dried fish sample.

$$\% \text{ Fiber Content} = \left(\frac{W_2 - W_3}{W_2 - W_1}\right) X\ 100$$

3.3.6 Determination of Energy Value

The energy content is given by the following equation.

Energy = (4 X Protein) + (9 X Fat) + (4 X Carbohydrate)

3.3.7 Determination of Carbohydrate Content

This is subtraction of the total protein and lipid content from organic matter.% Carbohydrate = % Organic Matter – (Protein Content + Lipid Content)

3.3.8 Determination of Vitamin A

5g of the sample was minced (cut) into fairly fine pieces 1g of aliquot and 3 – 5g of Na_2SO_4 were added to it. The tissue was transferred into mortar where it was pounded with pestle until a free – flowing powder was obtained. The powder was then transferred into 250ml conical flask and 80ml of petroleum ether (B. P. 40 – 60^0C) was added to it and covered with a cling film. The flask was then shaken for 3minutes to extract vitamin A after shaking it was allowed to stand in the dark for 10 minutes. During that interval trifluoroacetic acid reagent (TFAR) was pipetted into test tube and 5ml of chloroform added followed by 25ml trifluoroacetic acid. The tube was then stopper and mixed in the fume cupboard with the use of pipette filler. The spectrophotometer was set to zero absorbance at 620nm with a cuvette containing 0.1ml chloroform plus 0.1ml acetic anhydride plus 1.0ml trifluoroacetic acid reagent. 0.5ml of petroleum ether extract was put into a cuvette and evaporated by means of a gentle current of air. The residue was immediately redissolved in 0.1ml chloroform plus acetic anhydride and 1.0ml trifluoroacetic acid reagent was added to it and cuvette was transferred to spectrophotometer where the absorbance was read at 620nm exactly in 30 seconds after addition of reagent.

Calculation: A_{620m} X 650 = U_g vitamin A/g

3.3.9 Determination of Vitamin C

5g of the sample, 2ml of glacial acetic acid and 1ml of chloroform were all added together, it then produced a coloured sample and the sample was further titrated with a

solution of 2, 6 – dichlorophenol - indophenols in the burette until permanent faint pink were obtained, the titre T was recorded. The titration was repeated with 5ml distilled water for the blank (B) and 5ml of standard ascorbic acid solution (ST). The vitamin C content of the sample was thus calculated (mg/100g)

$$\text{Vitamin C Content} = \frac{T - B}{St - B} \text{ X n dilution}$$

Where T = value of sample.

B = Blank.

St = standard solution of ascorbic acid.

3.3.10 Determination of Phosphorous using Phosphovanadatemolybalate Complete:

Principle of the Method: The method is based on the fact that on the addition of complex reagents containing molybdate and vanadate in acid solution to a solution of orthophosphate, a yellow colour is produced.

Preparation of reagent; 0.05g of K_2HPO_4 was dissolved in 250ml of deionized water and used as standard. 10g of ammonium molybdate was also dissolved in 200ml of deionized water and 0.5g of ammonium metavanadate in 150ml of boiling deionizing water. Thus was cooled and about 70mls of conc. HNO_3 was added slowly with stirring, apart from the standard, the two solutions were added together and make up to 500ml with deionized water.

Preparation of calibration curve:

0, 1, 2, 3, 4 and 5ml of phosphorous standard was pipette into 50ml volumetric flask. It was then diluted with 20ml of demineralized water and 20ml of the phosphovandomolybdate solution. It was made up to the mark with deionized water and properly mixed. It was left to stand for about 2hours to develop maximum colour. The percentage transmittance was measure using spectrophotometer at 420nm.

Sample preparation:

1g of the sample half fresh catfish and tilapia fish) was ashed in the muffle furnace for at least 2hours at 450^0C after pre-ashing 1ml concentrated HNO_3 was added to the sample and was evaporated to digress using the hotplate. 5ml of 5 normal HCl was added to each of the sample and was made up to the mark in a 50ml volumetric flask with distilled water.

A suitable aliquot of the sample was collected using pipette into a 50ml volumetric flask and 20ml of phosphovandomolybdate solution was added and was made to the mark with deionized water. It was allowed to stand for 10mins and the percentage transmittance was taken at 420nm.

3.3.11 Determination of Potassium using Flame Photometric Method

Preparation of reagents:

0.47g of dye KCl was dissolved in distilled- deionized water and diluted in a 250ml volumetric flask. From this stock, standard ranging from 100-10ppm was prepared using distilled deionized water.

