CHEMICAL ANALYSIS OF FISH OBTAINED FROM ZARIA DAM

BY

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A Thesis submitted in partial fulfilment
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THESIS RECOMMENDATION

We hereby recommend that the thesis prepared by Major S. K. Oni entitled Chemical Analysis of Fish obtained from Zaria Dam be accepted in partial fulfilment of the requirements for the degree of M.Sc. Analytical Chemistry.

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A C K N O W L E D G E M E N T

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Finally, I say a big thank you to my wife, Yinko, for her understanding and interest in this study.

D E D I C A T I O N

To all Research Workers who will shoot Nigeria into higher spheres of Scientific Knowledge.

"Seek and ye shall find"

Mathew 7 verse 7.

MD

A 3 S T R A C T

Three species of fresh Water fishes from Zaria dam (Alestes nurse; Synodontis Schall and Tilapia zillii) were analysed for their water, fat, carbohydrate, total organic matter, protein, amino acid, ash, and mineral contents and also for their calorific values, using ten samples of each. The results shows that the three speciea contain the same percentage of body water content, but different fat, carbo-hydrate, organic matter, protein, amino acid, ash, mineral contents and calorific values.

A. nurse, S. schall and T zillii, are of low fat content, (17.40g, 9.55g and 12.33g/100g dry weight, respectively). The three species contain high amounts of protein (69.94g/100g for A. nurse, 61.91g/100g for S. schall and 54.36g/100g for I. zillii).

The carbohydrate content of the three species was found to be very low as shown by the values 2.52g/100g for A. nurse, 14.16g/100g for S. schall and 13.38g/100g for T. zillii. The calorific values of the three species shows that proteins contribute a lot to the calorific value than carbohydrate and fat.

A nurse has the highest mean calorific value of 55B.40Kcal/100g followed by T. zillii with a value of 500.6lKcal/100g and lastly S. schall with a value of 490Kcal/100g.

From the amino acid analysis, the following amino acids were found to be present in equal amounts in the three species; (i) lysines (ii) histidine, (iii) arginine, (iv) valine, (v) alanine (vi) threonine (vii) glutamic acid (viii) Methionine (ix) tyrosine and (x) phenylalanine.

Variations were observed only for (i) aspanftic acid (ii) glycine (iii) serine (iv) proline, (v) isoleucine and (vi) leucine values.

S. schall was found to be richer in all the mineral elements investigated than A nurse and T. zillii.

High levels of calcium and phosphorus content were recorded for the three species, while potassium sodium, and magnesium are present in appreciable amounts.

However, zinc, iron and copper are present in very small amounts in the three species.

Suggestions have been made for further investigation into the mineral and vitamins content, as well as the fatty-acid composition of the fat. Marine and brackish water fish samples have been suggested to be investigated along similar lines for a comprehensive chemical data for fishes obtained in Nigerian waters.

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CHAPTER I

INTRODUCTION

1.1 JUSTIFICATION FOR THIS WORK

Fish is a good source of protein for human beings. It is also one of the major components of poultry rations, in fact, the chief source of animal protein in poultry rations. However, fish contains a lot of other components which are useful particularly to poultry and livestock. With the recent introduction of Operation Feed The Nation (OFN) Programme in Nigeria, a lot of considerable interest has been shown in poultry and livestock farming.

Poultry especially is now becoming one of the major sources of proteins in Nigeria. The maintainance of the birds is posing serious problems in terms of provision of feeds.

Poultry feeds are very expensive and this has limited sizes of poultry farms both for backyard poultry or large scale poultry farming. The main reason for the high cost in prices of poultry feeds is that the major components (namely; maize (corn), fish meal, blood meal, bone meal and vitamins) are imported into the country.

Corn and fish meal are the major (sometimes only) sources of proteins in poultry feeds. Yellow corn supplies proteins, some fibres and part of the yellow pigment needed for yellow coloration of egg yolk. Fish meal has also been known to be a good source of other essential nutrients of poultry feed such as mineral elements (Ca, Mg, Na etc); vitamins (A, B, D and E) and bone meal, to a small extent compaired to the daily requirements for the bird.

It is already a common practice among poultry farmers to supplement poultry ration with smoked and dried fish of all sorts. In all cases, positive results (in terms of improvement in production of eggs and growth of bird) have been observed. The extent of this depends on quantity and quality of fish meal. Various species of fish are obtained in rivers and streams in Nigeria. Although these are mainly for human consumption, their 'quality' in terms of protein, minerals, vitamins and other useful nutrients has not been well established.

On the other hand, little information is available on the biochemical composition of Nigerian fishes and their protein concentrates. Considerable data need to be published on many aspects of the chemical and nutritional values of fish and fishery products.

If the data were available, then the industry, medical services, and the general public would have a good reliable source of information on the composition of fish.

For example, food manufacturing industries will need some of these data on labels of processed or canned fish or fishery products. On the basis of this information, fish meals can be selectively recommended by dieticians.(1)

These various needs have encouraged the researcher of the work reported in this paper to aim

(a) at developing a comprehensive data bank on the chemical composition of fish.

(b) at pointing out areas in the chemical composition of fish needing further investigations.

1.2 TYPES OF FISHES ANALYSED

The work reported in this paper has been carried out on three common fresh water species found in Zaria Dam. They are (a) Alestes nurse (b) Synodontis schall and (c) Tilapia zillii The three species were classified on the basis of the classification used by Mc Connel (2).

Alestes nurse (see figure1.1)

This is silvery in colour with a prominent black spot at the base of the caudal fin. The caudal varies from pink to bright red in colour. It is usually found in shallow in shore regions where it feeds upon a variety of food materials. They are usually seen in small groups and are very common in fresh waters.(2)

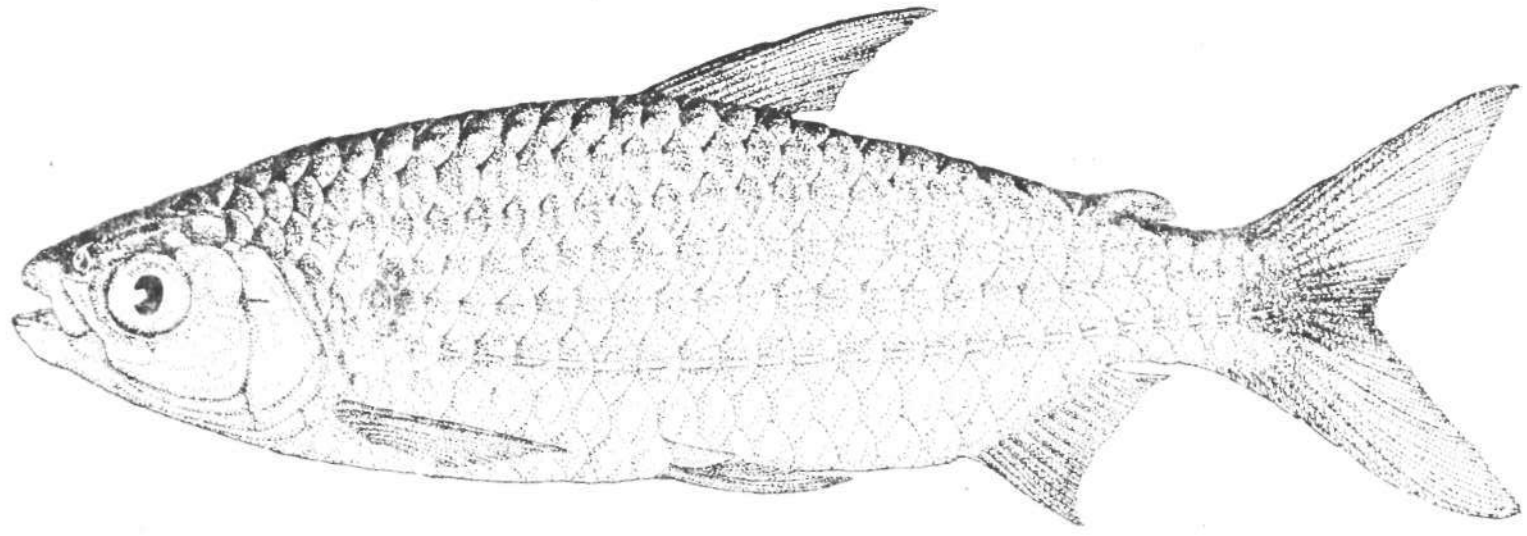
Synodontis schall (see figure1.2)

It has a dorsal surface of pectoral spine usually more coarsely serrated than the ventral surface.

The mandibular tooth band is less than half as wide as maxillary tooth band. The skin is generally covered with villosities (minute Hair-like projections). The crest of cephalo-nuchal shield immediately in front of dorsal spin is obtusely pointed. The diet is extremely varied and includes organic detritus, insect nymphs, larvae and eggs, molluscs, seeds, fish scales, zooplanleton and phytoplankton. This species is found in abundance in fresh waters.(2).

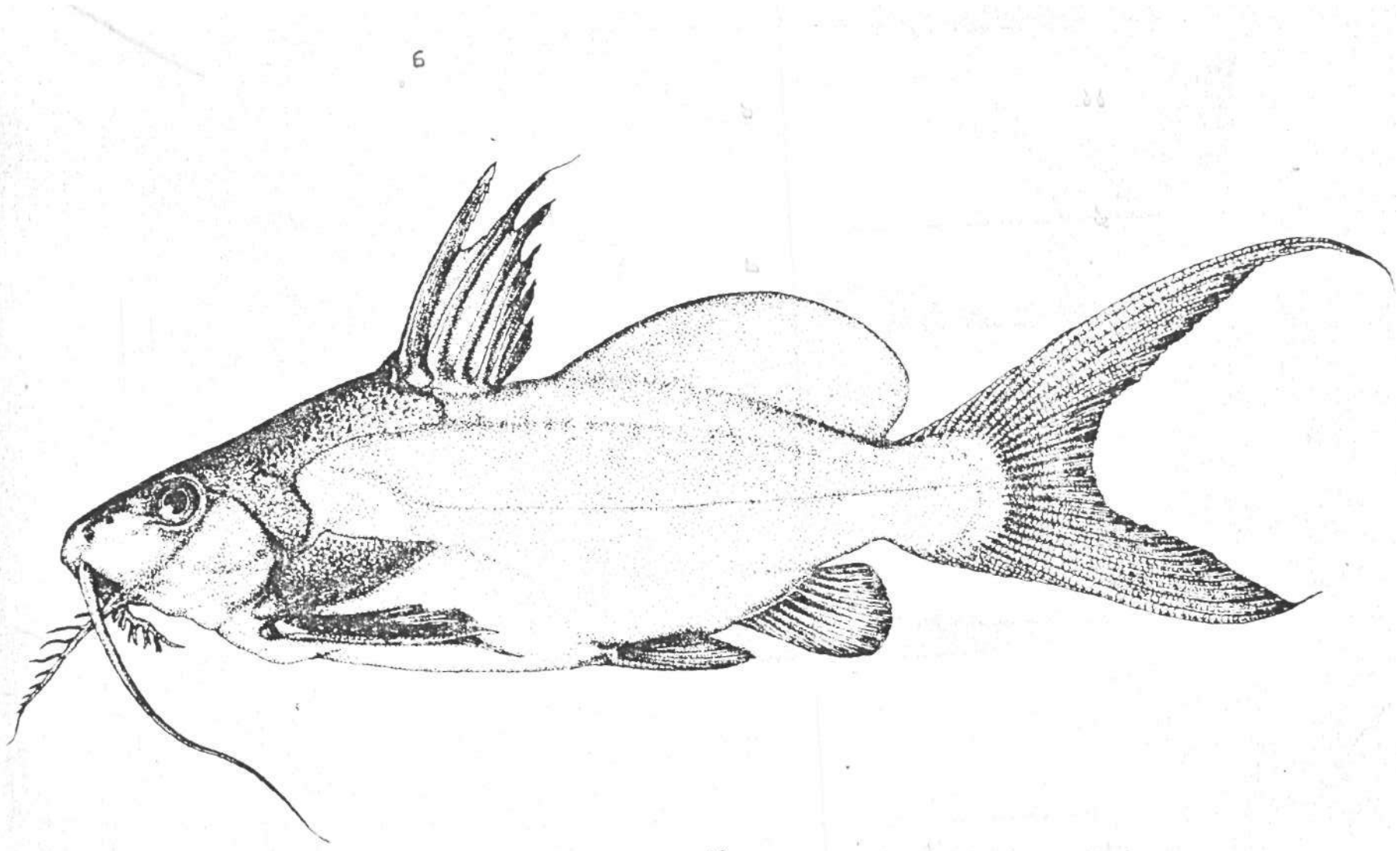
Tilapia zillii (see figure1.3)

This is a rather small species of Tilapia rarely exceeding 25cm long or 300g in weight. It is usually greenish yellow in colour with two dark horizontal bars on each flank, one running along



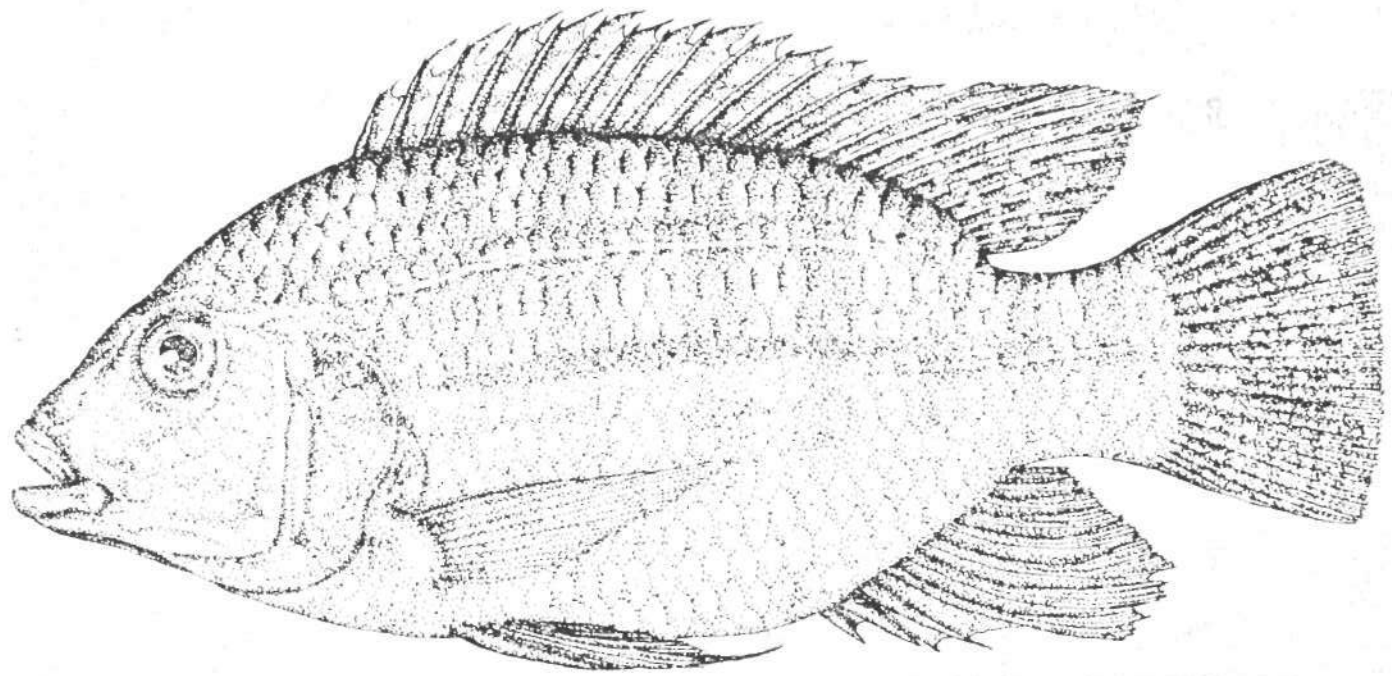
Alestes nurse

Fig. 1.1



Synodontis schall

Fig. 1.2



Tilapia zillii

Fig. 1.3

the midline and the other between the midline and the dorsal fin. The posterior part of the dorsal fin, the caudal fin and the anal fin are marked with a red-brown network over a yellow background. The network is less prominent at the edges of the fins which therefore appear more yellow. The posterior margin of the caudal fin is distinctly rounded. The diet of I. zillii consists of insects and plant material.(2)

1.3 SCOPE OF ANALYSIS

The experiments reported here are on investigations of some fishes obtained in a fresh water environment in Nigeria, to know mainly the proximate composition, the elemental composition and amino acid composition. The proximate composition includes the moisture or water content, crude protein, ether fat (that portion of a moisture free fish sample that can be extracted by ethyl ether or petroleum ether); ash; carbohydrate; organic matter; and calorific values of the three species.

