Sudan University of Science and Technology
College of Graduate Studies

Comparative Evaluation on Nutritive Value of Wild and Farmed African Catfish *Clarias gariepinus*

مقارنة تقيمية الغذائية لأسماك القرموط الأفريقي من المصادر الطبيعية والمستزرعه

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Declaration

I, the signing here-under, declare that I'm the sole author of the (M.Sc.) thesis entitled Comparative Evaluation on Nutritive Value Of Wild and farmed African Catfish Clarias gariepinus

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إقرار

أنا الموقع أدناه أقر بأنني المؤلف الوحيد لرسالة الماجستير المعنونة مقارنة تقييمية الغذائية لأسماك القرموط الأفريقي من المصادر الطبيعية والمستزرعة

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Dedication

This thesis is dedicated to soul of my late father; Okuki Deng Lual; and beloved mother Lucia Nyingok Ajak; and my loved wife; Alak Othom Ajang; to my daughter Esta Obany Okuki; Dikwan; Pouc for their love and encouragement and patience during the period of the studies.

It is also dedicated to my brothers and sister who have been through thick and thin by walking throughout this wonderful journey with me.

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ABSTRACT

The percentage yield, fillet chemical composition and mineral elements of wild and farmed male and female African catfish *Clarias gariepinus* are presented. Farmed males yielded 42.73% fillets compared to 49.86% for wild males, 51.11% for wild females and 46.86% for farmed females. Female gonadal mass strongly influences dressout percentage.

Result of proximate composition as percentage in moisture, fat, ash, crude protein, dry matter, nitrogen free extract were examined as parameters of fish flesh quality in both farmed and wild sample. The fillets of both farmed and wild males and females have significantly different ($p < 0.05$) in moisture (72.8% and 75%), dry matter (26.7% and 25%), protein (30.9% and 30.9%), Ether extract (8.4% and 8.1%), ash (1.7% and1.3%), nitrogen free extract (31.9 % and 34.5%) farmed and wild. But the chemical composition profiles within type were not influenced by sex.

Levels of the Macro elements (mg/l), phosphorus, potassium, manganese, sodium and calcium, and micro elements (mg/l), iron and Zinc different significantly between type and between sexes within type. No significantly differences were noted for calcium, magnesium, zinc, iron and potassium ($p < 0.05$).The mineral content of *Clarias gariepinus* fillets; farmed and wild (mg/L wet weight fillet) as percentage is Ca (4.02 and 4.32); P (2.87 and 2.80); Mg (2.65 and 2.56); Na (4.32 and 4.34); K (3.76 and 4.07); Fe (1.72 and 1.09) and Zn (0.096 and 0.097), Standard method of AOAC (1990).

ملخص البحث

تناولت الدراسة الخصائص الوزنية ، التركيب الكيميائي و الأملاح المعدنية للحوم الصافية لذكور وإناث أسماك القرموط الأفريقي الطبيعي و المستزرع . نسبة اللحوم الصافية لذكور القرموط المستزرع (42,37%) مقارنة بنسبة (49,86%) للذكور الطبيعية ، بينما بلغت نسبة لحوم الإناث الطبيعية (51,11%) مقابل (46,86) للإناث المستزرعة .

نتائج التحليل التقريبي كنسبة مئوية للرطوبة ، الدهون ، الرماد ، البروتين ، المادة الجافة و المستخلص الخالي من النيتروجين كمقاييس لجودة لحوم الأسماك الطبيعية و المستزرعة . تتباين لحوم ذكور و إناث اسماك القرموط المستزرعة و الطبيعية بدرجة معنوية ($P<0.05$) في نسبة الطوبة (72,8 – 75%) ، المادة الجافة (26,7 – 25%) ، البروتين (30,9 – 30,9%) ، الدهون (8,4 – 8,1%) ، الرماد (1,7 – 1,3%) و المستخلص الخالي من النيتروجين (31,9 – 34,5%) . بينما التركيب الكيميائي لأسماك البيئة الواحدة لم يتأثر بالجنس .

مستوي تركيز العناصر المعدنية الثقيلة (ملجم/لتر) للفوسفات ، البوتاسيوم ، المغنزيوم ، الصوديوم و الكالسيوم ، و العناصر الخفيفة (ملجم/لتر) للحديد و الزنك تختلف معنويا فيما بين النوع و الجنس . بينما لم تلاحظ اختلافات معنوية ($P> 0.05$) للكالسيوم ، الماغنزيوم ، الزنك ، الحديد و البوتاسيوم . بلغت نسبة التركيب الوزني للعناصر المعدنية للحوم اسماك القرموط الطازجة (4,02 – 4,32%) للكالسيوم ، (2,78 – 2,80) للفسفور ، (2,65 – 2,56%) للمغنزيوم ، (4,32 – 4,34%) للصوديوم ، (3,76 – 4,07 %) للبوتاسيوم ، (1,72 – 1,06%) للحديد و (0,096 – 0,097%) للزنك للأسماك المستزرعة و الطبيعية على التوالي ، وفقا للطريقة القياسية للمجلس الحكومي للتحاليل الكيميائية (1990) .

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CHAPTER ONE

INTRODUCTION

1.1 Back ground of the study

Fish is one of the most important foods and is valued for its nutritional qualities. Fish protein is a good source of high quality protein containing essential amino acids in the amount and proportion required for good nutrition. It also provides a good source of vitamins and minerals **(Onyia. *et al,* 2013).** It will also enhance the proper mental and immunity development against disease among growing children **(NAFDAC., 2003).** In low-income countries, staple foods such as rice, wheat, maize, and cassava make up the bulk of the food consumed by people and they supply majority of energy. However, some essential nutrients (essential amino acids and micronutrients) are not found in these staples. These important nutrients can be supplied by fish because they contain very light connective tissue **(Eyo., 2001).** The measurement of some proximate profiles such as protein contents, carbohydrates, lipids, moisture contents and ash percentage is often necessary to ensure that they meet the requirements of food regulations and commercial specifications **(Watermann., (2000).** Mineral elements are basic requirement of all living organisms. Some minerals are essential elements but these essential metals may be toxic at their high concentration in body of animals **(Tyrrell *et al.*, 2005).** The most important micro-nutrients in form of mineral salts include calcium, sodium, potassium, phosphorous, iron, chlorine while many others are also needed in trace amounts.

The deficiency in these principal nutritional mineral elements induces a lot of malfunctioning; as it reduces productivity and causes diseases, such as inability of blood to clot, osteoporosis, anemia etc. **(Shul'man., 1974 and Mills, 1980).** Fish is an indispensable source of micronutrients, such as iron, iodine, zinc, vitamin A and B **(Haruna., 2003; World Fish Centre, 2005)**. The measurement of some nitrogen free extract and crude fibre is often necessary to ensure that they meet the dietary requirements and commercial specification **(Onyia *et al*., 2010)**.

Preliminary estimates for 2005 global capture production indicate that in land water catches have increased by almost 0.4 million tones and marine catches have decreases by over 1.5 million tones **(Non., 2006**). However, less than one third of the marine captured production last in **2005** in comparison with **2004** can be attributed to be high variability of Peruvian anchovies, as total catches of all over marine species combined were reduced by about 1 million tones **(Non., 2006).** Aquaculture production contribution to global supplies of fish, and other aquatic animals continued to grow, increasing from 3.9% of total production by weight in **1970 to 27.1%** in **2000** and **32.4% in 2004** (**Non., 2006).**

Africa and Asia continue to contribute about 90% of the world total and their shares are fairly stable **(Non., 2006)**. Only recently Sudanese have adopted a taste and acceptance of fish as food **(Ali.,1994),** more than 70% of the actual fish production is consumed fresh (basically caught from the white Nile, Jebel Aulia reservoir and Lake Nubia) Catches predominated by tilapia, lates and Bagrus , as its

Clarias gariepinus ,followed by *labeo, synodontis* and catfishes mainly(*Clarias sp ,Auchenoglanis sp).* Act as the second grade. A total of, 25 families and 123 species are the recent records for inland water fishes in Sudan **(Ali. 1994).** The study of chemical composition of fish is an important aspect of fish flesh quality since it influences both keeping quality and the technological characteristics of the fish **(Huss, 1988).**To compare the chemical analytic composition of farmed fish with their natural counter parts is complex, study should be emphasized with more specialized geographical influence with diet playing an important role **(Malcolm lea., 1968 - 1977).** culture fish tend to be deficient in body protein and ash and that they almost always contain more lipid than do wild fish, such lipid being the more saturated.

1.2 Justification of the study

In understanding how *clarias gariepinus* adapt to changes in environment and been one of most important aquaculture species it`s important to study the nutritive value of farmed and wild clarias gariepinus to provide good indicator physiological and farmed sample. This information will help the understanding nutritive value of farmed.

1.3 Significance of the Study

Clarias gariepinus is generally considered to be one of the most important tropical catfish species for aquaculture. It has an almost Pan-African distribution, ranging from the Nile to West Africa and from Algeria to Southern Africa.

It provides food for the populace, it allows for improved protein nutrition because it has a high biological value in terms high protein retention in the body, higher protein assimilation as compared to other protein sources, low cholesterol content and one of the safest sources of animal protein.

1.4 Overall objective

to compare the proximate composition and mineral elements of wild and cultured *Clarias gariepinus* collected from different environments.

1.4.1 Specific objectives

1. To evaluate body characteristics and filleting yield induce among cultured and wild of African catfish *Clarias gariepinus*.
2. To the compare of chemical composition and biometry measurements of wild and cultured African catfish *Clarias gariepinus*.
3. To determine mineral elements such as macro **(i.e. Mg, Na, K, P, Ca),** and micro elements which represent **Fe and Zn** respectively.

CHAPTER TWO

LITERATURE REVIEW

2.1 General:

Fish is known to be the best and cheapest source of animal protein of very high digestibility and nutritive value. In general the biochemical composition of the whole body indicates the fish quality. Therefore, knowledge on biochemical composition of fish finds application in several areas. Due to an ever-increasing awareness about health foods, fish is finding more acceptances because of its special nutritional qualities. Fish is one of the most important components of feed for animals and human beings, because of their excellent nutritional profile and easily digestible characteristics. Precise information on the biochemical composition of fishes is necessary not only for the purpose of formulating fish feed of animals, but also for the purpose of processing and preservation of fish and fishery products for their export and other important means for human food, medicine and for industries. Chemical composition of fresh fish varies greatly from one species and from one individual to another depending on age, sex, environmental conditions and seasons **(FAO., 1986).**

2.2 Biological factors and Characteristics

Clarias gariepinus is generally considered to be one of the most important tropical catfish species for aquaculture. It has an almost Pan-African distribution, ranging from the Nile to West Africa and from Algeria to Southern Africa. They also occur in Asia Minor (Israel, Syria and South of Turkey).

The commonest *Clarias* in the Sudan found in vegetated fringes of rivers and lakes, isolated pools irrigation and sewage effluent canals. It is a major floodplain swamps migrant; it feeds on crustaceans, insects and small fish **Baliy., (2004).** *C. gariepinus* is characterized with naked skin and elongated body form with fairly long dorsal and anal fins. The dorsal fin has 61-80 soft rays and the anal fin has 45-65 soft rays. They have strong pectoral fins with spines that are serrated on the outer side Nwuba LA, **Aguigwo., (2002).**

It posses nasal and maxillary barbels and somewhat smallish eyes. Their colouring is dark grey or black dorsally and cream coloured ventrally. Adults posses a dark longitudinal lines on either side of the head; however, this is absent in young fish. Adult's heads are coarsely granulated, while the head is smooth in the young. The head is large, depressed, and heavily boned. The mouth is quite large and sub terminal **(Skelton, 1993).**

In *Clarias gariepinus*, exchange of respiratory gases (i.e. oxygen and carbon dioxide) takes place through the gills. Like any other mudfish, it has accessory breathing (arbores cent) organ which enables the fish not only to live in stagnant pools but to travel over damp ground.

Clarias gariepinus differs from other catfishes in having an auxiliary breathing organ in this special pocket 16 attached to the second and fourth gill arches and are responsible for the ability of *Clarias gariepinus to* live out of water much longer than other catfishes **(Haylor., 1993).**

2.3 The African Catfish

2.3.1 Classification of African catfish

Kingdom : *Animalia*

Phylum : *Chordata*

Sub- phylum : *Vertebrata*

Class : *Osteichthyes (Actinopterygii)*

Family : *Claridae*

Order : *Siluriformes*

Sub-order : *Siluroidei*

Genus : *Clarias and Heterobranchus*

Species : *Clarias gariepinus*

There are over hundred species in this family occurring naturally throughout most of Africa and the Southern half of Asia to Java and the Philipines **(Little. *et al*., 1999)**.