Preparation of standard curve:

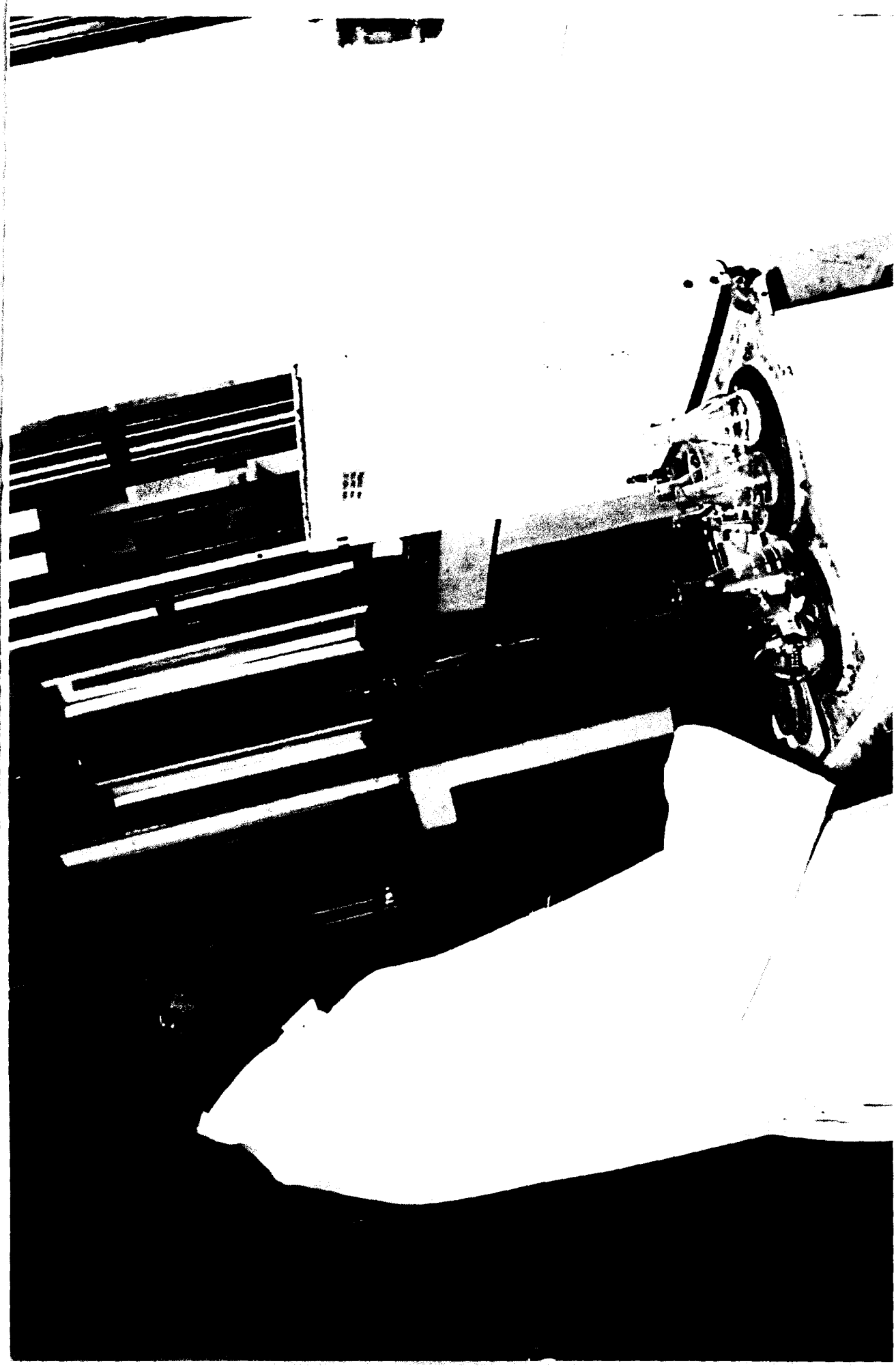
1.0, 2.5, 5.0, 7.5 and 10.0ml potassium chloride aliquot of the working standard solution were transferred to 100ml volumetric flask and was made up to the mark.