The elements investigated in this work include calcium, copper, Iron, magnesium, phosphorus, potassium, sodium and zinc. Amino acid analysis is necesitated because the quality of proteins is measured primarily in terms of the types of amino acids contained.(3)

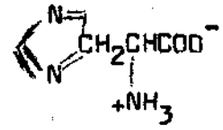
Chemically, protein are high polymers.

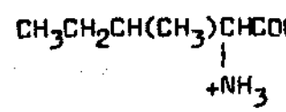
They are polyamides and the monomers from which they are derived are the α-amino carboxylic acids. A single protein molecule contains hundreds or even thousands of amino acid units.

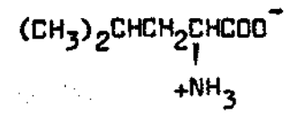
Generally, there are about twenty six amino acids that have been found in proteins. There are the essential amino acids, (cannot be synthesized by the animal and therefore must be fed to the animals) and the non-essential ones which can be synthesized by the animal.[4] Of these twenty six different types of amino acids found in proteins, only sixteen amino acids are investigated in this work due to the method of hydrolysis employed (only eighteen are generally found in fishes).

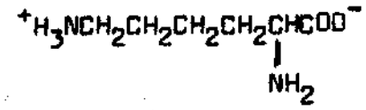
The ones investigated include

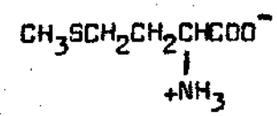
1.	Alanine (non-essential)	Ala	$CH_3-\underset{+NH_3}{CH}COO^-$
2.	Arginine (essential)	Arg	$H_2N\underset{+NH_2}{C}NHCH_2CH_2CH_2\underset{NH_2}{CH}COO^-$
3.	Asparitic acid (non-essential)	Asp	$HOOC\ CH_2\underset{+NH_3}{CH}-COO^-$
4.	Glutamic acid (non-essential)	Glu	$HOOC\ CH_2CH_2\underset{+NH_3}{CH}COO^-$
5.	Glycine (non-essential)	Gly	$\underset{+NH_3}{CH_2}COO^-$

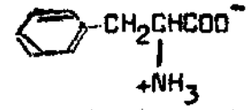
6. Histidine (essential) His 

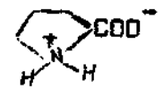
7. Isoleucine (essential) Ilue 

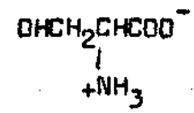
8. Leucine (essential) Leu 

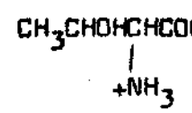
9. Lysine (essential) Lys 

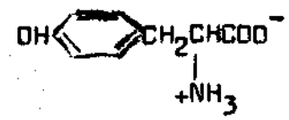
10. Methionine (essential) Met 

11. Phenylalanine (essential) Phe 

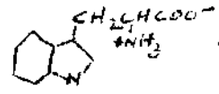
12. Proline (non-essential Pro 

13. Serine (non-essential) Ser 

14. Threonine (essential) Thr 

15. Tyrosine (non-essential) Tyr 

16. Valine (essential) Val $(CH_3)_2CHCHCOO^-$ (with $+NH_3$)

The two amino acids left out in this analysis owing non-availability of the analyser for such due to pressure of work on it, are Cystine, a non-essential amino acid ($-OOC-CHCH_2S-SCH_2CHCOO^-$, each CH with $+NH_3$) and Tryptophan an essential amino acid ().

From the above, the dipolar ion structure of amino acids can be observed which conforms consistently with the chemical and physical properties of amino acids (4).

This can be represented thus $+H_3N-CHR-COO^-$. It is this structure that is responsible for the chromatographic separation of amino acids on sulphonated polystyrene beads column when eluted with suitable elvents.

The polyoterono beads or resins, are highly cross-linked, high-molecular weight polymers which can be cation or anion exchangers. A cation-exchange resin is a high molecular weight cross-linked polymer containing sulphoric, carboxylic, phenolic, etc., group as an integral part of the resin and an equivalent amount of cations. An anion-exchange resin, on the other hand,

is a polymer containing amine or quarternary ammonium groups as integral parts of the polymer lattice and an equivalent amount of anions such as chloride, hydroxyl or sulphate ions.

During acid separation, there is exchange of ions between some ions of the resin and those of amino acids. The dominating factor in this separation is the pH value of the medium of elution[5].

1.4 PREVIOUS WORK

Previous work in the area of chemical analysis of fish and feeds in Nigeria is particularly limited. This is generally so in Africa. Hartley (6) published values for the composition of the feeding stuffs in Nothern Nigeria mainly as a guide to the then Northern Nigeria mixed farmers for feeding their cattle. Some non comprehensive data reflecting the results of workers in the services of the Nigerian Government have also been published in the Imperial Bureau of Animal Nutrition.[7] These data represent essentially proximate analysis values and therefore of limited value in today's context of chemical analysis of feeds. Such data could only be used in ration formulation based on crude protein content, which in the light of the present state of knowledge in nutrition is outdated.

Oyenuga[8-10] has made some systematic investigations of the composition and nutritive value of some Nigerian foods and feedingstuffs. However, the species of fish analysed in these investigations are not mentioned as well as their environment. The work has been mainly nutritional.

Watts, J. C. D. (II), made some investigations about the chemical composition of a West African fish named *Fimbriata* Deelstra; et al (12); Andrian (13); Baruh and Gillard, (14) are among other workers who have carried out some investigations into the composition of Tropical African fishes.

Recently, Olatunde A. A. (15) reported some work on certain aspects of the biochemical composition of three common schilbeid species of fish in Kainji Lake.

Over the years, however, the composition of fishes have been studied in advanced countries by several investigators including Atwater (16) and Reay, et al (17).

It has been discovered in general that the composition of fish seems to depend on age, sex, season and diet. (18-21). There has in recent years been a noticeable increase in the interest shown in both the analysis of trace elements and their phiosiological significance, the latter especially in connection with feed for domestic animals and poultry birds.

There are relatively few new data available on the content of many of the important trace elements to be found in fish (22, 23).

~~Virgina D. J.~~, James C. B. ~~and Cook, E.~~ ~~(1)~~ et al (24) carried out the determination of the proximate composition of the edible portion of thirty two commonly eaten crustaceans and mollusks, and fishes, which included the moisture, crude protein, ether fat, ash, crabohydrate, organic matter and calorific values. Their results are in general aggreement with those reported by most other authors who have worked in same area.

CHAPTER II

EXPERIMENTAL

2.1 SAMPLE COLLECTION

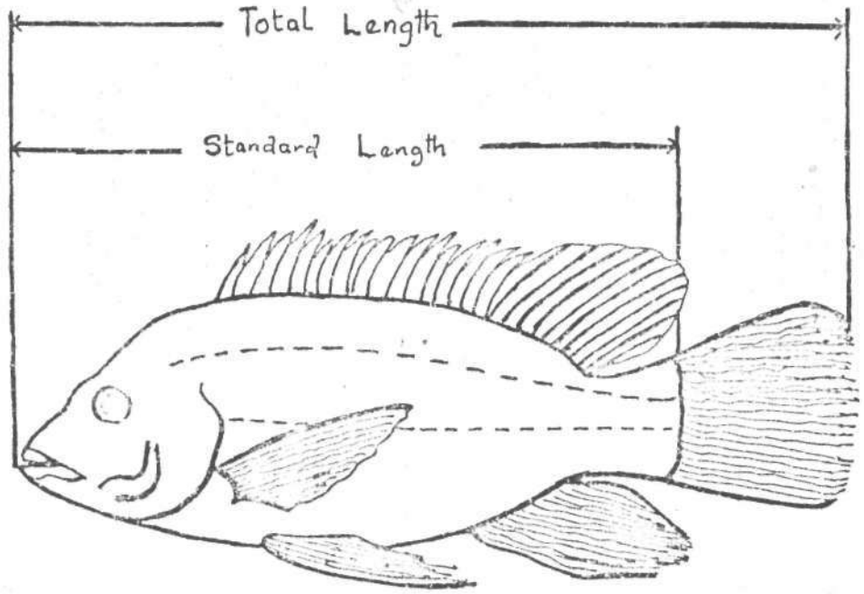
The fish samples used in the work described in this paper are fresh water species caught from Zaria Dam on the fourteenth day of August, 1978 at 2.00 p.m. The species were caught in the lower part of the Dam.

Three main species were caught, namely Alestes nurse; Synodontis schall; and Tilapia zillii.

The method of obtaining the fish samples was by the small mesh nets. As soon as the fish samples were caught, they were frozen in the ice in order to prevent their deterioration.

The fish samples were removed from the ice-chest in the laboratory and the total length, standard length as well as the weight of each fish sample was determined as described by Owodehinde(25). (see fig. 2.1)

The various values of lengths and weights of the three species are given in Table 1. The fish samples were immediately transferred into a deep freezer.



Method Used for Measuring Fish.

Fig. 2.1

2.2 PREPARATION OF SAMPLES FOR ANALYSIS

The thirty fish samples (ten of each species) used were kept in the deep freezer for not more than one week before analysis.

Due to the small size of the fish samples (length 6") whole fish including heads were used as recommended (26).

Each fish sample was cleaned, scaled and eviscerated before passing through a high speed blender. Blending was done for a short period, stopped and repeated several times until satisfactory results were obtained.

Each well-blendeddfish sample was recovered carefully and then weighed before drying at 68°C under reduced pressure for twenty four hours as suggested by Pearson(27).

The dry material was grounded to powder state with morter and stored in air tight and labelled containers.

2.3 DETERMINATION OF WATER CONTENT

The water content of a sample is usually recorded as the loss in weight of a sample as a result of oven-drying of the sample to a constant weight at one atmospheric pressure and at a temperature just above the boiling point of water. For many biological samples like fish meals, such drying results in loss of volatile fatty acids, and some sugars that decompose at temperatures above 70°C.

Such substances will obviously be counted in error as part of water content of the sample. Drying at lower temperatures in vacuo is sometimes used(28) to avoid such loss in components other than water.

Measurement of water by loss in weight of sample on heating is therefore only an approximation as this loss might include loss of volatile constituents and any loss by heat decomposition of organic constituents.

It is customary to report the proximate analysis on a moisture-free basis in tables of food composition. The problem of food storage is complicated by high moisture content. It has been reported that foods containing more than fourteen per cent moisture content cannot be stored in bulk (28).

2.3.1 METHOD

The determination of water content of each sample was carried out on the wet samples, which had not been heated at any stage.

Wet samples were weighed and then heated in an oven at $105^{o}C$ for 48 hours.

The oven-dried samples were weighed in order to determine the amount of moisture lost. The loss in weight due to the escape of water from fish sample was expressed as percentage water content of sample.

This is given by the expression:

$$\frac{\text{Weight of wet sample-weight of dry sample} \times 100}{\text{Weight of wet sample}}$$

This determination was carried out in triplicates. The results are contained in table 3.2.

2.4 DETERMINATION OF THE ASH CONTENT

Ash is the inorganic residue obtained when a sample is heated at a high temperature, usually above 500^{o}C. The nutritional significance of the ash figure will depend, in part, on the food under consideration. Crude ash may enable one to calculate calcium, phosphorus and other mineral elements in fish and other animals, with sufficient accuracy for practical use, since the abundance of such ash is relatively constant (28).

2.4.1 METHOD

The ash content was determined by incinerating known weights of each powdered fish sample in a cold muffle oven at 525^{o}C until ashing was complete. The ash was cooled and weighed.

The weight of the ash content for each species was calculated from

$$\frac{\text{Weight of ash}}{\text{Weight of unheated sample}} \times 100$$

recorded in Table 3.3 aspercentage (29)

2.5 DETERMINATION OF MINERAL ELEMENTS

The analysis of the mineral elements was carried out using analytical methods based on colorimetry and absorption spectrophotometry. Both methods are based on Beer-Lambert's laws.

$$\log\frac{I_o}{I_t} = (abc)$$

where I_o = intensity of incident light
I_t = " " transmitted light
a = molar absorptivity
c = concentration
b = thickness of medium

The concentration is therefore proportional to the logarithm of the transmittance.

The chief advantage of colorimetric and spectrophotometric methods is that they provide a simple means for determining minute quantities of substances. In analytical absorption spectrophotometry, a standard solution must be prepared for the determination of each element. The method is generally accepted to

be suitable for the routine determination of a given element in a given medium but not for routine qualitative analysis(30)

2.5.1 METHOD

A known quantity of each sample was accurately weighed and ashed in the furnace at 525°C as before. The ash was cooled in desiccator and weighed. 2 cm^3 concentrated hydrochloric acid was added to dissolve the ash. A few drops of concentrated nitric acid (10-15 drops) was added. The resulting solution was boiled on the water bath and evaporated almost to dryness. Distilled water was then added and the solution was filtered and transferred quantitively into 100cm^3 volumetric flask$ and made up to mark with distilled water. Appropriate dilutions of this stock solution were made for the determination of each element (31).

The following elements were determined by atomic absorption spectrophotometry (Perkin-Elmer Model 306) with digital readout; Calcium, Copper, Iron, magnesium, potassium, and zinc. Spectronic 20 was used to determine phosphorus; while a flame photometer was used to determine sodium. The results of the determinations are contained in table 3.4

2.5.1.1 PREPARATION OF STANDARDS

Standard solutions were prepared for the calibration curves needed for the final analysis of the elements. In all the determinations distilled water was treated in the same way as sample to give reference solution which was used in all cases.

2.5.1.2 SODIUM[32]

The instrument used for sodium analysis was EEL flame photometer.

2.5418g of sodium chloride (analytical grade) were made up into one litre solution with distilled water in a volumetric flask. This solution contained the equivalent of 1.0mg sodium per cm^3. The stock standard solution was diluted to give solutions containing 1.0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0 ppm of sodium ions. A calibration curve for sodium was plotted. The concentration of sodium ions was determined in the sample solutions using sodium filter.

2.5.1.3 POTASSIUM[32]

1.9070g of potassium chloride (analytical grade) was weighed and $10cm^3$ hydrochloric acid was added. These were made up to one litre with distilled water in a volumetric flask.

The stock solution contained 1000ppm of potassium ions. The solution was diluted to give solutions containing 3.0, 6.0, 9.0, 12.0, and 15.0 ppm of potassium ions.
(Due to the heat of acetylene, ionisation occurs when the atomic absorption spectrophotometer is used thereby resulting in lower reading).

In order to prevent ionisation in the flame, Lithium chloride (6.1g) was added to give 1% Lithium in the final solution.

Potassium in each dilute solution was determined at 766.5nm and a calibration curve plotted. The concentrations of potassium ions in the sample solutions were determined from the calibration curve.

2.5.1.4 ZINC (33)

1.0g of pure zinc metal was weighed and 10cm^3 conc. hydrochloric acid added. The mixture was boiled on water bath. The resulting solution was diluted to one litre in a standard flask with distilled water. The solution contained 1000 ppm of zinc ions.

From the stock, 1.0, 2.0, 3.0, 4.0 and 5 ppm dilute solutions were made. A calibration curve was prepared using a wavelength

of 213.9nm. The zinc ion concentration in the sample solutions was determined by the aid of the calibration curve.

2.5.1.5 COPPER[33]

1.0g of pure copper metal was dissolved in 5cm^3 concentrated nitric acid and 5cm^3 concentrated hydrochloric acid was added.