2.3.2 Ecology and Physiology

Clarias gariepinus live in a variety of freshwater environments, including quiet waters like lakes, ponds, and pools. They are also very prominent in flowing rivers, rapids, and around dams. They are very adaptive to extreme environmental conditions and can live in pH range of **6.5-8.0.**

Also they are able to live in very turbid waters and can tolerate temperatures of 8-35 degrees Celsius. Their optimal temperature for growth is **28-30** degrees Celsius **(Verreth., 1993).** African catfish are relatively poor swimmers that spend most of the time on the bottom of lakes and rivers **(NASS., 2010).** They are, however, able to move across land to another water source during damp conditions **(Skelton, 1993).**

They simply extend their strong pectoral fins and spines and begin crawling through shallow pathways. They are bottom dwellers and do most of their feeding there. They are also obligate air breathers, which mean they do spend some time on the surface. This species can live in very poorly oxygenated waters and is one of the last species to live in such uninhabitable place **Eyo JE, Mgbenka B.O (1992).**

They are also able to secrete mucus to prevent drying and are able to burrow in the muddy substrate of a drying body of water **(Skelton., 1993).**

Clarias gariepinus attains sexual maturity at about twelve months in pond culture system and about thirty months in the wild. They show seasonal gonadal maturation associated with rainy season; annual changes in photoperiodicity and a raise in water level. They participate in mass spawning and lay their eggs in vegetation. The larvae are able to swim and are able to feed within 2 or 3 days. Growth is very rapid, with males reaching an ultimately larger size than females **(NASS., 2010).**

Owing to seasonal gonadal maturation, artificial propagation is adopted in order to have mass production of the fish all year round.

Clarias gariepinus is an important Aquaculture species because of:

- Excellent adaptation to ambient climate.
- High growth rate and very efficient feed conversion ratio.
- Ability to mature and remain gravid throughout the year in captivity.
- Acceptance of relatively cheap feeds.
- High fecundity potential for all year round induction of final oocyte maturation.
- Ability to support high population density under culture conditions.
- Disease resistance.
- Consumers' acceptance. **(Haylor, 1993 and Pillay, 1990).**

2.3.3 Description of the Genus and Species

The catfish genus can be defined as displaying an eel shape, having an elongated cylindrical body with dorsal and anal fins being extremely long (nearly reaching or reaching the caudal fin) both fins containing only soft fin rays.

The outer pectoral ray is in the form of a spine and the pelvic fin normally has six soft rays. The head is flattened, highly ossified, the skull bones (above and on the sides) forming a casqued and the body is covered with a smooth scaleless skin.

The skin is generally darkly pigmented on the dorsal and lateral parts of the body. The colour is uniform marbled and changes from greyish olive to blackish according to the substrate. On exposure to light skin the colour generally becomes lighter It has four pairs of unbranched barbels, one nasal, one maxillar (longest and most mobile) on the vomer and two mandibulars (inner and outer) on the jaw. Tooth plates are present on the jaws as well as on the vomer.

The major function of the barbels is prey detection. A supra-branchial or accessory respiratory organ, composed of a paired pear-shaped air-chamber containing two arborescent structures is generally present. These arborescent or cauliflower-like structures located on the secondhand forth branchial arcs, are supported by cartilage and covered by highly vascularised tissue which can absorb oxygen from atmospheric air **FAO., (1990).** The air chamber communicates with the pharynx and with the gill chamber.

The accessory air breathing organ allows the fish to survive for many hours out of the water or for many weeks in muddy marshes. The most common habitats frequented are floodplain swamps and pools in which the catfish can survive during the dry seasons due to the presence of the accessory air breathing organs **Eyo and, Mgbenka.,(1992).**

2.3.4 Natural Food and Feeding

Although numerous studies on the food composition of *Clarias gariepinus* have been carried out, a consistent pattern has not emerged and they are generally classified as omnivores or predators **FAO., (1990).** Examined catfishes from the river Ubangui (Central African Republic) and found that *Clarias lazera (Clarias gariepinus*) fed mainly on aquatic insects, small fish and debris of higher plants.

They also feed on terrestrial insects, mollusc and fruits. Similarly, **Verreth., (1993)** found that catfish in Lake Sibaya (South Africa) fed mainly on small larvae fish or crustacean, and that terrestrial and aquatic insects were an important part of the diet of juvenile and adult fish which inhabit shallow areas. However, molluscs, diatoms, arachnids, plant debris were the minor food items consumed in this lake. **Gaffar ., (1996)**, studied the feeding habits of *Clarias gariepinus* in Lake McIIwaine (Zimbabwe) and found that feed composition changes as fish became larger. Diptera, particularly *chironomid pupae*, predominate in the diet of the smallest group but become progressively less important with increasing size.

Zooplankton became more important with increasing size and predominates in the diet of the largest fish.

Most of the minor food groups also showed a progressive increase or decrease in importance in relation to increasing size. The greater importance of zooplankton in the diet of large fish was believed to be due to the increased gape and number of gill rakers of the larger fish **Gaffar., (1996).**

2.4 Fillet yield

Filleting implies removal of bones and fins from the flesh. Filleting and trimming are important for logistics, economics, and addition of value along the marketing chain and for separation of edible part from the inedible ones. Filleting can be done either by machine or by hand. Hand filleting is labor intensive and time consuming **(Rørå *et al.*,(2001).** Therefore most large companies use machines for filleting. Fillet yield is the ratio between fillet weight and carcass weight and is a measure of the edible part of the body.

Weis., (1953) reported that the edible fraction of the different fish species varies widely between 30% - 50% of total weight. Furthermore **Finne.*et al*., (1980)** Found that the yield of deboned flesh of some of finfish species from Gulf of Mexico varied from a maximum of 31.3% to a minimum of 20.0%.

However **Babiker (1981**) studied some of the Nile fish and revealed that the edible portion of the fish flesh ranges between 50% - 60%.

Also **Clement and Lovel. (1994)** Reported that the fillet yield of *Oreochromis niloticus* and *ictalurus punctatus* ranges between 25.0 and 30.9%. The fillet yield was found to vary from one species to another, and was related to the specific anatomical make – up of the species, since that the size of each individual did not greatly influence fillet yield **(Gall *et al*., 1983).**

Ali *et al*., (1996) Studied body characteristics; yield assessment and proximate chemical composition of commercial fish species namely *Lates niloticus, O.niloticus, Sarotheradeo ngalilaeous, Labeo niloticus and Labeohorie*. The findings of body characteristics and yield indices revealed clearly decrease percentage in the order of fillets, heads, skeletons, viscera and skin for *Tilapia spp*. Compared to order of fillets, skeletons, viscera, head and skin for *Labeo spp*, respectively. More data were established by **Osman., (1995).**

Regarding body structure, yield indices and physical analysis of *Labeo niloticus* from commercial landings. The findings showed that the percent of body structure and yield indices were decreased in the order of fillet, skeleton, head, skin and viscera.

Consequently **Adam., (1996).** Found that fillet percentage ranged between 40 and 46%, and expressed that all species under investigation were organoleptically acceptable to the panelists.

Mac., (1996) studied body weight characteristics and chemical composition of some fish species from Lake Nubia, he found that body weight characteristics had clearly showed percentage of viscera, skeleton , head and fillet significantly differ ($p<0.01$ or $p<0.05$) among the treatments .

Jock, (1996), in his study on the percentage of fillet, head, viscera and skeleton of four different fish species (*Bagrus bayad, Bagrus docmac Barbusbynni and Synodontis spp*) at Nubia Lake, was as follows 46.86%, 5%, 4.48% and 20% - 45.90%, 27.83%, 5%&15.67% - 44.80%,13.04%, 7.37% and21.36% 43.3%, 14.17%, 11.40% and 18.43% respectively.

Siham., (1999) Showed that the percentages of head, viscera, skin, skeleton and fillet of *Protopterus aethiopicus, Malapaterurus electricus and Tetraodon fahakha* bought from Elmorada fish market were as follows 16.59%, 10.88%, 28.99%,10.26% and 29.2 - 19.26%, 17.9%, 16.02%, 13.35% and 27.29% - 5%, 24.58%, 13.76%, 21.66%, 6.61% and 30.56% respectively.

Mac., (1992) carried out the meat quality, yield and nutritional value determination of Oreochromis niloticus and Sarotherodon galilaeous. He found that the body characteristics of these species have the decreasing order of fillets, skeleton, head, viscera and skin. In a similar study , the body weight characteristics and filleting yield indices revealed clearly a decrease percentage in the order: fillet, head, skeleton and viscera for *B. bayad, B. docmac* and *Synodontis sp.*

While the percentage decrease order for *Barbus bynni* and *Labeo coubie* was fillet, skeleton head, viscera and skin. These results were in agreement with **Eyo., (1991)**, **obanu and Ikeme., (1988)** and **Ali *et al*., (1996)**.

The filleting yield of the studied fish species was a reflection of their anatomy i.e. species with large heads and skeleton relative to musculature give lower filleting yield than those with smaller heads and skeletons **(Eyo., (1989) and Ali *et al*., (1996).**

Generally, the percentage of body components of inedible parts (skin, skeleton, viscera and head) of the fresh water fishes was in most cases, higher than the edible parts (fillet). Since these inedible body components are usually discarded except for a few considerations where heads and skeletons are eaten, the purchaser may thus suffer economic loss. Therefore, the use of such inedible parts for manufacture of fish silage or fish meal in different fisheries sectors is suggested.

As with many animal products, fish and fishery products contain water, proteins and other nitrogenous compounds, lipids, carbohydrates, minerals and vitamins. However, chemical composition of fish varies greatly from one species and one individual fish to another depending on age, sex, environment and season **(Huss., 1988).**

Zaitsev. *et al*., (1969) conducted studies on fish curing and processing. They mentioned that the food value of fish is normally estimated only approximately according to amount of edible material (flesh) and its content of the basic nutrient (protein and fat).

According to **Babiker., (1981)** As a findings of his study of different genera of Nile genera of the Nile fish. He found also that a high relative proportion of tissue fat is indicative of high energy yield from the tissue; but from a nutritional point of view an overabundance of fat is negative feature.

2.5 Biochemical Composition of Fish

Fish is widely accepted because of its high palatability, low cholesterol and tender flesh **(Onyia *et al.*, 2010).** However, less number of consumers eats fish because of its nutritional value. It is therefore necessary to make information available to consumers and fishery workers on the nutritional contribution of some fish species in their diets **(Adewoye *et al.*, 2005).**

Proper knowledge on the biochemical composition of fish finds application in several areas. Today there is an ever-increasing awareness about healthy food and fish is finding more acceptances because of its special nutritional qualities. In this context a proper understanding about the biochemical constituents of fish has become a primary requirement for the nutritionists and dieticians. Fish and fishery products are used in animal feeds. In this case also, proper data on the biochemical composition is essential for formulating such products. ***Ganai*., (2012).**

Another vital area where accurate information on biochemical composition is a must is processing and preservation of fish and fishery products. Fish is an easily perishable commodity and deterioration in quality is due to the changes taking place to the various constituents like proteins, lipids etc. Information on the biochemical constituents will help a processing technologist to define the optimum processing and storage conditions, so that the quality is preserved to the maximum extent. ***Ganai*., (2012).**

Biochemical studies on fish muscles have drawn attention of several researchers as muscles are the major source of protein, lipids and carbohydrates **(Joshi *et al*., 1979)** and being the main energy reserves. The importance of such studies is to express the food value in terms of energy units **(Qasim., 1972).** The most exhaustive work on biochemical composition of fish has appeared from many countries of the world. Most notable references are those of (**Atwater., (1888),** his work covered about 53 species of American food fishes, since then considerable use of his work have been reported. It has been used by chemists and biologists.

Second notable work related to the fish biochemical composition was of **Clark and Almy., (1918)**, who analyzed large number of fishes at Atlantic coast. They reported for the variation seen in the biochemical composition of fish with seasons.

