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MUSCLE LIPID CONTENT AND LIPASE ACTIVITY IN THE LIVER AND DIGESTIVE TRACT OF SOME FRESHWATER FISHES (PISCES: TELEOSTEI)

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ABSTRACT

Lipid content of the muscle and activity of lipase enzyme in the liver and digestive tract of *Lates niloticus, Citharinus citharus* and *Auchenoglanis occidentalis* were studied. The highest lipid content (14%) was recorded in *A. occidentalis* adults, while the lowest lipid content was observed in *L. niloticus juveniles*. Lipase activity was observed in the liver, anterior, median and posterior portions of the digestive tract of *L. niloticus, C. citharus* and *A. occidentalis*. The activity of lipase enzyme in the liver was high in the three fish species studied and the activity was statistically different. High lipid content of the muscle correlated with high activity of lipase in the liver of the fish species.

Key words: Lipase, lipid, liver, digestive tract.

INTRODUCTION

Fish body composition and energy content can be used as indices for the physiological state of the fish. The lipid content of the fish fluctuates with age, season, physiological and nutritional status. (Craig 1977 and Sorieguer *et al.* 1996). Fish oil consists of unsaturated fatty acids which has beneficial effect on blood lipid composition. Fish oil supply preformed omega – 3 longer chain polyunsaturated fatty acids which are needed for cell membrane transport in higher vertebrates because fish bodies have already converted essential fatty acid alpha linolenic acid from various food sources. (Better Nutrition, 2000).

Among the works reported on fish lipids were: Padron et al. (1996) on bone fish *Albula sp.* They demonstrated that lipid catabolism accounted for about 80% of the total energy production in larvae during metamorphosis. Clucas and Ward (1996) classified fish based on their lipid content into lean fish less than 0.5% fat, semi-fat fish contain 0.5 – 2% and fatty fish have more than 2% fat. There is also variation in fat content with season. Achionye–Nzeh and Omorodion (1999, 2002), Achionye–Nzeh (2002) worked on some Nigerian freshwater fishes and demonstrated that *Heterotis niloticus, Brycenus nurse, Gnathonemus cyprinoids, Hepsetus odoe, Synodontis membranececus* and *O. niloticus* contained more than 2% fat and were classified as fatty fishes.

Some of the neutral lipids present in the fishes were: free fatty acid, and cholesterol esters and the phospholipids present in the fishes were phosphatidyl ethanolamine, phosphatidic acid and sphingomyelin. The ability of fish and other vertebrates to use nutrients has been attributed to factors such as synthesis of appropriate enzyme, the production of the enzyme in suitable amount and enzyme distribution along the gut lumen. Analysis of gut sections has been identified as the best way of assessing the digestive capacity of fish (Buddington *et al.* 1997, Lundstedt *et al.* 2002). In the Brazilian catfish *Pseudoplatystoma coruscan*, lipase activity was assessed along the gut and results obtained showed that there was activity of enzyme lipase in the anterior, middle and posterior sections of the gut with the highest activity recorded in the midgut, (lundstedt *et al*, 2002).

The fish species used in present study were *L. niloticus, C citharus* and *A occidentalis. L. niloticus* belongs to the family centropomidae. It is commonly called the Niger perch and it is the biggest freshwater fish in Nigerian water attaining a weight of 80kg (Holden and Reed 1972). *C citharus* and *A. occidentalis* belong to families Citharinidae and Bagridae respectively. These fishes are economically important to freshwater fisheries of Nigeria and they are consumed among the populace.

The objective of this work is to elucidate the lipid content of the muscle and activity of lipase enzyme in the gut and liver of *L. niloticus, A. occidentalis* and *C. citharus*, also to show if there is correlation between enzyme activity and lipid content of the muscle.

MATERIALS AND METHODS

Specimens of *A. occidentalis, C. citharus* and *L. niloticus* studied were collected between March and September 2004 in Ilorin, Nigeria. Sixty live specimens were collected during the research period. The fish were transported to the laboratory in ice chest. Standard length and total weights were taken. The head was decapitated. The digestive tracts were dissected out and the total length of each digestive tract was measured. The digestive tract was divided into three sections according to De Silva and Anderson (1995).

Lipid extraction from the muscle of *A. occidentalis, C. Citharus* and *L. niloticus* was carried out using Soxhlet extraction method of AOAC (1980). Five grams of the muscle of each specimen was used for the extraction.