The solution was evaporated almost to dryness and diluted with distilled water to one litre in a volumetric flask. This solution contained 1000ppm copper cons. From the stock, 5.0, 10.0, 20.0, 40.0 and 80.0 ppm dilute solutions were prepared. Copper was determined at a wavelength of 324.7nm. The concentration of copper ions in each sample solution was determined from the standard curve.

2.5.1.6 MAGNESSIUM[33]

1.0g of pure magnesium ribbon was weighed and dissolved in 10cm^3 concentrated hydrochloric acid. The solution was evaporated almost to dryness over water bath. The resulting concentrated solution was diluted to one litre with distilled water in volumetric flask. The solution contained 1000ppm magnesium ions. From the stock, 0.5, 1.0, 1.5, 2.0, and 2.5ppm dilute solutions were prepared for the standard curve.

Magnessium was determined at 285.2nm. The concentration of magnessium ions in the sample solutions was determined from the standard curve. To eliminate interferences from aluminium, silicon and sulphate ions that might be present 7.5cm^3 of 1,500 ppm strontium chloride solution was added to the stock and sample magnessium solutions before making up to mark. The strontium chloride added suppressed any form of interferences thereby improving accuracy.

2.5.1.7 IRON[33]

1.0g of pure iron wire was weighed and dissolved in 10cm^3 concentrated hydrochloric acid. The solution was evaporated almost to dryness over water bath. It was made up to one litre in a volumetric flask as the stock. This contained 1000 ppm ions of iron. Dilute solutions of 5.0, 10.0, 20.0, 40.0 and 80.00 ppm were prepared from the stock. The concentration of ions of iron was determined at 248.3nm. Using the standard curve, the concentration of iron in each sample solution was determined.

2.5.1.8 CALCIUM[33]

2.4973g of calcium carbonate, which had been oven dried at 105^{0}C overnight, was weighed after cooling. A few drops

of distilled water was carefully added followed by $10cm^3$ concentrated hydrochloric acid. The solution was warmed to ensure complete dissolution of the calcium carbonate: To avoid any interference due to aluminium, silicon and sulphate ions, a solution containing 10,000 ppm of strontium chloride was prepared by weighing 30.43g of strontium chloride, dissolving and making up to one litre. Out of this, 1,500 ppm dilute solution was prepared.

$7.5cm^3$ of 1,500 ppm strontium chloride ($SrCl_2$) was added to calcium carbonate solution which was finally made to one litre with distilled water to give a stock solution. From the stock, dilute solution of 3.0, 6.0, 9.0, 12.0 and 15.0 ppm of calcium ions were prepared.

Calcium was determined at 422.7 nm and a calibration curve was plotted. The concentration of calcium ions in the sample was determined after treatment of each sample solution with strontium chloride to eliminate interferences of other ions.

2.5.1.9 PHOSPHORUS[34]

0.2196g of potassium dihydrogen phosphate (KH_2PO_4) was weighed. 50g of ammonium molybdate was also weighed and dissolved in $700cm^3$ of distilled water. 2.5g of ammonium metavanadate

was weighed and dissolved in 500cm^3 hot distilled water (60^{0}C). The entire ammonium molybdate solution was mixed with the ammonium meta vanadate solution. The resulting solution was added to the potassium dihydrogen phosphate in a two litre flask.

700cm^3 per chloric acid was added and the solution was allowed to cool. The solution was made up to two litres with distilled water. This contained 1000 ppm of phosphorus ion. From the stock solution, 3.0, 6.0, 9.0, 12.0 and 15.0 ppm phoshorus were prepared and used for the standard curve. Phosphorus was determined at 44nm using Spectronic 20.

Phosphorus in the sample solution was determined from the standard curve.

2.6 DETERMINATION OF TOTAL ORGANIC MATTER

The total organic matter was obtained by substracting the ash weight from the weight of dry fish sample incinerated.(35) The values are shown in Table 3.5

2.7 DETERMINATION OF FAT

The fat content of a biological material can be estimated by extracting the material exclusively with a suitable fat extracting solvent. In most cases, the fat

obtained by mechanical extraction is almost the same as that extracted by a solvent like ether.

The ether extract consists of glycerides of fatty acids, free fatty acids, and cholesterol. Estimates of ether extract in fish can be made either (1) by weighing the extracted material after evaporating the solvent, or (2) by recording the loss in weight of the moisture-free sample following its extraction by anhydrous ether.

The second method makes it possible to employ a multiple-sample extraction procedure. The samples are weighed into Aluminium crucibles, oven dried, reweighed, placed in groups in the extraction chamber, extracted and again weighed following extraction of the sample. This procedure, however, does not offer accurate values and hence the method of single samples by standard soxhlet extractor was employed in this work. The weight of the fat obtained after evaporating the solvent from the extract represents the weight of fat present.

2.7.1 METHOD[32]

5.12g of each fish sample was weighed into a paper extraction thimble and covered with a light layer of cotton wool. This was extracted with 300cm^3 of petroleum ether in continuous extractor (soxhlet extractor) for 16 hours.

The ether was distilled off until the volume of liquid in the 500cm^3 flask became about 20cm^3. The content of the flask was transferred to a 100cm^3 beaker. The flask was washed free of all oil with ether and evaporated on a hot plate. The beaker and its content was placed in a vacuum oven at 80^{0}C and 620mm Hg pressure for one hour and transferred to desiccator to cool and then weighed.

The extracted fish sample residue in the thimble was transferred to 150cm^3 beaker.

60cm^3 of 4M hydrochloric acid was then added. The mixture was digested for one hour on a hot plate, stirring occasionally with glass rod and adding distilled water as needed to mantain volume in the beaker.

A complete removal of ether from the fish sample residue was necessary before digestion to prevent carrying of meal particles over side of vessel onto hot plate during boiling of solution in the beaker.

The digested sample was then filtered through filter paper and residue was washed with distilled water until acid free, using methyl red on portions of filtrate to follow the progress of washing. The filter and the fish sample were placed in 150cm^3 beaker and dried for one hour in air oven at 85^{0}C. The filter paper

and contents were transferred to thimble and extracted for 16 hours with petroleum ether. The solvent was removed and extract weighed as described above.

The sum of weights of extracts gives the sum of total fat. The percentage fat of the dry weight each fish sample was calculated from:

$$\frac{\text{total weight of fat extracted}}{\text{Known weight of by fish sample before extraction}} \times 100$$

and recorded in Table 3.6 The fish sample residue in each determination was later used for a second set of nitrogen determination.

2.8 DETERMINATION OF CRUDE PROTEIN[28]

Crude protein is obtained by multiplying the nitrogen content of the feed by the factor 6.25. For some other materials, crude protein is determined by multiplying the nitrogen content by some other factor, depending on the percentage of nitrogen that is known to be in the protein of that particular food.

In the case of fish, the crude protein value is obtained by multiplying the nitrogen by the factor of 6.25.

The protein content of any food appear to be the most important. This is because nowadays, foods are classified on

the basis of their protein content.

Protein serves both as a source of energy and as index of the total amino acids of any food.

However, the limitations of the proximate value must be noted. As a source of energy, protein is subject to a loss of about 20 per cent of the potential energy. Thus protein is not regarded as a main source of energy.

As for protein's being a measure of the total amino-acid complex, it should be noted that not all proteins contain 16% nitrogen and that estimating the protein as 6.25 times the nitrogen in the sample leads to inaccuracies of varying degrees. Hence the values obtainedare regarded as crude. Although (Nx6.25) (N=nitrogen) may be a somewhat rough estimate of total protein, and little or no measure of its quality, it is still regarded as reasonably satisfactory.

2.8.1 DETERMINATION OF NITROGEN IN NON-DEFATED SAMPLE METHOD

In estimating nitrogen in food stuffs the Kjeldahl's and the Nessler reagent methods are well known. Also, the Kjeldahl's method has been known to be the more accurate of the two (36).

0.1g of fish powder was weighed into a Kjedahl's digestion flask. 5g of potassium sulphate and a few crystals of anhydrous

Copper(II) sulphate plus 25.0cm^3 of concentrated sulphuric acid were added into the flask. The mixture was digested for 24 hours at 50^{0}C in a fume cupboard. A clear colourless solution was obtained after complete digestion.

Four replicates including a blank were set up for each sample.

After digestion, the nitrogen in the sample was converted to ammonium sulphate by added concentrated sulphuric acid. The ammonium sulphate formed was then decomposed by sodium hydroxide, (50% w/w).

The liberated ammonia was distilled into 120cm^3 of 0.1MHCl. 100cm^3 of distilled water was poured into a volumetric flask containing antibumping granules. The digested sample was added to the water in the volumetric flask.

Six drops of methyl red indicator and 100cm^3 of sodium hydroxide (50w/w) were added to the mixture. The four replicates including a blank, were treated similarly and set up ready for distillation. 50cm^3 of 0.05M sulphuric acid was pipetted into a conical flask and two drops of methyl red were added. The conical flask containing the 0.05M sulphuric acid was put in position to collect the distillate from the mixture in the volumetric flask and distillation was carried out for about 50 minutes after which, about half of the liquid had

~~been distilled over into the receiving flask.~~

been distilled over into the receiving flask.

The distillate collected into the flask already containing 0.05M sulphuric acid was titrated with 0.1M sodium hydroxide until the pink colour changed to about light yellow.

The protein content is expressed as g/100g of dry weight of fish sample[36].

2.8.2 DETERMINATION OF NITROGEN IN A DEFATED SAMPLE[34]

In this determination, the method of digestion remains the same as in 2.8.1

However, the nitrogen here was determined colorimetrically on the basis of the development of an emerald-green in the reaction between ammonia, sodium salicylate, sodium nitroprusside and sodium hypochlorite in a buffered alkaline medium at a pH of 12.8 - 13.0.

The absorption by ammonia-salicylate complex formed was read at 660 nm using a Technicon auto analyser.

The estimation of nitrogen is based on the fact that full scale deflection on the instrument is equivalent to 200mg of nitrogen, using a standard containing 200mg of nitrogen. After running the samples, the percentage nitrogen in each fish sample was claculated thus:

$$\frac{200\text{mg (full scale deflection)}}{100} \times \frac{h}{\text{Sample weight}} \times \frac{100}{1}$$

where h = value of sample height on the chromatogram obtained from the Auto Analyser (34).

2.8.2.1 PREPARATION OF REAGENTS (34)

Stock 20% Sodium Hydroxide Solution

400g of sodium pellets were dissolved in 600cm^3 of distilled water, cooled to room temperature (50% w/w), and diluted to one litre with distilled water.

Stock 20% Sodium Potassium Tartarate Solution

20g of sodium potassium tartarate ($NaKC_4H_4O_6.4H_2O$) were dissolved in 600cm^3 of distilled water and diluted to one litre with distilled water. This was mixed thoroughly.

Stock 0.5M Buffer Solution

134g of sodium phosphate dibasic crystal ($Na_2HPO_4.7H_2O$) were dissolved in 800cm^3 distilled water. 40g of aqueous sodium hydroxide solution, (50% w/w), were added and diluted to one litre with distilled water with thorough mixing.

Working Buffer Solution

To 250cm^3 of stock sodium potassium tartrate solution (20%) was added 200cm^3 of stock buffer solution (0.5M) followed

slowly by addition of 250cm^3 of sodium hydroxide solution (20%) with stirring. The total reagents were diluted to one litre with distilled water and 1.0cm^3 of Brij-35, (30%) solution (20-25 drops) were added with thorough mixing (Brij-35 is a detergent).

Sodium Salicylate/sodium Nitroprusside Solution

150g of sodium salicylate and 0.30g of sodium nitroprusside were dissolved in 600cm^3 of distilled water. This was filtered through a fast filter paper into one litre volumetric flask and diluted to volume with distilled water.

1.0cm^3 of Brij-35 was added and mixed thoroughly and stored in brown bottle.

0.315% Sodium Hypochlorite Solution

6.0cm^3 of sodium hypochlorite solution were diluted to 100cm^3 with distilled water. 0.1cm^3 (two drops) of Brij-35 was added and mixed thoroughly.

2.9 DETERMINATION OF CARBOHYDRATE

Carbohydrate values were calculated by the difference method. The amount of protein plus fat substracted from the total organic matter is assumed to give the value for carbohydrate (11)

2.10 DETERMINATION OF CALORIFIC VALUES

The calorific value of each fish sample has been calculated using conversion factors called Atwater factors. These are 5.5Kcal/g for protein, 4.1Kcal/g for carbohydrates and 9.5Kcal/g for fat (37).

2.11 PROTEIN AND AMINO ACID ANALYSIS

2.11.1 HYDROLYSIS OF PROTEIN

As the precision of analytical methods for the determination of amino acids has increased, the limiting factor in deriving the amino acid composition of a protein has become the extent to which the composition of the hydrolysate is a true reflection of the composition of the parent protein. Discrepancies arise owing to the decomposition of certain labile amino acids during hydrolysis and as a result of the fact that some amino acids are liberated from the peptide linkage with difficulty.

There are different methods of protein hydrolysis,

(a) the acid hydrolysis, which liberates sixteen of the eighteen common amino acids. Tryptophan and cystine are normally destroyed by acid hydrolysis (38). The destruction of tryptophan during acid hydrolysis in recent times is being prevented using thioglycollic acid, during hydrochloric acid and p-toluene sulphoric acid (39). Both techniques have been found to give large yields of tryptophan. These methods are interesting but still too novel to be adequately assessed.

(b) Alkaline hydrolysis, using sodium or barium hydroxide. However, only tryptophan is liberated while others are destroyed (39).

(c) Performic acid oxidation, using a mixture of 30% v/v hydrogen peroxide and 88% v/v of formic acid in ratio one to nine. This liberates cystine, cysteine and methionine during the analysis (40).

Acid hydrolysis was employed in this study. Acid hydrolysis of protein is normally carried out in two ways (i) the sealed tube vial system and (ii) the open flask method. The latter is preferred to the former because it is easier from the operational point of view and also the ease with which dissolved oxygen is removed. It also offers a better degree of repeatability as against the sealed tube (41).

Acid hydrolysis of proteins, even under controlled conditions, results in the loss, sometimes complete, of certain amino acids as reported by Hirs H.W. et al (42) and Smith et al (43).

2.11.1 ACID HYDROLYSIS OF THE PROTEIN SAMPLES

400mg of defated fish sample were weighed into a 250cm^3 flat bottom flask and 25cm^3 of freshly prepared 6M HCl was added. Some glass beads were introduced into the flask. This was done in duplicate. The flasks were fixed with reflux apparatus and solution boiled gently for 24 hours, after which they were removed from reflux apparatus and evaporated to dryness using water for suction.

25cm^3 of distilled water was added and the solution again evaporated to dryness. The fish sample was transferred quantitatively with water into a 100cm^3 volumetric flask and solution made to the mark.

The content of the volumetric flask was shaken well and then filtered. The filtrate contained the hydrolysate which was later fed into the amino-acid analyser after the pH was appropriately adjusted (44).

2.11.2 SEPARATION OF AMINO ACIDS

2.11.2.1 PREPARATION OF REAGENTS AND BUFFERS(45)

4.0M Sodium Acetate Buffer

3 litres of distilled water were placed in a 4-litre beaker and agitated with a glass stirrer 1312.00g of sodium acetate were then dissolved slowly in distilled water inside a beaker to obtain a homogeneous solution.

After cooling, 400cm^3 of glacial acetic acid was added slowly and the solution was allowed to cool again. The contents of the 4-litre beaker were then transferred into a 4-litre flask.

1.0cm^3 of 0.1% (disodium) EDTA was added to prevent the formation of divalent ion build-up on the resin bed. It was then diluted to mark using distilled water.

1% NINHYDRIN REAGENT

40.0g of Ninhydrin (1,2,3-triketohydrindene hydrate, 1,2,3-indiantrione monohydrate) were dissolved in 2 litres of methyl cellosolve (2-methoxyethanol, $CH_3OCH_2CH_2OH$) in a 4-litre beaker.

One litre of the 4.0M sodium Acetate buffer was added slowly with stirring. The contents of the 4-litre beaker were transferred into a 4-litre volumetric flask and made to mask with distilled water.