Love and Wood., (1937) work on fat metabolism of Herring. Love later revealed the chemistry of fish in his two books namely, 'Chemical Biology of Fish (1970-1980)'. On the basis of this Love is regarded as father of Fish Biochemistry.

Although several studies on the biochemical composition of many commercially important fishes have been reported from many countries of the world including Sudan such as **Mahmoud., (1977)** studied the meat quality of some common Nile fishes. He reported that the proximate composition of the fish species were in the range of 63.29 - 75.19 %, 14.99 – 22.01 %, 0.36 – 2.50 %, and 0.45 -1.94 % for Moisture, protein, fat and ash respectively. He also found that the females do showed more moisture, fat, ash, and less protein content than males.

Iskander., (1982) carried out studies on preliminary evaluation of the nutritional constituents of the commoner Nile Fishes (*Tilapia, Lates, Labeo, Bagrus, Synodontis and Schilbe species*). He reported that the protein content was between 15.27 and 21.39 %, and 15.37 and 20.82 % for the pectoral and caudal regions respectively. The fat content was ranged between 1.36 – 3.83 % and 1.22 – 3.63 % for pectoral and caudal regions respectively. Moisture content was found to be ranged between 78.75 – 79.71 % and 78.11 -80.20 % for the pectoral and caudal regions respectively.

According to **Omer., (1984)** carried out a preliminary study on chemical composition of the flesh of *Hydrocyon forskali*, he concluded that the proximate composition was77.47 % moisture, 17.34 protein, 1.43 % fat and 1.44 ash in fresh respectively.

Awouda., (1988) Studied the body composition of adult *Oreochromis niloticus* and *Alestes dentex* from white Nile at Khartoum area with special reference to season changes and gonadial maturity, **El Tay., (1994)** studied the chemical composition and quality grading of three fish species as related to environmental conditions in the blue Nile.

Salih (1995) studied the body structure, yield indices and physical analysis of Labeo niloticus , from commercial fish landing at Khartoum, and mentioned that, the fillet yield of this fish species is about 37 % of the total weight.

Ali, *et al*., (1996) studied body characteristics, yield and chemical composition of Labeo spp. They found that the results of the proximate chemical composition were 76.7%, 19.3%, 2.1% and 1.6% for moisture, protein, fat and ash respectively.

Adam, H (1996) stated, in his study on the body weight characteristics and physical composition of some fish species from Nuba lake, that the chemical composition was as follows: (14.99- 22.01%) protein, (0.36- 2.5%) ash and (63.29- 75.19%) moisture.

Jock, (1996) stated that, the chemical composition of five different fish species from Nuba lake were as follows: Bagrus sp, Domak sp, Barbus bynni, cadan sp and Synodontis spp. 18.8%,19.64%, 19.57%, 17.87% and 19.37% protein respectively, 1.99%, 1.77%, 2.75%, 1.95% and 2.56% fat respectively, 0.93%, 1.02%, 1.01%, 1.12% and 0.2% ash respectively.

Siham, (1999) study on the chemical composition of three different fish species (Protopterus aethiopicus, Malapaterurus elcctricus andTetradon fahakh) from Almawrada fish market, revealed that the protein percentages of the three fish species were as follows: 20.89%, 20.4% and 20.6% respectively. The fat content was 0.15%, 2% and 0.36% respectively. Ash content was 2.89%, 1.56% and 0.51% respectively.

2.6 Muscle structure and composition

The skeletal muscle (fillet) is the major part of the edible portion of fish. Unlike mammals and birds, whose skeletal muscles are arranged in very long bundles of fibers, the muscles of fish are shorter and arranged in muscle sheets which are termed myotomes or myomeres **(Brown., (2001).**These sheets run parallel adjacent to each other by making a complex W shaped folded structure along the fillet (Fig 2.1). The myotomes are connected to each other by several thin membranes made up of connective tissue (myocommata).

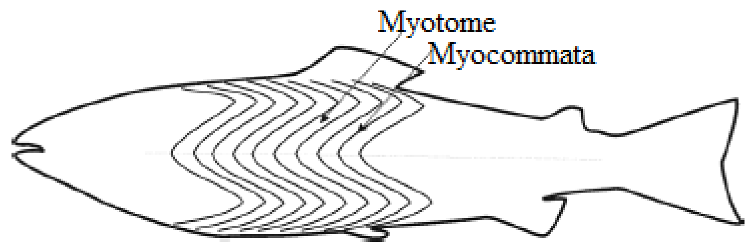

Fig (2.1): Schematic illustration of arrangement of myotomes and myocommata (Kiessling *et al.* 2006)

In almost of all adult fishes, the muscle fibers of the myotomes are mainly of two different kinds; red (slow) and white fibers (fast) which are easily distinguished in fish. The red muscle fibers are used for constant speed swimming and white muscle fibers used when fish to swim rapidly. The red muscle has smaller diameter than white muscle i.e., 20-50% of white muscle fibers **(Bone .*et al*.,(2008).** The red muscle is rich in myoglobin, mitochondria as compare to white muscle.

Fish muscle structure holds water, protein and other nitrogenous compounds, lipids, carbohydrates, vitamins and minerals. The chemical composition of muscles varies from species to species, and also within specie the variation can be substantial. The main structural factors that contribute to tenderness are muscle structure, amino acid content and collagen **(Brown.,(2001).**

2.7 Fish Quality

Fish quality is a very difficult concept to explain due to the variety of factors that must be considered. Population, fish species, spawning period, season, nutrition, post-harvest handling, and storage are some of the key factors that will impact the quality of a fish product **(Kinsella., (1988) and Nielsen *et al*., (2002).**

Quality of fish involves nutritional, microbiological, biochemical and physicochemical properties, however, consumers will decide to buy a fresh seafood product based solely on its "freshness". To determine freshness of a fish product, consumers use their senses for evaluation and will make a decision based on appearance (color, surface appearance) aroma, flavor and texture. Sensory analysis is considered to be the most important tool to determine freshness of a fish product by inspection services and fish industry in the European Union **(Parisi *et al*.,(2002).**

The most important indicators of flesh quality are: safety, fat content and distribution, color and texture **(Gill., (1990)**, however, nutritional factors such as n-3 (omega-3) fatty acids and mineral content (essential and heavy metals), also will play important roles in quality attributes.With the introduction of farmed fish into the market, a variety of differences in their composition and quality have been observed when compared with their wild counterparts. The most common difference between wild and farmed fish is the fillet lipid content **(Haard., 1992a, and Rasmussen., (2001).**

2.7 Proximate Composition of Fish

Proximate composition of fish involves the determination of moisture, lipid, protein and ash content. Carbohydrate is determined by difference. The proximate composition of fish is affected by a diversity of factors such as: size, sexual maturation, temperature, salinity, exercise, ration, time and feeding frequency, starvation, type and amount of dietary ingredients **(Shearer., (1994).** Protein and ash contents do not vary as often as lipid, since it is not impacted by diet, but mainly is determined by the species type, genetic characteristics and size **(Haard., (1992a), Shearer., (1994), Morris., (2001).**

Lipid content of fish flesh, on the other hand, is directly related to the nutrition of the fish. When comparing wild and farmed fish, higher lipid contents are found in farmed fish mostly because of the accessible and well formulated diets **(Higgs *et al*., (1989); Nettleton and Exler., (1992); Rueda *et al*., (1997); Cox and Karahadian., (1998); Alasalvar *et al*., (2002); Grigorakis *et al*., (2002); Grigorakis *et al*., (2003); Jankowska *et al*., (2003); and Orban *et al*., (2003).**

The lipid content of wild fish, however, cannot be manipulated by the fisherman and will be mainly influenced by the prey type and availability, among other factors (**Haard., 1992a**). The importance of nutrition in farmed fish is enormous and enables farmers with a powerful tool to design products that can not only impact human health positively, but also generate products preferred by consumers.

In short, proximate body composition is the moisture, protein, fat, and ash contents of the fishes. Therefore, the precise information about these biochemical constituents of fishes are necessary for the formulation of animal feed, fish feed, fish industry, human health, nutritionists, pharmaceuticals, chemists etc.

2.7.1 Fillet Moisture

The moisture content in the body and throughout the life span does not seem to be constant in view of the inter – relationships with many biological and physiological factors. Early instability in the juvenile stage and subsequent stability was mentioned by **parker and Vanstone., (1966).** The variation coinciding with the spawning season by **love., (1960),** and the inverse relationship between level and lipid content in the body by **Shearer., (1994), Clucas and Ward., (1996)** reported that, flesh from healthy fish contained 70–80% water.

2.7.2 Fillet Protein

Muscle protein are divided into three groups based on their solubility properties; sarcoplasmic, myofibrillar and insoluble protein (connective tissue protein).

- Fish sarcoplasma proteins consist largely of enzymes which are water soluble.
- Myofibrillar proteins are salt soluble. These proteins are primarily bound to the contractile network; hence they are called contractile proteins. The proportion of myofibrilar proteins and total protein in fish is higher than in mammalian

muscle tissue. The heat stability of fish proteins is lower than that of mammals, and the protein denaturation induced by urea occurs more readily and protein hydrolysis by trypsin is fast **(Belitz *et al.* 2009).**These properties provide additional evidence of the good digestibility of fish proteins.

- Collagen protein is the main component of the insoluble proteins with content of up to 90%. The remainder is mainly elastine. The shrinkage temperature of fish collagen is about 45 C°, i.e. much lower than for mammalian collagen (60-65 C°) **(Belitz *et al*., 2009).**

The collagen content and characteristics has a significant influence on the texture of raw fish meat. The body of land animals has average 15 percent connective tissue by weight whereas fish has only 3 percent collagen. The low collagen content is a main reason why fish is much tenderer than terrestrial animals. But different composition of collagen and a lower content of certain amino acids (hydroxyproline) are another reason of tenderness of fish. When fish is cooked, the collagen breaks down more easily at a lower temperature and converts to gelatin **(Brown 2001).**

Love., (1960) stated that protein content of the fish flesh does not show any regular cycle of change throughout the year. **Borgstrom., (1962)** showed an inverse relationship between protein and fat content and reported that water content and relative size of flesh as factors affecting the protein content. They also determined the range of protein in fish flesh between 30 – 90% of the dry weight. **Shearer., (1994).**

2.7.3 Fillet Fat

Lipids present of fish skeletal muscle may be divided into two major groups; phospholipids and triglycerides. The phospholipids have an important role for the structure of the cell membranes (structural lipids), whereas the triglycerides are lipids used for storage of energy in fat depots **(FAO.,(2005).**

In terms of quantity, lipid is the third major constituent in fish muscle. Variation in the fat content is much wider than that of protein. Fat content varies between species, and also between different organs within species. Fish with fat content as low as 0.5% and as high as 18-20% are common. In many species there is a buildup of fat during feeding season and its proportion decreases substantially after spawning. As far as the type of lipid in fish muscle is concerned, triacyl glycerol and phosphoglycerides both containing long chain fatty acids are the major components. Squalene and wax esters are other components found in unusually high concentrations in a few fish meat. It is generally accepted that the chemical composition of fish is not constant.

Love., (1960) described a marked variation in fat content that decreases in time of food scarcity. **Borgstrom (1962)** referred to the differences in fat content between lean and fatty to range between 0 – 0.7 % for lean, (3 – 10 % semi – fat), and (12 – 20 %) fatty fish.

2.8 Nutritional value of fish

The main chemical components of the fish are: water, proteins, and lipids. These components have the greatest importance in terms of nutritional value (**Ros *et al*.2010).** Further nutritional values of the fish dependant on many factors that can be encompass:

a) Intrinsic factors (species, age, sex and physiological factors),

b) Dietary factors (quality of diet: wild/farmed...);

c) Environmental factors (food availability, salinity, temperature) **(Grigorakis.,(2007).**

It is obvious that, considered the above it revealed that there is a big difference in the chemical composition between an aquaculture fish and a wild fish. For example, a farmed fish subjected to a regime of intensive growth has a higher percentage of fat and a low percentage of water compared to wild specimens from sea fishing **(Mnari *et al*.,(2007); Santaella *et al*., (2007).**

Also with regard to the minerals amount, many studies have shown that the concentration in minerals is greatly affected by different environmental factors and intrinsic such as those mentioned above **(Thodensen., (2001); Roy *et al*.,(2006).**

Water is the element that finded in greatest quantity in the composition of fish species and its presence is inverse to the percentage of fat (**Wheaterley *et al*.,(1983).** In whitefish and in semi - oily fish the percentage of water content is between 76% and 80% , while in oily fish the water content is less, it can reach a maximum concentration of 75%.

