SEASONAL VARIATIONS IN THE PROXIMATE AND MINERAL CONTENTS OF THREE FRESH WATER FISHES IN MAIRUWA RESERVOIR, FASKARI, KATSINA STATE

B Y

BABANGIDA ABDULKARIM

B.Sc. Applied Biology (Hons)

M Sc/SCI/47411/04-05

A THESIS SUBMITTED TO THE POST GRADUATE SCHOOL AHMADU BELLO UNIVERSITY, IN PARTIAL FULFILMENT OF THE REQUIRMENT FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN M.Sc. (ED. BIOLOGY)

DEPARTMENT OF BIOLOGICAL SCIENCES
AHMADU BELLO UNIVERSITY, ZARIA.

FEBRUARY, 2009

DECLARATION

I hereby declare that this work is wholly the author's work and has not been presented for any other qualification.

_____

_____

Babangida Abdulkarim **Date**

CERTIFICATION

This thesis entitled "SEASONAL VARIATIONS IN THE PROXIMATE AND MINERAL CONTENTS OF THREE FRESH WATER FISHES IN MAIRUWA RESERVOIR, FASKARI, KATSINA STATE" by Babangida Abdulkarim meets the regulations governing the award of the Degree of Master of Science (ed) in Biology of Ahmadu Bello University Zaria and is approved for its contribution to scientific knowledge and literary presentation

_____ _____

Dr. S. A. Abdullahi Date
(Chairman) Supervisory Committee
Department of Biological Sciences
ABU Zaria

_____ _____

Prof. J. K. Balogun Date
(Member) Supervisory Committee
Department of Biological Sciences
ABU Zaria

_____ _____

Dr. P. I. Bolorunduro Date
(Member) Supervisory Committee
NAERLS, ABU Zaria

_____ _____

Dr. J. Auta Date
Head of Department, Biological Sciences
ABU Zaria

_____ _____

Prof. S. A. Nkom Date

Dean Postgraduate School
ABU Zaria

DEDICATION

Dedicated to my Late Dad and Mum whose love for me while alive was not in doubt.

ACKNOWLEDGEMENT

I wish to acknowledge my able supervisor Dr. S. A. Abdullahi for his suggestion, criticisms, patience, accessibility and careful corrections of the manuscript.

My profound gratitude and appreciation to the members of my supervisory team Prof. J. K. Balogun and Dr. P. I. Bolorunduro for making very useful suggestions and corrections of the write up.

Gratitude and appreciation to Dr. Auta, Dr A. K. Adamu, Dr. M. L. Balarabe, Dr. Ndams, Mrs. S.A. Luka of the Biological Sciences Department ABU Zaria for their useful suggestions, advices and encouragement toward the entire programme and the write up.

My thanks to Mr. Monday and Mr. Gandu of NARICT (National Research Institute for Chemical Technology) Zaria for permitting me to use their laboratory and equipment during the chemical analyses.

I am highly indebted to my wife Aishat and children Muhammad and Abdullahi whose patience, endurance helped greatly toward making this work a reality.

My thanks go to my classmates Sani Ahmad, Hamid Sa'ad, Ibrahim Bala and Mrs. Amina for their friendly advices and encouragement.

Appreciation to Jabir Mukhtar Nass, Mukhtar Bala Liman, Abu Muhammad Bakori, Isah Sani, Abdulkarim Musa and others whose time and space cannot allow me to mention.

Lastly, thanks and appreciation to Nuhu Abdullahi, Abdulhamid Ahmad, Bashir Abdulkadir, Umar Lawal, Umar Bala, Isah Lawal, Muhammad Suleiman, Mohammed Sani Gidado, Usman Umar and Aminu Ibrahim all of Katsina State University for their advices and encouragement.

ABSTRACT

A total of 1347 fish samples consisting of *Synodontis clarias, Schilbe mystus and Mormyrus macrophthalmus* collected from Mairuwa Reservoir, Faskari, Katsina State were analysed for the proximate and mineral contents using some fish parts and the whole fishes during the two seasons (dry and rainy) using standard methods and procedures. The lipid and protein contents were significantly higher ($P \leq 0.05$) in the flesh. The carbohydrate contents were generally low in all the parts of the fishes studied. Ash contents were significantly high ($P \leq 0.05$) in the bones and least in the flesh. The moisture content was generally low in all the parts studied (flesh, head and bones). Calcium and phosphorus were significantly ($P \leq 0.05$) higher in the bones, while sodium and magnesium were significantly higher ($P \leq 0.05$) in the flesh of all the three fish species. Zinc and Iron were significantly higher ($P \leq 0.05$) in the bones, while potassium contents were least found in the bones. There were no significant differences ($P \geq 0.05$) in the moisture contents of all the three species in the two seasons. The ash contents were significantly lower ($P \leq 0.05$) during the rainy season. There were no significant differences ($P \geq 0.05$) in organic matter contents in all the three fish species in the two seasons. Carbohydrates and Lipids were significantly higher ($P \leq 0.05$) during the rainy season. However, protein contents were significantly higher ($P \leq 0.05$) during the dry season. Calcium, potassium, iron, sodium, phosphorus and zinc were significantly ($P \leq 0.05$) affected by the seasons, while copper and magnesium were unaffected by the seasons. Higher contents of calcium, potassium, iron, sodium, phosphorus and zinc were observed during the rainy season in all the three fish species. The fish species have high nutritive values; as such their utilization will assist in the remedy of health and malnutrition problems among the populace.

TABLE OF CONTENTS

CHAPTER TWO

CHAPTER THREE

LIST OF TABLES

LIST FIGURES

Figure

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

The hydrosphere of the earth plays a key role in the human life. As civilization advances the importance of different types of water bodies increased, at the same time, humans exert greater and greater influence upon the water cover of the planet (Bagrove, 2004).

Fish production just like any other sources of food production plays an important role in food security and nutrition especially in many developing countries. Production of this resource according to Babatunde and Olayide (1980) is undertaken by a large number of people, which includes small-scale producers.

Fish and shell fishes are a good source of protein, vitamins, minerals and fats (Lake, 1984 and Tobor, 1984). Fish as a source of nutrients have made important contribution to micro nutrient supplies such as vitamins, minerals and fatty acids (FAO, 2000). Fish oil contains vitamins A, D, E and K which have been successfully used in controlling coronary heart diseases, arthritis, arteriosclerosis, asthma, auto-immune deficiency diseases and cancer (Bhuiyan *et. al;* 1993; Ackman, 1989). Generally, fishes are good sources of high quality animal protein as well as dispensable and indispensable amino acids in humans and animals.

They also provide highly absorbable dietary minerals in human and animal nutrition (Abdullahi, 2000).

Fish as a source of protein, micro nutrients and essential fatty acids provide important complement to the predominantly carbohydrate – based diet eaten by most people especially the poor and the rural people which results to protein deficiency disease such as “kwashiorkor” and “marasmus”. Evidence has shown that fish play vital roles in prevention and management of many diseases such as heart disorders and neurological diseases. High percentages of poly unsaturated fatty acids found in fish are important in lowering blood cholesterol level (Kent, 1984). Increased intake of finfish reduces sudden death from heart attacks, improves symptoms of rheumatoid arthritis, decreases the risk of bowel cancer, reduce insulin resistance in the skeletal muscles and for normal development of foetus in pregnant women (Conquer and Holub, 2002).

The proximate composition of fish and shell fishes is important for easy formulation of diets for both human and animal consumption. Karakoltsidis *et. al;* (1985) and El-Faer *et. al;* (1992) reported that the most important minerals in fish and shell fish are potassium and calcium followed by phosphorus which are important for proper functioning of the nerves and bone formation respectively. They also observed that all the shell fishes investigated had high percentage of protein (18 – 22%). These

minerals although occurring in small quantities are important as enzyme co-factors, maintenance of colloidal system and regulation of acid base equilibrium (Halver, 1989). Dietary protein in form of amino acids are needed for growth, metabolism and maintenance of the body, especially in young ones.

The proximate composition, nutritive values and mineral compositions of fishes have been investigated in various parts of the world. For instance, Joaquin *et. al;* (1997) found out that the proximate composition of hake (*Merluccius merluccius*) and Ling (*Molva molva L*.) were 28.66% moisture, 39.1% protein, 14.13% fat, 11.2% carbohydrates, 6.69% Ash and 31.34% moisture, 43.6% protein, 14.80% Fat, 3.13% carbohydrates, 7.14% ash respectively.

Abdullahi and Abolude, (2006) studied the proximate and mineral compositions (contents) of the flesh and body parts of *Bagrus filamentosus* and *Hydrocynus brevis*, from Zaria and found out 18.75% lipid, 61.35% protein, 7.45% carbohydrate, 5.65% ash in flesh of *Bagrus filamentosus* and 18.50% lipid, 47.55% protein, 12.45% carbohydrate and 5.05% ash in flesh of *Hydrocynus brevis*.

1.2 Statement of the Research Problem

The prevalence of protein-energy malnutrition such as ‘marasmus’ and ‘kwashiorkor’ are high in Nigeria. Such deficiency diseases are associated with decreased anti-oxidant and auto-immune defence

mechanism. They increase oxidative stress from pulmonary oxygen toxicity (Taylor, *et al.* 1992). They are also characterized by high incidence of opportunistic infections and diarrhoea (Taylor, *et al.* 1997).

Despite abundant varieties of fresh water fish species in Africa and most particularly in Nigeria, most of the pharmaceutical raw materials such as fish oils are obtained from temperate countries, yet such fresh water fish species in Africa and Nigeria may contain such raw materials (Abdullahi, 2000).

Given that there are considerable evidences in the use of fish and fish products for solving health problems, the need therefore arises for the investigation of nutritional composition of fresh water fish species of Nigeria so as to find an alternative to the temperate fish species.

Climatological differences between two seasons may affect the nutrient composition of fish species. Such variations occur in the chemical composition of fishes of same species, different species at different geographical locations and in different seasons. (Balogun and Talabi, 1986).

The knowledge of fish nutrient contents such as the moisture, crude protein, ash, lipid, carbohydrate, amino acids and minerals, and factors affecting them allow for the assessment of fish health itself and the quality of the nutrients that will be available to the consumer (Sharer, 1994).

It is therefore, the intention of this research to find out whether seasonal variations affect the nutrient contents of the fishes namely *Synodontis clarias, Schilbe mystus and Mormyrus macrophthalmus.*

The three commercially important fish families in Mairuwa Reservoir used in this study are readily available in all seasons. The study of effects of seasons, bioaccumulation of metals and proximate contents of the three fish species in Mairuwa reservoir is scanty.

This study would render a platform to understand the amount of mineral contents available within the three (3) selected fish species. More importantly, this study would also help to compare the seasonal proximate and mineral contents of the three fish families.

1.3 Justification

Fish production is a major industry in those parts of Nigeria where riverine settlements are established (Ako and Salihu, 2004). These communities produce a substantial percentage of protein needs of the population of the surrounding villages and towns through fishing. In Katsina State, communities located along Mairuwa reservoir, Faskari witnessed substantial fishing activities. However, this fishing activities may be affected by the presence or absence of toxic metals or minerals in the water which may accumulate in the fish bodies and pose a health hazard to the public. The fishes may also contain nutrients in some

amounts that would contribute to sources of vitamins, minerals, amino acids, fatty acids etc. to human and other animals.

Mairuwa reservoir is blessed with commercially important species of fishes, most prominent among them are *Schilbe mystus, Synodontis clarias* and *Mormyrus macrophthalmus,* but very little studies have been done with regards to seasonal variations in proximate and mineral contents of the fishes.

The choices of *Schilbe mystus, Synodontis clarias* and *Mormyrus macrophthalmus* are due to their availability and adaptability in the reservoir. They are common and acceptable to consumers in the local markets and are highly relished by the people of the area.

1.4 Research Hypothesis

The following hypotheses were formulated:

Hypothesis 1:

- There is no significant difference in the proximate composition of the three fish species: *Schilbe mystus, Synodontis clarias* and *Mormyrus macrophthalmus* in the two seasons.

Hypothesis 2:

- There is no significant difference in proximate compositions of the bone, flesh and heads of the three fish species: *Schilbe mystus, Synodontis clarias* and *Mormyrus macrophthalmus*

Hypothesis 3:

- There is no significant difference in the seasonal levels of minerals in bone, flesh and heads of the three fish species.

Hypothesis 4:

- There is no significant difference in the mineral contents in bone, flesh and heads of the three fish species.

1.5 Objectives of the Study

The specific objectives of the study were:-

i. To determine the proximate composition of *Schilbe mystus*, *Synodontis clarias* and *Mormyrus macrophthalmus* in the two seasons.

ii. To determine and compare the proximate composition in flesh, bones and heads of *Schilbe mystus*, *Synodontis clarias* and *Mormyrus macrophthalmus*

iii. To determine the mineral contents of the three fish species in the two seasons.

iv. To compare the levels of mineral contents in the flesh, bones and heads of *Schilbe mystus, Synodontis clarias* and *Mormyrus macrophthalmus.*

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 General

Fish is very important in the diet as a source of protein which is needed by the body for growth, repair and replacement of worn out tissues. The nutritive value of fish is more than that of meat, in addition, fish has an edge over meat in that it is cheaper and relatively more abundant (Eyo, 1989).

Nigeria is blessed with vast expanse of inland fresh water ecosystem. The full extent of this natural endowment has been investigated at various level of distribution by many researchers. (Ita *et. al;* 1985).