2M HYDRAZINE SULPHATE SOLUTION

1.049g of hydrazine sulphate were dissolved in 3 litres of distilled water in a 4-litre volumetric flask. Four drops of concentrated sulphuric acid were added to make solution acidic as judged by a litmus paper. This was followed by the addition of four drops of 30% solution Brij-35, (a detergent). Distilled water was added to make volume to the mark.

50% METHYL CELLOSOLVE (2-Methoxyethanol)

This was prepared by adding 2 litres of distilled water to 2 litres of methyl cellosive in a 4-litre flask.

2.11.2.2 PREPARATION OF WORKING BUFFERS

Stock Buffer: The stock buffer was prepared by dissolving 420.0g of citric acid monohydrate in about 1.5 litres of distilled water with vigorous stirring in a 2-litre beaker.

165.0g of sodium hydroxide pellets were added in small portions with stirring. The solution was allowed to cool and transfered to a 2-litre volumetric flask. It was made to mark with distilled water. The solution was transferred to a storage container with a tight stopper and stored in a refrigerator.

WORKING BUFFER DILUTIONS

The pH and ionic strengths of the buffers used in the 76 minute amino acid analysis are as follows:

Buffer No.	pH	Na^+ mole l^{-1}	Citrate Mole l^{-1}	Methyl Cellosolve % v/v	Thiodiglycol % v/v
1	3.25	0.206	0.1	6	0.025
2	4.25	0.206	0.1	-	-
3	5.25	0.377	0.1	-	-
Sample	2.0	0.206	0.1	-	1.00

Buffer 1: 400cm^3 of stock buffer solution were poured into a 4-litre beaker equipped with stirrer. 3 litres of distilled water were added and the mixture stirred.

240cm^3 of methyl cellosolve and 1.0cm^3 of thiodiglycol were then added. The pH was adjusted to 3.25 by titrating with 6M hydrochloric acid. The solution was transfered to a 4-litre volumetric flask.

40.0cm^3 of 30% Brij-35 solution were added and made to mark with distilled water. The pH was rechecked and maintained at 3.25.

Buffer 2: This was prepared in the same way as Buffer 1 except that, methyl cellosolve was not added and the solution was titrated to pH 4.25 using 6M HCl.

Buffer 3: This buffer was prepared in the same way as buffer 2, except that 40.0g of sodium choride were added and solution was titrated to pH 5.25 using 6M HCl.

SAMPLE BUFFER

50.0cm^3 of stock solution was placed in a 600.0cm^3 beaker and 450.0cm^3 distilled water was added followed by stirring. 5.0cm^3 of thiodiglycol was added and the stirred mixture titrated with 6M HCl to pH 2.0.

2.11.2.3 0.2M SODIUM HYDROXIDE

32.0g of sodium hydroxide pellets and 4.0g EDTA (disodium) were dissolved in a 4-litre volumetric flask containing about 3 litres of distilled water with continuous stirring. The solution was made to mark with distilled water and stored in polyethylene container.

2.11.3 LOADING OF SAMPLES INTO CARTRIDGES

The cartridges were washed using 1.0cm^3 of 0.2M NaOH and then with 1.0cm^3 of buffer pH 2.0. The filler plug was first removed from cartridge followed by the addition of the 1.0cm^3 of 0.2M NaOH using a 1.0cm^3 plastic syringe. After forcing the liquid through the cartridge, it was emptied by inverting and shaking to remove all liquid.

This process was repeated using pH 2.0 buffer (0.2M sodium citrate). When the cartridge was empty and the resin inside equilibrated at pH 2.0, the internal standard, amino acid standard and sample were loaded in the following quantity and order.

(a) 10 µl of internal standard (norleucine) was pipetted with automatic pipett (2x50µ) into the empty clean cartridge.

(b) 10 µl of amino acid standard containing eighteen amino acids.

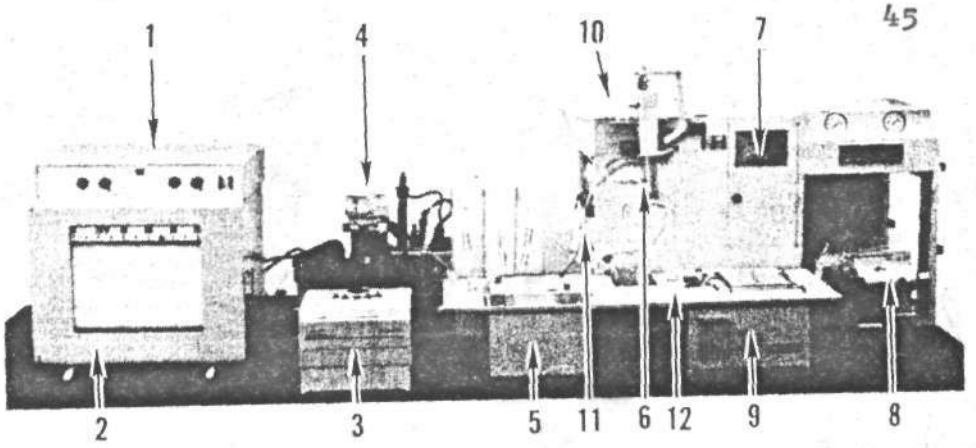
(c) 20µl of hydrolysate in buffer pH 2.0. While keeping the cartridge vertical, a vacuum was applied to the bottom of the cartridge. As soon as the sample containing (a), (b) and above had been drawn into the top filter, the vacuum was removed. The filler plug was replaced and cartridge placed in the sample tray ready for analysis.(45)

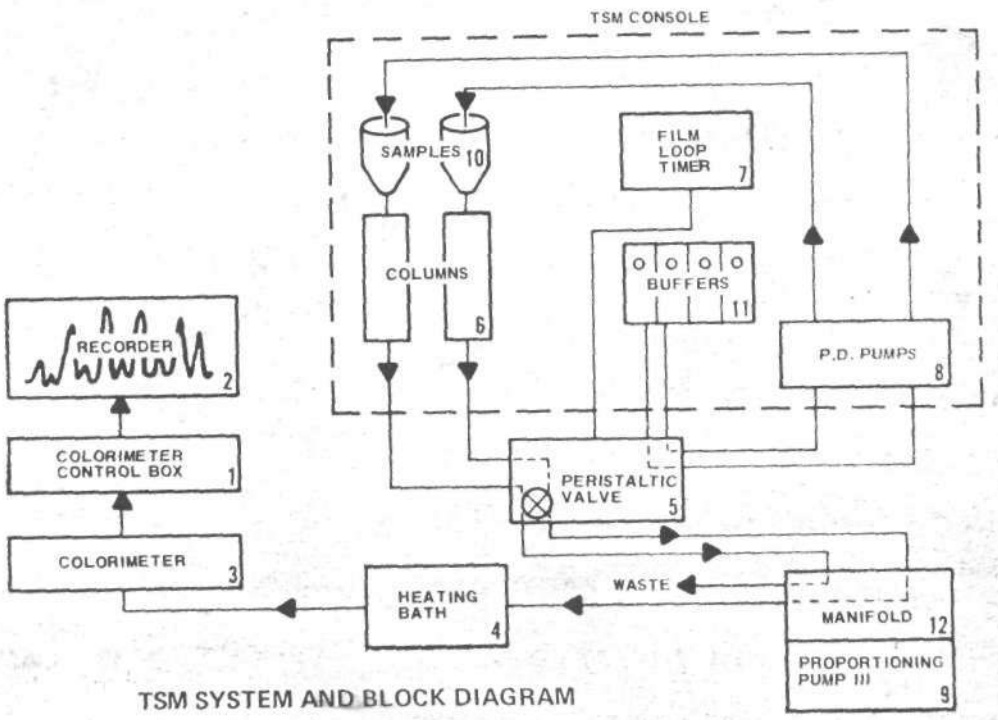
2.11.4 CHROMATOGRAPHIC ANALYSIS

METHOD: The automatic instrument used for this analysis is the Technicon Sequential Multisample Amino acid Analyser(TSM). (See fig. 2.2 .....)

The system can separate and analyse free, acidic, neutral, and basic amino acids from a protein hydrolysate in 76 minutes. The equipment was operated as described in the operation manual for TSM (45). The columns (two in number), one 250.0cm long for the neutral and acidic amino acids and the other 7.0cm long for the basic amino acids, were packed with a sulphonated polysterene resin which is a cationic exhanger. Influent buffers were drawn by pumping from reservoir columns. Precise amounts of ninhydrin and hydrazine sulphate reagents were combined to form hydrindantin. (See fig. 2.3 .....)

A segmental reagent stream flew under each analyzer column to join with eluting buffers. This stream, which carried amino

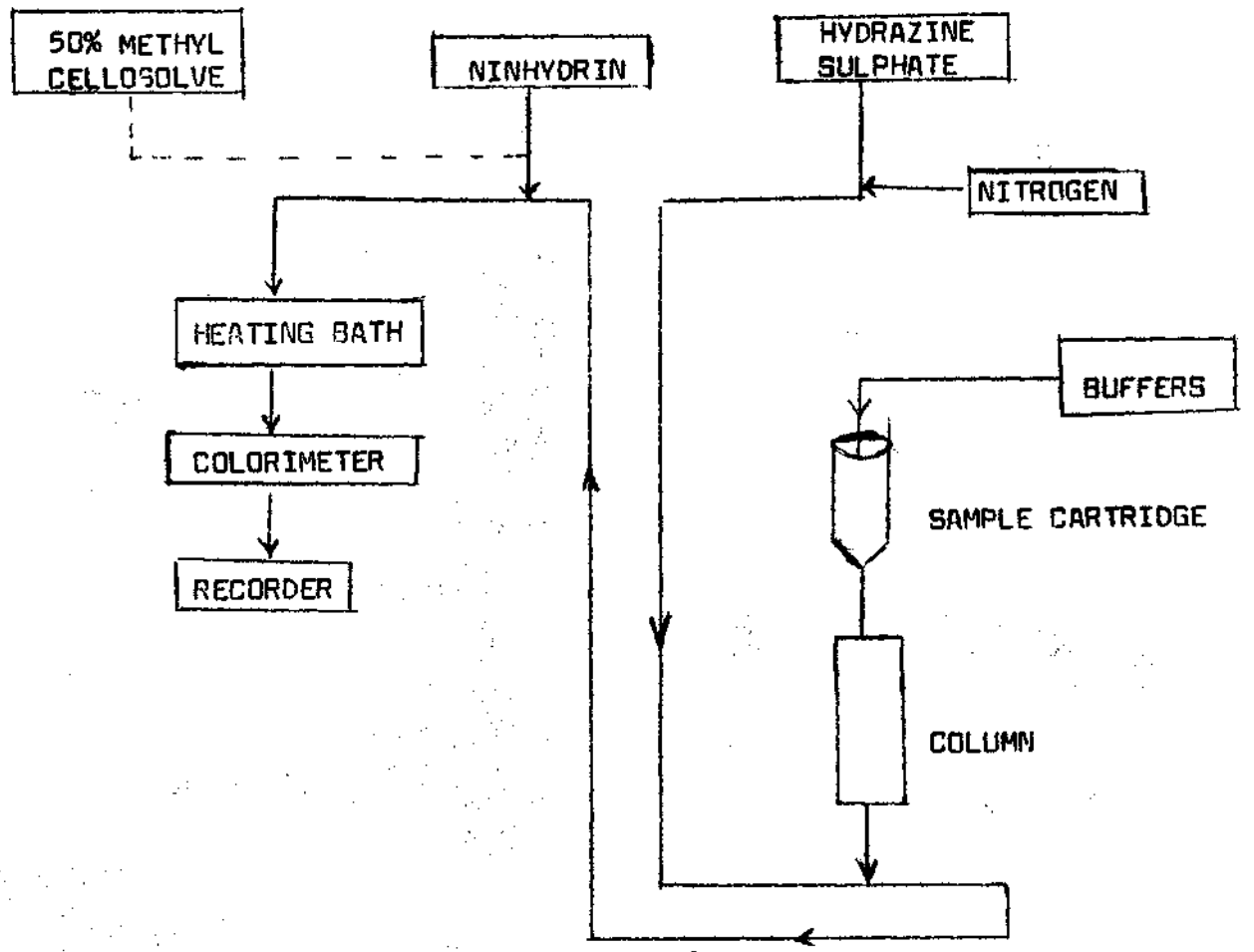




TSM SYSTEM AND BLOCK DIAGRAM

Fig. 2.2

acid reagent mixture went through a heating bath where development of the coloured reaction product occured. The absorbance is proportional to the concentration of each amino acid and was measured by the colorimeter built into the analyser.
A typical recorded chromatogram is shown in fig (2.5)



(Fig. 23.)

A schematic diagram of steps involved in the AA analysis.

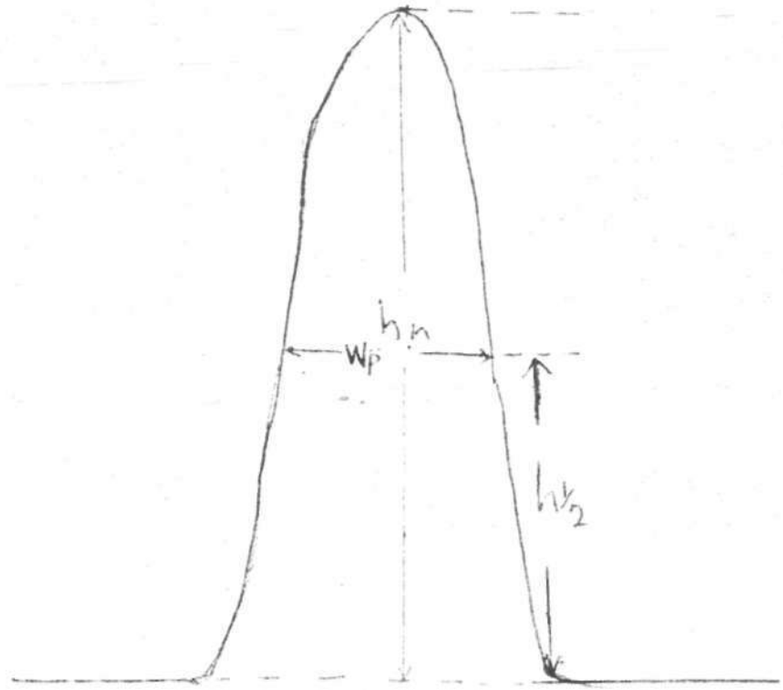


Fig. 2.4

MEASUREMENT OF PEAK HEIGHT, HALF HEIGHT, AND WIDTH AT HALF HEIGHT.