Also age, sex, sexual maturity and reproductive period are causes that can modify these parameters.

During the breeding season the female can concentrate fat storage in the visceral apparatus: and for this reason a decreased of fat in the meat with a consequent increase of water content Will be noted as for the protein content, it is in general between 13 and 20% **(Ros *et al*.,(2010),** respectively.

The protein compounds in fish are made up of all the essential amino acids, with an abundant amount of lysine and tryptophan (a like milk protein, eggs and meat of mammals), and this confirms a high biological value of the fish meat **(Aquerreta.,(2000).**

According to fat content in the edible portion of the fish, the fishes can be classified as follows:

- Non-oily fish: with a fat content of up to 2.5% (hake, greater fork beard, gilt head breametc.).
- Semi-oily fish: from 2,5 to 6% (mullet, anchovies, carp, etc.).
- Oily fish: from 6% to 25% (salmon, tuna, eel, etc.).

In non - oily fish the lipid content is more concentrated in the liver and mature gonads, while in oily fish it is localized mainly in the muscles and into the subcutaneous tissue, abdomen muscles and the muscles that allow the movement of the tail and fins **(Testi.,(2006); Mnari., (2007).** Also these factors greatly differ according to species, sex, season, and especially the diet composition.

If we compare farmed specimens and wild ones, It is clear that a farmed fish will have a higher percentage of fat than a wild one, and this is due to the composition of the diet it is fed but especially it is due to the high density of fishes in a same area that prevents them to swim in a free way **(Flos *et al*.2002; Mnari 2007).**

The minerals and trace elements become part of the muscles and skeleton of fish; they set acid-base balance and are also an important component of hormones and enzymes **(Lall 1995; Alasalvar *et al*. 2002).**The majority of the mineral salts, outside their specific function, take part in small concentrations in vital phenomena, as enzymes activators, transporters or regulators.

The fish takes minerals, necessary for its normal conservation of vital functions, through its diet and water that normally circulates through the gills or skin **(Watanabe *et al*., (1997); Lall., (2002).**The minerals and trace elements settle mainly on the fish skeleton as well as on the edible part and organs **(Lall., (2002).**

The main constituent elements are phosphorus and potassium (from 200mg/100g to 400mg/100g). Of course it important to take into account that sea fishes have a high iodine content and a relatively low sodium content (between 20 and 140mg/100g in the edible part), and this make them suitable for good diets. A Mediterranean diet, rich in oily fish and all the kinds of aquatic animal, can meet the 20% or more of the daily needs of phosphorus, iron, selenium and iodine **(Pèrez *et al*., 2005).**

The body nutrients composition and quality of nutrients in flesh of most fishes is reliant on their food type and feeding habit **(Fawole *et al*., 2007).**

2.9 Mineral elements

Minerals occurring in considerable amounts are called macro elements and those found in minute amounts are called trace elements or microelements. Calcium, phosphorus, sodium, potassium, sulphur, chlorine, Magnesium and Iron are found in appreciable amounts; coppers, iodine, manganese, cobalt, zinc, fluorine, selenium are found in smaller quantities whereas cadmium, boron, arsenic, aluminium, lead, nickel are found in trace quantities in different group of fishes. According to their age and size of fish, season of sample collection and food availability respectively. **(Reinitz .,(1983); Abdullahi.,(2001); Effiong et al (2011).** Mineral elements are basic requirement of all living organisms. Some minerals are essential elements but these essential metals may be toxic at their high concentration in body of animals **(Tyrrell *et al*., 2005).**

It is due to the tendency of bio-magnification of these toxic elements in the food chain and ultimately in the ecosystem. So, the bioaccumulation of toxic elements in aquatic ecosystems has been taken as an environmental problem globally **(Khare and Singh., 2002).**

The vital factors which disturb the ecosystem by increasing the amount of heavy metals are industrial wastes, sewage disposal, soil leaching, rainfall and the use of metal based fertilizers in agricultural revolution are increased day by day which could result in the rise of metal pollutants in freshwater due to the water flow. Because of all these facts there is a need to study the concentrations of heavy metals in freshwater fish **(Al- Bader, 2008; Rauf *et al.*, 2009; Yousaf *et al.*, 2010).**

Fish is a source of macro (Ca, Mg, Na, K, P, Cl, S), micro or trace (Fe, Zn, Mn, Cu, I, Co, Ni, F, V, Cr, Mo, Se, Sn, Si) and also some toxic elements (Hg, As, Pb, Cd). Fish usually contains small amounts of these minerals, some of which are essential nutrients, some are components of many enzyme systems and metabolic mechanisms, and as such contribute to the growth of the fishes.

The important mineral elements of fish are calcium, magnesium, potassium, phosphorus, iron and chlorine while many others are important in trace amounts. Their deficiencies cause a lot of malfunctioning, such as it reduces productivity, and causes disorders such as inability of blood to clot, osteoporosis and anaemia.

One of the major problems is pollution that poses serious health risk and environmental concern, which results from heavy metals bioaccumulation.

CHAPTER THREE

MATERIALS AND METHODS

3.1 The study area

The study was conducted at fisheries and wildlife science laboratory college of Animal production science and technology, Sudan University of Science and Technology 10km east of Khartoum (Kuku).

3.2 Fish sampling

Samples were abled to be collected and out numbering forty of commercially wild and cultured samples of African catfish *Clarias gariepinus* (Burchll 1822) belonging to family Clariidae (local name: Garmout), and size of each samples ranged from 300 – 450 g. The fish samples were collected from different environment, divided into two groups, wild and cultured fishes (20 fishes for each group). The wild fish group collected from local Market (El Mahile fish market) south Khartoum, while cultured group were collected from fish farm in Jebel Auila south Khartoum, and each group considered male and female presence equally.

3.3 Determination of Total Length and Weight

Fish samples were identified sexually as (Male and Female), cleaned and weighed by using sensitive balance and recorded in gram. The brand of weighing is electronic balance mode: 2003, max:200g, d: 0.001g power: AC220V/50Hz, S/N: 119, date 2014/08. Then the total length, standard lengths were measured by measuring tape (100 cm).

Further fishes were filleted, eviscerated, de-headed and skinned using sharpen knives. The weight of viscera, fillets (without ribs), fillet with skin, head, skeleton and fins (with some adhesive meat), were measured and weighed separately using weighing balance (5kg electronic kitchen scale) and 200g electronic balance with three decimal points.

The fish fillet for each fish group of wild and farmed *Clarias gariepinus* samples (male and female), trimmed and grounded homogenously using blending machine and placed in insulated plastic bags and chilled in refrigerator, until samples were taken to central veterinary research laboratories (Soba) South of Khartoum for proximate analysis and mineral elements analysis following the procedure given by **AOAC (1990).**

3.4 Flesh quality

Fish dressing was conducted on the same samples of fish collect from two different environment conditions. The following body traits were recorded in individually on each fish within each population.

3.4.1 Inedible parts traits

The following parameters were calculated to estimate the percentage value of whole body weight (BW) as follows:

Head weight (%) = head weight / total body weight × 100.

Viscera (%) = weight of viscera / total body weight × 100.

Fins weight (%) = fins weight / total body weight × 100.

Skin weight (%) = skin weight / total body weight × 100.

Frame and fins weight (%) = frame and fins (g)/ total body weight × 100.

Carcass ratio weight (%) = carcass ratio weight/total body weight × 100.

3.4.2 Edible parts traits

Fish weight after gutting and deheading(g)% = WAG+D/total body weight × 100

Weight after gutting (g) % = WAG / total body weight × 100

Fillet weight (g) % = Fillet W / total body weight × 100

3.5 Chemical Composition Analyses

Determination of the chemical composition of the samples were done by following the procedures as described by **AOAC, (1990) as:**

3.5.1 Protein content determination

The protein content will determine by Kjeldhal method (AOAC), (2000), **Calculated as follows**

Nitrogen (%) = T × 0.1 × 0.014 × 20 ÷ Weight of sample × 100.

Crude protein % = N × 6.25 = CP%

3.5.2 Moisture determination

Moisture was analyzed through weighing 5gm of the sample (flesh) into a weighed tarred silica or porcelain dish. Dry in the oven at 105°C for 24hrs, cool in a desiccators and weight loss in weight (represents moisture).

The moisture % was calculate as follow:-

$$\text{Moisture \%} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100.$$

3.5.3 Ash Determination

Total ash was measured by weighing out 5g of the sample into silica dish which has previously been ignited and cooled before weighting then the dish and contents were ignited first gently and consequently at 550°C until the Ash got a grey / white color. The dish was cooled at room temperature and by subtracting the weight before and after aching, the ash % will determine as:

$$\text{Ash \%} = \frac{\text{Fresh weight} - \text{Ashed weight}}{\text{Fresh weight}} \times 100.$$

3.5.4 Fat determination

Fat content determination was done by drying the samples at 100˚C in an oven and then extracting the crude fat with petroleum ether in a Soxhlet extractor for 4 hours.

3.5.5 Nitrogen Free Extract

Nitrogen free extract was computed by taking the sum of values for moisture, Protein, fat and ash contents and subtracted this from 100 (AOAC, 1995).

$$NFE\% = 100 - (A + B + C + D)$$

Where:

A = moisture C = fat

B = protein D = ash

3.6 Determination of mineral elements

The major elements, comprising calcium, magnesium, sodium, potassium, phosphorous, and trace elements (iron and zinc) the percentage mineral elemental concentration were determined using corning 400, flame photometer for Na and K and (AAS) Atomic Absorption Spectrophotometer phoenix – 986, (AOAC, 1975). All the samples were carried out in triplicate and reported as mean mineral content in mg/L.

3.7 Statistical analysis

The data of this study were analyze statistically using computer statistical package for social science (SPSS version 21). General Linear Model Two - way analysis of variance (ANOVA) and regression line as described by Gomez and Gomez (1984).

CHAPTER FOUR

RESULTS

4.1 Body characteristics and filleting yield induces

Fish collected from the farmed area showed significantly female larger than male and also smaller weights than those collected from market as wild sample ($p < 0.05$) as present in Table (4.4). Average total length of fish from farmed samples varied from 31.69±2.693 to 34.71±1.14 males and females, respectively although the difference was significant ($p < 0.05$), while for those collected from the wild was no significant ($p > 0.05$) as shown in Table (4.1), but there were significant differences in farmed and wild samples varied between 33.20 to 36.70.

Table (4.1): Minimum and maximum weight and total length of *Clarias gariepinus* samples collected from farmed and wild.

Trait	sex	Farmed samples	Wild samples
Average weight	Male Female	240.60±63.710 324.10±30.351	345.80±73.239 335.20±57.543
Maximum	Male Female	360 402	518 431
Minimum	Male Female	160 298	268 244
Average total length	Male Female	31.69±2.693 34.71±1.104	36.97±2.161 36.43±1.890
Maximum	Male Female	36.7 37.5	41.8 40
Minimum	Male Female	28 33.5	34.5 33.4

Data are means ±St.D

Table (4.2): Body characteristics of farmed and wild (male and female) Africa catfish *Clarias gariepinus.*

Fish	Parameters / Sex	T.B.W (g) M±St.D	T.L (cm) M±St.D	S.L (cm) M±St.D	WAG (g) M±St.D	V.W (g) M±St.D	H.W (g) M±St.D	WAG+D (g) M±St.D	F.W (g) M±St.D	F.F (g) M±St.D	Fillet w (g) M±St.D
Farmed	**Male**	240.6 ± 63.71^{a}	31.6 ± 2.69^{a}	27.8 ± 2.38^{a}	204.1 ± 60.83^{a}	25.9 ± 10.453^{a}	56.2 ± 15.58^{a}	147.7 ± 40.49^{a}	6.9 ± 2.666^{a}	42.1 ± 12.68^{a}	102.4 ± 27.67^{a}
	Female	324.1 ± 30.35^{b}	34.7 ± 1.10^{b}	30.6 ± 0.91^{b}	270.5 ± 28.41^{b}	46.2 ± 6.807^{b}	67.189 ± 5.89^{b}	199.9 ± 24.91^{b}	7.7 ± 2.051^{a}	44.0 ± 5.01^{b}	152.4 ± 21.46^{b}
Wild	**Male**	345.8 ± 73.23^{c}	36.9 ± 2.16^{c}	32.2 ± 1.72^{c}	294.7 ± 75.63^{c}	15.9 ± 6.652^{c}	90.827 ± 16.27^{c}	223.1 ± 49.67^{c}	8.7 ± 3.169^{b}	54.2 ± 13.35^{c}	172.4 ± 39.18^{c}
	Female	335.2 ± 57.54^{d}	36.4 ± 1.89^{c}	32.2 ± 1.78^{c}	313.0 ± 53.68^{c}	17.4 ± 7.611^{d}	82.6 ± 21.35^{d}	223.5 ± 38.99^{c}	7.7 ± 2.092^{a}	51.6 ± 13.82^{d}	171.2 ± 29.87^{d}

a,b,c,d means in the same column bearing the same superscripts are significantly different ($p<0.05$).