A compilation of the extent of fresh water in Nigeria including the wetland was estimated at 7,434,100 ha representing about 3.4% of the total area of Nigeria (Ita, 1993). An estimated total of 230 fish species have been identified to inhabit the various fresh water ecosystem thus indicating the potential and fish species diversity in rivers, lakes and reservoirs in Nigeria (Ita, 1993).

The important and aggregate contribution of fresh water fish species particularly fin-fishes to the production and utilization in the tropics has been reviewed (Tacon, 1993). The contribution of fresh water fish species to the total domestic fish production in Nigeria has been

estimated at 248,000 metric tonnes (Ita, 1993) representing about 47.8% of the fish catches. These species are so diverse and are produced mainly by the artisanal fishermen scattered all over the lakes, rivers and reservoirs in Nigeria.

Wide attention has been paid to the fact that acid deposition into the environment including water bodies, mainly through various forms of combustion related to human activities, has caused an increase in the environment mobility of acid soluble polluted substances (materials) and in many aquatic and soil systems (Campbell *et. al;* 1983). The metals get into the hydrobiont organism mainly through food chain. In fishes, the metals (minerals) can come by way of mechanical capture of suspended particles of hydroxides in gills, by a way of hemosorption of ions on the mucous membrane (Perevoznikov and Bognadova, 2004).

Throughout the year, fishes are subjected to considerable environmental changes and fluctuations in availability and compositions of feed that will affect the proximate and mineral composition (Olsson *et. al;* 2002). Factors affecting proximate and mineral composition of fish can be either endogenous or exogenous. The endogenous factors are generally controlled and are associated with the life cycle of fish (Mahmut *et. al;* 2004). Many other exogenous factors (temperature and salinity) may also affect the proximate and fatty acid composition (Bandarra, *et. al;* 1997).

2.2 Biology of the species

2.21 *Schilbe mystus*

According to Lewis (1974a) *Schilbe mystus* belongs to the fish family *Schilbeidae*, and fishes of this family have broad heads, which are not heavily armoured, and have wide mouths. The anal fin is very long in contrast to the dorsal fin, which is very short.

Schilbe mystus commonly called "butter fish" has no adipose fin and its barbels do not extend beyond the gill cover. Its back is black, shading to white on the belly with overall golden sheen. It is the commonest and does not grow very large, 350mm being a big fish. It is a voracious predator. The spines are weak, but very sharp (Lewis, 1974a).

2.22 *Synodontis clarias*

Synodontis clarias belongs to the family *Mochokidae* and are characterized by short, stumpy bodies and a head shield. That is the whole of the head region as far as the bases of the dorsal and pectoral fin is ossified, the bone usually being rough and granular. Each of these fins has serrated spine which can be blocked in an extended position. There is a large adipose fin extending from the dorsal fin to the caudal. Nasal barbels are absent.

Synodontis clarias has a red tail fin, the rest of the body is grey, except for the white belly and the first two soft rays of the dorsal fin. All

the barbels are fringed with a narrow membrane. The fish feeds on small detritus and phytoplankton.

2.23 *Mormyrus macrophthalmus*

The *Mormyrus macrophthalmus* belongs to the family *Mormyridae* or "Elephant Snouts" as they are popularly named. The common characteristic are small scales, tiny eyes, usually covered by a thin skin, narrow gill openings with the opercula bones hidden beneath a layer of skin, small mouth and upward pointing pectoral fins. There is inferior mouth which indicates that the fish is bottom dweller feeding on worms, detritus etc.

The simplest character by which to recognize *Mormyrus macrophthalmus* is the distinctive shape of its head. The colour is almost uniformly dull grey rather darker on the head (Lewis, 1974).

2.3 Distribution of minerals and metals in fish tissues

Distribution of minerals and or metals in fish organs have been studied by many researchers. Mathis and Cummings (1973) while studying minerals (metals) in sediment water of the Illinois River found out that Zinc was significantly higher in omnivorous fish.

Benoit *et. al;* (1976) measured Cadmium in water for up to 38 weeks, reported that the kidney accumulated the highest concentration, followed by liver and gills. The concentration of Chromium in the brain of fish samples showed that the highest concentration (0.721 ppm wet

weight). On the other hand flesh were found to have the lowest concentration (0.08 ppm), bone, gonad, and liver contained 0.38, 0.673 and 0.311 ppm wet weight respectively. Copper was found at concentrations of 2.26 and 1.60 ppm in brain and gonad respectively. Gills and flesh had the lowest concentration (0.54 and 0.422 ppm). However, bone and liver had intermediate concentrations (0.88 and 0.78 ppm, respectively).

For manganese, the collected fish samples indicated that the concentration of manganese in brain (0.33 ppm) was higher than in other organs. However, flesh had the lowest concentration (0.048 ppm). The concentrations of manganese in gonad, bone, liver and gills were 0.281, 0.158, 0.152 and 0.136 ppm respectively (*Benoit et. al; 1976).*

Wiener and Giesy (1979) reported that the concentration of manganese in muscle ranged from 0.13 to 0.70 ppm which is lower than in liver (0.80 – 12.96 ppm dry weight). They also reported that copper concentrations were lower in axial muscle tissue than liver tissue, which ranged from 0.06 to 2.52 ppm and 4.10 – 918.90 ppm dry weight respectively. Jeng and Sung (1983) reported higher concentration of Zinc in kidney than in muscle.

Eisenberg and Topping (1986) reported that the concentration of zinc ranged from 2.9 to 3.8 ppm in flesh and ranged from 9.4 to 23.0 ppm in gonad samples of American shad harvested from the water of Harford

County. They also reported that copper accumulated at higher concentrations in gonad (1.21 – 7.22 ppm) than flesh (0.40 – 0.78 ppm).

Hernandez *et. al;* (1990) found low cadmium concentrations in muscle as well as gonads and gills. They also reported that an important accumulation of this metal took place in liver and kidney in the order: Muscle < liver < Kidney. Hernandez *et. al;* (1990) also reported that the lowest value of chromium was detected in muscle ranging from (0.0 – 0.10 ppm) and was increased in gills (0.125 – 0.775 ppm).

Stripp *et. al;* (1990) observed that the concentrations of cadmium in kidney and liver of yellow perch (*Perca flavescens*) was higher in muscle. Berninger and Pennanen (1994) found out that the lowest metal concentrations were found in muscles. The highest cadmium, lead, and zinc concentrations were found in kidney, whereas the highest aluminum and iron concentrations occurred in liver.

Rajan *et. al;* (1994) studied the accumulation of heavy metals in sewage grown fishes and reported that the zinc concentration was highest (4.70mg/kg) in omnivorous *C. carpiovar. communis.* Gomaa *et. al;* (1995) studied distribution pattern of some heavy metals in Egyptian fish organs and found out that for cadmium the lowest concentration was detected in flesh (0.05 ppm) and gills (0.15 ppm) followed by bone (0.27 ppm), liver (0.31 ppm) and gonad (0.37 ppm). The highest concentration of cadmium was recorded in brain (0.82 ppm). They also noticed that fish

brain sample contained a larger amount of iron (1.41 ppm) than the other organs. In contrast, flesh samples had the lowest concentration of iron (mean value 0.191 ppm). The concentrations of iron in liver, gonad, gills and bone were 1.16, 0.93, 0.601 and 0.356 ppm respectively. The results also indicated that lead in the brain of the collected fish samples showed the highest mean concentration of 1.24 ppm wet weight, followed by gonad, liver and bone being 0.981, 0.889 and 0.368 ppm, respectively. The lowest concentration was found in flesh which showed 0.149 ppm.

Vigh *et. al;* (1996) studied comparison of heavy metal concentration of grass carp in a shallow eutrophic lake and fish pond. Nickel, copper, zinc, cadmium, lead and mercury concentrations were determined in gills, liver, kidney, muscle and gut of grass carp collected from Lake Balaton (Hungary) and from a fish farm nearby.

The body weight normalized heavy metal concentrations in different organs/tissues were compared for both lake Balaton and the fish farm. Metal concentrations, in most cases were highest in kidney or in liver, and lowest in muscle or in gut. Nickel concentration was lower in muscle, liver and gills of the fish samples. Mercury concentration was also lower in the guts of grass carp from Lake Balaton, but the other organs showed higher concentrations at this location. Their results suggest that the accumulation mechanism of mercury may be different from other metals in non-predatory fish species. Mercury uptake from

food may be dominant for all fish species, but “biomagnification” becomes obvious only in the case of predatory species.

Adebisi and Fasakin (1997) found out that phosphorus concentrations in percentages in flesh of *Hydrocynus vittatus* was 0.3565%, 0.1945% in *Labeo senegalensis*, 0.1690% in *Eutropius niloticus*, 0.2140% in *Sarotherodon galilaeus*, 0.1450% in *Oreochromis niloticus*, 0.2145% in *Tilapia zilli*, 0.1565% in *Synodontis filamentosus*, 0.1750% in *Auchenoglanis occidentalis*, 0.1905% in *Lates niloticus*, and 0.15069% in *Synodontis eupterus* respectively. Calcium concentrations for *H*. v*ittatus* was 0.01%, 0.006% for *L. senegalensis*, 0.009% for *E. niloticus*, 0.006% for *S. galilaeus*, 0.009% for *O. niloticus*, 0.002% for *T. zilli*, 0.005% for *S. filamentosus*, 0.006% for *S. eupterus*, 0.001% for *A. occidentalis* and 0.01% for *L. niloticus.*

Iron concentrations in the flesh of the fish species were found to be 3.3 ppm for *H. vittatus*, 3.6 ppm for *L. senegalensis* 2.93 ppm for *E. niloticus.* 3.63 ppm for *S. galilaeus*, 3.29 ppm for *O. niloticus*, 3.49 ppm for *T. zilli*, 3.24 ppm for *S. filamentosus*. Copper (Cu) concentrations for the flesh of *H. vittatus* was 0.022 ppm, 0.029 ppm for *L senegalensis*, 0.015 ppm for *E, niloticus*, 0.048 ppm for *S. galilaeus*, 0.012 ppm for *O. niloticus*, 0.012 ppm for *S. filamentosus*, 0.010 ppm for *S. eupterus*, 0.010 ppm for *A. occidentalis* and 0.024 ppm for *L. niloticus.*

Zinc concentrations for the flesh of *H. vittatus* was 0.36 ppm, 0.18 ppm for *L. senegalensis*, 0.15 ppm for *E. niloticus*, 0.22 ppm for *S. galilaeus*, 0.15 ppm for *O. niloticus*, 0.14 ppm for *T. zilli* and *A. occidentalis* respectively. Manganese concentrations for the flesh of *H. vittatus* was 0.095 ppm, 0.105 ppm for *L. sengalensis*, 0.085 ppm for *E. niloticus*, 3.115 ppm for *S. galilaeus*, 0.115 ppm for *O. niloticus*, 0.205 ppm for *T. zilli*, 0.085 ppm for *S. filamentosus*, 0.087 ppm for *S. eupterus*, 0.10 ppm for *A. occidentalis*, 0.075 ppm for *B. bayad*, 0.085 for *C. nigrodigitatus*, 0.120 ppm for *H. niloticus* and 0.115 ppm for *L. niloticus*. Iron concentrations of the flesh of the fishes as found by Adebisi and Fasakin (1997) were *H. vittatus* 3.3 ppm, *L. senegalensis* 3.61 ppm *L. niloticus* 2.93 ppm, *S. galilaeus* 3.63 ppm, *O. niloticus* 3.29 ppm, *T. zilli* 3.49 ppm, S. *filamentosus* 3.24 ppm, *S. eupterus* 3.18 ppm, *A. occidentalis* 2.94 ppm, *H. boyad* 2.59 ppm, *H. niloticus* 3.59 ppm, and *L. niloticus* 3.33 ppm respectively.

Perevoznikov and Bognadova, (1999) found out that in Kuibyshevskii water Reservoir (Russia) minimum quantity of manganese is contained in muscle and gills of Sabre fish (*Pelecus cultratus*) and roach (*Rutilus rutilus*),that of copper is contained in the bream (*Abramis*) muscles. The skins of bream (*Abramis*) and Pike (*Esox lucius*) contained a minimum amount of zinc, and a minimum quantity of lead is contained in muscles of sabre fish, roach, bream and in the bream liver.

Analysis of fishes from the River Oka basin in Russia by same researchers has revealed irregularity of the metal distribution in the fish organs. In all species, except the bream and white eyed bream (*Abramis sapa*), copper was absent in the muscles while in the liver of silver bream (*Blicca bjorkna*) its content exceeded allowable amount by 1.3 times, and in the livers of bream, sabre fish, and white eyed bream. Its level exceeded by a factor of 3.1, 5.5, and 17.8 respectively. Spawn of sliver bream and white eyed bream contained significant amount of copper.

Yukaezoe *et. al;* (2001) studied the distribution of trace element in tissues of fish living in natural and acid environments of Yangmingshan National park, Taiwan and found out that most of the element tended to accumulate in fish in the acid environments. The concentration of aluminum clearly reflects the effects on living things, so it is an appropriate indicator for acidification of the environments. The concentration of aluminum in each tissue of *C. asiatica* living in the acid environment was higher than that in the neutral environment. The accumulation pattern of aluminum in *T. hakonesis* living in Usoriko was different from that of *C. asiatica* living in Lengshuikeng. The tissue with the greatest accumulation of was the gill. Therefore, the amount of aluminum accumulated in gills of *C. asiatica* is smaller that that of *T. hakonensis*. The concentrations of manganese and zinc did not show remarkable differences between both fishes that lived in the acid and

neutral environments, and as for copper (Cu), the concentration was rather small.