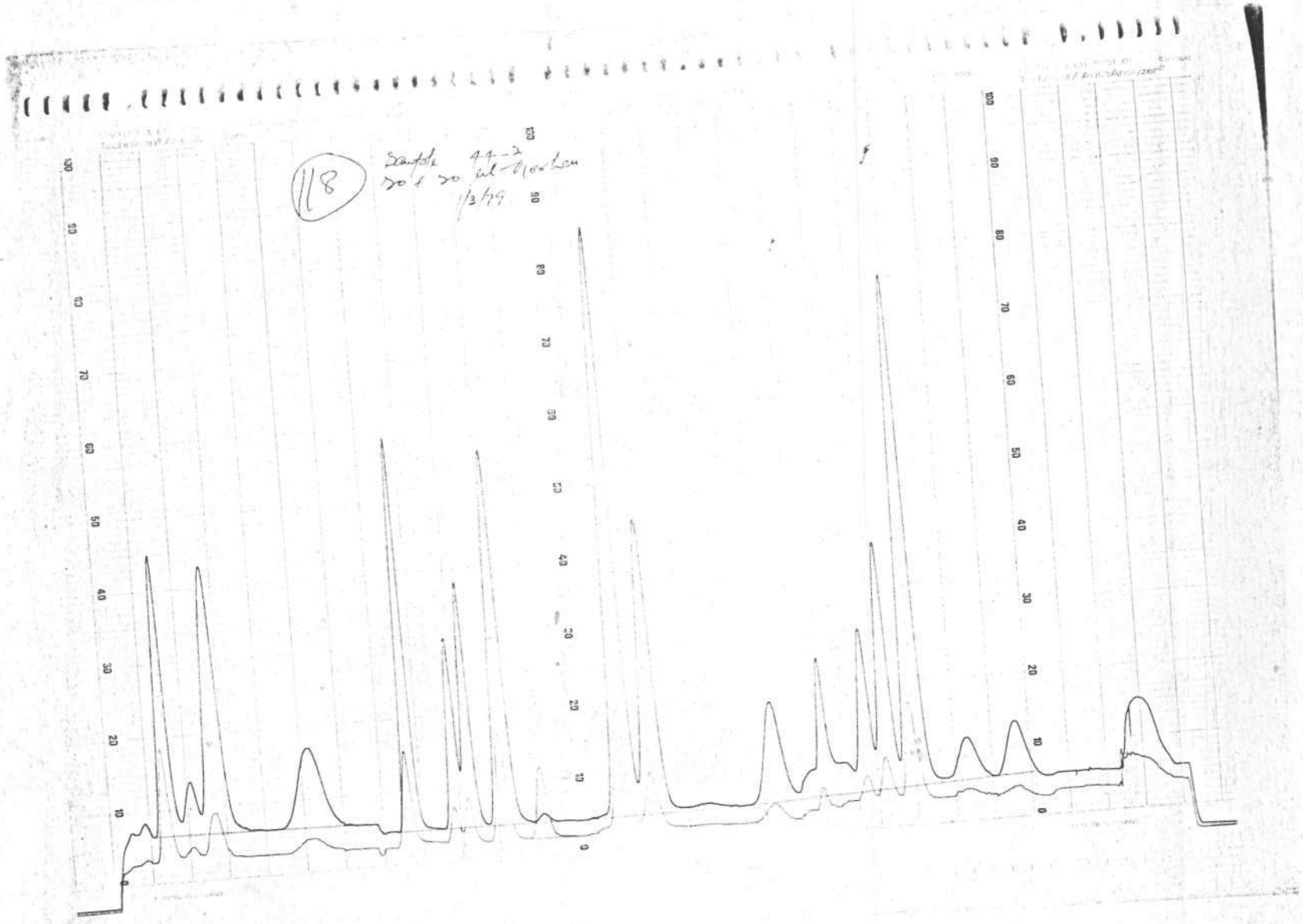


Fig. 2.5

The following amino acids were separated, and identified by the aid of the standards.

Lysine	Glutamic acid	Iso leucine
Histidine	Proline	Leucine
Arginine	Glycine	Tyrosine
Aspartic acid	Alanine	Phenylamine
Threonine	Valine	
Serine	Methionine	

2.11.4.1 CALCULATION OF QUANTITY PERCENTAGE OF AMINO ACID IN THE SAMPLE

The area under a peak is known to be proportional to the product of the height of the peak and the width of the peak at half the height (38).

METHOD:- The measurement was carried out in this order.

(a) The net height of the peak was measured using a metric scale (hn).

(b) The half-height on the chart was then measured by dividing the net height by two and measuring that distance up from the base line ($h_{1/2}$).

(c) The width of the peak was measured at the half-height using a ruled (w_p)

(d) The net-height results were multiplied by the width at half-height. (See fig. 2.4)

(e) The norleucine equivalent (NE) for each amino acid in the standard mixture was calculated thus:

$$N.E. = \frac{\text{Area Norleucine peak}}{\text{Area each amino acid}}$$

(f) The amount of each amino acid present in each fish, sample was calculated using an accepted formula (45).

$$\text{Amount of aminoacid in grams} = \frac{A_{pi}}{Aun} \times NEsp \times M_{sp} \times Mwtc \times C$$

in g/16gN

where Api = Area of peak of interest

Aun = Area of Norleucine peak from the same chromatogram

NEsp = Norleucine equivalent of the corresponding peak from a standard chromatogram

Msp = Moles of amino acid in the standard sample

Mwt = Molecular weight of the amino acid

$$C = \frac{\text{Dilution factor for sample} \times 16}{\text{Sample weight}_{(g)} \times \% \text{ Nitrogen in sample} \times 10 \times \text{Volume loaded}}$$

The concentrations of the various amino acids in each sample were expressed in grams per 16 grams of nitrogen as is the general practice (46)

C H A P T E R III

3.1 RESULTS AND DISCUSSIONS

3.1.1 WEIGHT AND LENGTH MEASUREMENTS

The measurements of the total length, standard length and wet weight for the three species are reported in Table 3.1.

From the values of ratio of wet weight to standard length measurements, Alestes nurse are smaller compared with both Synodontis schall and Tilapia zillii

S. schall may be said to the biggest of the three species. There is little variation between the standard length measurements for the three species of fish analysed.

3.1.2 WATER ESTIMATION

The results of water estimation for the fish samples are shown in table 3.2 and are expressed in grams per 100 grams of wet weight of sample.

The T-test was performed on these values, (see Appendix). The mean value of water in Alestes nurse is 74.03g/100g of wet weight, while the mean for Synodontis schall, and Tilapia zillii

TABLE 3.1

WEIGHT AND LENGTH MEASUREMENTS OF THE 3 SPECIES OF FISH

SAMPLE No.	TOTAL LENGTH (CM)	STANDARD LENGTH (CM)	WET WEIGHT g	STANDARD LENGTH / WET WEIGHT	SAMPLE No.	TOTAL LENGTH (CM)	STANDARD LENGTH (CM)	WET WEIGHT g	STANDARD LENGTH / WET WEIGHT	SAMPLE No.	TOTAL LENGTH (CM)	STANDARD LENGTH (CM)	WET WEIGHT g	STANDARD LENGTH / WET WEIGHT
A_1	15.20	12.60	36.19	2.87	S_1	19.12	14.00	58.58	4.18	T_1	18.72	15.61	134.31	8.61
A_2	12.71	10.51	19.25	1.83	S_2	17.00	13.12	50.47	3.85	T_2	19.71	15.13	114.45	7.58
A_3	16.72	14.00	44.72	3.19	S_3	18.00	13.00	71.89	5.53	T_3	15.50	12.70	66.71	5.25
A_4	16.63	13.61	48.36	3.56	S_4	19.51	14.63	77.52	5.31	T_4	14.00	11.12	43.43	3.91
A_5	13.00	10.52	20.37	1.94	S_5	17.13	13.12	50.74	3.87	T_5	16.00	12.61	80.72	6.41
A_6	14.71	12.21	31.33	2.57	S_6	16.22	11.51	42.33	3.68	T_6	17.12	14.00	99.62	7.12
A_7	15.40	12.00	25.42	2.12	S_7	17.50	13.20	66.69	5.05	T_7	14.31	11.42	56.64	4.97
A_8	13.12	10.72	22.33	2.09	S_8	17.00	12.24	47.49	3.89	T_8	18.32	14.90	115.10	7.72
A_9	14.53	12.00	26.61	2.22	S_9	17.30	13.21	50.57	3.83	T_9	19.22	15.32	134.52	8.79
A_{10}	10.00	8.21	11.73	1.43	S_{10}	16.81	12.93	42.62	3.30	T_{10}	14.41	11.90	51.92	4.36

A = ALESTES NURSE S = SYNODONTIS SCHALL T = TILAPIA ZILLII

TABLE 3.2

WATER ESTIMATION FOR 3 SPECIES OF FISHES g/100g of wet weight

	1	2	3	Mean		1	2	3	Mean		1	2	3	Mean
A_1	75.01	75.11	76.20	75.43	S_1	74.00	76.91	76.30	75.73	T_1	79.21	79.00	80.50	79.57
A_2	72.00	72.00	74.01	72.73	S_2	75.21	75.42	78.10	76.23	T_2	76.60	74.61	76.82	76.00
A_3	76.41	74.71	76.50	75.87	S_3	78.70	78.01	79.10	78.60	T_3	74.50	75.30	74.71	74.83
A_4	77.01	76.81	78.11	77.31	S_4	81.21	80.00	78.91	80.03	T_4	72.51	74.51	70.70	72.56
A_5	72.60	74.41	72.60	73.06	S_5	75.50	76.01	75.20	75.63	T_5	76.60	74.00	76.40	75.67
A_6	70.00	70.60	72.20	70.93	S_6	73.00	73.60	74.10	73.56	T_6	76.50	76.60	74.40	75.83
A_7	75.20	73.00	75.71	74.63	S_7	76.00	74.00	76.31	75.43	T_7	73.30	75.21	75.40	74.63
A_8	71.01	74.00	71.40	72.13	S_8	75.51	72.10	74.80	74.13	T_8	76.80	74.70	75.80	75.77
A_9	72.30	75.20	72.41	73.30	S_9	76.71	75.60	74.40	75.57	T_9	80.00	80.81	79.90	80.23
A_{10}	74.50	71.80	72.40	72.90	S_{10}	74.60	76.41	74.20	75.06	T_{10}	75.00	73.52	75.70	74.73

A = ALESTES NURSE S = SYNODONTIS SCHALL T = TILAPIA ZILLII

are 76.00g/100g of wet weight and 75.98g/100g of wet weight respectively. On application of T-test to these values, it is discovered that there is no significant difference in the mean water values.

Thus the fish samples may be said to contain similar amount of water. This is in agreement with report by Olatunde A. O.(15) However, Sidwell et al (1) reported a variation in water content which was said to be due mainly to the natural season variation, age, size and type of fish analysed. The variation of body water content with age is also shown by Denton et al.(47(From the mean values, fish may be said to contain very high percentage of water which is responsible for its storage problem.

3.1.3 ASH CONTENT

The results of ash content in the fish samples analysed are shown in Table 3.3.

The mean values for A. nurse, S. schall, and T. zillii are 10.35g/100g dry weight, 14.70g/100g dry weight and 14.43g/100g dry weight respectively.

The values for A. nurse fish samples vary from 8.95g to 13.15g/100g dry weight and seems to have no relationship with the standard length and wet weights of the samples. This is

TABLE 3.3

ASH CONTENT ESTIMATION FOR 3 SPECIES FOR FISHES in g/100 dry Weight

Sample No.	1	2	Mean		1	2	Mean		1	2	Mean
A_1	10.50	10.80	10.65	S_1	15.50	15.60	15.55	T_1	14.90	15.00	14.95
A_2	13.30	13.00	13.15	S_2	15.80	15.40	15.60	T_2	15.30	15.20	15.25
A_3	11.81	10.50	11.15	S_3	13.50	13.60	13.55	T_3	15.00	14.70	14.85
A_4	9.50	9.30	9.40	S_4	16.20	16.00	16.10	T_4	13.80	13.90	13.85
A_5	8.91	9.00	8.95	S_5	15.60	15.20	15.40	T_5	16.21	16.41	16.31
A_6	9.60	9.60	9.60	S_6	10.20	9.80	10.00	T_6	14.81	15.01	14.91
A_7	9.60	9.91	9.75	S_7	17.00	18.11	17.55	T_7	15.20	15.00	15.10
A_8	11.00	10.80	10.90	S_8	13.81	13.70	13.75	T_8	9.81	9.81	9.81
A_9	9.81	9.70	9.75	S_9	16.50	16.41	16.45	T_9	14.81	14.61	14.71
A_{10}	10.20	10.31	10.25	S_{10}	13.00	13.10	13.05	T_{10}	14.50	14.60	14.55

A = ALESTES NURSE S = SYNODONTIS SCHALL T = TILAPIA ZILLII

because the samples showing the highest and the smallest ash content values respectively do not show the highest and the smallest values for their standard lengths and weights.

In the case of S. schall, the values vary from 10.00g to 17.55g/100g dry weight. This variation is wide. It is interesting to note that there appears to be a simple relationship between the ash content values and the standard lengths and the wet weights within this species. The values for T. zillii vary from 9.8g to 16.3g/100g dry weight. This is another wide variation but unlike the S. schall, there seems to be no such simple relationship between these values and the standard length and wet weight measurements.

Apart from sample T_8 with a comparatively low value of ash content, the values for the other samples are fairly high. T-test comparisen (see appendix) confirms that there is a very highly significant difference in the ash content values between A. nurse and S. schall on one hand, and A. nurse and T. zillii on the other hand.

However, there is no significant difference in the ash content values of S. schall compared with T. zillii. S. schall samples show the highest ash content value, followed by T. zillii and lastly A. nurse. This trend follows the difference in the sizes of the various fish samples. The ash content value

for any particular fish has been reported to be relatively constant during growth of fish, thus indicating that the relative proportion of skin, scales, and bones in the fish should not change appreciably with age. (47)

3.1.4 MINERAL CONTENTS

The results of the eight different mineral elements investigated for the fish samples are shown in Table 3.4

Calcium

All the fish samples indicate high levels of calcium ions followed by phosphorus. Potassium, sodium, and magnessium also make significant contributions to the mineral pool. However, other elements like Iron, Zinc and copper in particular, contribute very little to the mineral content of the fish samples. This general trend of the concentrations of the elements investigated agree with the working of both Olatunde A. O.(15) and Furr, A. K.; et al (40). The mean values for calcium ions in A. nurse, S. schall and T. zillii are 3764.51mg, 6057.60mg, and 4587.33mg/100g of dry weight respectively. S. schall contains more of calcium ions than each of the other two species. T-test on these values of mineral contents reveals that there is a very

significant difference between the values for A. nurse and S. schall and also between S. schall and T. zillii.
The values for phosphorus content in A. nurse vary from 2125.00mg to 2958.55mg. Those in S. schall vary from 3250.00mg to 4124.91mg while for T zillii, they vary from 2333.55mg to 3066.45mg. There appears to be no simple relationship between the phosphorus level in all the fish and their standard lengths and wet weights.

Sodium

The mean values for sodium are 206.00mg for A. nurse, 241.00mg for S. schall and 253.9mg for T. zillii. T-test reveals that there is no significant difference between the values in S. schall and T. zillii, while there is a highly significant difference in the values shown by A. nurse and T. zillii. The sodium ion content in A. nurse varies from 170.52mg to 247.25mg. The variation of sodium ions in both S. schall and T. sillii is not significant, as shown in table 3.4. There seems to be no simple relationship between the sodium ion concentration in A. nurse and their standard lengths and wet weights. This is also true of S. schall and T. zillii.

Potassium

The mean values for potassium ion content are 712.40mg for A. nurse, 796.10mg for S. schall and 665.5mg for T. zillii. S. schall contain more of potassium ions than A. nurse and .zillii. The difference in values of potassium for A. nurse and T. zillii are found to be statistically insignificant, while there is a significant difference between the values of A. nurse and S. schall. There is also a very highly significant difference in the values for S. schall compared with those for T. zillii. Again there appears to be no simple relationship between the values of potassium ion content and the standard lengths and wet weights in the fish samples.

Magnesium

The mean values for magnesium ion content are 138.61mg for A. nurse, 154.72mg for S. schall and 126.00mg. for T. zillii. There is a significant difference in magnesium content for A. nurse compared to those of S. schall, and A. nurse compared to T. zillii. The difference in values shown by S. schall and T. zillii are very highly significant.

Iron

The level of Iron concentration in the fish samples is generally low as shown by the following mean values; 34.23mg for A. nurse, (the Small est); 137.12mg for S. schall, (the highest) and 106.82mg for I. zillii. T-test confirms that there are very highly significant difference in the values found in the three species.

Zinc

The mean values of zinc are very low, these are 18.10mg for A. nurse, 19.21mg for S. schall and 17.00mg for I. zillii. Statistically, there is no significant difference between the values of zinc ions in the fish samples.

Copper

Of the mineral elements studied, copper is present in the smallest amounts.

0.56mg was obtained as mean for A. nurse, 0.82mg obtained for S. schall and 1.73mg for I. zillii. This is the only instance where I. zillii contains more of the ions investigated than S. schall, which on the whole contains more of the mineral elements than the two other species.