Whereas:

HW = Head weight (g),

WAG+D = Fish weight after gutting and deheading (g),

T.B.W = Total Body weight (g),

FW = Fin weight (g),

T.L = Total length (cm),

F.F = Frame (skeleton) and fins (g),

S.L = Standard length (cm),

Fillet W = Fillet weight (g),

WAG = Weight after gutting (g),

VW = Viscera weight (g),

M = Mean, **St.D** = standard deviation, Table (4.3): **Body characteristics of farmed and wild of Africa catfish *Clarias gariepinus*.**

Parameters / Fish	T.B.W (g) M±St.D	T.L (cm) M±St.D	S.L (cm) M±St.D	WAG (g) M±St.D	V.W (g) M±St.D	H.W (g) M±St.D	WAG+D (g) M±St.D	F.W (g) M±St.D	F.F (g) M±St.D	Fillet w (g) M±St.D
Farmed samples	282.4±64.75[a]	33.2±2.53[a]	29.25±2.29	61.5±3.53[a]	36.1±13.34[a]	61.8±12.75[a]	173.9±42.28[a]	7.3±2.35[a]	43.1±9.44[a]	127.3±35.16[a]
Wild samples	340.5±64.33[b]	36.7±1.9[b]	32.3±1.78	65.6±3.78[b]	16.7±6.99[b]	86.7±18.5[b]	223.3±43.46[b]	8.3±2.66[b]	52.9±13.29[b]	172.0±33.92[b]

a,b means in the same column bearing the same superscripts are significantly ($P < 0.05$)

Whereas:

HW = Head weight (g),
WAG+D = Fish weight after gutting and deheading (g),
T.B.W = Total Body weight (g),
FW = Fin weight,
T.L = Total length (cm),
F.F = Frame (skeleton) and fins (g),
S.L = Standard length (cm),
Fillet W = Fillet weight (g),
WAG = Weight after gutting (g),
VW = Viscera weight (g),
M =Mean, **St.D** = standard deviation.

Table (4.4): Slaughter yield of farmed and wild Africa catfish *Clarias gariepinus* male and female (mean values ± St.D)

Fish	Parameters / Sex	WAG %± St.D	V.W %± St.D	H.W %± St.D	WAG+D %± St.D	F.W %± St.D	F.F %± St.D	Fillet w %± St.D	Carcass %± St.D
Farmed	Male	84.4 ± 8.92^{a}	10.7 ± 1.98^{a}	23.4 ± 1.59^{a}	61.3 ± 4.20^{a}	2.8 ± 0.61^{a}	17.4 ± 2.03^{a}	42.7 ± 4.42^{a}	51.5 ± 3.54^{a}
	Female	83.4 ± 2.34^{a}	14.3 ± 1.96^{b}	20.7 ± 1.73^{b}	61.6 ± 2.59^{a}	2.41 ± 0.65^{a}	13.6 ± 0.97^{b}	46.9 ± 2.45^{b}	48.7 ± 1.86^{b}
Wild	Male	91.0 ± 9.54^{b}	4.6 ± 1.24^{c}	26.4 ± 1.67^{c}	64.5 ± 4.73^{b}	2.5 ± 0.48^{a}	15.6 ± 1.49^{c}	49.9 ± 1.95^{c}	46.6 ± 2.16^{c}
	Female	93.4 ± 1.62^{c}	5.1 ± 1.84^{c}	24.7 ± 4.52^{a}	66.7 ± 2.23^{c}	2.3 ± 0.35^{a}	15.3 ± 2.67^{c}	51.2 ± 2.59^{d}	45.2 ± 4.99^{c}

a,b,c,d means in the same column bearing the same superscripts are significantly different ($p<0.05$)

Whereas:

HW = Head weight,

WAG+D = Fish weight after gutting and deheading (g),

WAG = Weight after gutting (g),

FW = Fin weight (g),

VW = Viscera weight (g),

F.F = Frame (skeleton) and fins (g),

WFWS (fillet) = Weight of fillets with skin (g),

M = Mean,

St.D = standard deviation , **Carcass (g)**

Table (4.5): illustrate body characteristics wild, farmed of African Catfish *Clarias gariepinus.*

Parameters / Fish	WAG (%) M±St.D	V.W (%) M±St.D	H.W (%) M±St.D	WAG+D (%) M±St.D	F.W (%) M±St.D	F.F (%) M±St.D	Fillet w (%) M±St.D	Carcass (%) M±St.D
Farmed samples	83.93 ± 36.37^{a}	12.48 ± 2.66^{a}	22.11 ± 2.11^{a}	61.45 ± 3.34^{a}	2.62 ± 0.65^{a}	15.51 ± 2.5^{a}	44.79 ± 4.07^{a}	50.109 ± 3.124^{a}
Wild samples	92.23 ± 6.775^{b}	4.88 ± 1.55^{b}	25.57 ± 3.42^{b}	65.58 ± 3.78^{b}	2.39 ± 0.42^{b}	15.47 ± 2.11^{a}	50.48 ± 2.32^{b}	45.894 ± 3.813^{b}

a and b means in the same column bearing the same superscript are significantly different ($p<0.05$)

Whereas:

HW = Head weight (%),

WAG+D = Fish weight after gutting and deheading (%),

F.F = Frame (skeleton) and fins

FW = Fin weight (%),

WAG = Weight after gutting (%),

Fillet W = Fillet weight (%),

VW = Viscera weight (%),

St.D = standard deviation,

M = Mean , **Carcass (%)**

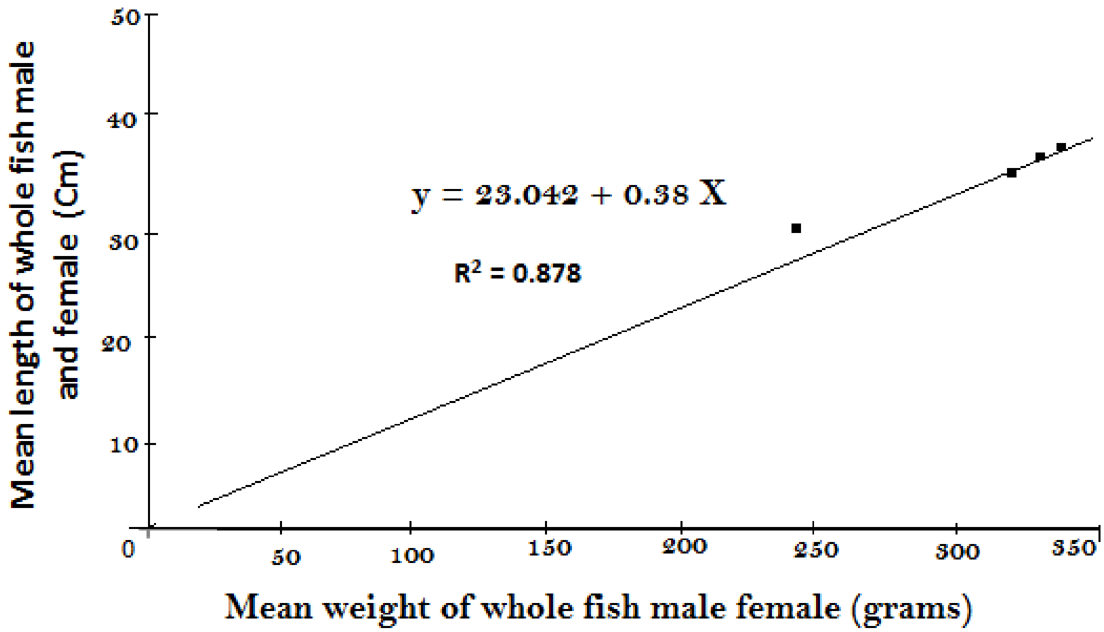

Figure (4.2): Relationship between length – weight of *Clarias gariepinus* farmed and wild samples.

From the result of linear regression for length and weight of C. gariepinus there were strongest positive correlation at R = 0.937 and significant different at 0.05 or ($p < 0.05$).

Figure (1) indicate the regression line of mean weight of whole male and female against the mean length of male and female, thus the size of fish were linearly related to its length.

Carcass traits of different of *clarias gariepinus* mass were presented in table (2, 3, 4, 5). The results showed significant difference($p < 0.05$), in all carcass traits studied among different catfish *clarias gariepinus* collected from different environment.

Head weights as percentage of body weight ranged from 22.113 to 25.573% farmed and wild, 23,432±1.599 to 20.795±1.727 farmed males and females. While wild males and females head weight as percentage of body are 26.423±1.671 to 24.725±4.517.

Viscera percentage ranged from 12.481% to 4.850% in farmed and wild samples, while farmed males and females samples ranged from 10.679±1.977 to 14.284±1.961, in comparison to wild males and females samples which ranged from 4.578±1.240 to 5.123±1.844, respectively.

Fins percentage of farmed and wild samples ranged from 2.624 to 2.399%, while the percentage of farmed males and females samples varied from 2.840±0.608 to 2.410±0.657 against wild males and females samples which appeared to be less with figures as 2.504±0.483 to 2.295±0.349 with no significant different among farmed and wild *clarias gariepinus* sample grouping.

Fins and frame as backbone of farmed and wild ranged 15.514 to 15.470%, while percentage for farmed males and females ranged from 17.441±2.030 to 13.587±0.973 and wild fins and frame males and females varied from 15.594±1.498 to 15.346±2.669.

Weight after gutted (WAG) of farmed and wild samples ranged from 83.928 to 92.226% while percentage of farmed males and females samples varied from 84.444±8.924 to 83.414±2.344, compared with wild males and females samples which varied from 91.030±9.546 to 93.422±1.619.

Weight after gutted – Dehead (WAG+D) of farmed and wild samples varied from 61.447 to 65.579%, while the percentage of farmed *clarias gariepinus* males and females varied from 61.311±4.200 to 61.584±2.598, compared to wild males and females which varied from 64.460±4.732 to 66.698±2.233.

The non- edible portion (Carcass) for farmed and wild samples varied from 50.109 to 45.894%, respectively. The percentage for farmed *clarias gariepinus* varied between 51.552±3.535 to 48.668±1.868 males and females, compared to wild which ranged from 46.595±2.165 to 45.194±4.992 males and females samples tested.

The edible portion as percentage of fillet for farmed and wild samples varied from 44.793 to 50.485%, while farmed *Clarias gariepinus* males and females varied between 42.725±4.418 to 46.862±2.451, compared with wild which ranged between 49.862±1.953 to 51.108±2.590 males and females. The evaluation of flesh quality of different farmed and wild mass of African catfish *Clarias gariepinus* tested can be resulted in a genotype suitable characteristics for aquaculture.