Bagrove (2004) reported that the mercury accumulation in large oceanic predatory fishes (Tuna (*Thunnus*), shark, sword. Fish (*Xiphias*) and mammals is by the order and more higher than other representative of the piscifauna. In this case, their irreversible accumulations of natural mercury in the predatory fishes take place through the food chain. The lead and cadmium are the most accumulated in the coating and bone structures.

Chatterjee *et. al;* (2006) studied trace metal distribution in tissue of Cichlids (*Oreochromis niloticus and O. mossambicus*) collected from waste water fed fish ponds in east Calcutta wetlands, or Ramsar site. Comparisons of the metal concentrations in the organs of both samples collected showed that liver was found to be the dominant site for metal accumulation in both species. Interestingly, between the two species, the highest (908.9 ± 306.42mg. kg^{-1}) and the lowest (797.9 ± 112.02mg kg^{-1}). Concentrations of zinc had been found in *O. niloticus* liver and muscles respectively.

Similarly, the concentration of chromium was found higher in the liver of Nile *Tilapia* (32.1 ± 3.20mg. kg^{-1}) than that of Mozambique *Tilapia* (9.4 ± 0.85mg. kg^{-1}). However, gill and bone of *M. Tilapia* accumulate higher amounts of Chromium than that of *Nile Tilapia*. Lead

a non essential toxic element was accumulated in liver of both the species in highest concentrations (17.9mg. kg^{-1} in Nile and 14.7mg kg^{-1})in Mozambique *Tilapia.*

Bioactive elements like iron showed almost similar accumulation pattern with liver found as major site followed by gill, bone and muscles. Gill was found to be the major site for manganese build up (106.5mg.kg^{-1}) and (96.5mg. kg^{-1}) in *Nile Tilapia*). However, highest concentration of manganese was found in bones (159.2mg. kg^{-1}) in Nile and (180.7mg. kg^{-1}) in Mozambique *Tilapia.*

Abolude *et. al;* (2006) studied the proximate and mineral content of the flesh and body parts of *Bagrus filamentosus* and *Hydrocynus brevis* in Zaria, and reported that calcium was significantly higher in bones (15,238.16 and 11,862.14mg/100g) followed by the head of both species (6105.43 and 84,21.79mg/100g) of *B. filamentosus* and *H. brevis* respectively. Phosphorus in bones were 864.46 and 754.56mg/100g and fins 183.99 and 445.05mg/100g of *B. filamentosces* and *H. brevis* respectively. The least phosphorus was recorded in the head of both species followed by the viscera of *B. filamentosus*. The least potassium was recorded in the head of both species. Sodium and magnesium were more concentrated in the head and bones with the least concentration in the viscera of *B. filamentosus* and *H. brevis.* Manganese was more in the bone and head of *H. brevis* than in *B. filamentosus.* Copper, zinc and iron

were generally more concentrated in *H. brevis* body parts than in *B. filamentosus*. Scales had significantly high concentrations of all the minerals.

Abdullahi (2001) investigated the nutritional status of some members of the family *Bagridae* and reported that the mineral contents of *Chrysichthys nigrodigitatus* were calcium (2942.0 ± 107.3), potassium (703.1 ± 106.1), iron (32.2 ± 9.1), magnesium (210.5 ± 22.4), sodium (318.2 ± 23.3), copper (4.3 ± 1.3), phosphorus (25.0 ± 3.1) and zinc (18.2 ± 1.0). In *Bagrus filamentosus*, calcium was (3010.0 ± 278.7), potassium, (732.0 ± 11.3), iron (42.3 ± 5.8), magnesium (240.6 ± 28.7), sodium (278.7 ± 21.1), copper (3.2 ± 0.8), phosphorus (25.1 ± 3.4) and zinc (19.0 ± 8.4) and for *A. occidentalis* calcium was (2898.2 ± 148.6), potassium (635.7 ± 36.4), iron (35.8 ± 6.3), magnesium (200.4 ± 32.7), sodium (308.6 ± 22.7), copper (4.1 ± 1.1), phosphorus (25.3 ± 2.6) and zinc (17.5 ± 1.3).

Abdullahi (2002) studied the seasonal and locational variations in the proximate, amino acid and mineral contents of *Lates niloticus*, *Heterotis niloticus* and *Gymnarcus niloticus* in Nigeria and found that magnesium, iron, phosphorus and zinc were significantly affected by seasons. Higher contents were observed during the rainy season.

Abdullahi (2005) also reported high concentrations of potassium, iron, phosphorus and zinc during the rainy season in *M. electricus.*

Abdullahi and Abolude (2005) studied seasonal levels of some nutrients in three *Bagrids* from two localities in Northern Nigeria and observed that calcium dominated the mineral pool and the least recorded was copper for the two seasons and locations. Sodium, copper and phosphorus, in *C. auratus,* potassium, iron, magnesium, sodium, phosphorus and zinc in *B. docmac.* Calcium, potassium, copper and zinc in *C. laticeps* are insignificantly higher in fish from the Niger-Benue confluence. However, the mineral contents were generally higher in all the species during the rainy season.

Abdullahi and Abolude (2006) while studying effect of seasons and geographical location on nutrient content of two families (*Cichlidae* and *claridae*) reported that the contents of minerals (mg/100g) in *Clarias gariepinus* were calcium (39102 ± 102.9), potassium (638.7 ± 22.6), iron (52.7 ± 5.6), magnesium (31.6 ± 6.4) sodium (260.6 ± 16.7), copper (2.4 ± 0.4), phosphorus (16.2 ± 1.7), zinc (18.9 ± 1.6). *Oreochromis niloticus* calcium (4289.2 ± 110.9), potassium (633.4 ± 28.1), iron (13.0 ±3.2), magnesium (32.7 ± 3.1), sodium (300.3 ± 11.7), and zinc (16.0 ± 1.3).

2.4 Proximate Composition and Effect of Season on the nutrient levels.

Joaquin *et. al;* (1997) studied the proximate and mineral composition of dried salted rose of hake (*Merluccius merluccius L.)* and Ling (*Molva molva L*.) and reported that the moisture composition of

hake was 28.66% crude protein 39.1%, fat 14.13%, carbohydrate 11.2%, ash content 6.69%, and for ling was 31.34% moisture, 43.6% crude protein, 14.80% fat 3.13% carbohydrate and 7.14% ash.

Adebisi and Fasakin (1997) studied proximate composition of the flesh of some fresh water fish species and found that for *Hydrocynus vittatus* the proximate composition were 19.53% protein, 14.80% lipid, 60.00% moisture and 5.00%ash content. *Euterus niloticus* 16.95% protein, 20.40% lipid, 55.00% moisture, 7.50% ash content. *Labeo senegalensis* 15.78% protein, 2.40% lipid, 75.00% moisture and 5.00% ash content. *Oreochromis niloticus* 14.85% protein, 2.40% lipid, 77.50% moisture and 5.00% ash content. *Sarotherodon galilaeus*, 20.04% protein, 1.00% lipid, 72.50% moisture and 50.00% ash content. *Tilapia zilli* 18.15% protein, 0.80% lipid, 80.00% moisture, 1.00% ash content. *Synodontis filamentosus* 18.18% protein, 2.20% lipid, 70.00% moisture and 8.00% ash content. *Synodontis euterus* has 15.91% protein, 9.80% lipid, 67.50% moisture and 5.00% ash content. *A. occidentalis* has 22.30% protein, 2.80% Lipid, 70.00% moisture, 3.75% ash content. *Bagrus bayad* 23.63% protein, 7.60% lipid, 61.50% moisture, 5.00% ash. *Heterotis niloticus* 25.92% protein, 2.00% lipid, 70.00% moisture and 1.25%ash content. *L. niloticus* 20.50% protein, 1.20% lipid, 75.00% moisture and 2.50% ash content.

Abolude *et. al;* (2006) reported 61.35%, 43.20%, 14.85%, 31.45%, 58.67% protein in the flesh, head, bone, fin and viscera of *B. filamentosus* and 47.55%, 39.45%, 14.50%, 29.85%, 51.40% protein in the flesh head, bone, fin and viscera of *H. brevis* respectively. The researchers also found18.75%, 26.70%, 12.75%, 18.55%, of lipids in the flesh, head, bone, fin and viscera of *Bagrus filamentosus* and 18.50%, 24.25%, 10.15%, 13.45%, and 17.10% of lipids in flesh, head, bone, fin and viscera of *Hydrocynus brevis* respectively.

Carbohydrates content for the flesh, head, bone fin and viscera of *B. filamentosus* were 7.45%, 2.30%, 6.65%, 7.50% and 13.35% respectively, while for the *H. brevis* they were 12.45%, 10.35%, 4.65%, 8. 95% and 19.00% respectively. The moisture content for the flesh, head, bone, fin and viscera of *B. filamentosus* were 6.65%, 6.35%, 6.30%, 4.15%, 3.65% and for *H. brevis* 6.45%, 5.85%, 5.70%, 5.75% and 3.20% respectively. The ash contents for the flesh, head, bone, fin and viscera of *B. filamentosus* were 5.65%, 21.65%, 59.60%, 20.00%, 54.90%, 41.90% and 9.40% respectively.

Abulude *et. al;* (2006) studied the proximate composition, mineral and functional properties of *Penaus notalis*, *Macrobranchium vollenhovenii, palaenon* specie and *Procambanis clarkii* from coastal area of Ondo state of Nigeria and found that moisture content of *P. notalis* to

be 50.21g 100g-1 DM, *M. vollenhovenii 53.11g 100g^{-1} DM, P. species 43.20g 100g^{-1} DM, P. clarkii* 45.22g *100g^{-1} DM*.

Crude protein in *P. notalis* 20.71g *100g^{-1} DM, M. vollenhovenii* 22.50g *100g^{-1} DM*, P. species 21.31g *100g^{-1} DM, P. clarkii* 21.82g *100g^{-1} DM*. Ash content *P. notalis* 13.62g *100g^{-1} DM, M. vellenhovenii* 7.50g *100g^{-1} DM, P. species* 8.20g *100g^{-1} DM, P. clarkii* 11.20g *100g^{-1} DM*.

Carbohydrate content *P. notalis* 47.19g *100g^{-1} DM, M. vollenhovenii* 45.45g *100g^{-1} DM, P. species* 50.14g *100g^{-1} DM, P. clarkii* 46.27g *100g^{-1} DM*, respectively.

Umar (2006) studied some aspect of the proximate composition of *Oreochromis niloticus* and found 9.00g/dry weight moisture content, 15.00g/dry weight lipid contents, 45.10g/dry weight crude protein content, 28.00g/dry weight ash content and 4.07g/dry weight carbohydrate content.

Fish from different geographical zones and in different season may not contain same type and concentration of nutrients even when they are of the same species.

Narcisa *et. al;* (2001) studied the seasonal variation in the chemical composition of horse mackerel (*Trachurus trachurus*) and found that fat content ranged between 1.4% and 7.5% and protein content ranged between 18.3% and 19.9%. The highest fat content was recorded in August and December and the lowest in February.

Abdullahi (2002) studied the seasonal and locational variations in the proximate, amino acids and mineral contents of *Lates niloticus, Heterotis niloticus* and *Gymnarcus niloticus* in Nigeria and found that the moisture content of *L. niloticus* during the rainy season was 73.21g/100g and 81.039/100g during the dry season. The moisture content of *H. niloticus* during the rainy season was 76.12g/100g and 80.42g/100g during dry season.

The ash content for *L. niloticus* during raining season was 17.4g/100g and 19.2g/100g during dry season. For *H. niloticus* 17.7g/100g during rainy season and 19.7g/100g during dry season. *G. niloticus* 13.3g/100g during rainy season and 17.5g/100g during dry season.

The moisture contents were generally above 70g/100g in all the three species. However, the moisture and ash contents were high during the dry season. There was no significant difference in the organic matter and carbohydrate contents in the two seasons. The lipid, proteins were significantly higher during the rainy season in all the three species.

Abdullahi and Abolude (2002) studied the effects of season and geographical location on the nutrient content of two families (*Cichlidae* and *claridae*) namely *Clarias gariepinus, Clarias angullaris, Oreochromis niloticus, Tilapia zilli, Sarotherodon galilaeus* and *Hemichromis fasciatus.* They found that the moisture contents were

generally above 70.00g/100g wet weight in all species. They were not significantly different in all the species for two season and locations. The ash and organic matter were unaffected by the locations and season of the year. For each species, there was no significant different in the proximate composition in samples from the two locations. Calcium, sodium phosphorus and zinc were significantly higher in samples obtained from Niger – Benue confluence compared to samples from Tiga Dam. More minerals were observed during the rainy season.

The effects of seasonal variations on the proximate and fatty acid compositions of wild common sole (*Solea solea*) were studied by Mahmut *et. al;* (2004) and found that the level of lipid displayed pronounced seasonal fluctuations with the highest values in February and August (0.45 – 0.83% fresh weight) and the lowest in April and November. Protein levels were similar, but dry matter fluctuations were observed for all seasons.