Tissue extracts: Samples from liver, anterior, median and posterior sections of the digestive tract were homogenized in cold 0.25M sucrose solution (temp 4°C); the ratio of the tissue to sucrose solution was 1.5 (W/V). The homogenate were centrifuged at 2,000 g for 15 minutes and the supernatant (crude extract) were used as enzyme source.

Enzyme Assay: Lipase determination was by the method of Tietz and Fiereck (1966) modified by Isong (1987). 2 ml of crude extract were put into two test tubes labelled test and blank. The blank was placed in boiling water for 5 minutes and cooled. 0.5 ml of phosphate buffer of pH 7.4 and 2 ml of substrate (olive oil) were

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introduced into both test and blank test tubes. The test tubes were shaken and incubated at 27^{0}C for 24 h. The sample was transferred into a conical flask and 2 ml of ethanol and 2 drops of phenolphthalein indicator were added to the incubated samples in the conical flask and titrated with standard 0.05N NaOH. Lipase activity was computed and expressed in mg per ml per minute. Analysis of variance for significant difference in the lipase activity in anterior, median and posterior sections of gut, and also the liver of the species were carried out.

RESULTS

The results of the standard length, total weight and gut length of L. *niloticus* C. *citharus* and *A. occidentalis* are shown in Table I. The standard length of the adults of *L. niloticus* ranged from 26.2 to 36.5 cm while the standard length range for *C. citharus* adult was 26.4 to 30.2 cm.

In *A. occidentalis* the standard length for adults varied from 19.4 to 23.2 cm. The longest gut length was recorded in adult *C. citharus*, the gut mean length was 200 cm. In *A. occidentalis* and *L. niloticus* the gut mean lengths obtained were 41.8 and 28.0 cm respectively.

The lowest percentage of lipids in the muscle was obtained in juveniles of *L. niloticus* and *C. citharus* (Table 2). The highest lipid content of the muscle was observed in *A. occidentalis* adult. *A. occidentalis* contained about 14.05% lipid (mean value) while juvenile had about 9% lipid content in the muscle. In adults of *L. niloticus* and *C. citharus* the lipid content of the muscle were about 7% and 8% respectively.

Presence of enzyme lipase was observed along the whole length of the intestine of *L. niloticus*, *A. occidentalis* and *C. citharus*. In *L. niloticus* lipase activity was low in the stomach, with mean values observed for juveniles and adults being 5.8 and 11.2 mg/ml/min. Higher activity of lipase was recorded in the middle section of the gut and the mean values were 14.9 and 21.0 mg/ml/min for juveniles and adults respectively (Table 3).

In *C. citharus* there was decrease in the activity of enzyme lipase along the length of the gut. The highest activity of lipase was obtained in the anterior section; the values obtained were 16.0 and 18.8 mg/ml/min in the juvenile and adult respectively. In the middle section of the digestive tract of *C. citharus* the activity of lipase were 8.75 mg/ml/min in juveniles and 13.85 in adults. The lowest values of lipase activity were obtained in the posterior section of the digestive tract (Table 3). In *A. occidentalis* highest activity of lipase occurred in the anterior section of the digestive tract, with the mean values being 14.75 mg/ml/min for juveniles and 17.75 mg/ml/min for adults.

The liver of *L. niloticus*, *C. citharus* and *A. occidentalis* showed high activity of lipase and the highest activity was observed in the liver of *A. occidentalis*. (Table 3)

Result of statistical analysis for significant difference using ANOVA showed that $P < 0.05$ indicating that there was significant difference in the lipase activity between the anterior, median, posterior sections of gut and the liver.

DISCUSSION

The lipid content of the muscle of *L. niloticus*, *A. occidentalis* and *C. citharus* in both juvenile and adult were higher than 1%. According to the classification of fish based on their fat content by Clucas and Ward (1996) *L. niloticus*, *A. occidentalis* and *C. citharus* are fatty fishes.