TABLE 3.4

MINERAL ESTIMATION FOR 3 SPECIES OF FISH mg/100g dry weight

Sample No.	Na (1)	Na (2)	Mean	K (1)	K (2)	Mean	Cu (1)	Cu (2)	Mean	Fe (1)	Fe (2)	Mean
A_1	247.00	247.50	247.25	783.30	778.00	780.65	0.21	0.21	0.21	33.80	33.75	33.78
A_2	247.25	247.00	247.13	750.00	751.50	750.75	0.21	0.22	0.22	55.80	55.81	55.80
A_3	170.04	171.00	170.52	666.00	662.50	664.25	1.25	1.30	1.28	35.41	35.60	35.50
A_4	172.50	173.10	172.80	687.50	686.50	687.00	1.04	1.05	1.05	35.01	35.00	35.00
A_5	225.80	224.80	224.90	760.41	760.40	760.40	1.04	1.04	1.04	40.00	40.10	40.05
A_6	180.00	180.20	180.10	739.60	739.80	739.85	1.25	1.26	1.26	30.00	30.00	30.00
A_7	245.80	246.00	245.90	739.60	740.11	739.85	0.21	0.21	0.21	30.40	30.35	30.35
A_8	207.50	207.20	207.35	597.91	598.20	598.05	0.21	0.21	0.21	25.80	25.71	25.75
A_9	182.50	182.60	182.65	645.81	647.21	646.51	0.21	0.21	0.21	34.20	34.20	34.20
A_{10}	186.50	187.21	186.85	766.70	756.20	761.45	0.21	0.21	0.21	25.80	25.85	25.80

A = ALESTES NURSE

TABLE 3.4

MINERAL ESTIMATION FOR 3 SPECIES OF FISH mg/100g dry weight

Sample No.	Zn (1)	Zn (2)	Mean	Mg (1)	Mg (2)	Mean	P (1)	P (2)	Mean	Ca (1)	Ca (2)	Mean
A_1	21.80	21.81	21.80	162.50	163.20	162.85	2958.30	2958.80	2958.55	4433.31	4434.10	4433.70
A_2	25.80	25.61	25.70	166.70	165.80	166.25	2891.71	2891.71	2890.85	4583.33	4583.11	4583.22
A_3	16.51	16.60	16.55	133.30	133.31	133.30	2375.00	2375.51	2375.25	3433.40	3433.31	3433.35
A_4	13.30	13.30	13.30	129.20	130.00	129.60	2375.01	2375.00	2375.00	3450.01	3451.60	3450.80
A_5	16.30	16.31	16.30	133.30	133.31	133.30	2875.01	2876.20	2875.60	3508.31	3508.30	3508.30
A_6	18.60	18.40	18.50	137.51	137.60	137.55	2625.00	2626.11	2625.55	4066.71	4064.20	4065.45
A_7	19.31	19.60	19.45	129.20	129.21	129.20	2491.70	2490.20	2490.95	3333.3	3332.51	3332.90
A_8	16.50	16.50	16.50	114.60	114.51	114.56	2125.01	2125.00	2125.00	3000.00	3001.21	3000.61
A_9	19.60	19.60	19.60	140.41	140.40	140.40	2600.01	2602.10	2601.05	3734.00	3733.61	3733.50
A_{10}	27.10	27.30	27.20	143.81	144.10	143.95	2750.00	2748.91	2749.45	4108.31	4109.00	4108.65

A = ALESTES NURSE

TABLE 3.4

MINERAL ESTIMATION FOR 3 SPECIES OF FISH mg/100g dry weight

Sample No.	Na (1)	Na (2)	Mean	K (1)	K (2)	Mean	Cu (1)	Cu (2)	Mean	Fe (1)	Fe (2)	Mean
S_1	255.01	256.20	255.60	883.31	883.40	883.35	1.04	1.04	1.04	124.51	124.60	124.55
S_2	250.01	250.62	250.31	847.90	850.21	849.05	0.21	0.22	0.22	172.91	172.80	172.85
S_3	265.02	266.50	265.76	850.01	849.80	849.90	0.21	0.21	0.21	157.50	157.50	157.50
S_4	223.25	225.01	224.13	708.31	708.00	708.15	2.11	2.20	2.15	135.01	135.10	135.05
S_5	246.81	247.10	246.95	812.51	813.00	812.75	1.04	1.05	1.05	102.10	102.01	102.05
S_6	223.25	224.50	223.90	822.90	823.01	822.95	0.21	0.21	0.21	121.70	121.72	121.71
S_7	246.75	246.21	246.48	654.21	654.20	654.20	2.10	2.10	2.10	152.12	152.10	152.11
S_8	245.02	245.82	245.42	787.50	787.20	787.35	1.04	1.04	1.04	137.90	137.80	137.85
S_9	207.50	208.21	207.85	750.01	750.10	750.05	2.10	2.11	2.10	135.01	135.02	135.01
S_{10}	250.00	248.51	249.25	850.00	848.91	849.45	0.21	0.21	0.21	136.71	136.60	136.65

S = SYNODONTIS SCHALL

TABLE 3.4

MINERAL ESTIMATION FOR 3 SPECIES OF FISH mg/100g dry weight

Sample No.	Zn (1)	Zn (2)	Mean	Mg (1)	Mg (2)	Mean	P (1)	P (2)	Mean	Ca (1)	Ca (2)	Mean
S_1	21.91	21.72	21.81	183.31	183.30	183.30	3941.71	3942.40	3942.05	6708.20	6710.21	6709.25
S_2	22.32	22.30	22.31	166.72	166.90	166.81	4000.05	4002.41	4001.23	6666.70	6666.70	6666.70
S_3	21.30	21.21	21.25	162.51	162.40	162.45	3691.21	3692.04	3691.62	5591.70	5593.01	5592.35
S_4	18.81	18.90	18.85	142.30	141.72	142.01	3525.04	3523.44	3524.24	6375.02	6375.22	6375.12
S_5	20.80	20.70	20.75	160.40	156.91	158.65	4000.01	4001.83	4000.92	6033.52	6033.30	6033.41
S_6	15.30	15.61	15.45	141.72	141.91	141.81	3250.06	3250.01	3250.03	4916.71	4920.12	4918.41
S_7	21.00	21.10	21.05	164.60	160.51	162.55	4125.01	4124.82	4124.91	7550.06	7550.22	7550.14
S_8	17.71	17.60	17.65	141.70	141.80	141.75	3975.03	3972.00	3973.51	5166.74	5166.70	5166.72
S_9	16.80	16.90	16.85	147.90	147.80	147.85	3316.71	3318.13	3317.42	6183.30	6185.61	6184.45
S_{10}	21.51	21.40	21.45	145.81	146.01	145.91	3775.05	3778.62	3776.83	5383.30	5384.32	5383.81

S = SSYNODONTIS SCHALL

TABLE 3.4

MINERAL ESTIMATION IN 3 SPECIES OF FISHES mg/100g dry weight

Sample No.	Na (1)	Na (2)	Mean	K (1)	K (2)	Mean	Cu (1)	Cu (2)	Mean	Fe (1)	Fe (2)	Mean
T_1	273.30	274.20	273.75	754.20	754.20	754.20	1.25	1.25	1.25	118.70	118.71	118.70
T_2	282.50	281.75	281.75	756.30	754.80	755.55	2.10	2.11	2.10	89.22	89.80	89.51
T_3	246.00	247.20	246.60	652.10	652.20	652.15	1.04	1.04	1.04	116.70	116.60	116.65
T_4	238.31	240.00	239.15	670.80	670.70	670.75	2.10	2.10	2.10	86.41	86.10	86.25
T_5	273.30	273.00	273.15	781.30	781.30	781.30	2.50	2.41	2.45	112.90	112.91	112.90
T_6	250.00	252.00	251.00	512.50	513.00	512.75	2.10	2.11	2.10	110.40	110.41	110.40
T_7	246.01	248.01	247.01	654.20	654.62	654.41	1.04	1.04	1.04	118.30	118.60	118.45
T_8	239.21	239.80	239.50	695.81	695.60	695.70	1.25	1.25	1.25	106.30	106.40	106.35
T_9	250.21	248.61	249.41	516.70	516.80	516.75	2.10	2.10	2.10	112.10	112.00	112.05
T_{10}	240.00	242.20	241.10	666.70	666.12	666.44	2.11	2.10	2.10	101.30	101.30	101.30

T = TILAPIA ZILLII

TABLE 3.4

MINERAL ESTIMATION FOR 3 SPECIES OF FISH mg/100g dry weight

Sample No.	Zn (1)	Zn (2)	Mean	Mg (1)	Mg (2)	Mean	P (1)	P (2)	Mean	Ca (1)	Ca (2)	Mean
T_1	17.81	17.83	17.82	133.30	133.00	133.15	3066.71	3066.20	3066.45	4783.30	4783.61	4783.45
T_2	18.60	18.50	18.55	143.80	143.51	143.65	2925.04	2925.08	2925.03	5258.31	5258.00	5268.15
T_3	18.81	18.70	18.75	131.31	131.51	131.41	3050.60	3052.11	3051.35	4783.30	4783.00	4783.15
T_4	17.10	17.20	17.15	116.71	116.80	116.75	2333.30	2333.80	2333.55	3883.44	3883.82	3883.63
T_5	17.52	17.50	17.51	143.80	144.20	144.00	3125.03	3124.61	3124.82	5275.01	5276.30	5275.65
T_6	15.20	15.31	15.25	120.80	120.81	120.80	2750.01	2752.10	2751.05	4783.31	4784.00	4783.65
T_7	15.70	15.60	15.65	114.60	115.10	114.85	2375.02	2375.21	2375.11	3900.02	39001.22	3900.62
T_8	20.51	20.60	20.55	125.01	125.10	125.05	2750.05	2750.00	2750.02	4516.62	4516.81	4516.71
T_9	15.30	15.40	15.35	120.81	121.60	120.95	2775.01	2776.80	2775.90	4791.72	4791.74	4791.73
T_{10}	17.20	17.11	17.15	114.61	114.62	114.71	2404.10	2400.01	2402.05	3900.03	3903.61	3901.82

T = TILAPIA ZILLII

highly significant difference in calcium ion values between A. nurse and S. schall. There is no significant difference between the values shown by A. nurse and T. zillii. While there is a very highly significant difference between the values shown by S. schall and T. zillii.

The calcium ion values in A. nurse very from 3000.61mg to 4583.22mg, while the variation in S. schall and T zillii are from 5166.72mg to 7550.14mg and 3883.63mg to 5275.65mg respectively.

Although, there appears to be no simple relationship between the calcium ion level in A. nurse and their standard lengths and wet weights, there seems to be one in both S. schall and T. zillii.

Van Dosten,[92] has established that calcium as the principal cation of skin and scales, increases with the size of the fish.

Phosphorus

The mean values of phosphorus are 2606.31mg for A. nurse, 3759.83mg for S. schall and 2755.22mg for T. zillii. Thus S. schall contain the highest phosphorus content value followed by T. zillii, while A. nurse contains the least phosphorus content. T-test shows an insignificant difference between the values for A. nurse and T. zillii. However, there is a very highly significant difference between the values for S. schall and T. zillii

3.1.5 TOTAL ORGANIC MATTER

The results of the total organic matter in the fish samples are given in Table 3.5. The calculated mean values range from 83.28g to 89.65g/100g dry weight. The mean values are 89.65g for A. nurse, (the highest) 85.28g for S. schall (the least), and 85.57g for T. zillii. The test of significance of difference of means shows that the values in A. nurse and S. schall; and also those of A. nurse and T. zillii are very highly significant The values of S. schall and T. zillii show no significant difference. On the whole, the fish samples show very high levels of total organic matter.

3.1.6 FAT CONTENT

The values for the total fat content in the fish samples are shown in Table 3.6. The mean values of fat content are 17.40g for A. nurse, (the highest), 9.55g for S. schall (the smallest), and 12.33g for T. zillii. (see Appendix). The mean water content values, 74.03g for A. nurse (the least), 76.00g for S. schall, (the highest) and 75.90g for T zillii are compared here. These data confirm the known inverse relationship of body fat to water content already well established in fish by Gerking[49], Brown[50], Lagler, Bardach and Miller[51].

TABLE 3.5

TOTAL ORGANIC MATTER ESTIMATION IN 3 FISH SPECIES IN g/100g of dry weight

Sample No.	1	2	Mean		1	2	Mean		1	2	Mean
A_1	89.50	89.30	89.40	S_1	84.50	84.40	84.45	T_1	85.1	85.00	85.05
A_2	86.70	87.00	86.85	S_2	84.20	84.60	84.40	T_2	84.7	84.80	84.75
A_3	88.20	89.50	88.85	S_3	86.50	86.40	86.45	T_3	85.00	85.30	85.15
A_4	90.50	90.70	90.6	S_4	83.80	84.00	83.90	T_4	86.20	86.10	86.15
A_5	91.10	91.00	91.05	S_5	84.40	84.8	84.60	T_5	83.80	83.60	83.70
A_6	90.40	90.40	90.40	S_6	89.8	90.20	90.00	T_6	85.20	85.00	85.10
A_7	90.40	90.10	90.25	S_7	83.00	81.90	82.45	T_7	84.80	85.00	84.90
A_8	89.01	89.21	89.11	S_8	86.20	86.30	86.25	T_8	90.20	90.20	90.20
A_9	90.20	90.30	90.25	S_9	83.50	83.60	83.55	T_9	85.20	85.40	85.30
A_{10}	89.80	89.70	89.75	S_{10}	87.00	86.90	86.75	T_{10}	85.50	85.40	85.45

A = ALESTES NURSE S = SYNODONTIS SCHALL T = TILAPIA ZILLII

TABLE 3.6

FAT CONTENT DETERMINATION IN 3 FISH SPECIES IN g/100g of dry weight

Sample No.	1	2	Mean	Sample No.	1	2	Mean	Sample No.	1	2	Mean
A_1	14.00	14.40	14.20	S_1	5.70	7.74	6.72	T_1	9.79	9.13	9.46
A_2	15.90	16.50	16.20	S_2	7.81	7.91	7.86	T_2	11.84	12.30	12.07
A_3	14.00	15.96	14.98	S_3	8.10	8.44	8.25	T_3	10.84	10.00	10.42
A_4	17.00	17.20	17.10	S_4	13.90	14.30	14.10	T_4	15.00	15.40	15.20
A_5	16.70	17.48	17.09	S_5	10.06	9.50	9.78	T_5	9.48	8.00	8.74
A_6	16.3	16.12	16.26	S_6	13.24	12.90	13.07	T_6	16.70	17.50	17.10
A_7	20.15	20.00	20.07	S_7	6.70	5.00	5.85	T_7	9.84	9.50	9.67
A_8	19.50	19.86	19.68	S_8	7.80	8.22	8.01	T_8	16.0	17.86	16.93
A_9	18.00	19.70	18.85	S_9	11.04	11.10	11.07	T_9	14.3	14.20	14.25
A_{10}	19.70	19.52	19.61	S_{10}	11.64	10.0	10.82	T_{10}	9.40	9.60	9.50

A = ALESTES NURSE S = S YNODONTIS SCHALL T = TILAPIA ZILLII

However, these values suggest that the fish samples analysed are of low fat contents when the results of Lagler et al[51] and Olatunde O. A.[15] are compared.

3.1.7 PROTEIN CONTENT

The values for the protein content of the non-defated fish samples are given in Table 3.7, while those for the defated samples are given alongside with the aminoacid values in Table 3.10.

The mean values for non-defated samples are 69.94g for A. nurse, 61.91g for S. schall, and 54.36g for T. zillii. Those for the defated samples are 74.98g for A. nurse, 63.41g for S. schall and 71.54g for T. zilli. Thus higher protein values were obtained for defated samples. This is to be expected. The values shown in Table 3.7 confirm the fact that all the fish samples are rich in protein.

A nurse having the highest protein content, followed by S. schall and then T. zillii. The values obtained for the non defated fish samples, statistically show no significant difference between the values for A. nurse and S. schall on one hand; S.. schall and T.zillii. Again, there appears to be no simple relationship between the protein values of the fish samples and their standard lengths and wet weights.