Abdullahi (2005) studied the seasonal nutrient variability of the Electric cat fish (*Malapterus electricus (Gmelin*) obtained from three sites Niger-Benue confluence, Zaria and Tiga Dams and discovered that there was no significant differences in the moisture content of *M. electricus* between seasons and the three locations. The mean values of carbohydrate significantly decreased (14.85 – 12.92g/100g) from rainy to

dry season. Similarly, the lipid content decreased from 673.56 – 488.84k cal/100g.

Abdullahi and Abolude (2005) studied seasonal levels of some nutrients in three *Bagrids: Chrysichthys auratus*, *Bagrus docmac* and *Clarotis laticeps* from Niger-Benue confluence and Tiga Dam in Northern Nigeria and found that the moisture content in the species was in the range (74.46 – 76.88g/100g wet weight). There was no significant difference in the moisture content of the species for the seasons and locations. The amount of organic matter during the dry season in all the three species did not increase significantly. The carbohydrate content was significantly higher in *C. auratus* and *C. laticeps* during the dry season but unaffected in *B. domac*. The protein and lipid contents were significantly higher during the wet season in all the three species but unaffected by locality.

Tzikas *et. al;* (2005) also studied the seasonal variation in the chemical composition and microbiological condition of Mediterranean horse (*Trachurus mediterranean*) muscle from the North Aegean sea (Greece) and found that the proximate composition of the muscle during the year was moisture 76.8 ± 1.39%, proteins 20.3 ± 0.68%, fat 1.3 ± 1.08% and ash 1.5 ± 0.08%. In March, April and May an increase in fat content of the muscle (2.5%, 2.8% and 2.1% respectively) and a decrease in water content of the muscle (between 75.9%) were observed. On the

contrary, fat content showed a decrease in September and October (0.4% and 0.6% respectively), while moisture content of the muscle increased during these months (78.2% and 77.6% respectively). The protein content of the muscle remained at high values, while the ash content was almost constant during the year.

CHAPTER THREE

3.0 MATERIALS AND METHODS.

3.1 Study area

The study area, Mairuwa Reservoir with surface area of 144.0ha was constructed in 1973 with the primary purpose of meeting the water need of Funtua and its environs. The secondary purpose of Mairuwa reservoir is fishing activity.Mairuwa Reservoir in Faskari Local Government, Katsina State is located between Longitude 7^0 14' 36" to 7^0 15' 35" E and Latitude 11^0 30' 00" N to 11^0 31' 01" N. about 14km from Funtua along Gusau road Katsina State. (Figure 3.1).

3.1.1 Fish Collection

One thousand three hundred and forty seven (1347) samples of the three fish species were purchased randomly from the commercial catches of fishermen at Mairuwa Reservoir. The fishes were purchased bi-weekly in the early morning of the dry and rainy season of 2005 and 2006.

Three hundred and fifty (350) *Synodontis clarias,* 270 *Schilbe mystus* and 315 *Mormyrus macrophthalmus* were purchased during the rainy season (July – September, 2005) and 150 *Synodontis clarias,* 107 *Schilbe mystus* and 155 *Mormyrus macrophthalmus* were purchased in the dry season (December – March 2006). Each time the fishes were purchased from the fishermen they were degutted and transported in insulated boxes containing ice to the Department of Biological Sciences Ahmadu Bello University, Samaru Zaria, and prepared for analysis.

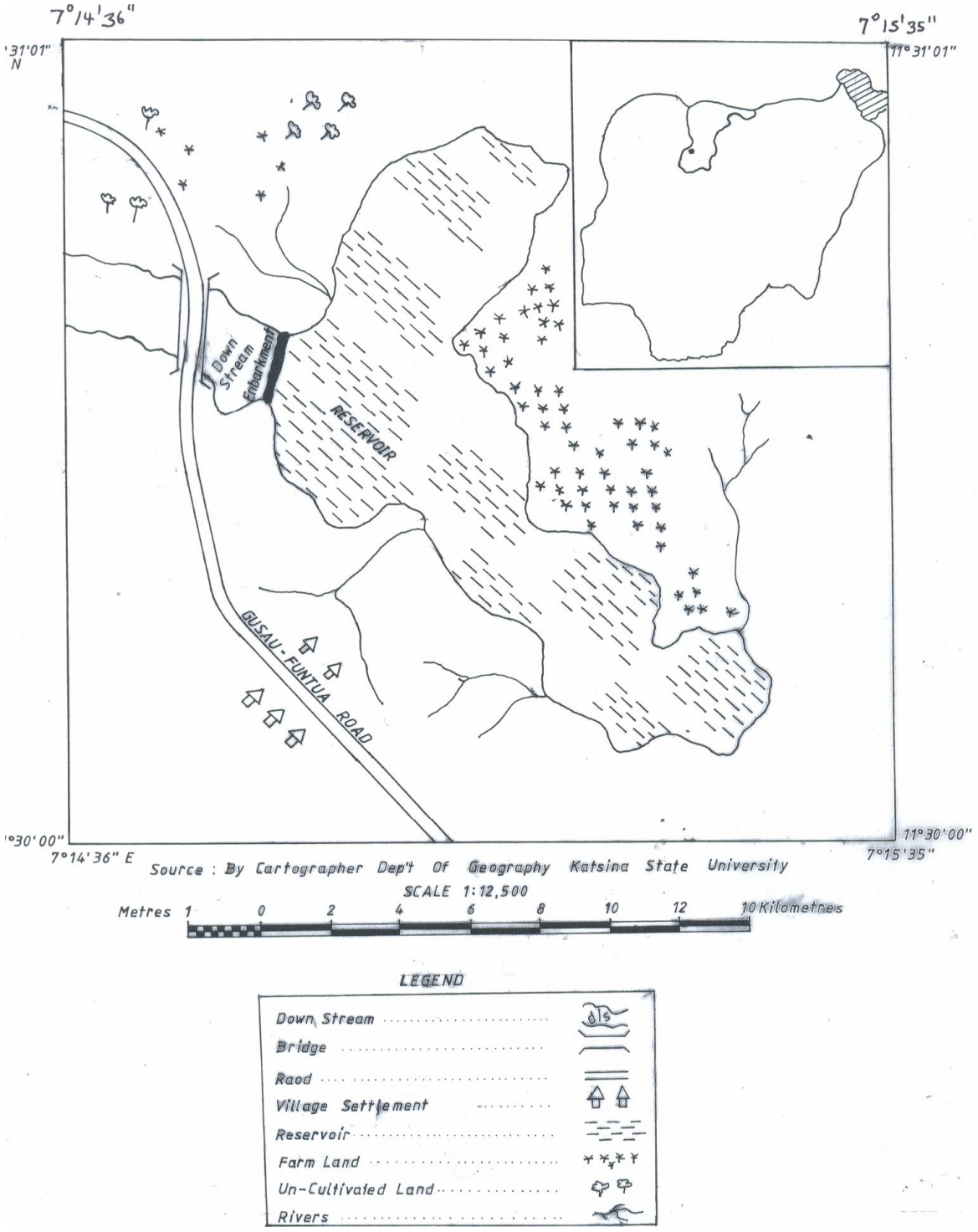

FIGURE 3.1: MAP (LAY OUT) OF MAIRUWA RESERVOIR, FASKARI L. G. AREA

INSERTION IS THE MAP OF NIGERIA SHOWING THE LOCATION OF MAIRUWA RESERVOIR IN KATSINA STATE.

3.1.2 **Fish Processing**

The fresh fish samples were washed and blotted dry. Individual fresh samples were separated into their anatomical fractions head, bones, flesh using standard methods of (A.O.A.C, 1990). The fractions and whole samples were oven dried at 105^0C. The dried parts were pooled and milled into homogenous powder. The parts were labelled and transported to the National Research Institute for Chemical Technology (NARICT) along Basawa Zaria where the analysis were carried out.

3.2 Proximate analyses

The proximate composition (moisture, crude protein, crude fibre, lipid, carbohydrates and ash) of the three fish species were determined using the standard methods of the Association of Official analytical Chemists (AOAC, 1980). All the chemical analyses were carried out in duplicate.

3.2.1 **Moisture content determination**

Principle: - This was done based on the differences between the net weight and the weight after drying to a constant temperature (at 100^0C). They were later removed and placed in a dessicator and weighed (W_1). Five grams 5g of the sample was placed in the weighed crucible (W_2). The crucible containing the sample was kept in an oven at 100^0C for 24 hours and then weighed. It was kept back in the oven and reweighed after about 3 hours to ensure a constant weight (W_3). Loss in

weight was equal to water content of the original sample. The percentage moisture content was calculated as follows:-

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

Where: W_1 = Weight of an empty crucible

W_2 = Weight of known amount of sample (fresh)+ crucible

W_3 = Weight of oven dried sample

3.2.2 Crude Protein Determination

Principle:- Nitrogen is used as an index of the protein and so is termed crude protein because it represents all of the nitrogen that is in the form of non-protein Nitrogen. (NPN) such as nitrates, ammonia, urea and single amino acids, as well as the nitrogen present as true protein. The multiplication by a conversion factor of 6.25 is based on the assumption that true protein contains 16% nitrogen.

Procedure:- Protein determination was carried out in three stages as follow:-

Digestion:- One gramme of sample was weighed and placed into a 50ml digestion – flask and the Kjeldahl mixture which acts as a digestion catalyst was added with 5ml concentrated sulphuric acid (H_2S0_4). Some pumice stones (anti – bumping granules) were also added. The flask

containing the sample mixture was heated gently at an inclined angle in a Kjeldahl digestion rack until frothing subsided. It was then boiled until the solution became colourless. Heating of the mixture released the nitrogen in the various samples which was then converted to ammonia with the concentrated sulphuric acid. It was later allowed to cool. The sample was transferred to a 100ml volumetric flask and diluted with distilled water to the mark. It was then mixed thoroughly. The mixture was further allowed to cool before distillation. A blank containing only the sulphuric acid and catalyst was also heated.

Distillation: A known aliquot (10ml) was transferred to the sample addition funnel of the distillation apparatus and then introduced to the sample chamber. 10ml of 40% sodium hydroxide was added to the sample addition funnel and released to the sample chamber at a slow rate. The ammonia was entrapped in a receiving solution containing 10ml 2% boric acid solution into which 4 drops of bromocresol green/2drops of methyl red indicator had been put. Distillation was continued until the pink colour turned greenish.

Titration: Titration with standard HCl acid (0.01N) was then carried out and the percentage of crude protein determined with the following calculation:

$$\% \text{ Nitrogen} = \frac{\text{Titre value (A-B) X Normality of acid X vol of dilute X } N_2 \text{ x } 100}{\text{sample wt (mg) X vol of digest (aliquot)}}$$

$$= \frac{\text{Titre value X } 0.01 \text{ X } 100 \text{ X } 14.007 \text{ X } 100}{\text{Sample wt (mg) X } 10}$$

Where: A = Titre value for the digestion sample

B = Titre value for the blank

% crude protein = % N_2 X 6.25

3.2.3 **Crude Lipid Determination**

Principle:- This is the continuous extraction of fat content from a sample using a suitable solvent in a soxhlet extractor.

Procedure:- Two grammes of the dried sample (residue from moisture determination) was placed into a pre – weighed extraction thimble (w_1) and the weight recorded (w_2). A dry 250ml round bottom quickfit flask was weighed (w_3) with a few anti bumping granules inside. The thimble was fitted into the extraction unit of the soxlhlet extraction apparatus using a pair of forceps. 300ml of petroleum ether (40 – 60^0C boiling point) was poured into the quickfit flask. The apparatus was connected to a condenser. The heating rate was adjusted to give a condensation rate of 2 to 3 drops. After reflux extraction for 8 hours, the thimble was removed and the ether was reclaimed using the apparatus by distilling out some ether. The removal of ether from the flask containing a mixture of ether and extracted fat was completed on a boiling water bath and the flask

dried in an oven at 105^0C for 30 minutes. After this, the flask with the pure fat content was cooled in a desiccator and weighed (w_4).

The percentage crude fat was calculated as follows:-

$$\% \text{ Crude fat} = \frac{w_4 - w_3}{w_2 - w_1} \times 100$$

$$= \frac{\text{fat}}{\text{Sample}} \times 100$$

3.2.4 **Ash Content Determination**

Principle:- By ashing the sample, all the volatile organic constituents in the sample were burnt off leaving behind the non-volatile mineral elements.

Procedure:- An empty crucible was dried in the oven. After drying it was cooled in the desiccator and weighed (W_1). 2g of the already dried sample obtained after moisture extraction was put into the crucible and the weight recorded (W_2). This was then put into a muffle furnace and incinerated at 525^0C for 24 hours. After this, it was placed in a desiccator for cooling and then re-weighed (W_3). Percentage ash content was computed by carrying out the following calculations:

$$\% \text{ Ash content} = \frac{W_3 - w_1}{W_2 - w_1} \times 100$$

$$= \frac{\text{Ash}}{\text{Sample}} \times 100$$

3.2.5 **Crude Fibre Determination**

The method of AOAC (1980) was adopted in the determination of the crude fibre content. Two grams (2g) of the sample was put into a soxhlet apparatus and extracted with petroleum ether and diethyl ether. The extraction method was similar to that of the lipid (3.4.2). The extracted sample was air dried and put to dry in 100ml conical flask. 200ml of boiled 0.25N sulphuric acid was added. The content of the flask was boiled gently for 30 minutes. The flask was rotated so as to mix the contents and remove particles from sides.