Enzyme lipase occurred along the whole length of the digestive tract of *L. niloticus*, *C. citharus* and *A. occidentalis* indicating that the diet of these fishes contained fat as hydrolysis required lipase. However there was variation in the activity of lipase in the various sections of the gut. *C. citharus* had the longest gut length and activity of lipase was highest in the anterior section of the gut. The presence of long digestive tract is associated with fishes which utilize plant materials in their food and plant materials generally have lower lipid content than animals. The long digestive tract increases the retention time of the food in the tract so that enzyme can hydrolyze the food (Bond 1996). It is plausible that the anterior section of the gut of *C. citharus* is not too acidic and therefore Lipase enzyme activity was high. Bond (1999) showed that there are other enzymes in the stomach of some fishes that act on food other, than proteins. Chitinase have been obtained from stomach of insectivores and species that feed on crustaceans. Lipase was identified from anterior section of clupeids and mozambique tilapia. The result obtained in the present work supports Bond (1999) findings on the presence of lipase in the stomach of fishes. Lundstedt *et al.* 2002 also found lipase in the stomach of *Pseudoplatystoma coruscans*.

The results obtained in this work showed that *L. niloticus* had digestive tract about ten times shorter than the length of the digestive tract *of C. citharus*. The result also indicated that activity of enzyme lipase was low in the anterior section of the digestive tract of *L. niloticus* but high in the medium section of the digestive tract of the same fish *L. niloticus* is known to be a voracious carnivore feeding mostly on fish (Holden and Reed 1972). The stomach is acidic to enable the action of pepsin, which breaks down protein in the food of *L. niloticus*. It is possible that the presence of acid in the stomach reduced the activity of lipase enzyme, which acts in alkaline medium therefore high activity of lipase enzyme was recorded in the median section of the digestive tract of *L. niloticus*.

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Table 1: Standard length, total weight and gut length of *Lates niloticus, Citharinus citharus and Auchenoglanis occidentalis*

Species	Size group	Number of species	Standard Length (cm)			Total Weight (g)			Gut Length (cm)		
			Range	Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.
L. niloticus	Juvenile	10	17.8-24.3	21.57	3.37	121.6-270	213.87	80.53	16.0-21.0	19	2.65
	Adult	10	26.2-36.5	29.14	3.45	380-750	497.14	127.42	24.0-31.5	27.56	2.82
C. citharus	Juvenile	10	17.6-26.2	22.45	4.52	150-475	316.25	180.62	105-194	149.5	48.58
	Adult	10	26.4-30.2	28.16	1.65	500-870	640	143.53	165.5-224	200.10	21.56
A. occidentalis	Juvenile	10	13.5-15.90	14.93	1.11	80.4-105.4	92.4	11.37	31.3-35.0	32.18	1.93
	Adult	10	19.4-23.3	20.73	2.05	150 – 200	168	27.12	41.5-45.4	41.8	2.87

n= 60

Table 2: Total lipid content of the muscle of *Lates niloticus, Citharinus citharus and Aucheoglanis occidentalis*

Species	Size group	Range (%)	Mean (%)	S.D.
L. niloticus	Juvenile	3.64 - 4.32	4.09	0.39
	Adult	6.22 - 8.02	7.42	1.04
C. citharus	Juvenile	3.8 - 5.56	4.17	0.92
	Adult	6.8 - 8.82	8.45	0.65
A. occidentalis	Juvenile	8.22 - 10.02	9.12	0.89
	Adult	13.24 -15.14	14.05	0.80

n = 60

Table 3: Lipase activity (mg/ml/min) in the liver anterior, medium and posterior section of the digestive tract of *Lates niloticus, Citharinus citharus and Auchenoglanis occidentalis*

Species	Size group	Anterior	Middle	Posterior	Liver
L. niloticus	Juvenile	5.80 ± 0.72	14.90 ± 0.79	6.66 ± 1.15	19.33 ± 4.16
	Adult	11.20 ± 2. 68	21.00 ± 2.58	11.70 ± 2.62	24.50 ± 2.54
C. citharus	Juvenile	16.00 ± 1.63	8.75 ± 1.50	7.93 ± 2.47	24.75 ± 0.96
	Adult	18.00 ± 3.35	13.85 ± 1.66	5.10 ± 2.43	25.15 ± 3.53
A. occidentalis	Juvenile	14.75 ± 2.21	8.00 ± 2.16	6.30 ± 1.50	24.90 ± 1.23
	Adult	17.75 ± 1.70	9.85 ± 1.53	7.40 ± 3.07	26.60 ± 1.15

Each value is a mean of 5 values ± S.D.