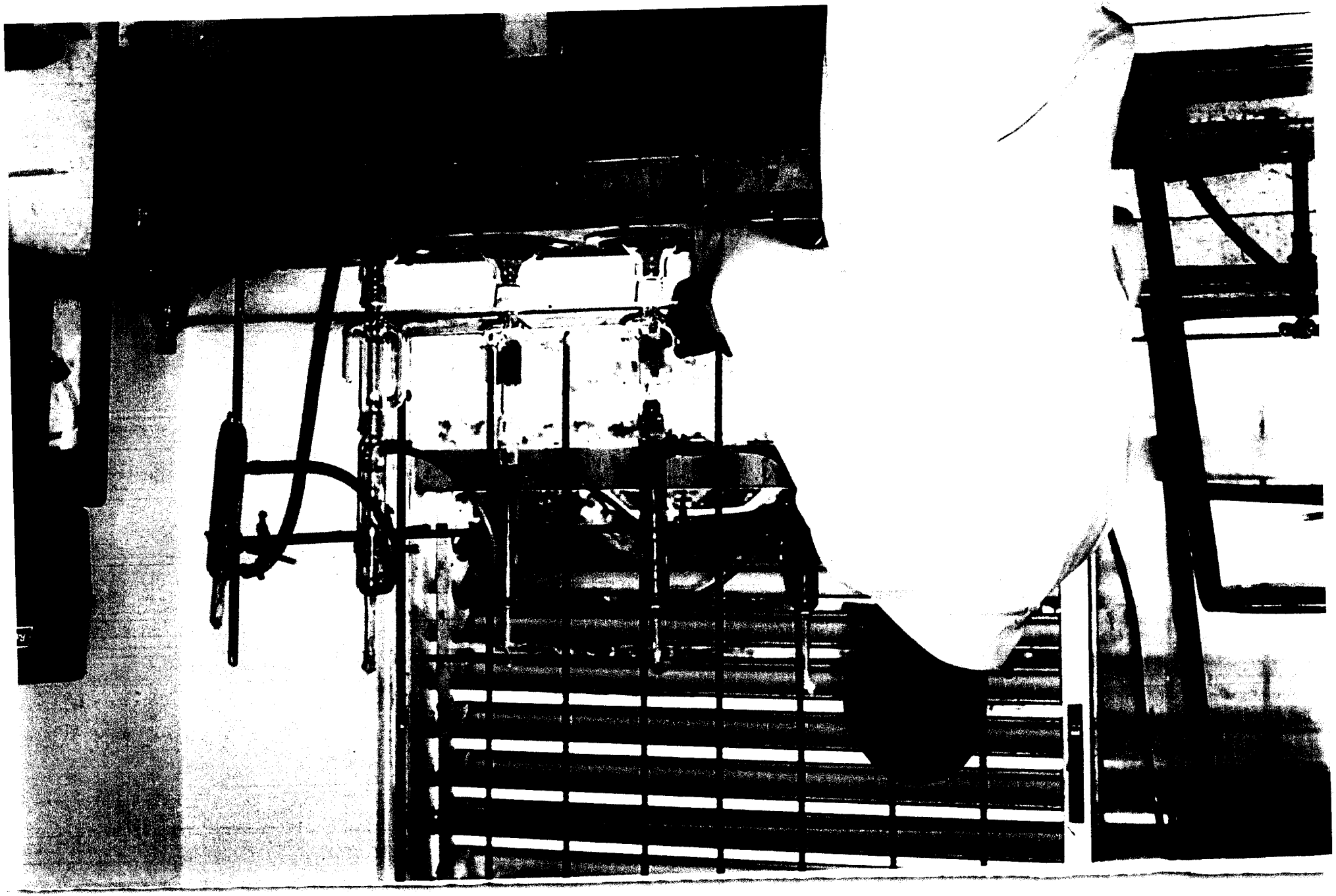
Sample preparation:

1g of the sample (Fresh catfish and Tilapia fish) was ashed for 2hours at 450°C in the muffle furnace after pre-ashing. 1ml of concentration Nitric acid (HNO_3) was added to the samples in the crucible and evaporated to dryness using a burner. 5ml of 5 normal HCl was added to each of the sample and made up to 100ml in a volumetric flask with distilled water.

Operation of the flame photometer

The flame photometer was used in the determination of potassium. The equipment was set at the range potassium concentration (absorbance) determination and was zeroed with the blank at 0 ppm after which the various standards in ppm were aspirated with their reading being recorded. The samples were aspirated in some process as the blank, standard and the absorbance was taken at 400nm. This experiment was also carried out on the dried samples.





CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Data Presentation and Analysis

The nutritional analysis of fresh catfish and tilapia fish are presented in Table 4.1. Each value is the mean of three replicate determinations. The nutritional compositions of fish dried using electric oven are shown in Table 4.2 while the nutritional compositions of fish dried using smoking kiln are shown in Table 4.3.