A Buckner funnel fitted with a perforated plate cover with filter paper was preferred. The boiling water was then poured into the funnel, allowed to remain until the funnel was hot. The water was then removed by suction. The boiling period was 30 minutes after which the acid mixture was allowed to stand for 1 minute and then it was poured immediately into a shallow layer of hot water by gentle suction in the preferred funnel. The suction was adjusted so that the quantity of the 200ml would be collected in 10 minutes. Boiling water was used to wash the insoluble matter until it was acid free.

The insoluble matter was then washed back into the original flask by means of a washed bottle containing 200ml of 0.313N sodium hydroxide solution measured at ordinary temperature and brought to boiling point. The boiling continued for half an hour and then the mixture

was allowed to stand for 1 minute and then filtered. All the insoluble materials were transferred to filter paper and washed first with the boiling water and then with 1% HCl. Lastly, it was washed with boiling water until it was acid free. The washing continued two times with alcohol and with ether thrice. The insoluble matter was then put into a dried weighted ash less filter paper and dried at 100^0C until a constant weight was gotten (obtained). The content and the paper were incinerated to ash at a dull red heat. Because of the insoluble materials the weight of the ash was subtracted from the increased weight of the paper. The difference was the fibre content weight.

$$\% \text{ Crude fibre} = \frac{y - x}{z} \times 100$$

where: x = weight of the ash less filter paper

y = weight of ash after incineration

z = weight of the sample

3.2.6 **Determination of Carbohydrate (By Difference)**

The total carbohydrate was determined by difference. The sum of the percentage moisture, ash, crude lipid, crude protein and crude fibre was subtracted from 100.

3.3 Mineral Composition Analyses

The minerals in the ash (samples) powder were brought into solution by wet digestion using concentrated nitric acid (63%),

concentrated Hydrocholoric acid (60%) and concentrated sulphuric acid in the ratio 4:1:1 (Harris, 1979). These were digested slowly at moderate heat in a fume cupboard. Digestion continued for 15 minutes. After the appearance of white fumes, the solution was cooled and filtered with whatman filter paper No. 44 and further diluted with distilled water. Blank digestion was also carried out.

The minerals were determined by Perkin–Elmers Atomic absorbtion spectrophotometer (AAS) (model 29 B Perkin – Elmer Co. Ltd, USA) (AOAC, 1980).

3.4 Statistical analyses

The data obtained were subjected to analysis of variance (ANOVA) and where there was significant difference at $P \leq 0.05$. The differences in the means were sorted out by the use of Duncan multiple Range Test (DMRT) (Duncan, 1955).

3.5 Limitations of the study

- Lack of constant electricity during the work led to delay in the chemical analysis and also prolonged weight measurements unduely.
- It was also difficult to collect the fish samples especially during the dry season compared with wet season.

CHAPTER FOUR

RESULTS

4.1 Proximate Analyses.

Table 4.1a shows the proximate composition of fish components in the rainy season. The flesh of the three species contain high amount of protein in the range of 52.56 – 59.19g/100g, followed by their heads in the range 39.06 – 49.30g/100g and the content of protein in the bones were generally low in the range of 2.03 – 3.01g/100g.

Lipid contents were significantly ($P \leq 0.05$) high in the flesh in the range of 16.24– 19.64g/100g, while the heads of all the three species have a range of 12.02 – 16.29g/100g and bones were found to have low amount of lipid contents in the range of 4.23 – 7.03g/100g. The flesh of the three fish species contain high contents of carbohydrate in the range 11.53 – 18.76g/100g and low in the bones in the range of 3.01 – 4.50g/100g.

The moisture contents were also low in the flesh of the three species in the range of 8.11 – 9.12g/ 100g, head in the range of 7.01 – 8.06g//100g and bones with least amount in the range of 2.24 – 3.75g/100g. However, ash contents were significantly ($P \leq 0.05$) high in the bones in the range of 83.60 – 87.40g/100g. The head had ash contents in the range of 12.50 – 26.16g/100g and ash contents were generally low in the flesh of all the three species in the range of 3.00 – 3.35g/100g. The crude fibre content was generally low in the range of 1.17 ± 0.30 – 3.53 ± 0.11g/100g in all fish species studied.

Table 4.1a. **Proximate composition of sampled fish parts in the rainy season, July – September (g/100g).**

Fish Species	Body Parts	Protein	Lipid	Carbohydrate	Moisture	Ash	Fibre
Schilbe mystus	Flesh	59.19 ± 1.20	19.24 ± 1.32	11.53 ± 1.41	8.82 ± 1.10	3.22 ± 2.60	2.04 ± 1.00
	Head	49.13 ± 1.50	14.37 ± 1.10	11.17 ± 1.04	7.76 ± 0.21	18.57 ± 1.26	2.79 ± 1.23
	Bone	3.01 ± 0.32	4.23 ± 1.22	4.50 ± 0.88	3.26 ± 0.24	85.0 ± 2.20	1.57 ± 0.24
Synodontis clarias	Flesh	52.56 ± 2.11	18.22 ± 1.30	18.76 ± 1.60	8.11 ± 0.02	3.35 ± 2.10	3.16 ± 0.32
	Head	39.06 ± 2.07	12.02 ± 2.23	15.75 ± 1.03	7.01 ± 0.04	26.16 ± 1.55	3.53 ± 0.11
	Bone	2.34 ± 0.82	5.02 ± 0.92	3.01 ± 1.23	2.24 ± 1.22	87.4 ± 1.32	2.03 ± 0.21
Mormyrus	Flesh	54.24 ± 2.27	17.64 ± 0.73	15.02 ± 0.58	9.12 ± 1.60	3.00 ± 0.21	1.17 ± 0.30
Macrophthalmus	Head	50.30 ± 1.11	16.29 ± 1.09	13.85 ± 0.68	8.06 ± 1.20	12.50 ± 1.22	2.59 ± 0.12
	Bone	2.03 ± 2.15	7.03 ± 1.06	3.59 ± 1.28	3.75 ± 1.20	83.60 ± 1.20	1.62 ± 0.50

Values represent means and standard deviations of duplicate determinations.

Table 4.1b shows the proximate composition of fish components in dry season (December – March). It is observed that protein contents were significantly ($P \leq 0.05$) high in the flesh in the range of 50.55 – 56.19g/100g in all the three fish species, followed by the head in the range of 39.05 – 48.27g/100g, with bones having low amount of protein in the range of 1.33 – 3.01g/100g.

The lipid contents were also significantly ($P \leq 0.05$) high in the flesh in the range of 15.25 – 16.60g/100g in the three species. Lipid contents in the head were in the range of 12.02 – 16.03g/100g and were low in the bones in the range of 2.02 – 6.53g/100g.

The carbohydrate contents were generally low in the flesh of the three species in the range of 11.03 – 18.50g/100g followed by the head in the range of 10.08 – 15.75g/100g and the contents were generally very low in the bones in the range of 1.59 – 4.40g/100g.

The moisture contents were generally low in the flesh of all the species in the range of 9.23 – 11.13g/100g, head in the range of 9.01 – 10.17g/100g and bone with very least content in the range of 3.27 – 7.06g/100g.

The ash contents were high in the bones of all the species in the range 84.60 – 88.01g/100g, head with intermediate in the range 15.07 – 29.18g/100g and were generally low in the flesh of all the three fish species in the range of 6.25 – 7.05g/100g. The crude fibre content was generally low in the range of 0.90 ± 0.30 – 2.99 ± 0.20g/100g in all fish species studied during the dry season.

Table 4.1b. **Proximate composition of fish parts in dry season, December – March (g/100g).**

Fish Species	Body Parts	Protein	Lipid	Carbohydrate	Moisture	Ash	Fibre
Schilbe mystus	Flesh	56.19 ± 1.86	15.25 ± 2.01	11.03 ± 1.01	10.07 ± 1.20	6.71 ± 1.20	0.92 ± 0.20
	Head	47.31 ± 2.01	12.39 ± 1.11	10.08 ± 1.23	9.86 ± 0.22	20.23 ± 0.50	1.05 ± 0.10
	Bone	3.01 ± 0.39	4.22 ± 1.12	4.40 ± 0.83	3.27 ± 0.13	86.0 ± 1.33	0.98 ± 0.30
Synodontis clarias	Flesh	50.55 ± 2.27	16.50 ± 1.30	18.50 ± 1.60	9.23 ± 1.60	6.25 ± 2.10	0.98 ± 0.10
	Head	36.05 ± 2.07	10.02 ± 2.22	15.75 ± 1.03	9.01 ± 0.04	29.18 ± 1.55	2.99 ± 0.22
	Bone	1.33 ± 0.82	2.02 ± 0.92	1.59 ± 1.22	7.06 ± 1.22	88.01 ± 1.30	2.01 ± 0.40
Mormyrus	Flesh	52.29 ± 2.27	15.60 ± 0.73	14.02 ± 0.58	11.13 ± 1.60	7.05 ± 1.20	0.90 ± 0.30
macrophthalmus	Head	47.27 ± 1.11	14.03 ± 1.09	12.75 ± 0.60	10.17 ± 1.23	15.07 ± 1.22	2.57 ± 0.10
	Bone	2.01 ± 2.15	6.53 ± 1.06	2.69 ± 1.28	4.17 ± 1.20	84.60 ± 1.02	1.55 ± 0.20

Values represent means and standard deviations of duplicate determinations.

The results of the mean proximate composition of *Schilbe mystus*, *Synodontis clarias* and *Mormyrus macrophthalmus* in two seasons are presented in Table 4.2. There was no significant difference ($P \geq 0.05$) in the moisture content of all the three fish species 74.60 – 77.83g/100g.

The mean ash content was significantly ($P \leq 0.05$) low during the rainy season 12.20 ± 1.32g/100g – 13.10 ± 1.82g/100g. Organic matter content 78.05 ± 1.93 – 85.0 ± 1.03g/100g among the three species were not significantly different ($P \leq 0.05$) between the two seasons. The mean values of carbohydrate decreased significantly (≤ 0.05) from rainy season to dry season 10.60 – 8.52 ± 1.30g/100g in *Schilbe mystus*, 12.77 ± 0.32 – 10.20 ± 1..80g/100g in *Synodontis clarias*, and 12.22 ± 1.40 – 10.23 ± 1.03g/100g in *Mormyrus macrophthalmus*. Similarly, the lipid contents decreased significantly ($P \leq 0.05$) from rainy season to dry season 35.30 ± 1.08 – 33.01 ± 2.17g/100g in *Schilbe mystus*, 38.27 ± 3.01 – 36.20 ± 1.30g/100g in *Synodontis clarias*, 30.33 ± 2.73 – 28.27 ± 1.21g/100g in *Mormyrus macrophthalmus*. However, the protein contents were significantly high ($P \leq 0.05$) during the dry season 45.02 ± 1.55 – 47.22 ± 1.04 in the three species. Fibre contents decreased significantly ($P \leq 0.05$) from rainy reason to dry season in the range 6.40 ± 0.32 – 2.95 ± 0.50g/100g in *Schilbe mystus*, 8.72 ± 1.08 – 5.98 ± 1.20g/100g in *Syndontis clarias* and 5.38 – 5.02 ± 0.32 in *Mormyrus macrohthalmus* respectively.

Table 4.2 **Mean proximate composition of whole fishes obtained from Mairuwa reservoir in rainy and dry seasons (g/100g).**

Seasons	Fish Species	Moisture	Ash	Organic matter	Carbohydrate	Lipid	protein	Fibre
Rainy Season	Schilbe mystus	a	b	b	b	b	b	b
		77.40 ± 1.6	12.20 ± 1.32	85.0 ± 1.03	10.60 ± 1.20	35.30 ± 1.08	42.70 ±1.00	6.40 ± 0.32
	Synodontis clarias	a	b	a	b	B	b	b
		74.60 ± 1.2	13.10 ± 1.82	78.05 ± 1.93	12.77 ± 0.32	38.27 ± 3.01	38.30 ± 1.23	8.72 ± 1.08
	Mormyrus	a	b	b	b	B	b	b
	macrophthalmus	76.32 ± 1.4	12.65 ±1.86	82.0 ± 1.93	12.22 ± 1.40	30.33± 2.73	44.83 ± 2.01	5.38 ± 1.80
Dry Season	Schilbe mystus	a	b	b	b	B	b	b
		76.64 ± 1.6	13.80 ± 1.28	83.6 ± 1.32	8.52 ± 1.30	33.01± 2.17	45.02 ± 1.55	2.95 ± 0.50
	Synodontis clarias	a	b	a	b	B	b	b
		75.24 ± 1.3	15.05 ± 1.3	79.0 ± 2.20	10.20 ± 1.80	36.20± 1.30	36.01 ± 1.32	5.98 ± 1.20
	Mormyrus	a	b	b	B	B	b	b
	macrophthalmus	77.83 ± 1.2	14.28 ± 1.01	80.7 ± 1.73	10.23 ± 1.03	28.27± 1.21	47.22± 1.04	5.02 ± 0.32

Values represent means and standard deviations of duplicate determinations.

a. Indicates no significant difference at ($P > 0.05$)

b. Indicates significant difference ($P \leq 0.05$)

4.2 **Mineral content of the fishes**

Table 4.3a shows the mean mineral contents of fish parts (mg/100g) during the rainy season. Calcium contents were significantly ($P \leq 0.05$) higher in the bones 1370.0mg/100g – 1470.40mg/100g, followed by the flesh 510 – 790.05mg/100g and the head 490.03mg/100g – 657.0mg/100g. Potassium contents were significantly ($P \leq 0.05$) higher in the flesh 533 – 604.0mg/100g. Iron contents were significantly ($P \leq 0.05$) higher in the head 3.3 – 70.03mg/100g with bones having the least value 2.10 – 16.01mg/100g.