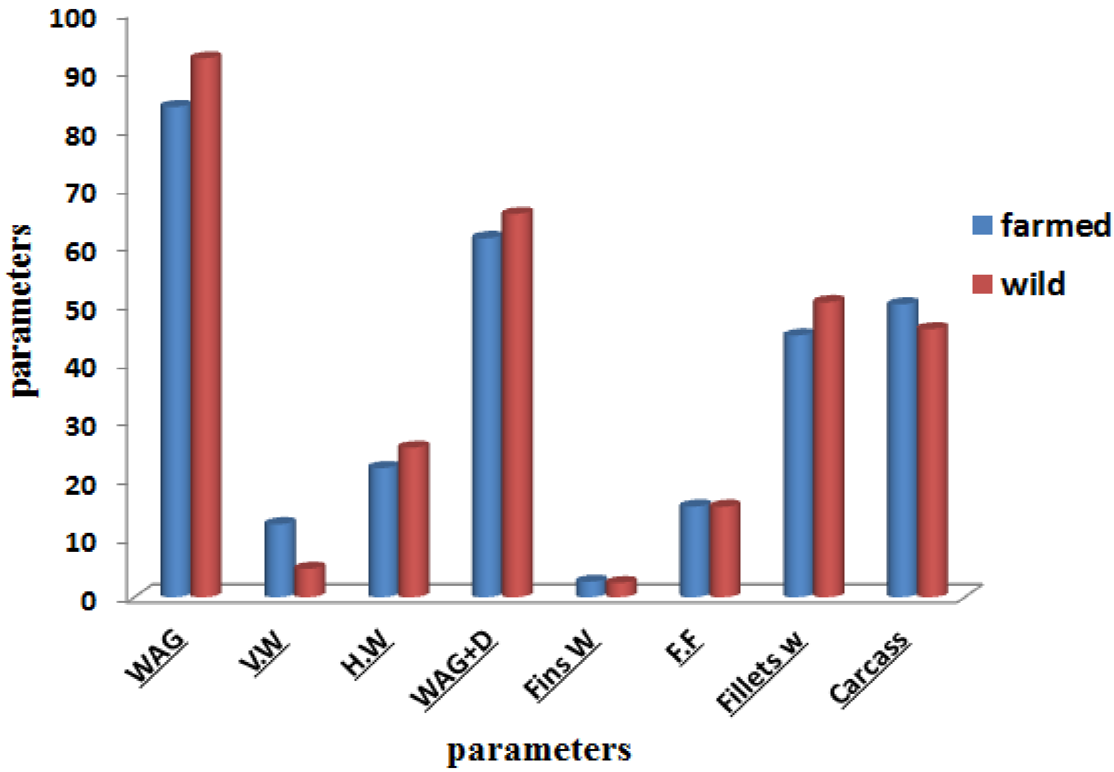

Figure (3): body characteristics of African catfish *Clarias gariepinus* farmed and wild.

4.2 Chemical composition of fish

4.3 Fish flesh quality

Result and finding of proximate composition as percentage of moisture, fat, ash, crude protein, dry matter, and nitrogen free extract were examined as parameters of fish flesh quality in both farmed and wild sampling groups.

However there were insignificant different between the farmed and wild samples. This confirms *clarias gariepinus* as good source of these nutrients. The high percentage of protein showed that the farmed and wild *clarias gariepinus* can be considered as a sole source of animal protein.

Protein as one of most important measures ranging from 30.865 to 30.983% farmed and wild samples, while 31.003±0.917 to 30.727±0.516 for farmed male and female samples, and 31.283±0.524 to 30.683±0.461representing wild male and female samples respectively, Table (6) showed there were no significant differences among fish groups ($p > 0.05$).

Table (4.6): Proximate composition of fillet from farmed and wild *Clarias gariepinus.*

Clarias gariepinus				
Parameters	**Farmed**		**Wild**	
	Male	**Female**	**Male**	**Female**
Chemical composition (%)				
Moisture	73.000±8.717^{c}	72.667±3.511^{d}	74.133±1.872^{b}	75.900±2.52^{a}
Dry matter	27.000±8.717^{a}	26.333±4.042^{b}	25.867±1.872^{c}	24.100±0.461^{d}
Crude protein	31.003±0.917^{a}	30.727±0.516^{b}	31.283±0.524^{a}	30.683±0.461^{b}
Ash	1.667±0.577^{a}	1.667±0.577^{a}	1.367±0.322^{a}	1.267±0.252^{a}
Ether extract	8.400±0.435^{a}	8.400±0.200^{a}	7.867±0.153^{b}	8.333±0.306^{a}
N.E.F	31.930±9.432^{c}	31.877±4.412^{c}	33.383±1.372^{b}	35.617±1.754^{a}

Value are means of three replicate, Means in a row with the similar superscripts are significantly different ($p \leq 0.05$) from one another.

Ether Extract, being another major constituent, recorded the range of 8.400 to 8.100% farmed and wild samples, while 8.400±0.435 to 8.400±0.200 for farmed male and female, compared to 7.867±0.153 to 8.333±0.306 from wild male and female fishes, table (6) fishes showed there were no significant differences ($p > 0.05$).

Moisture content ranged from 72.833 to 75.016% for farmed and wild samples while 73.000±8.717 to 72.667±3.511 in fish tested from farmed male and female fishes and varied from 74.133±1.872 to 75.900±2.52 in fish samples from wild in both sexes. Table (6) which showing there were significant differences among groups ($p < 0.05$).

Ash content, showed a less variations in a sense of 1.666 to 1.316 % farmed and wild samples, while 1.667±0.577 to 1.667±0.577 in fish from farmed male and female group against wild male and female ranged 1.367±0.322 to 1.267±0.252. Table (6) shows significant differences between two environments, in ash content there were no significant ($p < 0.05$).

Table (4.7): Proximate composition of whole body from farmed and wild *Clarias g.*

	Clarias gariepinus			
Parameters	**Farmed**		**Wild**	
	Male	**Female**	**Male**	**Female**
Chemical composition (%)				
Moisture	60.333±0.577[d]	63.333±1.154[c]	70.733±2.926[a]	68.733±1.817[b]
Dry matter	39.667±0.577[a]	36.667±1.154[b]	29.267±2.926[d]	31.266±1.817[c]
Crude protein	32.027±0.142[a]	31.237±0.235[b]	32.802±0.311[a]	31.830±0.462[b]
Ash	2.667±0.577[a]	2.000±1.000[a]	2.633±0.321[a]	2.367±0.473[a]
Ether extract	8.900±0.100[b]	8.567±0.153[b]	9.000±0.200[a]	8.733±0.153[b]
N.E.F	17.073±1.157[d]	21.530±1.768[c]	26.297±3.040[a]	25.803±1.904[b]

Value are means of three replicate, Means in a row with the similar superscripts are significantly different ($p < 0.05$) from one another.

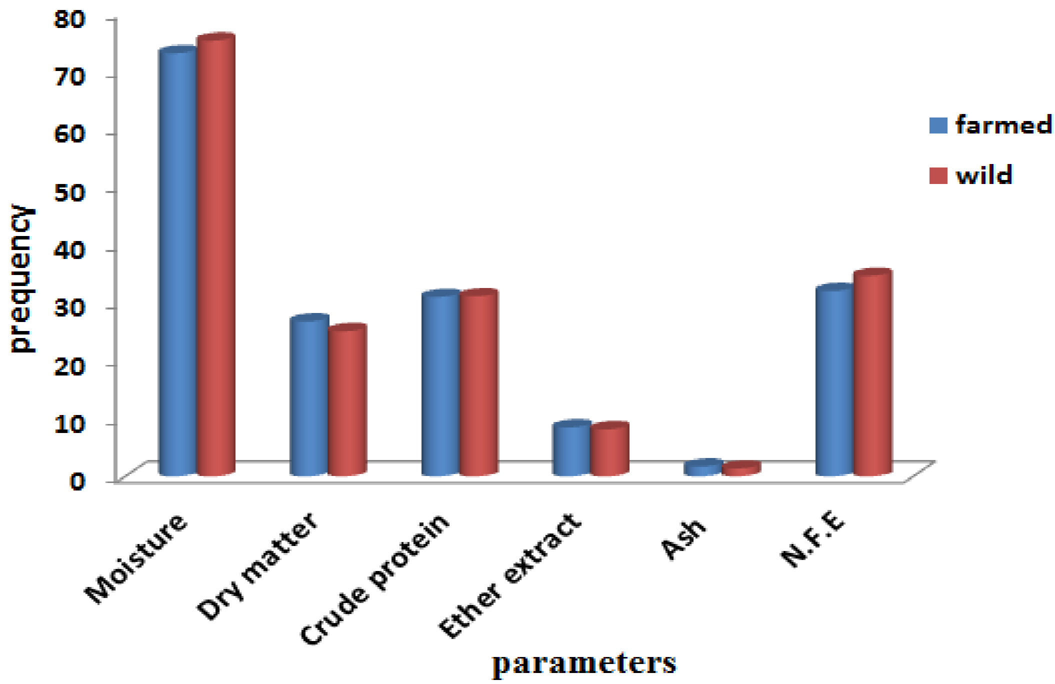

Figure (4): chemical composition of African catfish *Clarias gariepinus* farmed and wild.

4.4 Mineral elements

The results shown means concentration (mg/l) ± st.D, as a percentages of mineral contents, no clear trends were been detected in mineral elements of farmed and wild African catfish *clarias gariepinus* muscle tissues with the sex variations as shown in table (7). There was no significantly different with relation to sex ($p > 0.05$), using general linear model (two – ways ANOVA). But there were highly significant differences observed in concentration of all selected minerals in whole body male and female of the same species when compared with muscle tissues ($p < 0.05$) as shown in table (8). Except microelements which have no significant difference ($p > 0.05$) using general linear model (two – ways ANOVA), as showed in table (7).

Table (4.8): Mineral composition of fillet African catfish *Clarias gariepinus* farmed and wild mg/l, as percentage.

Clarias gariepinus				
Minerals (Mg/L)	**Farmed**		**Wild**	
	Male	**Female**	**Male**	**Female**
Macro elements(Mg/L)				
Ca	4.323±o.404[a]	3.707±0.336[b]	4.847±0.076[a]	3.790±0.236[b]
P	3.235±0.220[a]	2.511±0.109[b]	3.211±0.048[a]	2.382±0.091[b]
Mg	2.949±0.196[a]	2.351±0.116[a]	2.888±0.208[a]	2.230±0.088[a]
Na	4.583±0.036 [a]	4.051±0.312 [a]	4.597 ±0.011 [a]	4.084±0.266 [a]
K	4.111±0.171 [a]	3.399±0.127[b]	4.167±0.180 [a]	3.978±0.313[b]
Micro elements (mg/l)				
Zn	0.098±0.002 [a]	0.094±0.005 [a]	0.102±0.0.004 [a]	0.092±0.004 [a]
Fe	1.190±0.018 [a]	1.154±0.041 [a]	1.036±0.782 [a]	1.144±0.046 [a]

Results are mean of triplicate determinations on a dry weight basis ± standard deviation.

Table (9): Mineral composition of whole African catfish *Clarias gariepinus* farmed and wild on mg/l, as percentage.

Clarias gariepinus				
Minerals (Mg/L)	**Farmed**		**Wild**	
	Male	**Female**	**Male**	**Female**
Macro elements(Mg/L)				
Ca	**6.297± 0.400[a]**	**5.130±0.201[b]**	**6.380±0.399 [a]**	**5.223±0.313[b]**
P	**4.532± 0.362[b]**	**5.114±0.130[a]**	**4.598±0.188[b]**	**5.228±0.043[a]**
Mg	**3.575±0.096[a]**	**3.203±0.191[a]**	**3.407±0.136[a]**	**3.130±0.233[a]**
Na	**5.113±0.174[a]**	**5.063±0.169[a]**	**5.298±0.017[a]**	**5.129±0.142[a]**
K	**6.721±0.806[a]**	**6.425±0.444[a]**	**6.529±0.647[a]**	**6.532±0.604[a]**
Micro elements (mg/l)				
Zn	**0.120±0.005[a]**	**0.115±0.005[a]**	**0.124±0.006[a]**	**0.120±0.004[a]**
Fe	**1.402±0.014[a]**	**1.352±0.040[a]**	**1.428±0.043[a]**	**1.322±0.033[a]**

Results are mean of triplicate determinations on a dry weight basis ± standard deviation.