TABLE 3.7 **PROTEIN ESTIMATION FOR 3 SPECIES OF FISHES** g/100g dry weight

ALESTES NURSE						SYNODONTIS SCHALL						TILAPIA SP.					
Samples No.	1	2	3	Mean		Sample No.	1	2	3	Mean		Sample No.	1	2	3	Mean	
A_1	73.50	74.40	73.50	73.80		S_1	65.60	64.80	64.81	65.10		T_1	59.50	60.40	60.40	60.10	
A_2	68.30	69.10	69.10	68.80		S_2	63.00	61.30	61.30	61.90		T_2	61.30	60.40	61.30	61.00	
A_3	71.80	70.90	70.90	71.20		S_3	60.40	60.40	59.50	60.10		T_3	58.60	59.50	59.50	59.20	
A_4	70.80	70.80	71.50	71.03		S_4	63.00	62.10	61.30	62.10		T_4	57.80	58.60	59.50	58.60	
A_5	68.30	70.00	70.00	69.40		S_5	62.10	62.10	61.30	61.80		T_5	58.60	57.80	57.80	58.60	
A_6	70.90	71.80	72.60	71.80		S_6	59.50	61.30	61.31	60.70		T_6	61.30	61.30	62.10	61.60	
A_7	67.40	69.10	69.10	68.50		S_7	63.00	63.00	62.10	62.70		T_7	59.50	60.40	60.40	60.10	
A_8	68.30	67.40	69.10	68.30		S_8	62.10	61.30	61.30	61.60		T_8	61.30	61.30	63.00	61.90	
A_9	68.30	67.40	68.30	68.00		S_9	62.10	63.00	62.1	62.40		T_9	61.30	60.40	63.00	61.60	
A_{10}	68.30	68.30	69.10	68.60		S_{10}	60.40	60.40	61.3	60.70		T_{10}	58.60	58.60	59.50	58.90	

A = ALESTES NURSE S = SYNODONTIS SCHALL T = TILAPIA ZILLII

3.1.8 CARBOHYDRATE CONTENT

The values are shown in table 3.8. The relative amount of carbohydrates ranged from 1.92g to 4.81g/100g with a mean value of 2.52g for A. nurse, 7.25g to 19.63g/100g with a mean value of 14.16g/100g dry weight for S. schall; and 6.72g to 15.68g/100g dry weight with a mean value of 13.38g/100g dry weight.

The difference between the values of A. nurse and S. schall is significant, while it is highly significant for those of A. nurse compared with T. zillii and very highly significant for the values of S. schall compared with T. zillii. The carbohydrates values are generally low and are in general agreement with the values reported by Olatunde[15] and Sidwell et al[1].

3.1.9 CALORIFIC VALUE

The calculated calorific values are shown in Table 3.9. The table shows that proteins contribute a lot to the calorific value of fish. The contribution from fat is bigger than that of carbohydrate but less than that from protein. The contribution made by carbohydrate is small. The contributions to total calorific

TABLE 3.8

CARBOHYDRATE DETERMINATION IN 3 FISH SPECIES g/100g dry weight

Sample No.	1	2	Mean	Sample No.	1	2	Mean	Sample No.	1	2	Mean
A_1	2.01	1.83	1.92	S_1	13.20	11.86	12.53	T_1	15.81	15.47	15.64
A_2	2.50	1.40	1.95	S_2	13.39	13.39	13.39	T_2	11.56	12.10	11.83
A_3	2.40	2.64	2.52	S_3	18.00	17.56	17.78	T_3	15.56	15.80	15.68
A_4	1.70	2.70	2.20	S_4	6.90	7.60	7.25	T_4	13.40	13.10	13.25
A_5	6.10	3.52	4.81	S_5	11.64	13.20	12.42	T_5	15.72	16.10	15.91
A_6	2.20	2.48	2.34	S_6	15.26	24.00	19.63	T_6	7.20	6.24	6.72
A_7	2.85	1.40	2.12	S_7	13.30	13.30	13.30	T_7	15.46	15.10	15.28
A_8	2.20	1.74	1.97	S_8	16.30	16.78	16.54	T_8	12.90	11.04	11.97
A_9	3.90	3.20	3.55	S_9	13.60	12.38	12.99	T_9	9.60	10.80	10.20
A_{10}	1.80	1.88	1.84	S_{10}	14.96	16.50	15.73	T_{10}	17.50	17.20	17.35

A = ALESTES NURSE S = SYNODONTIS SCHALL T = TILAPIA ZILLII

value of fish by each of protein, fat and carbohydrate obviously depends on the quantity of each of these nutrients present in fish. Considering the total calorific value of each species, A. nurse has the highest mean calorific value, of 558.40Kcal/100g followed by T. zillii with a value of 500.61Kcal/100g and lastly S. schall with a value of 490.71Kcal/100g.

The mean values of S. schall and T. zillii are not different statistically, while there are very highly significant differences in the values given by A. nurse compared to those of S. schall; and A. nurse to T. zillii.

These values are slightly lower than those reported for some fresh water fishes of different species by Olatunde[15], but higher than those reported for some marine fishes by Sidwell et al[1]

No simple relationship is observed between the calofic values of the fish samples and their standard lengths and wet weights.

3.1.10 AMINO ACID CONTENT

The amino acid values for the fish samples are shown in Table 3.10. These figures, even though different from those obtained by Oyenuga[10] and Owusu-Domfeh et al[53] are very similar

TABLE 3.9 (a)

CALORIFIC VALUES OF 12 FISH SAMPLES Kcal/100g

Sample No.	FAT (1)	FAT (2)	Mean	Carbohydrates (1)	Carbohydrates (2)	Mean	Protein (1)	Protein (2)	Mean	Total
A_1	133.00	136.80	134.90	8.20	7.38	7.79	404.25	409.20	406.73	549.42
A_2	151.05	156.75	153.90	10.25	5.74	7.99	375.65	380.05	377.85	539.74
A_3	133.00	151.62	142.31	9.84	10.82	10.33	394.90	389.95	392.43	545.07
A_4	161.50	163.40	162.45	6.97	11.07	9.02	389.40	389.40	389.40	560.87
A_5	158.65	166.06	162.36	25.01	14.43	19.72	375.65	385.00	380.30	562.38
A_6	154.85	153.14	153.99	9.02	10.17	9.60	389.95	394.90	391.98	555.57
A_7	191.43	190.00	190.72	11.69	5.74	8.72	370.70	380.05	375.40	574.84
A_8	185.30	188.70	187.00	9.02	7.13	8.08	375.65	370.70	373.20	560.28
A_9	171.00	187.20	179.10	15.90	13.12	14.51	375.65	370.70	373.20	566.81
A_{10}	187.20	185.40	186.30	7.38	7.71	7.55	375.65	375.65	375.65	569.50

A = ALESTES NURSE

TABLE 3.9 (b)

CALORIFIC VALUES OF THE FISH SAMPLES Kcal/100g

Sample No.	Fat (1)	(2)	Mean	Protein (1)	(2)	Mean	Carbohydrates (1)	(2)	Mean	Total
S_1	54.20	73.50	63.85	360.80	356.40	358.6	54.12	48.8	51.46	473.91
S_2	74.20	75.15	74.68	348.50	337.20	342.85	54.90	54.90	54.90	472.43
S_3	76.95	80.20	78.58	332.20	332.20	332.20	73.80	72.0	72.90	483.68
S_4	132.10	135.90	134.0	348.50	341.60	345.10	28.30	31.2	29.75	508.85
S_5	95.60	90.30	92.95	341.60	337.20	339.40	47.70	54.10	50.90	483.25
S_6	125.80	122.60	124.2	327.30	337.20	332.25	62.60	98.40	80.50	536.95
S_7	63.70	47.50	55.6	348.50	348.50	348.50	54.50	54.50	54.50	458.60
S_8	74.10	78.10	76.1	341.60	337.20	339.40	66.80	68.8	67.80	483.30
S_9	104.90	105.50	105.2	341.60	348.50	345.10	55.80	50.80	53.30	503.60
S_{10}	110.60	95.00	102.8	332.20	337.2	334.70	61.30	67.90	64.60	502.10

S = SYNODONTIS SCHALL

TABLE 3.9 (c)

CALORIFIC VALUES OF THE FISH SAMPLES Kcal/100g

Sample No.	Fat (1)	Fat (2)	Mean	Protein (1)	Protein (2)	Mean	Carbohydrates (1)	Carbohydrates (2)	Mean	Total
T_1	93.00	86.74	89.87	327.25	332.2	329.73	64.82	63.43	64.13	483.73
T_2	116.85	114.67	337.20	337.20	332.2	334.70	47.40	49.61	48.51	497.88
T_3	102.98	95.0	98.99	322.30	327.30	324.80	63.80	64.78	64.29	488.08
T_4	142.50	146.30	144.40	317.90	322.30	320.10	54.94	53.71	54.33	518.83
T_5	90.06	76.00	883.03	332.30	317.90	320.10	64.45	66.01	65.23	468.36
T_6	158.65	166.25	162.45	337.20	337.20	337.2	29.52	25.42	27.47	527.12
T_7	93.48	90.25	91.87	327.30	332.20	329.75	63.39	61.91	62.65	484.27
T_8	152.00	159.67	155.84	337.20	337.20	337.20	52.89	45.26	49.08	542.12
T_9	135.85	134.90	135.38	337.20	332.20	324.80	39.36	44.28	41.82	502.00
T_{10}	89.30	91.20	90.25	332.30	332.30	332.30	71.75	70.52	71.14	493.69

T = TILAPIA ZILLII

to those reported by Fetuga et al[46]. The variations noticed in the figures reported in this work and those reported elsewhere are not, however, peculiar for reviews of several reports on amino acid composition of a given feeding stuff have shown the same variations [54]. The similarity with the report of Fetuga et al [46] does not imply very identical figures in all the amino acids.

Variations in reported figures may be due to a genuine difference in the level of amino acid in different lots of the same sample or to methods and conditions of protein hydrolysis or both of these possibilities. It should be noted that the variation in values reported by different workers indicates that problems may be encountered in the use of literature values for amino acid composition in rationing.

From test of significance of difference of means, it has been noted that the following amino acids are the same in terms of composition in the fish samples. These include (i) Lysine (ii) Histidine (iii) Arginine (iv) Threonine (v) Glutamic acid (vi) Alanine (vii) Valine (viii) Methionine (ix) Tyrosine and (x) Phenylalanine. (See appendix).

In the case of Aspartic acid, the values reported for A. nurse, S. schall and T. zillii show a lot of significant differences.

TABLE 3.10 (a)

AMINO ACIDS AMINO ACID ANALYSIS

OF: ALESTES NURSE

Average Protein for A mix = 74-99 g/100g dry wt

	LAB. No.	SAMPLE DESCRIPTION	LYS	HIS	AMM	ARG	ASP	THR	SER	GLU	PRO	GLY	ALA	CYS	VAL	MET	ILEU	LEU	TYR	PHE	D.M. % N2	% PROTEIN
			CONCENTRATIONS ARE EXPRESSED IN g/ 16g N2;																			
1		A_1	8.02	3.70	X	5.81	10.06	3.74	4.69	11.81	4.84	6.42	6.62	X	4.30	3.66	4.25	7.80	2.77	3.68	11.66	72.88
2			8.74	3.71	X	6.19	9.70	4.39	5.13	12.50	5.14	6.62	6.05	X	4.35	3.48	3.92	7.04	2.54	3.46	11.60	72.50
3	Mean		8.38	3.70	X	6.00	9.88	4.07	4.91	12.15	4.99	6.52	6.33	X	4.32	3.57	4.09	7.42	1.66	3.57	11.63	72.69
4																						
5		A_2	9.84	3.04	X	6.60	10.87	4.03	4.26	14.21	5.21	6.98	6.79	X	4.63	4.04	4.00	7.99	2.87	3.40	11.75	73.44
6.			9.68	3.08	X	5.28	10.02	4.07	4.38	13.26	5.39	6.01	6.42	X	4.00	3.39	4.56	8.02	2.67	4.0	11.31	70.69
7	Mean		9.76	3.36	X	5.94	10.45	4.05	4.32	13.74	5.28	6.50	6.60	X	4.32	3.72	4.28	8.01	2.77	3.70	11.53	72.06
8																						
9		A_3	9.87		X	6.45	10.40	4.83	5.51	14.87	6.24	8.32	7.59	X	5.96	3.98	3.85	8.06	3.13	3.89	11.67	72.94
10			9.24	2.86	X	6.93	10.35	4.81	5.42	13.68	6.10	7.39	7.23	X	4.83	4.12	4.49	8.83	2.87	3.57	11.42	71.38
11	Mean		9.55	3.15	X	6.69	10.38	4.82	5.46	14.27	6.17	7.86	7.39	X	5.40	4.65	4.17	8.45	3.0	3.73	11.54	72.13
12		A_6	8.17	3.16	X	5.38	9.83	4.33	4.72	12.77	5.07	6.24	6.95	X	4.41	3.92	3.55	6.36	2.74	3.54	12.12	75.75
13			8.93	2.73	X	6.03	9.76	4.23	4.64	11.45	5.82	6.79	6.96	X	4.34	3.26	4.02	7.67	2.68	3.18	12.24	76.50
14	Mean		8.55	2.94	X	5.71	9.80	4.28	4.68	12.11	5.44	6.52	6.95	X	4.37	3.34	3.79	7.01	2.71	3.36	12.18	76.13
15																						
16		A_7	11.08	3.12	X	6.85	9.94	4.51	4.41	14.27	4.96	7.80	7.45	X	5.15	3.47	3.63	6.87	3.52	3.95	12.47	77.94
17			11.43	3.42	X	6.12	9.24	4.49	4.18	14.12	4.29	7.43	7.37	X	4.43	3.24	4.08	7.20	2.87	3.62	12.20	76.25
18	Mean		11.25	3.27	X	6.48	9.59	4.50	4.30	14.20	4.62	7.62	7.41	X	4.79	3.35	3.85	7.04	3.20	3.78	12.33	77.06
19		A_8	10.78	2.94	X	5.76	10.38	3.84	3.98	13.24	4.75	7.34	7.09	X	4.75	3.69	4.26	6.98	2.90	3.32	12.91	80.69
20			10.36	2.29	X	5.82	10.86	3.62	3.69	13.88	3.77	7.06	6.37	X	4.74	3.50	4.00	7.33	2.51	3.98	12.63	78.94
21	Mean		10.57	2.61	X	5.79	10.62	3.73	3.83	13.56	4.83	7.20	6.73	X	4.75	3.60	4.13	7.16	2.70	3.65	12.77	79.80

TABLE 3.10 (b)