Magnesium contents were significantly ($P \leq 0.05$) high in the flesh of all the species in the range of 16.72 – 56.03mg/100g followed by the bones with immediate contents and the head with least amount. Sodium, contents were found to be significantly ($P \leq 0.05$) higher in the flesh of all the three fish species in the range of 159.01 – 201.1mg/100g followed by the head 59.00 – 102.03mg/100g and the bones with least value in the range 6.03– 10.03mg/100g Copper contents were found to be significantly ($P \leq 0.05$) higher in the head in the range 0.12 – 1.40mg/100g followed by the bones 0.4 – 1.20mg/100g and flesh with least value in the range 0.29 – 1.03mg/100g Phosphorus contents were found to be significantly ($P \leq 0.05$) higher in the bones of all the fish species in the range 10.73 – 16.91mg/100g followed by the head 7.12 – 16.01mg/100g and flesh with least value in the range of 5.63 – 8.73mg/100g. Zinc

contents were significantly (P≤0.05) higher in the head of all the three species in the range 10.03 – 21.23mg/100g followed by the bones in the range 6.01 – 14.71mg/100g and low in the flesh in the range of 5.29 – 7.29mg/100g. Iodine contents were significantly (P≤0.05) high in the bones in the range 7.00 – 15.00mg/100g and low in the flesh in the range 6.00 – 8.00mg/100g in the three fish species.

Table 4.3b shows the mean mineral contents of fish parts (mg/100g) during the dry season. Calcium contents were also found to be significantly (P≤0.05) high in the bones in the range 1370 – 1469.5mg/100g in all the three species followed by head 490.03 – 657.0mg/100g then followed by the flesh 510.23 – 790.05mg/100g Potassium contents were found to be significantly (P≤0.05) high in the flesh 533.01 – 603mg/100g followed by the head 68.01 – 270mg/100g and bones with the least value 27.03 – 150.00mg/100g Iron contents were also found to be significantly (P≤0.05) high in the head in the range 3.33 – 70.03mg/100g among all the three fish species and low in the bones in the range 2.20 – 16.00mg/100g. Magnesium contents were found to be significantly (P≤0.05) high in the flesh of all the three fish species in the range of 16.72 – 56.03mg/100g followed by bones with 21.03 – 39.00mg/100g and head with 9.60 – 39.00mg/100g respectively.

Table 4.3a **Mineral content of fish parts During Rainy Season (mg/100g)**

Fish Species	Body Parts	Calcium	Potassium	Iron	Magnesium	Sodium	Copper	Phosphorus	Zinc	Iodine
Schilbe mystus	Flesh	510.23± 50.6	537.01±50.3	5.60± 2.3	16.72± 3.3	166.01± 9.03	0.29 ± 0.2	8.73 ± 0.51	7.29 ± 0.5	6.00 ± 0.2
	Head	657.0± 77.3	69.03 ± 6.2	22.27 ± 4.6	9.67 ± 2.0	102.03 ± 7.0	0.14 ± 0.1	16.01 ± 1.7	21.23 ± 0.4	7.00 ± 0.1
	Bone	1470.4±100.4	27.04 ± 2.1	15.70 ± 2.5	22.03 ± 2.3	8.33 ± 2.3	0.9 ± 0.2	16.91 ± 1.6	14.71 ± 0.9	7.00 ± 0.3
Synodontis clarias	Flesh	790.05± 88.3	604.0± 63.0	10.06± 1.0	47.03± 3.2	159.01± 10.1	1.03 ± 0.1	5.63 ± 0.32	5.29 ± 0.3	8.00 ± 0.6
	Head	490.03± 42.0	270.0 ± 19.0	70.03 ± 6.3	23.73 ± 1.7	98.03 ± 7.2	0.12 ± 0.3	7.12 ± 0.42	10.03 ± 0.6	11.00±0.5
	Bone	1370.0 ±99.0	120.03 ±13.0	16.01 ± 1.3	40.01 ± 0.5	6.03 ± 1.2	0.4 ± 0.01	10.73 ± 1.1	6.01 ± 0.2	15.00±0.2
Mormyrus	Flesh	653.70± 51.0	533.07± 52.0	3.51± 1.01	56.03± 1.9	201.1± 11.03	0.5 ± 0.1	6.33 ± 0.39	6.59 ± 0.8	6.01 ± 0.3
Macrophthalmus	Head	540.03±47.03	173.09±15.03	3.33 ± 0.5	39.01 ± 2.60	59.00 ± 4.60	1.40 ± 0.7	13.07 ± 1.30	10.29 ± 0.2	7.53 ± 0.3
	Bone	1453.01±93.1	150.07±10.7	2.01 ± 5.2	33.03 ± 1.8	10.03 ± 2.7	1.20 ± 0.6	15.03 ± 1.52	8.05 ± 1.2	9.00 ± 0.2

Values represent means and standard deviations of duplicate determinations.

Sodium contents were also found to be significantly ($P \leq 0.05$) high in the flesh in the range of 159 – 210.0mg/100g followed by the head 59 – 102mg/100g and bone with least values of 6.03 – 10.00mg/100g respectively. Copper contents were found to be high in the head 0.11 – 1.30mg/100g and followed by the flesh 0.28 – 1.00mg/100g and bones with least value of 0.20 – 1.00mg/100g. Phosphorus contents were found to be high in the bones of all the fish species in the range 10.70 – 15.70mg/100g followed by the head 7.12 – 14.0mg/100g and flesh with least value in the range of 5.53 – 8.73mg/100g respectively. Zinc contents were significantly ($P \leq 0.05$) high in the heads of all the three fish species in the range 10.03 – 21.22mg/100g followed by the bones in the range of 5.00 – 14.00mg/100g and low in the flesh in the range of 5.29 – 7.21mg/100g respectively. Iodine contents were significantly ($P \leq 0.05$) high in the bones among the three fish species in the range of 7.02 – 14.00mg/100g and followed by the head 5.00 – 10.00mg/100g and flesh with least value 5.00 – 7.00mg/100g respectively.

Table 4.3b **Mineral content of fish parts During Dry Season (mg/100g)**

Fish Species	Body Part	Calcium	Potassium	Iron	Magnesium	Sodium	Copper	Phosphorus	Zinc	Iodine
Schilbe mystus	Flesh	509.21±50.6	536.0±50.3	5.60±2.3	16.72±9.03	165.0±9.03	0.28±0.1	8.73±0.51	7.21±0.5	5.00±0.1
	Head	655.0±77.3	68.01±6.20	22.20±4.6	9.60±2.03	102.01±7.0	0.14±0.1	14.0±1.7	21.22±0.4	5.00±0.2
	Bone	1469.5±100	27.03±2.1	15.70±1.7	21.03±2.3	8.33±2.3	0.8±0.2	15.70±1.6	14.00±0.8	7.02±0.2
Synodontis clarias	Flesh	788±88.3	603±62.0	10.0±1.0	47.03±3.2	159.01±10.1	1.00±0.1	5.53±030	5.29±0.3	7.00±0.1
	Head	490.03±41.0	270±19.0	7.03±6.3	23.73±1.7	97.03±7.2	0.11±0.3	7.12±0.42	10.03±0.6	10.00±0.5
	Bone	1370.0±99.0	118±1.20	16.00±1.3	39.00±0.5	6.03±1.2	0.20±0.01	10.70±1.1	5.00±0.1	14.00±0.2
Mormyrus	Flesh	653.70±51.0	533.01±52.0	3.51±1.01	56.03±1.8	201±11.0	0.5±0.1	6.30±0.39	6.59±0.8	6.01±0.3
Macrophthalmus	Head	540.03±46.0	173.09±15.0	3.33±0.4	39.01±2.60	59.0±4.60	1.30±0.6	13.07±1.30	10.29±0.2	7.53±0.3
	Bone	1453.0±93.0	150±10.6	2.20±5.1	32.00±1.8	10.00±2.0	1.00±0.4	14.01±1.40	7.01±1.1	8.00±0.1

Values represent means and standard deviations of duplicate determinations.

Table 4.4a and 4.4b provide data on the mean mineral contents of the whole fishes (mg/100g) in both wet and dry seasons respectively. The calcium contents in the species in both seasons were in the range of 2632.71 – 2646.74mg/100g, and were significantly different between the two seasons ($p \leq 0.05$) in *Schilbe mystus* and *Synodontis clarias* and not significantly different ($p > 0.05$) in *Mormyrus macrophthalmus.* In *Schilbe mystus* and *Synodontis clarias* the calcium contents were higher during the rainy season. Potassium contents in the species in both wet and dry season were in the range 619.91 – 739.49mg/100g. The potassium contents were significantly higher during the wet (rainy season) in all the three species ($p \leq 0.05$).

Iron contents in the three species in both the seasons were in the range of 41.50 – 96.10mg/100g, and significantly higher ($p \leq 0.05$) in rainy season. Magnesium contents were in the range of 53.35– 251.11mg/100g in the species. The content of magnesium were not significantly different in all the three species ($p > 0.05$). The sodium contents in the species in both the seasons were in the range of 261.04 – 276.37mg/100g. The contents of sodium were significantly higher in rainy season ($p \leq 0.05$). The copper contents in all the three species were in the range of 1.22 – 3.15mg/100g. There is no significant difference ($P > 0.05$) in the concentrations of the copper between the two seasons in all the three species.

The zinc contents among the three species of fishes were in the range of 20.88 – 44.23mg/100g. The content of zinc was significantly higher ($P \leq 0.05$) during the rainy seasons. The iodine contents in all the three species were in the range 20.00 – 44.00mg/100g. The content of iodine in both seasons were significantly different ($P \leq 0.05$) in S*chilbe mystus* and *Synodontis clarias.* However, the there was no significant difference ($P > 0.05$) in the contents of iodine between the two seasons in *Mormyrus macrophthalmus.* The content of phosphorus was significantly ($P \leq 0.05$) higher in rainy season 25.48 – 49.77mg/100g among all the three species.

Table 4.4a Mineral Content of whole fishes obtained from Mairuwa Reservoir in rainy season (mg/100g)

Fish Species	Calcium	Potassium	Iron	Magnesium *	Sodium	Copper *	Phosphorus	Zinc	Iodine
Schilbe mystus	2637.63±94.2	622.95± 53.0	43.57± 5.50	53.43± 5.70	276.37±14.0	1.33± 0.40	49.77± 2.70	44.23± 3.70	22.00±1.70
Synodontis clarias	2650.08±82.0	884.03±56.03	96.10± 4.80	223.79± 10.8	263.07±10.00	1.55± 0.22	25.48± 1.70	21.33± 1.72	44.00± 2.30
Mormyrus Macrophthalmus	2646.74±120.40	739.49±36.70	23.87± 2.20	251.11±20.00	270.13±22.03	3.15± 1.20	44.41± 3.02	24.93± 1.80	22.55± 1.63

Values represents means and standard deviations of duplicate determinations.

* ***No significant difference at P > 0.05***

Table 4.4b Mineral Content of whole fishes obtained from Mairuwa Reservoir in dry season (mg/100g)

Fish Species	Calcium	Potassium	Iron	Magnesium *	Sodium	Copper *	Phosphorus	Zinc	Iodine
Schilbe mystus	2632.71 ± 93.01	619.91 ± 53.0	41.50 ±5.30	53.35 ± 5.70	274.34 ± 14.0	1.22 ± 0.40	47.76 ± 2.70	42.14 ±3.70	20.00 ± 1.70
Synodontis clarias	2648.03 ± 80.03	882.0 ± 52.07	93.04± 4.80	223.77 ± 10.8	261.04 ± 10.00	1.41 ± 0.22	23.38 ± 1.70	19.33 ±1.72	40.00 ± 2.76
Mormyrus macrophthalmus	2646.73 ±120.40	737.10 ± 36.00	20.87 ± 2.20	250.11 ± 20.00	269.03 ± 22.03	3.05 ± 1.20	42.38 ± 3.02	20.88 ±1.80	22.55 ± 1.60

Values represents means and standard deviations of duplicate determinations.

* ***No significant difference at P > 0.05***

CHAPTER FIVE

DISCUSSION

The nutritional compositions of *Schilbe mystus, Synodontis clarias* and *Mormyrus macrophthalmus* show that protein was significantly ($p \leq 0.05$) concentrated in the flesh of all the three species 52.29 – 59.19g/100g, followed by the head (36.05 – 49.13g/100g) while least protein was recorded in the bones (2.01 – 3.01g/100g). The protein results compared well with those reported for *Bagrus filamentosus* and *Hydrocynus brevis* (Abolude *et. al;* 2006). The high value of protein in the flesh and head in the three species indicated that they are rich sources of protein to consumers.

The carbohydrate contents were generally low in all the parts studied (head, flesh and bones). The contents recorded in the head were in the range 10.08 – 15.75g/100g and bones with 2.69 – 3.59g/100g. This agrees with the work of Martinez (2000) and Abolude *et. al;* (2006). The low content of carbohydrate in all the species might be due to the conversion of carbohydrate to fat in tissues and organs of the fishes (Love, 1980).

The crude lipid in the flesh (all the three fishes) was in the range of 15.25 – 19.24g/100g followed by the head with 12.02 – 14.37g/100g. This does not conform with the work of Abolude *et. al;* (2006) where high content of lipid was recorded in the head of *B. flilamentosus* and *H. brevis*.