Table 4.1: Nutritional Compositions of Fresh Fish

Nutritional composition	Tilapia fish	Catfish	Tilapia fish	Catfish
Moisture %	70.12	71.90	70.18	71.80
Protein %	23.09	19.38	23.03	19.63
Lipid %	2.81	4.41	12.88	14.14
Ash %	28.14	33.08	28.17	33.03
Fibre %	1.92	0.98	1.9	0.98
Carbohydrate %	3.64	5.48	3.69	5.48
Energy value/100g	5.96	4.85	5.92	4.93
Vitamin A %	0.00028	0.00037	0.00022	0.00035
Vitamin C mg/ml	0.00025	0.0012	0.0020	0.0010
Potassium %	0.00012	0.00012	0.00012	0.00012
Phosphorus %	0.00012	0.00012	0.00012	0.00012

Table 4.2: Nutritional Composition of Fish Dried using Electric Oven

Nutritional Composition	Catfish	Tilapia
Moisture (%)	15.62	17.13
Protein (%)	67.21	64.10
Ash (%)	3.62	15.46
Lipid(%)	29.60	20.25
Fibre(%)	1.96	1.45
Energy value/100g	6.24	7.34
Carbohydrate(%)	3.84	3.64
Vitamin A (%)	0.00073	0.00084
Vitamin C (mg/ml)	0.0014	0.0023
Potassium(%)	0.00048	0.00052
Phosphorous(%)	0.00040	0.00042

Table 4.3: Nutritional of Fish Dried using Smoking Kiln

Nutritional Composition	Catfish	Tilapia fish
Moisture (%)	28.92	20.12
Protein (%)	53.10	63.64
Ash (%)	3.92	15.76
Lipid (%)	21.20	28.03
Fibre (%)	1.71	1.06
Energy value/100g	4.14	4.27
Carbohydrate (%)	2.78	2.57
Vitamin A (%)	0.00053	0.00046
Vitamin C (mg/ml)	0.001	0.004
Potassium (%)	0.00045	0.00058
Phosphorous (%)	0.00026	0.00042

4.2 Discussion of Results

The nutritional constituents of fresh fish both Catfish and Tilapia fish are presented in the Table 4.1 which shows that there are slight differences in the moisture content of catfish and tilapia fish which are relatively high. Cat fish lipid content is higher than the lipid content of tilapia fish while tilapia fish protein content is higher than the protein of catfish, and there are low amount of carbohydrate, energy value/100g and fibre contents in fresh fish which also contains minute amount of potassium, phosphorous, vitamin A and vitamin C.

However, the results of moisture, lipid, protein, crude fibre and ash contents falls within the range of the similar study reported in the previous work (Eyo, 1998; Burt, 1989).

The nutritional compositions of fresh fish and fish dried are presented in 4.1. The fresh catfish has moisture content of 71.90%, protein content 19.38%, lipid content 4.41%, ash content 33.08%, fibre content 0.98%, carbohydrate content 5.48%, energy value 4.85%, potassium content 0.00012%, phosphorous content 0.00012%, vitamin A content 0.00037 and vitamin C content 0.0012mg/ml while fish dried has moisture content 15.62%, protein content 67.21%, ash content 3.62%, lipid content 29.60%, fibre content 1.96%, energy value 6.24%, carbohydrate content 3.84%, potassium content 0.00048%, phosphorous content 0.00040%, vitamin content 0.00073% and vitamin content 0.0014mg/ml.

From the above, it shows that fish dried can be store for a longer period of time, sustain its nutritional quality and taste when compared with fresh fish that has shorter life storage span and possible dwindle of the nutritional quality.

The nutritional composition of dried fish using electric oven and smoking kiln are presented in the Tables 4.2 and 4.3 respectively. The catfish dried using electric oven has moisture content of 15.26%, protein content of 67.12%, ash content of 3.62%, lipid content of 29.60%, fibre content of 1.96%, energy value of 6.24J/g, carbohydrate content of 3.84%, potassium content of 0.00048%, phosphorous content of 0.00040%, vitamin A content of 0.00073% and vitamin C content of 0.0014mg/ml while the catfish dried using smoking kiln has the moisture content of 28.92%, protein content of 53.10%, ash content of 3.92%, lipid content of 21.20%, fibre content of 1.71%, energy value of 4.41J/g, carbohydrate content of 2.78% potassium content of 0.00045%, phosphorous content of 0.00036%, vitamin A content of 0.00053% and vitamin C content of 0.001mg/ml.

From the above, it shows that, the electric oven method is more effective in drying fish than the smoking kiln.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In the course of this study, it has been established that the nutritional content of fresh and dried fish varieties (*Clarias gariepinus* and *Oreochromis nilotieus*) are comparable with each other.