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The liver showed high lipase activity in *L. niloticus C. citharus* and *A. occidentalis*. This is indicative of the fact that the liver is involved in conversion of carbohydrates and amino acids into fatty acids through acetyl co-enzyme A (Guttman 1999).

The results showed that there is a correlation between the lipid content of the fish and lipase activity. *A. occidentalis* had the highest lipid content in the muscle and it also had the highest activity of lipase in the liver. This finding is in line with the finding of Clucas and Ward (1996) that the energy reserve in fishes is in the form of lipids. The lipid in the muscle of the fish that will be consumed by higher vertebrate is a function of activity of lipase enzyme in the liver. The more the activity of the enzyme the more lipid is produced.

Other factors that can contribute to the variation in the lipid content of the muscle are reproductive season and activity of the fish. *L. niloticus* and *C. citharus* are swift swimmers and utilize their lipid as a main source of the energy supply during swimming. It is plausible that the low lipid content in the muscle of *L. niloticus* and *C. citharus* could be associated to their swift swimming activity.

This study has shown that there is interrelationship between the lipid content of the muscle of the fish and hydrolysis of lipid by lipase in these fish species.

REFERENCES

Achionye–Nzeh C.G and Omorodion O. (1999). Comparative studies on the lipid content of the muscle of some scaled and scaleless fishes. *Nigerian Journal of Pure and Applied Science. 14*: 793 – 796

Achionye–Nzeh C.G. and Omorodion O. (2002). Lipid composition of the fishes *Heterotis niloticus, Brycenus nurse Gnathonemus cyprinoids*, and *Sarothenodon galilacus* from a small lake in Nigeria. *Revista de Biologia Tropical 50* (1): 253 – 257

Achionye–Nzeh C.G. (2002). Lipid composition of some Nigerian freshwater fishes *Nigerian Journal of Pure and Applied Science 17*: 1189 – 1193.

AOAC (1980). Method of analysis. Association of Official and Analytical Chemist Washington D.C., USA. 1108 pp.

Better Nutrition August 1 (2000): Better Nutrition Magazine. Volume 62, issue 8 section: Nutritional supplements.

Bond C.E. (1999) Biology of fishes Saunders College Publishing, Orlando Florida, USA. 750 pp

Buddington R.K.A, Krogdahl A and Bakke Mckellep A.M. (1997). The intestine of carnivorous fish, structure and function and the relation with diet *Acta Physiology Scandinavia. 638*: 67 – 80.

Clucas I.J. and Ward A.R (1996). Post harvest Fisheries Development: A guide to handling, preservation, processing and quality. publisher Natural Resources Institute, Chartham Kent U.K. 443 pp.

Craig J.F. (1977). The body composition of adult perch *Perca fluviatilis* in Windermere with reference to seasonal changes and reproduction. *Journal of Animal Ecology 46*: 617 - 632

Desilva S.S. & Anderson T.A. (1995) Fish nutrition & Aquaculture Chapman and Hall London, U.K. 121 pp.

Guttman B.S. (1999). Biology, WCB/McGraw Hill. New York U.S.A. 1177 pp.

Holden M and Reed W. (1972). West African Freshwater fish Longman Group Ltd London U.K. 68 pp.

Isong E.U.(1987). Bio Chemical and Nutritional studies of Rat fed thermally oxidized palm oil (*Elaeis guinensis*) Ph.D. Thesis University of Calabar, Calabar Nigeria 198 pp.

Lundstedt L.M, Melo J.F, Band G.F. and Moraes G.(2002)Induction of Digestive enzyme in the Brazilian catfish. *Pseudo Platystoma coruscans. Comparative Biochemistry and Physiology. Part B. 137*: 331 – 339

Padron D., Lindley V.A. and Pfeiler E.(1996) Changes in lipid composition during metamorphosis of bonefish (*Albula sp*) *Leptocephali. Lipids 31*: 513 – 519.

Soriguer F., Serna S., Valverde E., Hernando J, Martin–Reyes A Soriguer M., Pareja A, and Esteva F, (1996). Fat, Protein and caloric content of difference fish, seafood and mollusk. Atlantic and Mediterranean habitually consumed in the South of Spain. *Nutritional Hospital 11*: 245 – 257.

Tietz N.W and Fiereck E.A. (1966). A specific method for serum lipase determination. *Clinical Chemist Acta 13*:352

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