Fatty fish are known to deteriorate due to oxidation of the fat (lipid) content of the flesh resulting in rancidity and off-flavour (FAO, 1977).

Ash content were significantly high ($p \leq 0.05$) in the bones 83.60g/100g – 87.40g/100g) and least in the flesh 3.00 – 7.05g/100g. This also conforms to the work of Abdullahi (2000) and Abolade *et. al;* (2006).

The moisture content in all the three species was generally low in the flesh, head and bones 8.82-11.13g/100g, 7.01-10.17g/100g and 2.24 - 4.17g/100g respectively. This conforms to the work of Abolade *et. al;* 2006). The implication of the high ash contents and low moisture content is that there will be low bacterial and fungal activities leading to better shelf life of the dry fish.

On the aspect of the minerals, calcium was significantly high in the bones 1370-1470mg/100g, followed by the head of all the three species 540.03-657.0mg/100g, least concentration was found in the flesh. The results of this study indicated that calcium was most concentrated in the bony structures (hard tissues) and least concentrated in the flesh (soft tissues) of all the three species. Topping and Eisenberg, (1986) observed that marine fish species show preferential bio-accumulation of metal especially in the bony structures depending on their physiological needs. Hernandez *et. al;* (1990) similarly reported high concentrations of calcium in the bony

structures of marine fish species. Similar trends were also reported by Martinez *et. al;* (2000) and (Abolade *et. al;* 2006).

Phosphorus contents were higher in the bones of all the three fish species in the range of 10.70-15.70mg/100g which agreed with the findings of Martinez *et. al;* (2000) and (Abolude 2006). Sodium 159-201.0mg/100g and magnesium 16.72–56.03mg/100g contents were found to be high in the flesh of all the three fish species which differ from the work of Abolude *et. al;* (2006) where sodium and magnesium were more concentrated in the head and bones, but agreed or supported by the findings of Windom *et. al;* (1987) and Khan *et. al;* (1987) which showed that variations in the concentrations of elements from one sample of fish to another was due to the chemical forms of the elements and their concentrations in the local environments.

Potassium contents were least found in the bones 27.0-150.07mg/100g and higher in the flesh 533-604.0mg/100g this agreed with findings of (Martinez *et. al;* 2000). Zinc and iron were higher in the head of all the three species, while iodine contents were higher in the bones. This is supported by works of Kirchgessner and Schwarz, (1986) who said that within a species of fish, mineral retention depends mainly on the feed and feeding interaction with the environmental water and the total energy supply.

Zinc content was low in the flesh of all the three fish species 5.29-7.29mg/100g. This result is in accordance with those obtained by Elsenberg and Topping (1986) and Gomaa *et. al;* (1995) who studied the distribution pattern of some heavy metals in Egyptian fish organs.

The contents of copper were found to be generally low in the parts of all the fish species 0.12-1.40mg/100g. The mean proximate composition of *Schilbe mystus, synodontis clarias* and *Mormyrus macrophthalmus* indicated that there were no significant differences ($p > 0.05$) in the moisture content of all the three fish species between seasons. The values are comparable with those reported for temperate marine fishes (Abdullahi and Hails, 1983) and those reported for *Cichlidae* and *Claridae* (Abdullahi and Abolude 2000) and those reported for *Bagrids* (Abdullahi and Abolude, 2005) and those obtained in *Malapterurus electricus* (Abdullahi 2005), but higher than those reported for beef ($640g/Kg^{-1}$) lamb ($530g/Kg^{-1}$) and pork ($540/Kg^{-1}$), (Brain and Allan, 1977). Since water constitutes about 70% of every living cell, these fishes showed tendency toward maintaining such levels irrespective of season.

The mean ash content 12.20g/100g was significantly lower ($p \leq 0.05$) during the rainy season and high during the dry season. This agrees with the work of Abdullahi (2002), Abdullahi (2005) and does not conform with the

work of Abdullahi and Abolude (2000) who studied seasonal and location effect on nutrient content of *Cichlidae* and *Claridae and* concluded that ash content were unaffected by seasons of the year. Tzikas *et. al;* (2005) also pointed out that ash content was almost constant during the year in Mediterranean horse mackerel (*Trachurus mediterraneus*). The low mean ash content recorded may be explained by the possibility that absorption occurred during the rainy season and gradually accumulated to its peak during the dry season.

The amounts of organic matter in all the three species were in the range 78.05 – 85.0g/100g and were not significantly difference ($p > 0.05$) in the two seasons. A reason advanced is that organic compounds are being used up for energy rather than being stored, in the course of the fish actively moving around in search of food (Sharer, 1994). Similar findings were reported by Abdullahi (2002), (Abdullahi and Abolude 2005).

The mean values of carbohydrate significantly ($p \leq 0.05$) decreased 10.6 – 8.52g/100g and 12.22g/100g – 10.23g/100g from rainy season to dry season in *Schilbe mystus* and *Mormyrus macrophthalmus* and not in *Synodontis clarias*. Similarly, the lipid content decreased 35.30 – 33.0g/100g) from rainy season to dry season. This was supported by work of

Abdullahi (2005). The decreased carbohydrate and lipid contents may be due to their usage for physiological processes and subsequent starvation period after spawning (Connell, 1980; Pusey and Kennard, 1996). All the fish species studied spawned during the rainy season (Lewis, 1974b; Lowe-Mc-Connell 1987). The high content of carbohydrate (12.77g/100g) during the dry season in *Synodontis clarias* was similarly reported by Abdullahi and Hails (1983) in *Temperate trichogaster*. High content of carbohydrate was also recorded during dry season in *C. auratus* and *C. Laticeps* by Abdullahi and Abolude (2005). Shulman (1984) reported that high carbohydrate content during the dry season might be due to season glycogen level in the blood, liver and muscles of fishes.

The protein content was significantly higher ($P \leq 0.05$) during the dry season in all the three species. It increased from 38.30g/100g during the rainy season to 47.22g/100g during the dry season. This conforms with the reports of Connell (1980); Abdullahi and Abolude (2002); Abdullahi (2005). According to Connell (1980) the low level of protein during the rainy season must be due to its usage for synthesis of various enzymes, hormones and the entire process of egg production. This result is not in accordance with Abdullahi (2002); Abdullahi and Abolude (2005), and Tzikas *et. al;* (2005) who reported high contents of protein during the wet season and Narcisa *et.*

al; (2001) who reported that protein content remained fairly constant during the whole year in horse mackerel (*Trachurus trachurus*).

Substantial differences between seasons were observed in the calcium levels of *Schilbe mystus* and *Synodontis clarias*. The calcium contents are significantly ($p \leq 0.05$) higher 2650.08 – 2637.63mg/100g in rainy seasons in *Schilbe mystus* and *Synodontis clarias* and not affected by seasons in *Mormyrus macrophthalmus*. The higher contents of calcium in rainy season may be due to the fact that during this period, run offs carry dissolved minerals from adjacent land into the larger water bodies and therefore made them readily available to the fish (Abdullahi, 2002).

Potassium contents were significantly higher 884.03mg/100g during the rainy season. ($p \leq 0.05$). The contents of iron are also significantly ($p \leq 0.05$) higher 96.10mg/100g during the rainy (wet) seasons in all the three species. The contents of magnesium were not significantly different ($p > 0.05$) and unaffected by the seasons. Koda *et. al;* (1995) reported that essential nutrient in organism are homoestatically regulated by the species metabolism. This also agreed with the work of Abdullahi (2002).

The contents of sodium are significantly higher ($p \leq 0.05$) in rainy season 270 – 276.37mg/100g than dry season. There was no significant

differences ($p > 0.05$) in the concentration of copper between the two seasons 1.22 – 3.15mg/100g. This agrees with work of (Abdullahi 2002).

The phosphorus contents 25.48 – 49.77mg/100g were significantly higher ($p \leq 0.05$) in rainy season among the three species of fishes. Similarly, the zinc contents among the three species were significantly higher (44.23mg/100g) during the rainy season.

The contents of iodine were significantly different ($p \leq 0.05$) in *Schilbe mystus* and *Synodontis clarias* with high content 22 – 44mg/100g in rainy season. However, there was no significant difference ($p>0.05$) between the seasons 22.55mg/100g in *Mormyrus macrophthalmus.*

Similar seasonal variations in mineral contents were earlier reported in *Skipjack tuna* (Balogun and Talabi, 1986), *Citharinadae* (Abdullahi, 1999), three Nigerian fresh water fishes (Otitologbon *et. al;* 1997); *Cichlidae* and *Claridae* (Abdullahi and Abolude, (2000); *Lates niloticus*, *Heterotis niloticus* and *Gymnarcus niloticus* (Abdullahi, 2002) and in *Malapterurus electricus* (Abdullahi, 2005). Essential minerals are in higher demand for metabolic and physiological activities. Phosphorus, zinc, iron and even calcium are required for enzyme activities and breeding processes

of the fish. This accounts for the higher concentrations of these elements or minerals during the rainy season and or breeding period (Quayam, 1984).

Another reason for higher contents of minerals during the rainy season might be attributed to more nutrients, dietary materials as well as increase in minerals washed into the natural habitats. However, the results contrast the report of Koda *et. al;* (1995) in which essential minerals are said to be homoestatically regulated by species-specific metabolism. Beside the above mentioned factors, a combination of other factors such as size, sex and seasons of the year are other possible reasons for the variability in chemical and mineral composition of the fishes (Adebisi and Fasakin 1997.)

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

The proximate composition of fish is important for easy formulation of diets for both animal and human consumption. With regards to the proximate and minerals composition of the three fish species (*Schilbe mystus, Synodontis clarias* and *Mormyrus macrophthalmus*) it has been observed that protein, lipids, carbohydrate, and moisture contents were more concentrated in the flesh of all the three fish studied, while the ash contents were more concentrated in the bones.

Furthermore, calcium, phosphorus, and iodine were more concentrated in the bones, while potassium, sodium, magnesium were found to be more concentrated in the flesh. Copper and zinc were more concentrated in the head of all the three fish species.

Essential minerals such as calcium, potassium, iron, sodium, phosphorus and zinc were found to be higher during the rainy season, while copper and magnesium were not affected by season. Fats and carbohydrates were also found to be higher in rainy season.

Conclusion

In conclusion, the sampled fresh water fish species: *Schilbe mystus*, *Synodontis clarias* and *Mormyrus macrophthalmus* have great potentials as health food and sources of therapeutic substances. The levels of carbohydrate, protein, lipid and essential minerals present in them indicate that the species could be industrially processed and used as supplement in remedy of health and nutrition problems among the populace. In addition, the higher levels of fat, carbohydrate and essentials minerals during the rainy season make the three species highly desirable for consumption during this period.

Recommendations

From the foregoing, the recommendations are on the utilization of these species :

i. Bony structures such as heads, and bones of fish should be technically processed and incorporated in some foods to increase the level of calcium and phosphorus in the diet of the populace.

ii. The stocking of these fish species in reservoir should be encouraged since they appear to be rich in proteins.

iii. The nutritive values of the three fish species also indicate that they are good candidates for aquaculture in Nigeria.

iv. It is recommended that further research need to be done on the seasonal variations of the proximate and mineral contents of more tropical fish species to enhance their utilization.

REFERENCES

Abdullahi, U and Hails, S. (1983). Temporal changes in fats and protein level in tropical *Anabamantids. (Trichogaster Pectoralis). Journal Fish Biology.* 22:202-213

Abdullahi, S.A. (1999). Nutrient Content of *Citharinus Citharus* and *Citharinus latus.* Family Citharinidae (Geoffery). *Journal of Pure Applied. Sciences. 2:1:65-68*

Abdullahi; S.A. Balogun, J.K. Amen, B.J. and Ibrahim H. (1999) Preliminary Investigation of nutritional value of some species of family Characidae. *Nigerian Journal of Biochemistry and Molecular Biology* 14:26-30

Abdullahi, S.A. (2000) Studies on the nutrient contents of the Fresh water species. *Labeo coubic, Labeo senegalensis* and *Barbus occidentalis*; Family Cyprinidae (Ruppel). *Nigerian Journal of Biochemistry and Molecular Biology,* 15:11:39-44.

Abdullahi, S.A. and Abolude, D.S. (2000). Studies on the effect of season and geographical location on nutrient content of two fish families (Cichlidae and Claridae). *Nigerian Journal of Experimental and Applied Biology*. 12:117-123.

Abdullahi, S.A. and Abolude D.S. (2001). Nutrient levels of three species of Bagridae collected in two seasons and two locations of Northern Nigeria. *Bio Science Research Communications.* 13:3:231-235.

Abdullahi, S.A. (2002). Seasonal and locational variations in the proximate, Amino acid and mineral contents of *Lates niloticus, Heterotis niloticus* and *Gymnarcus niloticus* in Nigeria. *Journal of Agriculture and Environment 3:2:359-366.*

Abdullahi, S.A. (2005). Seasonal study on nutrient variability of the electric cat fish (*Malapterurus electricus (*Gmelin) obtained from three sites of the Nigerian Savanna. *Journal of Tropical Biosciences.* 5:62-65.

Abdullahi, S.A. and Abolude, D.S. (2005). Seasonal levels of some nutrients in the three Bagrids from two localities in Northern Nigeria. *Nigerian Journal of Scientific Research* 5:2:43-47.