Evaluation of some properties of the two fish species revealed basic differences between these results. The study shows higher moisture content in fresh fish and higher protein content in dried fish. Both methods (smoking kiln and electric oven) used in drying fish shows that, electric oven method dried fish more effectively. As time and temperature are constant in the course of drying, it is faster, less energy consuming and smoking kiln is time consuming because regular supervision is needed to avoid charring of the fish being dried.

5.2 Recommendations

The following recommendations are made:

i Fish catches in large quantity that cannot be used at once should not be delayed but dried to sustain the fish quality to serve consumer future need.

ii More electric oven should be constructed and made available to fishermen at a cheaper price.

iii There is the need to improve on the smoking kiln method in order to make drying of fish easy and faster.

iv Smoking kiln improved upon would also serve as a substitute to electric oven especially in an environment where incessant power failure becomes the order of the day.

REFERENCES

Afolabi O. A., O. A. Arawomo and O. L. Oke (1984). Quantity Changes of Nigeria Traditional Processed Freshwater Species. I. Nutritive and organoleptic changes. J. food Techno. 19: 333- 340.

Association of Official Analytical Chemists, (AOAC) (1981). Official Methods of Analysis, 15th Edition Washington D.C

Burt, T. J.R. (1989). The effects of smoking and drying on the nutritional properties of fish. Pp 23-4

Clifford M. N; S.L Tang and A.A. Eyo (1980). The development of analytical method for investigating chemical change during fish smoking. In: Advance in fish science and technology. Fishing News Books Ltd, farnham. 276-290.

Chmaivasagam H.N and G.S Vidanapathorana. (1985). Quality changes and bacterial flora associated with French sardines (Amblygaster surm) under delayed icing conditions. In: spoilage of tropical fish and product Development. A Reilly (ed) pp. 1-10. FAO fish. Rep.317 suppl: 474 pp.

Clucas, I. J. (1985). Fish handling, preservation and processing in the tropics-part 1. Tropical Development and Research institute. London 141 pp

Cruickshank, E.M. (1962). Fat soluble vitamins. In: Fish as food G. Borgs from (Ed), Academy press, London, vol.2, p. 175.

Curran C.A, V.De, B.Crammond and L.Nicolaudes (1981). Spoilage of fish firm Hong Kong at different storage temperature.2. Quality changes in thread fin bream (Nemipterus yaponicus) stored at 0°C and 10°C. sci.23, pp.129-145

Doe, P.E., Curran, C.A. and Poulter, R.G. (1983). Determination of the water activity and shelf life of dried fish products. In: The production and storage of tropical dried fish, D. jame (Ed.) fisheries report 279 suppl. FAO, Rome, pp. 202-8.

Eves. A and R. Brown (1993). The effect of traditional drying processes on the nutritionalvalue of fish. Tropical science, 33,183-189.

Eyo A.A (2001) fish processing Technology in the tropics published by National institute for Freshwater Fisheries Research (NIFFR). PMB 6006, New Bussa, Nigeria. p.10, 15, 20, 165-171.

Eyo A.A (1998). Shelf life of moonfish (Citharinus citharus) and tumk fish (Mormyrus rume) during storage at ambient temperature and on ice. FAO Fisheries report N_O.574. PP35-37

Food and Agriculture Organization (1996). Responsible fish utilization. FAO Technical Guidelines for Responsible fisheries. FAO, Rome 33.pp

Food and Agriculture Organization (1999). Fisheries Country Profile for Nigerian. FIDCP/NIR Rev. 4, 99

Food and Agriculture Organization (1999). World Production of Fish Crustaceans Molluses by Major Fishing areas. Fisheries Information and Statistics Unit (FIDI) Fisheries Department, FAO Rome

Foster, W.W.and T.H.Simpson (1961) studies on the smoking process for fish. I. Importance of vapours. J.sci. Food Agric 12:363.

http://www.i4at.org/surv guide. htm

Hall, G.M (1992). *Fish Processing* Technology Blackie Academic and Professional published North America by VCH publishers, Inc, New York, pp.56-70

James, D. (Ed) (1983). The production and storage of dried fish. In: Proceedings of the workshop on the production and storage of dried fish, University Pertanian Serdang, Malaysia, 2-5 November 1982, FAO Fisheries Res. 50, 1-12.

Janson, A. C. (1958). A study of evaporation and diffusion processes in the drying of fish muscle. In: Fundamental Aspect of the Dehydration of foodstuffs. Society of chemical industries of London and MacMillan, New York. Pp 103- 135.

Kosak, P. H. and Toledo, R. T. (1981). Effects of Microbial Decontamination on the Storage Stability of fresh fish. Food Science, 46.