AMINO ACIDS ANALYSIS

OF: SYNOPONTIS SCHALL

	LAB. NO.	SAMPLE DESCRIPTION	CONCENTRATIONS ARE EXPRESSED IN g/ 16g N2; g % D.M.; g % AIR																		D.M.	
			LYS	HIS	AMM	ARG	ASP	THR	SER	GLU	PRO	GLY	ALA	CYS	VAL	MET	ILEU	LEU	TYR	PHE	% N2	% protein
1		S_1	9.92	3.51	X	7.19	9.19	4.52	4.85	13.62	4.49	9.06	7.25	X	4.34	3.71	4.85	7.08	2.78	3.36	10.19	63.69
2			9.55	3.50	X	7.99	8.51	5.09	4.70	14.33	4.97	9.19	7.56	X	5.36	3.57	4.57	6.97	3.34	4.07	10.33	64.56
3	Mean		9.73	3.50	X	7.59	8.85	4.80	4.77	13.98	4.73	9.13	7.40	X	4.85	3.65	4.68	7.02	3.06	3.71	10.26	64.13
4																						
5		S_3	8.85	3.60	X	6.35	10.01	6.02	5.34	13.49	6.72	9.27	7.70	X	5.42	4.00	4.61	7.41	2.75	4.03	9.96	62.25
6			8.48	3.04	X	5.80	8.94	5.67	5.09	11.97	6.29	8.28	7.17	X	4.16	3.46	4.11	7.16	3.38	4.21	9.64	60.25
7	Mean		8.66	3.32	X	6.08	9.48	5.85	5.22	12.23	6.50	8.78	7.44	X	4.79	3.73	4.36	7.28	3.07	4.12	9.80	61.25
8		S_4	8.39	2.53	X	5.70	9.23	3.72	4.39	12.57	6.21	9.20	6.62	X	3.97	2.99	4.07	6.93	2.25	2.99	10.50	65.63
9			8.21	2.30	X	5.39	8.78	3.55	4.18	12.26	5.94	8.68	6.38	X	3.81	3.40	4.11	6.92	2.50	3.13	10.72	67.00
10			8.30	2.41	X	5.35	9.00	3.63	4.29	12.41	6.07	8.94	6.50	X	3.89	3.20	4.09	6.92	2.37	3.06	10.61	66.31
11																						
12		S_6	9.70	3.26	X	5.90	9.52	4.07	4.19	12.99	5.70	9.50	6.60	X	4.32	3.74	4.65	7.66	3.14	3.59	11.09	69.30
13			9.71	3.03	X	6.76	9.33	4.68	4.39	12.89	6.07	9.98	6.47	X	4.38	3.74	4.81	7.07	2.69	4.25	11.25	70.31
14	Mean		9.70	3.15	X	6.33	9.43	4.38	4.29	12.79	5.89	9.75	6.54	X	4.35	3.74	4.73	7.37	2.92	3.91	11.17	69.81
15		S_7	9.42	2.59	X	6.94	8.31	4.32	4.27	13.33	6.18	9.87	8.46	X	4.53	3.43	4.28	6.68	2.71	3.62	9.43	58.94
16			9.96	2.91	X	7.18	8.42	4.87	4.71	14.37	6.83	10.31	8.11	X	5.30	3.83	4.92	7.39	3.03	3.65	9.68	60.50
17	Mean		9.69	2.75	X	7.06	8.37	4.60	4.49	13.85	6.50	10.09	8.28	X	4.91	3.63	4.60	7.04	2.87	3.64	9.55	59.69
18																						
19		S9	9.04	3.50	X	7.16	9.92	4.36	5.47	12.77	7.09	9.46	7.97	X	4.38	4.33	4.85	7.83	2.77	3.01	9.12	57.00
20			9.32	3.18	X	7.79	10.99	4.19	5.90	13.64	7.34	10.37	7.30	X	4.94	4.61	4.37	7.31	3.32	3.96	9.86	61.63
21	Mean		9.18	3.34	X	7.48	10.45	4.27	5.68	13.20	7.21	9.91	7.64	X	4.66	4.47	4.61	7.57	3.05	3.49	9.49	59.31

TABLE 3.10 (c)

AMINO ACIDS ANALYSIS

OF: TILAPIA ZILLII

	LAB. NO.	SAMPLE DESCRIPTION	CONCENTRATIONS ARE EXPRESSED IN g/ 16g N2; g % D.M.; g, % AIR																	D.M.	
			LYS	HIS	AMM	ARG	ASP	THR	SER	GLU	PRO	GLY	ALA	CYS	VAL	MET	ILEU	LEU	TYR	PHE	% N2	% Protein
1		T1	6.46	2.39	X	4.43	8.86	3.47	3.56	11.49	5.18	8.69	6.99	X	3.94	2.82	3.59	6.33	2.43	2.78	11.33	70.81
2			6.75	1.63	X	4.55	8.77	3.15	3.21	11.15	4.67	7.79	6.40	X	3.46	2.39	3.59	6.15	2.35	2.90	11.42	71.38
3	Mean		6.60	2.01	X	4.49	8.81	3.31	3.39	11.32	4.92	8.24	6.69	X	3.70	2.61	3.59	6.24	2.39	2.84	11.37	71.06
4																						
5		T2	8.40	1.87	X	5.74	8.99	3.62	3.77	11.33	5.75	8.32	7.57	X	3.57	3.31	4.02	6.75	2.18	2.81	11.78	73.63
6			9.29	2.59	X	6.05	10.23	3.62	3.78	13.05	5.23	9.40	6.74	X	4.67	3.06	3.99	7.04	2.67	3.59	12.10	75.63
7	Mean		8.85	2.23	X	5.90	9.61	3.62	3.77	12.19	5.49	8.86	7.06	X	4.12	3.19	4.00	6.90	2.42	3.20	11.94	74.63
8		T5	8.25	1.37	X	6.60	8.77	4.88	4.03	15.47	5.52	9.60	7.33	X	5.63	4.20	4.52	7.61	3.41	3.32	11.13	69.56
9			8.27	1.95	X	6.53	9.02	5.23	4.79	14.60	4.92	10.07	7.02	X	5.39	3.42	3.96	6.04	2.80	3.42	11.15	69.69
10	Mean		8.26	1.66	X	6.56	8.90	5.05	4.41	15.03	5.22	9.84	7.18	X	5.51	3.81	4.24	6.77	3.10	3.37	11.14	69.63
11																						
12		T6	8.29	3.13	X	5.68	8.73	4.40	4.21	12.30	5.43	8.44	6.71	X	3.91	3.77	4.38	7.34	2.77	3.57	11.14	69.63
13			9.06	3.96	X	6.83	8.80	4.77	4.50	13.72	5.97	8.96	7.57	X	5.13	3.39	3.77	7.01	3.14	4.75	11.24	70.25
14	Mean		8.67	3.30	X	6.25	8.77	4.58	4.36	13.01	5.70	8.70	7.14	X	4.52	3.58	4.08	7.18	2.96	4.15	11.19	69.94
15		T7	8.59	3.90	X	5.85	8.89	4.49	4.05	12.07	5.08	8.83	6.60	X	4.05	4.61	4.69	6.80	2.59	3.37	10.33	64.56
16			8.26	3.70	X	5.83	9.79	4.85	4.40	12.64	5.48	9.63	7.10	X	4.60	4.11	4.00	6.87	3.09	4.66	10.40	65.00
17	Mean		8.42	3.30	X	5.84	9.37	4.67	4.22	12.36	5.28	9.23	6.85	X	4.34	4.36	4.35	6.83	2.84	4.02	10.36	64.75
18																						
19		T8	8.27	2.95	X	5.70	7.93	3.74	3.94	10.67	4.84	8.62	6.13	X	4.60	2.41	4.06	7.04	2.96	4.08	12.54	78.38
20			10.20	3.55	X	6.48	8.56	3.56	3.79	11.91	5.23	8.70	6.19	X	4.24	2.63	3.84	6.91	2.92	3.98	12.82	80.13
21	Mean		9.23	3.25	X	6.09	8.24	3.65	3.87	11.29	5.03	8.66	6.16	X	4.42	2.52	3.95	6.98	2.69	4.03	12.68	79.25

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There is a significant difference in the values reported for serine only when S. schall and T. zillii are compared, otherwise there is no significant difference when A nurse is compared with S. schall and A. nurse with T. zillii.

There is a significant difference in the values reported for proline in all the three fish samples, except those of A. nurse compared to those of zillii, where there is no significant difference.

Glycine values of the three species show different extents of differences when compared. Isoleucine values show some highly significant differences except the values of S. schall when compared with T. zillii Leucine values, however, are the same statistically except the values of A. nurse when compared with those of of T. zillii. From Fetuga et al[13], it is possible to deduce the level of Tryptophan and Cystine not determined in this work. This may vary from 1.01 to 1.24 for cystine and 0.89 to 1.02 for tryptophan.

3.1.11 CONCLUSION

The results of this work show that the fish samples analysed are rich in fat, protein and essential mineral elements, and are of high calorific value.

A. nurse contains more protein than the others, while S. schall is richer in all the mineral elements investigated than the others.

These results show that the fish samples investigated will be good fish meals for purposes of human consumption and for poultry feeds as these will supply the protein requirement as well as part of the mineral requirements.

The vitamins requirement will also be supplied. This area needs to be investigated. More work should be done in the area of mineral element composition, and the state in which they exist. The fat composition should be investigated more to determine the fatty acid composition.

These suggested areas of investigation will give a comprehensive chemical data for the fish samples analysed.

Marine as well as brackish water fishes need to be investigated. This will provide a basis of comparison with the fresh water fishes already investigated and will point out whether marine or brackish water fishes will be preferred to fresh water fishes to meet the protein, mineral, vitamin and calorific needs for human and poultry.

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A P P E N D I X

TESTING DIFFERENCE OF MEANS FOR A K-LEVEL FACTOR

1. First perform an analysis of variance using F-test according to the following formulae:

(i) Total SS = $\sum_{i=1}^{K} \sum_{j=1}^{n_i} x_{ij}^2 - \frac{\left(\sum_{i=1}^{K} \sum_{j=1}^{n_i} x_{ij}\right)^2}{\sum_{i=1}^{K} n_i}$

(ii) Between-groups SS (sometimes called "treatment SS")

$$= \sum_{i=1}^{K} \left\{ \frac{\left(\sum_{j=1}^{n_i} x_{ij}\right)^2}{n_i} \right\} = \frac{\left(\sum_{j=1}^{K} \sum_{j=1}^{n_i} x_{ij}\right)^2}{\sum_{i=1}^{K} n_i}$$

(iii) Within-groups SS (sometimes called "error SS")

= Total SS - treatment SS

(iv) df_1 = treatment df = K-1

(v) df_2 = error df $= \sum_{i=1}^{K} n_i - K$

(vi) treatment MS = $\frac{\text{treatment SS}}{\text{treatment df}}$

(vii) error MS = $\frac{\text{error SS}}{\text{error df}}$

(viii) F_{calc} = $\frac{\text{treatment MS}}{\text{error MS}}$ with df_1, df_2 degrees for freedom

(ix) Turn to F-table and read

(a) $F_{0.05}$ (df_1, df_2)

(b) $F_{0.01}$ (df_1, df_2)

(c) $F_{0.001}$ (df_1, df_2)

(x) (a) If F_{calc} is less than $F_{0.05}$ then we say that the test is NOT SIGNIFICANT, this implies that the means can be regarded as being equal.

(c) If F_{calc} is equal to $F_{0.01}$ or if it is greater than $F_{0.01}$ but less than $F_{0.001}$ then we say that the test is HIGHLY SIGNIFICANT; this also implies that we should not regard all the means as being equal.

(d) If F_{calc} is equal to or greater that $F_{0.001}$ then we say that the test is VERY HIGHLY SIGNIFICANT, this also implies that we should not regard all the means as being equal.

2. (a) If the test in 1 above results in "NOT SIGNIFICANT" then we conclude that the means can be regarded as being equal.

(b) If the test results in SIGNIFICANT or HIGHLY SIGNIFICANT or VERY HIGHLY SIGNIFICANT then we perform the LSD test according to the following formulae.

LSD means least significant difference

(i) Turn to the t-table and read

$$t_{0.05}(df_2)$$
$$t_{0.01}(df_2)$$
$$t_{0.001}(df_2)$$

(ii) Note that the LSD test here applies only if the values of n_i (i.e. the number of observations in each level) are equal. Suppose $n_i = m$ meaning that there are m observations in each level.

Then LSD is calculated by the following formula:-

$$\text{LSD} = t_{\alpha} \times \sqrt{\frac{2 \times \text{error MS}}{m}}$$

i.e.
$$\text{LSD}_{0.05} = t_{0.05} \times \sqrt{\frac{2 \times \text{error MS}}{m}}$$
$$\text{LSD}_{0.01} = t_{0.01} \times \sqrt{\frac{2 \times \text{error MS}}{m}}$$
$$\text{LSD}_{0.001} = t_{0.001} \times \sqrt{\frac{2 \times \text{error MS}}{m}}$$

where t is the value obtained from the t-table

and error MS is the value obtained in 1(vii) above .

(iii) Suppose we are dealing with three means

$$\bar{x}_A, \bar{x}_B, \bar{x}_C$$

calculate the differences between the means neglecting the sign

$$d_{AB} = \bar{x}_A - \bar{x}_B \qquad \text{(neglect the sign if negative)}$$

$$d_{AC} = \bar{x}_A - \bar{x}_C \qquad \text{(neglect the sign if negative)}$$

$$d_{BC} = \bar{x}_B - \bar{x}_C \qquad \text{(neglect the sign if negative)}$$

(iv) Just as we have it in 1(x) if any particular d is less than $LSD_{0.05}$ we say that that particular difference is "not significant" and the two means which give this difference can be regarded as being equal.

SUMMARY OF RESULTS

FROM TEST OF SIGNIFICANCE OF DIFFERENCE OF MEANS

SUBSTANCE	$\bar{x}_A$	$\bar{x}_S$	$\bar{x}_T$	F	d_{AS}	d_{AT}	d_{ST}
Water	74.03	76.00	75.98	2.97	-	-	-
Protein (non-defated)	69.94	61.91	~~54.36~~ 60.16	5.01*	8.03	15.58**	7.55
Protein (defated)	74.98	63.42	71.54	12.32***	11.56***	3.44	8.12**
Fat	17.40	9.55	12.33	21.42***	7.85***	5.07***	2.78*
Organic matter	89.65	85.28	85.57	19.70***	4.37***	4.08***	0.29
Ash	10.35	14.70	14.43	19.44***	4.35***	4.08***	0.27
Carbohydrate	2.52	14.16	13.38	54.24***	2.55*	3.46**	4.60***
CALORIFIC VALUES							
Fat	165.30	90.79	116.68	21.91***	69.51***	48.62***	25.89*
Carbohydrate	10.33	58.06	54.86	54.29***	47.73***	44.53***	3.20
Protein	383.61	341.81	330.30	104.0***	41.8***	53.30***	11.50**
TOTAL	558.40	490.71	500.61	35.33**	67.7***	57.8***	9.90

75.31

SUBSTANCE	$\bar{X}_A$	$\bar{X}_S$	$\bar{X}_T$	F	d_{AS}	d_{AT}	d_{ST}
MINERALS							
Sodium	206.0	241.0	253.9	11.61	35.00**	47.70***	12.70
Potassium	712.4	796.3	665.5	7.6***	83.9*	46.9	130.80***
Copper	0.56	0.82	1.73	10.15***	0.26	1.17**	0.91***
Iron	34.23	137.12	106.82	140.69***	102.9***	72.60***	30.30***
Zinc	18.10	19.21	17.00	1.14	-	-	-
Magnesium	138.61	154.72	126.00	11.05***	16.1*	12.60*	28.70***
Phosphorus	2606.31	3759.83	2755.22	46.41***	1153.50***	148.90	1004.60***
Calcium	3764.51	6057.60	4587.33	33.74***	2293.10***	822.80	1470.3***

* = Significant

** = Highly significant

*** = Very highly significant

AMINO ACIDS

SUBSTANCE	$\bar{X}_A$	$\bar{X}_S$	$\bar{X}_T$	F	d_{AS}	d_{AT}	d_{ST}
Lysine	9.68	9.21	8.34	3.37	-	-	-
Histidine	3.26	3.08	2.63	2.01	-	-	-
Arginine	6.10	6.68	5.86	2.41	-	-	-
Aspartic Acid	10.12	9.26	8.95	7.24^{**}	0.86^{*}	1.17^{**}	0.31
Threonine	4.24	4.59	4.15	0.82	-	-	-
Serine	4.58	4.79	4.00	3.78^{*}	0.21	0.58	0.79^{*}
Glutamic acid	13.34	13.16	12.53	0.98	-	-	-
Proline	5.13	6.15	5.27	4.52^{*}	1.02^{*}	0.15	0.88^{*}
Glycine	7.04	9.43	8.92	29.23^{***}	2.40^{***}	1.89^{***}	0.51
Alanine	6.90	7.30	6.85	1.38	-	-	-
Valine	4.66	4.58	4.44	0.33	-	-	-
Methionine	3.71	3.74	3.35	0.93	-	-	-
Isoleucine	4.05	4.51	4.04	7.96^{**}	0.46^{**}	0.02	0.48^{**}
Leucine	7.51	7.20	6.82	4.33^{*}	0.31	0.69^{*}	0.38
Tyrosine	2.84	2.89	2.73	0.58	-	-	-
Phenylalanine	3.63	3.66	3.60	0.027	-	-	-

V I T A

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1. Primary School:	St Peter's Cath. School, Ijero-Ekiti.	1953-1959	School Leaving Certificat
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3. University:	University of Lagos, Lagos.	1969-1972	B.Sc.
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Employment experience:

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