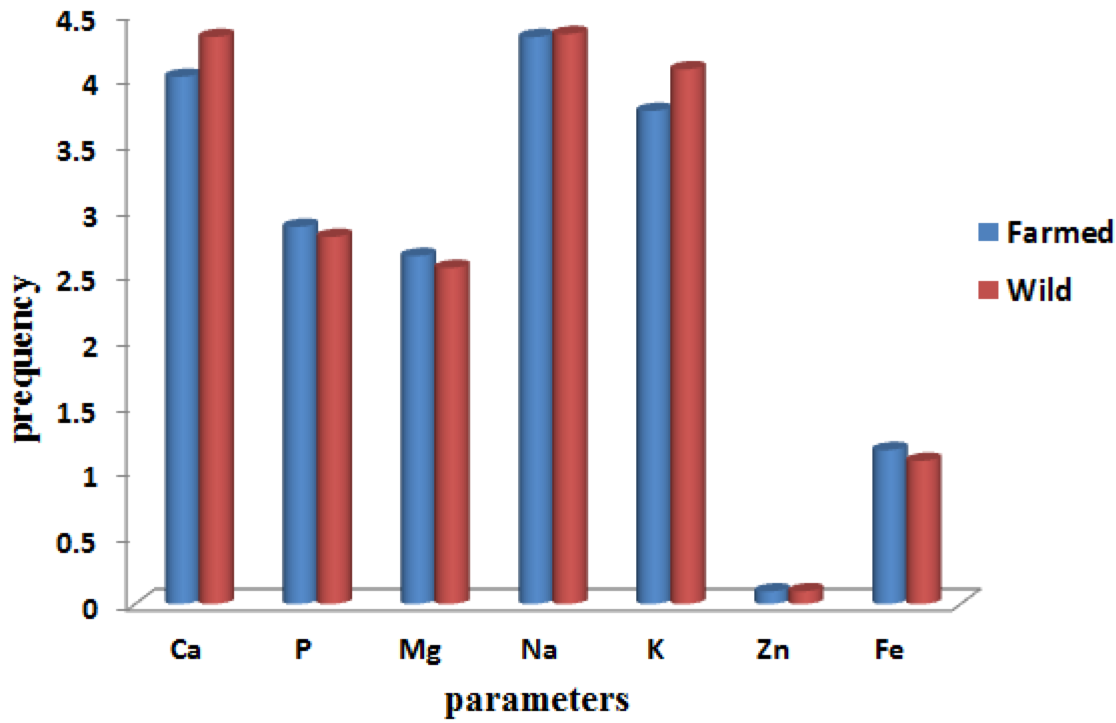

Figure (5): Mineral elements of African catfish *Clarias gariepinus* (farmed and wild).

CHAPTER FIVE

DICUSSION

The results of this study were conducted on body weight characteristics, filleting Indices chemical composition (Proteins, moisture, Ether extract, ash and nitrogen free extract), and mineral contents of *clarias gariepinus* farmed and wild groups with variations of sex. The findings were the major constituents by which considered eventually in evaluating the nutritional value of the fish samples tested.

The edible portion as percentage of fillet for farmed and wild samples varied from 44.793 to 50.485 % while farmed *clarias gariepinus* males and females group varied between **42.725±4.418** to **46.862±2.451**, in comparison to wild group which ranged between **49.862±1.953** to **51.108±2.590** males and females fishes.

This result is in agreement with Eyo (1991), **obanu and Ikeme (1988)** and **Ali *et al.*, (1996)**. Also agree with **Babiker (1981)** studying some Nile fish and concluded that the edible portion of the flesh fish ranges between 40% - 60%, as obtained and shown in tables (,3,4,5).

The chemical composition of African catfish *clarias gariepinus* farmed and wild groups with variation in sex showed high crude protein contents recorded as 30.865 to 30.983 % farmed and wild, while 31.003±0.917 to 30.727±0.516 for farmed male and female samples against wild male and female respectively 31.283±0.524 to 30.683±0.461

(Table 6). These findings are in accordance with the findings of FAO (2015) for freshwater fish example *Lophius piscatorius*.

The ether extract or (fat contents) obtained and estimated as 8.400 to 8.100% farmed and while while 8.400±0.435 to 8.400±0.200 for farmed male and female in samples, comparison to 7.867±0.153 to 8.333±0.306 for wild male and female samples, respectively. Table (6) reveals that differences in fat levels in the fish tissues could have been due to the impact of food **(Oniya *et al.,* 2010).**

The ash contents in African catfish *clarias gariepinus* farmed and wild groups varied from 1.666 to 1.316 %, while the variations in sex were ranged from 1.667±0.577 to 1.667±0.577 in fish from farmed male and female samples, and 1.367±0.322 to 1.267±0.252 in wild male and female groups as shown in table (6). This result were in Agreement with **Mahmoud., (1977)** studied the meat quality of some common Nile fishes; and found that the females do showed more moisture, fat, ash, and less protein content than males.

The relatively high percentage of crude protein may be attributed to the fact that these fishes are good source of protein but the differences observed among the selected groups could be as a result of fish consumption or absorption capability and conversion potentials of essential nutrients from their diets or their local environment. Similar findings were revealed by **Onyia, *et al.* (2010), Jabeen and Chaudhry (2011) and Fawole *et al.* (2007).**

For mineral contents, all the fish samples examined in this study contained appreciable concentrations of macro elements like phosphorus, sodium, potassium, magnesium and calcium and micro elements like Zinc and Iron suggesting that these fishes could be used as good sources of minerals. Na, K and Mg are the essential minerals in human nutrition. The presence of appreciable concentration of Na, K, Ca and Mg recorded in this study suggests that Catfish species could be as a good source of Na, K, Ca and Mg.

While comparing the concentration male and female **Ca** (4.323±0.404) and (3.707±0.336), **P** (3.235±0.220) and (2.511±0.109), **Mg** (2.949±0.196) and (2.351±0.116), **Na** (4.583±0.036) and (4.051±0.312), **K** (4.111±0.171) and (3.399±0.127) for farmed males and females compared to wild males and females group as **Ca** (4.847±0.076) and (3.790±0.236), **P (**3.211±0.048) and (2.382±0.091), **Mg (**2.888±0.208) and (2.230±0.088), **Na (**4.597 ±0.011) and (4.084±0.266), **K (**4.167±0.180) and (3.978±0.313). The results revealed in this study were considered within the limits of **FAO., (2015**). Also values of Ca, P, Mg, Na and K, range fish muscles as a percentage, were in harmony with the finding of Hei and **Sarojnalini (2012) in** Cyprinus Carpio and Labeo Rohita.

Further, the presence of Zinc and Iron in the samples could mean that *Clarias gariepinus* can play valuable roles in blood boosting and help in pregnancy for the normal growth of both fetus and mother, the conception of said metal were ranged between (0.098±0.002) and (0.094±0.005) **Zn**, and for **Fe** (1.190±0.018) and (1.154±0.041) as means of males and females farmed group *clarias gariepinus*.

Compared to wild means of males and females samples **Zn** (0.102±0.0.004) and (0.092±0.004), **Fe** (1.036±0.782) and (1.144±0.046), also the percentage is ranged **Zn** (0.096±0.004), **Fe**(1.172±0.034) for farmed samples, while for wild varied from **Zn** (0.097±0.006), **Fe** (1.090±0.498), respectively. **Binghama., (2005).**

In general, fish is said to be an excellent source of protein, Ether extract, Ash and minerals. The wide arrays of results detected in this study have attested the same. However, the contents varied in their concentrations when compared with earlier reports in the identical **line (Hei and Sarojnalini 2012; Effiong and Fakunle 2011; Sultana *et al*. 2011; Kabahenda *et al*. 2011; Onyia *et al*. 2010; Pirestani *et al*. 2009; Fawole *et al*. 2007; Hoq 2004)**.

These variations can be due to differences in environmental conditions, Mineral contents of fish, in particular, make fish unavoidable as healthy diet **(Eyo., 2001).** Mineral contents in fish depend on its availability in their environment followed by diet absorptive capability and preferential accumulation of same by the fish **(Windom *et al*. 1987; Ibiyo *et al*. 2006; Adewoye and Omotosho., 1997),**

Minerals play numerous roles as Calcium and phosphorus together help in skeleton formation. Phosphorous helps in the activity of adenosine polyphosphates and phospholipids **(Nair and Mathew., 2001).** Furthermore Potassium helps in normal functioning of nerves, muscle and heart, sugar metabolism, acid-base balance and oxygen metabolism in the brain, respectively.

CHAPTER SIX
CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Fish carcass composition of African catfish *clarias gariepinus* is a good indicator of the physiological condition of a fish samples but it is relatively time consuming to measure portions in manual filleting. The percentage of edible portions, and head were estimated to be more expressed in wild groups than cultured ones. The percentages head variations with sex wild male samples were higher than culture fishes. The percentages of viscera were recorded also higher in farmed than revealed wild group.

The results of comparative analysis of nutritional composition of farmed and wild African catfish *clarias gariepinus* groups with their variations in sexed identifies, muscle in relation to their whole body nutrient profile showed both the farmed and wild groups *clarias garipinus* are intensively rich in term of nutritional values and physiological benefits to humans health on consumption.

Having high concentration of protein, ether extract, and have good source of carbohydrate and minerals contents bring catfish to the level of nearly high value commodity fish in the near future.

6.2 Recommendations

1. To encourage preference and consumption of farmed fish, it is important that the consumers should be oriented about food safety, healthiness and nutritional value of farmed fish and aquaculture products in general.
2. Consumers must be perceptive to the extent that farmed fish and other aquaculture products are healthier and they contain similar values as the captured fish. This can be done through research technologies, extension, government-sponsored, radio and television advertisements.
3. The major issues facing aquaculture is lack of market information for farmed fish against the growing demand for fish. Fish marketing Cooperatives societies can use the information generated in this study to improve market access for *clarias gariepinus* aquaculture future and practices.
4. I recommended that after this study someone will make research on the amino acid and vitamins in future.

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Appendix (1): Biometric parameters of *Clarias gariepinus* farmed

No	Species	Parameter Sex	T.B.W (g)	T.L (cm)	S.L (cm)	WAG (g)	VW (g)	HW (g)	WAG+D (g)	Fins W (g)	F.F (g)	FW (g)
1.	C.gariepinus	Male	242.000	31.000	27.900	220.00	21.520	53.200	162.066	8.562	45.338	114.336
2.	C.gariepinus	Male	360.000	36.700	32.000	301.00	52.160	91.626	203.000	7.264	68.088	121.640
3.	C.gariepinus	Male	220.000	31.500	27.700	198.00	17.329	50.140	143.000	7.325	47.261	93.125
4.	C.gariepinus	Male	338.000	35.500	31.000	299.00	34.612	74.989	221.000	12.959	54.540	163.134
5.	C.gariepinus	Male	261.000	33.100	29.200	234.00	23.176	56.708	167.020	8.488	42.472	117.310
6.	C.gariepinus	Male	196.000	29.500	25.500	173.00	20.449	45.417	121.920	4.950	27.728	91.845
7.	C.gariepinus	Male	207.000	30.000	26.700	125.14	21.036	54.620	122.130	4.870	33.284	84.562
8.	C.gariepinus	Male	194.000	30.400	26.500	168.672	21.500	45.993	119.340	5.398	33.340	84.470
9.	C.gariepinus	Male	160.000	28.000	24.200	133.00	19.659	39.516	91.656	3.944	27.285	63.989
10	C.gariepinus	Male	228.000	31.200	27.400	189.26	28.377	50.644	126.250	5.250	41.973	89.893
11	C.gariepinus	Female	342.000	35.000	31.000	284.000	52.273	71.254	208.000	5.869	44.361	162.630

12	C.gariepinus	Female	328.000	34.500	30.000	275.000	46.440	67.150	203.000	7.444	48.446	152.250
13	C.gariepinus	Female	309.000	33.800	30.000	250.000	50.620	59.876	186.000	8.094	37.101	143.484
14	C.gariepinus	Female	402.000	37.500	33.000	342.000	53.185	74.691	264.000	9.860	54.520	207.000
15	C.gariepinus	Female	318.000	35.000	31.000	264.000	46.952	62.872	199.000	8.448	42.858	150.992
16	C.gariepinus	Female	305.000	33.500	29.800	240.000	54.675	59.399	178.000	11.530	38.771	133.433
17	C.gariepinus	Female	298.000	35.000	30.600	258.000	33.468	62.506	192.946	8.681	44.254	145.676
18	C.gariepinus	Female	302.000	34.300	30.600	254.000	42.232	70.240	181.000	5.138	43.353	132.057
19	C.gariepinus	Female	322.000	34.200	30.200	277.000	38.808	68.045	205.000	7.668	46.322	155.750
20	C.gariepinus	Female	315.000	34.300	30.600	261.000	43.570	75.862	182.645	5.062	40.263	140.220

Appendix (2): Biometric parameters of *Clarias gariepinus* wild:

No	Species	Parameter Sex	B.W (g)	T.L (cm)	S.L (cm)	WAG (g)	VW (g)	HW (g)	WAG+D (g)	FinsW (g)	F.F (g)	FW (g)
1.	C.gariepinus	Male	342.000	36.000	31.500	326.000	12.659	91.106	233.000	9.662	59.384	170.489
2.	C.gariepinus	Male	289.000	35.000	30.500	277.000	10.560	85.069	188.000	8.235	49.322	135.496
3.	C.gariepinus	Male	518.000	41.800	36.600	282.000	32.999	123.074	324.000	16.045	82.606	263.000
4.	C.gariepinus	Male	419.000	38.300	34.500	399.000	14.941	114.710	279.000	11.520	64.456	212.000
5.	C.gariepinus	Male	319.000	35.500	31.200	307.000	8.757	83.337	220.000	5.335	50.746	165.569
6.	C.gariepinus	Male	306.000	35.900	31.500	285.000	15.276	77.245	161.039	7.184	39.473	160.671
7.	C.gariepinus	Male	336.000	38.400	33.500	318.000	13.062	86.190	229.000	6.315	55.117	169.770
8.	C.gariepinus	Male	307.000	36.600	32.300	284.000	16.720	87.867	192.000	6.311	48.247	142.285
9.	C.gariepinus	Male	354.000	37.700	32.100	228.000	18.144	90.493	233.000	9.745	57.274	175.861
10	C.gariepinus	Male	268.000	34.500	30.500	241.000	16.853	69.183	172.000	7.538	35.040	132.809
11	C.gariepinus	Female	431.000	40.000	35.300	411.000	14.455	130.360	280.000	11.938	76.740	205.000

12	C.gariepinus	Female	361.000	36.100	32.700	324.000	35.173	48.990	229.000	7.589	38.289	192.701
13	C.gariepinus	Female	337.000	36.100	31.700	316.000	18.100	89.961	220.000	7.738	59.806	161.577
14	C.gariepinus	Female	304.000	36.300	32.200	283.000	16.777	73.934	203.000	7.594	34.086	167.909
15	C.gariepinus	Female	342.000	36.400	31.900	316.000	16.810	85.694	233.000	7.500	62.679	170.908
16	C.gariepinus	Female	413.000	38.500	34.200	385.000	24.495	91.036	289.000	8.849	64.156	223.000
17	C.gariepinus	Female	292.000	34.500	30.500	277.000	10.577	76.728	198.000	7.518	48.821	146.940
18	C.gariepinus	Female	344.000	37.500	33.200	320.000	16.325	86.569	234.000	9.407	50.538	177.953
19	C.gariepinus	Female	244.000	33.400	29.500	232.000	8.775	61.860	168.000	4.729	39.736	126.670
20	C.gariepinus	Female	284.000	35.500	31.000	266.000	12.592	81.000	181.000	4.818	41.283	139.230

Appendix (3): Biometric parameters of *Clarias gariepinus* farmed as percentages:

No	Species	Parameter Sex	WAG %	VW %	HW %	WAG+D %	FinsW %	F.F %	FW %	Carcass %
1.	C.gariepinus	Male	90.909	8.893	21.983	66.969	3.538	18.735	47.246	49.611
2.	C.gariepinus	Male	83.611	14.489	25.452	56.389	2.018	18.913	33.789	58.854
3.	C.gariepinus	Male	90.000	7.877	22.791	65.000	3.330	21.482	42.330	52.150
4.	C.gariepinus	Male	88.462	10.240	22.186	65.385	3.834	16.136	48.264	48.562
5.	C.gariepinus	Male	89.655	8.880	21.727	63.992	3.252	16.273	44.946	46.880
6.	C.gariepinus	Male	88.265	10.433	23.172	62.204	2.526	14.147	46.860	47.752
7.	C.gariepinus	Male	60.456	10.162	26.386	59.000	2.353	16.079	40.851	52.628
8.	C.gariepinus	Male	86.944	11.082	23.708	61.515	2.782	17.186	43.541	51.976
9.	C.gariepinus	Male	83.125	12.287	24.698	57.285	2.465	17.053	39.993	54.037
10	C.gariepinus	Male	83.009	12.446	22.212	55.373	2.303	18.409	39.427	53.068
11	C.gariepinus	Female	83.041	15.285	20.835	60.819	1.716	12.971	47.553	49.090

12	C.gariepinus	Female	83.841	14.159	20.473	61.890	2.270	14.770	46.418	49.401
13	C.gariepinus	Female	80.906	16.382	19.377	60.194	2.619	12.007	46.435	47.766
14	C.gariepinus	Female	85.075	13.230	18.580	65.672	2.453	13.562	51.493	45.372
15	C.gariepinus	Female	83.019	14.765	19.771	62.579	2.657	13.477	47.482	48.013
16	C.gariepinus	Female	78.689	17.926	19.475	58.361	3.780	12.712	43.749	50.113
17	C.gariepinus	Female	86.577	11.231	20.975	64.747	2.913	14.850	48.885	47.056
18	C.gariepinus	Female	84.106	13.984	23.258	59.934	1.701	14.355	43.727	51.598
19	C.gariepinus	Female	86.025	12.052	21.132	63.665	2.381	14.386	48.370	47.570
20	C.gariepinus	Female	82.857	13.832	24.083	57.983	1.607	12.782	44.514	50.697

Appendix (4): Biometric parameters of *Clarias gariepinus* wild as percentages:

No	Species	Parameter Sex	WAG %	VW %	HW %	WAG+D %	Fins W %	F.F %	FW %	Carcass %
1.	C.gariepinus	Male	95.322	3.701	26.639	68.129	2.825	17.364	49.851	47.704
2.	C.gariepinus	Male	95.848	3.654	29.436	65.052	2.849	17.066	46.884	50.156
3.	C.gariepinus	Male	93.050	6.370	23.759	62.548	3.097	15.947	50.772	46.077
4.	C.gariepinus	Male	95.227	3.566	27.377	66.587	2.749	15.383	50.597	46.326
5.	C.gariepinus	Male	96.238	2.745	26.124	68.966	1.672	15.908	51.903	44.777
6.	C.gariepinus	Male	93.137	4.992	25.243	52.627	2.348	12.900	52.507	43.135
7.	C.gariepinus	Male	94.643	3.888	25.652	68.155	1.879	16.404	50.527	45.943
8.	C.gariepinus	Male	92.508	5.446	28.621	62.541	2.056	15.716	46.347	49.783
9.	C.gariepinus	Male	64.407	5.125	25.563	65.819	2.753	16.179	49.678	46.868
10	C.gariepinus	Male	89.925	6.288	25.815	64.179	2.813	13.075	49.556	45.178
11	C.gariepinus	Female	95.360	3.354	30.246	64.965	2.770	17.805	47.564	51.405

12	C.gariepinus	Female	89.751	9.743	13.571	63.435	2.102	10.606	53.380	33.920
13	C.gariepinus	Female	93.769	5.371	26.695	65.282	2.296	17.747	47.946	49.812
14	C.gariepinus	Female	93.092	5.519	24.320	66.776	2.498	11.212	55.233	41.052
15	C.gariepinus	Female	92.398	4.915	25.057	68.129	2.193	18.327	49.973	48.299
16	C.gariepinus	Female	93.220	5.931	22.043	69.976	2.143	15.534	53.995	43.508
17	C.gariepinus	Female	94.863	3.622	26.277	67.808	2.575	16.720	50.322	46.618
18	C.gariepinus	Female	93.023	4.746	25.165	68.023	2.735	14.691	51.731	44.602
19	C.gariepinus	Female	95.082	3.596	25.352	68.852	1.938	16.285	51.914	45.234
20	C.gariepinus	Female	93.662	4.434	28.521	63.732	1.696	14.536	49.025	47.491

HW = Head weight (g)

Where:

B.W = Body weight (g)

T.L = Total length (cm)

S.L = Standard length (cm)

WAG = Weight after gutting (g)

VW = Viscera weight (g)

WAG+D = Fish weight after gutting and deheading (g)

FW = Fin weight (g)

F.F = Frame and fins (g)

WFWS = Weight of fillets with skin (g)

SW = Skin weight (g)

Fillet W = Fillet weight (g)

Appendix (5): Format for collection data of Chemical composition for (farmed and wild):

No	species	Parameter Size	Moisture %	Crude protein %	Ether extract %	Ash content %	NFE %	Dry matter %
1.	C.gariepinus Farmed	Male	77.00	31.21	8.60	2.00	35.19	23.00
		Male	63.00	31.80	7.90	2.00	21.30	37.00
		Male	79.00	30.00	8.70	1.00	39.30	21.00
2.	C.gariepinus Farmed	Female	76.00	30.19	8.60	1.00	36.21	24.00
		Female	69.00	31.22	8.40	2.00	27.39	31.00
		Female	73.00	30.77	8.20	2.00	32.03	24.00
3.	C.gariepinus Wild	Male	72.00	30.90	7.70	1.60	31.80	28.00
		Male	75.50	31.07	8.00	1.50	34.23	24.50
		Male	74.90	31.88	7.90	1.00	34.12	25.10
4.	C.gariepinus Wild	Female	73.70	30.27	8.40	1.00	34.03	26.30
		Female	75.80	31.18	8.00	1.30	35.32	24.20
		Female	78.20	30.60	8.60	1.50	37.50	21.80

Appendix (6): Data of mineral elements for (fillet and whole body of farmed *clarias gariepinus*):

No	species	Elements Sex	Ca %	K %	Mg %	P %	Na %	Fe %	Zn %
1.	C.gariepinus Farmed fillet	Male	3.890	4.200	2.809	3.300	4.590	1.170	0.096
		Male	4.690	3.914	3.173	2.990	4.616	1.205	0.098
		Male	4.390	4.219	2.864	3.416	4.545	1.196	0.100
2.	C.gariepinus Farmed whole body	Male	5.890	5.890	3.555	4.160	5.220	1.405	0.115
		Male	6.690	7.500	3.679	4.555	5.207	1.386	0.120
		Male	6.310	6.773	3.491	4.882	4.912	1.414	0.124
3.	C.gariepinus Farmed fillet	Female	3.320	3.519	2.232	2.400	4.410	1.166	0.089
		Female	3.870	3.266	2.463	2.619	3.905	1.188	0.094
		Female	3.930	3.414	2.359	2.515	3.840	1.109	0.099
4.	C.gariepinus farmed whole body	Female	5.320	5.912	3.279	4.992	4.875	1.366	0.117
		Female	5.150	6.684	3.344	5.100	5.109	1.307	0.110
		Female	4.920	6.678	2.986	5.250	5.204	1.383	0.119

Appendix (7): Data of macro mineral elements for (fillet and whole body of farmed *clarias gariepinus*):

No	species	Elements Size	Ca %	K %	Mg %	P %	Na %	Fe %	Zn %
1.	C.gariepinus wild fillet	Male	4.760	3.966	2.919	3.174	4.610	1.190	0.098
		Male	4.900	4.315	3.079	3.265	4.588	1.730	0.105
		Male	4.880	4.220	2.666	3.193	4.594	.189	0.103
2.	C.gariepinus Wild whole body	Male	6.480	5.783	3.476	4.759	5.313	1.388	0.128
		Male	6.720	6.917	3.250	4.643	5.280	1.474	0.118
		Male	5.940	6.889	3.495	4.392	5.300	1.423	0.127
3.	C.gariepinus wild fillet	Female	3.590	4.339	2.135	2.469	4.386	1.106	0.088
		Female	4.050	3.818	2.246	2.391	3.977	1.195	0.095
		Female	3.730	3.777	2.310	2.288	3.888	1.130	0.093
4.	C.gariepinus Wild whole body	Female	5.510	5.844	3.220	5.268	4.966	1.359	0.116
		Female	5.270	6.781	2.865	5.182	5.194	1.298	0.120
		Female	4.890	6.973	3.306	5.233	5.227	1.309	0.124

Appendix (8) Regression linear analysis for weights and lengths.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	df1
1	.937[a]	.878	.875	1.01473	.878	272.815	1

Model Summary[b]

Model	Change Statistics		Durbin-Watson
	df2	Sig. F Change	
1	38[a]	.000	.800

a. Predictors: (Constant), weight
b. Dependent Variable: length

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	280.912	1	280.912	272.815	.000[b]
	Residual	39.128	38	1.030		
	Total	320.040	39			

a. Dependent Variable: length
b. Predictors: (Constant), weight

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	23.042	.739		31.198	.000
	weight	.038	.002	.937	16.517	.000

a. Dependent Variable: length