Love, R.M. (1970). The Chemical Biology of fish. Academic press London Agriculture

Love R.M. (1990). Depletion in: The chemical biology of fishes, Academic press, London, pp 222- 57.

Lupin, H. M. (1983). Basis of National fish drying. FAO/ DANIDA Workshop Tanzania.

Nettleton, Joyce A. (1985). In: Seafood Nutrition. Facts, issues and marketing of nutrition in fish and shell fish, Osprey books, Huntington, New York, pp 280.

Mayer, B., Samuel, R. and Flick, G. (1986). A sea food Quality program for the Mid-Atlantic fisheries Development foundation.

Murray, J. and J.R. Burt (1977). The composition of fish. Ministry of Agric fisheries and food. Torry Research station, Advisory note No. 38. 13pp.

Peter E.D. (1996). Fish drying and smoking production and quality. Pp 12- 13.

Poulter, N.H. and L. Nicolaides. (1985). Quality changes in Bolivian freshwater fish species during storage in ice. In; spoilage of tropical and development. A Relly (ed) FAO Fish. pp. (317) Supply: pp 11-28

Ross, D.A. (1977). Lipid metabolism of cod gadus morhua L. PhD thesis University of Aberdeen pp.3.

Syvaoja, E.L., K Salmineu, V. Piironen, P Varo, O. Keroyoki, and P. Koivistomen (1985). Tocopherol and tocotuenols in finish food: Fish and fish products. J. Amer. Oil chem. Soc. 62(8): 1245- 1248.

Troller, J.A. and Christian, J.H.B. (Eds) (1978). Water activity and food Academy press, New York, pp 235.

Townley, R. R. and Lanier, T. C. (1981) Effect of early evisceration on the keeping Quality of Atlantic croaker (Micropogon Undulatus) and grey trout (Cynoscion regalis) as determined by subjective and objective methodology. J. Food sci. 46, 863.

Wentz, B.A., Duran, A. P. and Swartzentruber, A. (1985). Microbiological Quality of Crabmeat during Processing. pp.48

APPENDIX

The results obtained in chapter four are calculated as follows

A_1 is for Moisture Content (M.C) using the formular below:

$$\% \text{ Moisture Content} = \frac{W_2 - W_3}{W_2 - W_1} \text{ X } 100$$

Where

W_1 is the weight of the petri-dish.

W_2 is the weight of the petri-dish plus sample.

W_3 is the weight of the sample plus sample after dried.

Therefore

For Catfish, $W_1 = 43.19$, $W_2 = 43.69$, $W_3 = 48.98$

$$\% \, Moisture \; Content = \frac{63.69 - 48.98}{63.69 - 43.19} \, X \, 100 = 71.8\%$$

For Tilapia fish, $W_1 = 43.07$, $W_2 = 63.57$, $W_3 = 49.19$.

$$\% \, Moisture \; Content = \left(\frac{63.57 - 49.19}{63.57 - 43.07}\right) X \, 100 = 70.18\%$$

A_2 is for Protein Content (P.C) using the following formular below.

$$\% \, Nitrogen = \frac{corrected\ titre\ (V_1 - V_2) X\ 14 X 5 X\ 100}{1000 X 70 X\ Sample\ weight}$$

$$= \frac{corrected\ titre\ (ml)}{10 X\ Sample\ weight}$$

The percentage protein was calculated by multiplying the percentage by a factor of 6.25

% Protein = % Nitrogen x 6.25

Where

V_1 = Dye titre value against standard

V_2 = Dye titre value against standard

Therefore

For Catfish, V_1 = 100, V_2 = 68.6 and weight of sample = 1g

$$\% \text{ Nitrogen} = \frac{(100 - 68.6)}{10 X\ 1} = \frac{31.4}{10} = 3.14$$

% Protein = 3.14 X 6.25 = 19.63%

Therefore

For Tilapia fish, V1 = 100ml, V_2 = 63.1ml, and weigh of the sample = 1g

$$\% \text{ Nitrogen} = \left(\frac{100 - 63.1}{10 X\ 1}\right) = \frac{36.9}{10} = 3.69\%$$

A_3 is for Ash Content using the formular below:

$$\% \text{ Ash Content} = \left(\frac{W_3 - W_1}{W_2 - W_1}\right) X\ 100$$

W_1 is the weight of the crucible

W_2 is the weight of the crucible plus sample

W_3 is the weight of the crucible plus sample after dried

Therefore

For Catfish, $W_1 = 33.12$, $W_2 = 37.24$, $W_3 = 33.302$

$$\% \text{ Ash Content} = \frac{33.302 - 33.12}{37.24 - 33.12} X\ 100 = 4.41\%$$