Abolude, D.S, Balogun, J.K., Oladipo; MOA, Abdullahi, S.A., Ajibola, V.O. and Ewa; I.O.B. (2006). Proximate and mineral contents of the flesh and body parts of *Bagrus filamentosus* and *Hydrocynus brevis* from Zaria. *Nigerian Journal of Fisheries* 2/3(1) 245-255.

Abolade, F.O., Lawal L.O., Ehikhamen G; Adesanya W.O. and Ashafa S.L. (2006). Chemical composition and functional properties of some prawns from the coastal area of Ondo State, Nigeria. *Electronic Journal of Environmental, Agriculture and Food Chemistry* 1:1-7.

Ackman, R.G. (1989). Nutritional composition of fats in sea food programme. *Nutritional Science.* 13:161-241.

Adebisi, B.M. and Fasakin, E.A. (1997). Flesh yield and Aspects of chemical composition of the flesh of some commercially important fresh water fish species in Nigeria. *Journal of Agricultural Technology (JAT.)*. 4:1:32-40.

Ako, P.A and Salihu, S.O. (2004) Studies on some major and trace metals in smoked and oven dried fish. *Journal of Applied Sciences and Environmental Management.* 8:2:5-9.

AOAC (1980). Association of official analytical chemist official methods of analysis of the AOAC 16th Edn. Washington, D.C. 19:132-136.

AOAC (1990). Association official analytical chemist. Official methods of analysis of the AOAC 17th Edn. Arlington, V.A. U.S.A. 9-140-250.

Babatunde, G.M. and Olayide, S.O. (1980) Natural resources production by Nigerians small earners. *Niger small earners.* CARD Pp. 35-50.

Balogun, A.M. and Talabi, S.O. (1986). Studies on size distribution on skipjack tuna. (*Katsuwonus pelamis*); effect on chemical composition and implications for its utilization. *Journal of Food Technology*. 21:443-449.

Bayagbona, E.O. (1996). Public and Private sector challenges in Nigerian fisheries pages 72 – 74 in: *Proceedings of the 20th Anniversary of Fisheries Society of Nigeria (FISON) Abuja Nigeria*.

Bandarra, N.M; Batista, I; Nunes, M.L; Empis, J.M. and Christie, W.W. (1997). Seasonal changes in lipid composition of sardine (*Sardine pilchardus). Journal of Food Sciences.* 62, 40-42.

Bagrove, E. (2004). Environment impact on Aquaculture production. Retrieved from *www.greenplanet.eolss.net*

Benoit, D.A.; Leornard, E.N.; Christensen, G.M. and Fiandt, J.T. (1976). Toxic effect of cadmium on three generations of brooktrout (*Salvelinus fontinalis*). *Trans. A.M. Fish Society*. 105(4), 550 – 560

Berninger, A. and Pennanen, G. (1994). Contaminated food and uptake of heavy metals in fish. A review and proposal for further research. *Oecologia*. (74) 100 – 102.

Bhuiyan, A.K.M.; Ratnayake, W.M.N.; Ackman, R.G. (1993): Nutritional composition of raw and smoked Atlantic mackerel (*Scomber scombrus*): oil-water soluble vitamins. *Journal of Food Composition and Analysis.* 6: 172 – 184.

Brain, A.F; and Allan G.C. (1977). *Food Sciences. A Chemical Approach.* (3rd edn). 92-341.

Campbell; P.G.C.; Bission M; Boagie, R; Tessler A. and Villeneuve J.P. (1983). *Analytical Chemistry.* 55: 2246.

Connell, J.J. (1980). *Advance in Fish Science and Technology.* Fishing News books, Farnham, Surrey 513p.

Conquers, J. and Holub, B.J. (2002). Human health effects of docosahexaenic acid in: J. Shi, G. Mazza and M.L. Maguer (eds). Functional foods: *Biochemical and Proceeding Aspects.* Vol. 2. CRC Bocaraton. Pp 311-329.

Chatterjee, S; Chattopadhyay, B. and Mukhopadhyay, S.K. (2006). Trace metal distribution in tissues of cichlids collected from waste water fed

fish ponds in East Calcutta. A Ramsar site. *A.I. Et piscatoria.* 36(2): 119-125.

Duncan, D.B. (1955). Multiple range and multiple F – test. *Biometrics.* 42p.

Eisenberg, M. and Topping, J.J. (1986). Trace metal residues in fin Fish from Maryland waters, 1978 – 1979. *Journal of Environmental Science and Health.* B. 21 (1), 87 – 102.D

El-faer, M.Z; Raudal, T.N., Attaar, K.M. and Arab. M. (1992). Mineral and proximate composition of some commercially important fish of the Arabian Gulf. *Food chemistry.* 45: (2): 95 – 98.

Eyo, A.A. (1989). The roles of fisheries technology in the development of fisheries resources in Nigerian in the *Proceedings of two decades Conference in the Kainji Lake basin*, p179.

F.A.O. (1977. Freezing in fisheries. *F.A.O. Fish Tech. Paper* (167) 83p

F.A.O (2000). Post mortem change and handing of caught fish by terushiga moto hiro. *Nigerian Journal of Fishing* 1 (6): 26

Gaal, S; Fiizesi I. and Penzes, B. (1985). Heavy metal content of the fishes in Lake Balaton, Danube and Tisza during the period of 1979 – 1982. *Symposia Biological Hungarica*, 29, 91 – 104.

Gomma, M.N.E.; Abou-Arab, A.A.K., and Badawy, A; Khayria N. (1995). Distribution pattern of some heavy metals in Egyptian fish organs. *Food Chemistry* 53: 385 – 389.

Harris, E. (1979). *Nutritional Research Techniques for Domestic and wild Animals.* S.I. Utah publishing co. utah, U.S.A. 150pp.

Halver, J.E. (1989). *Fish Nutrition* 2nd Ed. Academic press Inc. San Diego California. U.S.A. 280pp.

Hernandez, Z.F.; Medira, J. Ansuategui, J. and Lopez, F.J. (1990). Application, simple procedure of digestion for the determination of trace metals in marine organisms. *Analysis* 18:327-330

Ita, E.O. Omorinkoba, N.S. and Bankole, N.O. (1985). Second post impoundment fishery of Jebba Lake. Kainji Lake Research Institute *1984 Annual Report.* 62-75p

Ita, E.O. (1993). Inland fishery resources of Nigeria. *CIFA occasional paper.* p23

Jeng, C. and Sung. B. (1983). Heavy metals level in fish. *Geochemical Journal.* 31, 345.

Joaquin, R. Gasper, R. Periago, J.P.J Carlos, L. and Josefina, O. (1997). Proximate and mineral composition of dried salted roes of Lake (*Merluccious merluccious, L.* and Ling (*Molva molva, L.*). *Journal of food chemistry.* 63. (2) 221 – 225.

Karakoltsidis, P.A Zotos, A. and constantinides S.M. (1995). Composition of the commercially important Mediterranean. Fin fish, crustacean and mollusces. *Journal of Food Composition and Analysis.* 8 (3) : 258 – 273.

Kent, G. (1984). Fish and Nutrition in India. *Food Policy* 2 (2): 161-175.

Khan, A.H, Ali, M. Blaswas, S.K. and and Hadi, D.A (1987). Trace elements in marine fish from the bay of Bengal. *The Science of the Total Environment.* 61:12-130.

Kirchgessner, M. Schwarz, F.J. (1986). Mineral content (major and trace elements) of carprent protein and energy supplies. *Aquaculture*. 54:3-9.

Koda, K.F.H.; Fchihashi, H. Longhlin T.R.; Baba N.K. and Ryo, T. (1995). Distribution of heavy metals in the muscle, liver and kidney of Northern seal caught in Japan. *Journal of Environmental Pollution* 90: 57-60.

Lake, B. (1984). *Principles of Fish Nutrition and Diet Therapy*. Little Brown. Boston. 176pp

Lewis, D.S.C. (1974a). *An illustration key to fishes of Kainji Lake.* London Crown Agents p25

Lewis, D.S.C. (1974b). The effects of the formation of Lake Kainji (Nigeria) upon the indigenous fish population. *Hydrobiologia Vol. 45*, p2-3

Love, R.M. (1980). *The Chemical Biology of fishes* Academic press. New York. Pp 467.

Lowe-Mc-connel, R.H (1987). Ecological Studies in Tropical Fish Communities. London Crown agents p98-99.

Mathis, B.J. and Cummings, T.F. (1973). Selected metals in sediments water and biota in the Illinois River. *Journal of Water Pollution and Contamination Federation.* 45, 1573-83.

Martinez, I.V. Maria, J.P, Marina S., Gaspar, R. (2000) The content and nutritional significance of minerals on fish flesh in the presence and absence of bone. *Journal of Food Chemistry*. Pp503-509

Mahmut, A.G. Oguz, T. and Mehmet C.S.S.T. (2004). Seasonal variations in proximate and fatty acid compositions of female common sole (*Solea solea*). *Journal of Food Chemistry* 88: 419-423.

Narcisa, M.B. Irineu, B; Maria, L. Jose; M.E. (2001). Seasonal variation in the chemical composition of horse-mackerel (*Trachurus trachurus*). *Food Research Technology.*. 212: 535-539.

Otilogbon, A.A; Agbaje, E.B peters O.A. and Oniye, S.J. (1997). Proximate and mineral composition of three Nigerian fresh water fishes. *Journal of Science and Food Agriculture.* 75: 312-314.

Olsson, G.B; Olsen, R.L; Carlehog, M. and Ofstad, R. (2002). Seasonal variation in chemical and sensory characteristics of farmed and wild Atlantic halibut (*Hippoglossus hippoglossus*). *Aquaculture.* 217 (1-4), 191-205.

Perevoznikov, M.F and Bognadova E.A (1999). *Heavy metals in fresh water Ecosystems.* St Petersburg. 228p.

Perevoznikov, M.F and Bognadova E.A (2004). Pollution impact on Biological Resources of the World Ocean. *greenplanet.eolss.net* pp1-23.

Pujin, V. Djukie, N; Maletin, S. Obaradovic; S. and Kostic D. (1990). Content of heavy metals in some fish species in the section of th Danube flowing through Vojvodina. *Water Science Technology.* 22(5), 79-85.

Pussey, B.J. and Kennard, M.J. (1996). Species richness and geographical variation of assemblage structure of the fresh water fish fauna of the wet tropics region of Northern Queensland. *Marine Fresh Water Research.* 47: 563-573.

Quayam, S. (1984). Levels of constituents of glycoprotein in the pacific salmon. *Journal of Fish Research.* 28: 1173-1179.

Rajan, M.R.; Balasubramanian, S; and Raj. S.P. (1994). Accumulation of heavy metals in sewage-grown fishes. *Journal of Biological Resources Technology.* 52: 41-43.

Shulman, M. (1984). *Biochemical Circles in Fish.* John Wiley and sons, Landhulsted, New York. Pp 20-31.

Sharer, K.D. (1994). Factors affecting the proximate composition of cultured fishes with emphasis on Salmonids. *Aquaculture.* 119, 63-88.

Stripp, B; jense A, Geiger, W. (1990). Trace metal residues in yellow perch (*Perca flavescens*) from Maryland. *Journal of Environmental Science and Health.* 23(2) 61-67.

Tacon, A.G.J. (1993). Feed ingredients for warm water fish. Fish meal and other processed feedstuffs. *FAO Fisheries Circular.* No 856. Rome FAO 64p.

Taylor, C.G; Bauman, P.F, Sikorski, B, Bray, T.M (1992). Evaluation of lung glutathione by oral supplementation of L-2-oxothiozotidine-4-carboxylate protecting against oxygen in protein energy malnutrition rates. *FASEB T.J. 6:3010—3107*

Taylor, C.G; Alan, J.P.; Peter, R.S (1997): Splenocyte glutathione and D3 mediated cell proliferate reduced in mice fed a protein deficient diet. *Journal of Nutrition. 127: 1: 44-50*

Tobor, J.G (1984). A review of the fish industry in Nigeria and status of fish preservation methods and future growth pre-requisites to cope with anticipated increase in production. *NIOMR Technical Paper. 17:14pp*

Topping, J.J. and Eisenberg, M. (1986). Trace metal residues in fin fish from Maryland waters, 1978-1979. *Journal of Environmental Science and Health.* B. 21(1) 87-102.

Tzikas, Z.; Amvrosiadis, I., Soultos, N., and Georgaki S. (2005). Seasonal variation in the chemical composition and microbiological condition of Mediterranean horse muscle from the North Aegean sea (Greece). Retrieved from *www.sciencedirect.com*

Umar, R. (2006). Growth performance and feed utilization of *Nile tilapia* fed different levels of (*Senna occ*identalis *linneaus)* seed diet. *M.Sc. Fishery unpublished thesis*. A.B.U. Zaria, Nigeria.

Vigh, A.; Barron, M.G. and Reid, S.D. (1996). Comparison of heavy metal concentrations of grasscarp (*Ctenopharyngodon idella cuv. etval)* in a shallow eutrophic Lake and fish pond. *Journal of Water Pollution Control Federation*. 80: 1573-1583.

Wiener, j.G. and Giesy, J.P (1979). Concentrations of cd, cu, mn, p6 and zn in fishes in a highly organic soft pond. *Journal of Fish Research Board of Canada*. 36, 270-9.

Windom,H;Stein,D;Sheldon,R;andSmith,R.(1987).Comparison of trace metal concentrations in muscle of benthopelagic fish(*Coryphaenoic des armatus*)from the atlantic and Pacific oceans. *Deep sea Research*.34(2):213-220.