For Tilapia fish, $W_1 = 33.12$, $W_2 = 37.28$, $W_3 = 33.24$

$$\% \text{ Ash Content} = \left(\frac{33.24 - 33.12}{37.28 - 33.24}\right) X\ 100 = 2.88\%$$

A_4 is for Lipid Content using the formular below:

$$\% \text{ Lipid Content} = \left(\frac{W_4 - W_3}{W_2 - W_1}\right) X\ 100$$

Where

W_1 is the weight of the thimble

W_2 is the weight of the thimble plus sample

W_1 is the weight of the round flask

W_4 is the weight of the sample plus flask after extraction

Therefore

For Catfish, $W_1 = 2.18$, $W_2 = 3.72$, $W_3 = 4.74$, $W_4 = 5.26$.

$$\% \text{ Lipid Content} = \left(\frac{5.26 - 4.74}{3.72 - 2.18}\right) X\ 100 = 33.03\%$$

Therefore, for Tilapia fish, $W_1 = 2.18$, $W_2 = 3.39$, $W_3 = 3.26$, $W_4 = 3.60$.

$$\% \text{ Lipid Content} = \left(\frac{3.60 - 3.26}{3.39 - 2.18}\right) X\ 100 = 28.17\%$$

A_5 is for the calculation of Fiber Content using the formular below:

$$\% \text{ Fiber Content} = \left(\frac{W_2 - W_3}{W_2 - W_1}\right)$$

Where

W_1 is the weight of the conical flask

W_2 is the weight of the conical flask plus sample

W_3 is the weight of the conical flask plus sample after heating

Therefore

For Catfish, $W_1 = 5.77$, $W_2 = 6.78$, $W_3 = 6.77$.

$$\% \text{ Fiber Content} = \left(\frac{6.78 - 6.77}{6.78 - 5.77}\right) X\ 100 = 0.98\%$$

Therefore

For Tilapia fish, $W_1 = 5.77$, $W_2 = 6.78$, $W_3 = 6.76$

$$\% \text{ Fiber} = \left(\frac{6.78 - 6.76}{6.78 - 5.77}\right) X\ 100 = 1.97\%$$

A_6 is for the calculation of Vitamin

$$\mu g/g\ Vitamin\ A = 650\ X\ A_{620m}$$

Where

A_{620m} is the absorbance which is read at 620nm

For Catfish, $A_{620m} = 0.053$

$$\mu g/g\ Vitamin\ A = 650\ X\ 0.053 = 35 \mu g/g$$

$$\mu g/g = 0.0001\%$$

Therefore

% Vitamin = 35 x 0.0001 = 0.00035%

For Tilapia fish, $A_{620m} = 0.034$

$$\mu g/g \text{Vitamin A} = 650\ X\ 0.034 = 22 \mu g/g$$

$0.0001\% = 1\mu g/g$

Vitamin A = 0.0001 X 22 = 0.00022%

A_7 is for the calculation Vitamin C using the formular below

$$\text{Vitamin C} = \frac{T - B}{ST - B}$$

Where

T = Value of sample

B = Blank

ST = Standard solution of a ascorbic acid

For Catfish, T = 0.32, B = 0.2, ST = 111.10

$$\text{Vitamin C} = \frac{0.32 - 0.2}{111.10 - 0.2}$$

$$= 0.0010 \text{ mg/ml}$$

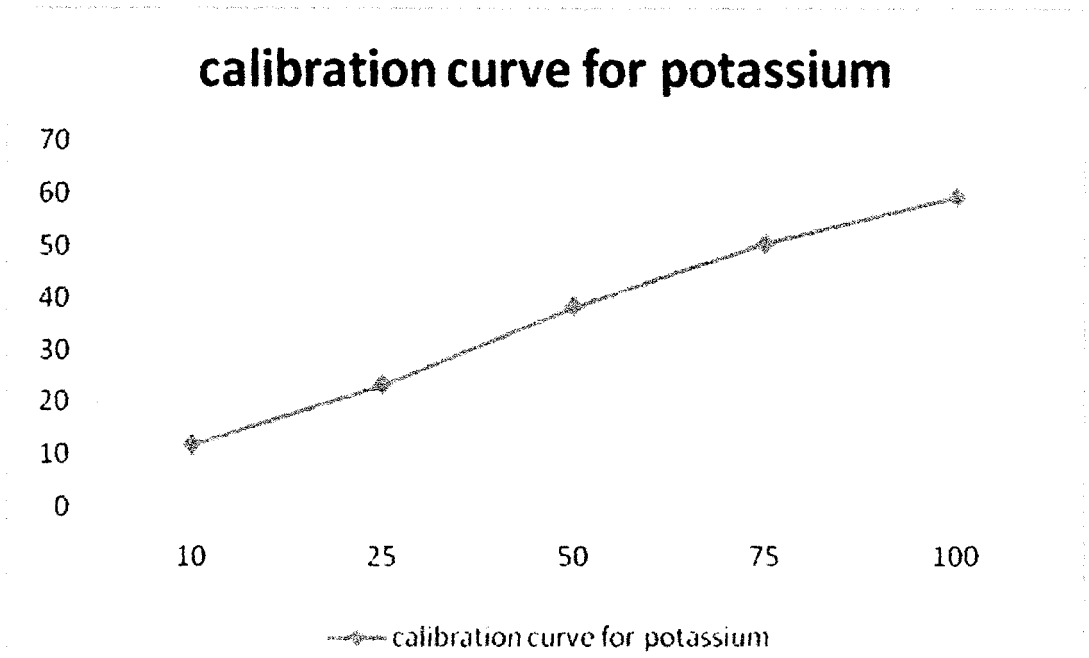
For Tilapia fish, T = 0.29, B = 0.2, ST = 37.6

$$\text{Vitamin C} = \frac{0.29 - 0.2}{37.6 - 0.2}$$

A_8 The flame photometric method is used in determining potassium.

The serial dilution for calibration curve.

Concentration (ppm)	Absorbance (nm)
100	59.4
75	50.5
50	38.3
25	23.4
10	11.9



The absorbance of the sample is 26nm while the concentration of the sample is 27ppm obtained

from the graph.

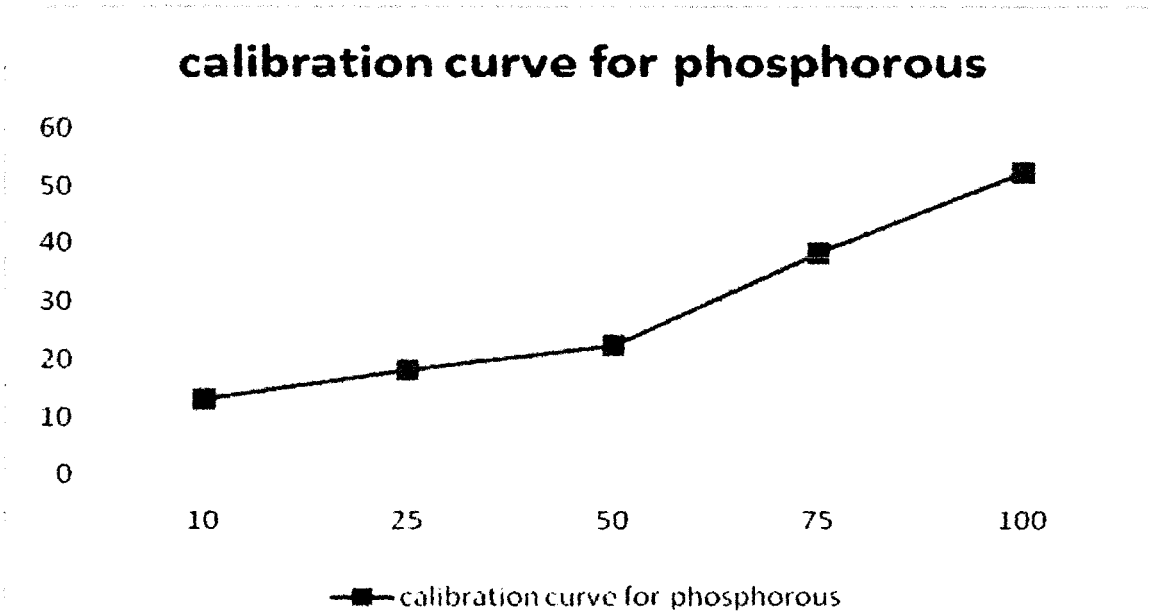
Therefore

1ppm = 0.0001%

The potassium = 27 X 0.0001 = 0.00027%

A_9 The flame photometric method is used in determining phosphorus, the serial dilution for calibration curve are;

Concentration (ppm)	Absorbance (nm)
100	52.3
75	38.3
50	22.3
25	18.1
10	13.0



The absorbance of the sample is 25nm while the concentration of the sample is 18ppm obtained

from the graph.

Therefore

1ppm = 0.0001%

The phosphorous = 0.0001 X 18 = 0.00018%