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Digestibility, Growth and Hepatosomatic Index of *Oreochromis Niloticus* (Linnaeus, 1758) Fed Diets Containing Blanched *Lemna paucicostata* (Hegelm)

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Research Article

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Abstract

This study evaluated digestibility, growth and hepatosomatic index of *Oreochromis niloticus* fed diets containing blanched *Lemna paucicostata* as a replacement for toasted soybean meal. Five iso-proteinous diets were formulated using feed solution software, blanched *Lemna paucicostata* was used to replace toasted soybean meal progressively at 0%, 25%, 50%, 75% and 100% respectively. Fifteen Hapa nets of 1m2 each were used. Ten *Oreochromis niloticus* juveniles were introduced into each of the nets. The fish were fed at 5% body weight three times daily for a period of six months. There was significant difference (P≤0.05) in the apparent protein digestibility coefficient among the treatments and the control. Highest apparent protein digestibility coefficient of 92.94% was recorded in the diet containing 75% blanched *L. paucicostata* meal while the least value of 86.86% was obtained in the diet with 100% *L. paucicostata* meal. The fish fed diet containing 75% blanched *L. paucicostata* meal recorded significantly highest (P≤0.05) mean final weight of 468.01g followed by the fish fed with 50% blanched *L. paucicostata* meal with 453.68g, the fish fed 100% blanched *L. paucicostata* meal recorded significantly lowest (P≤0.05) value of 401.54g. The fish fed diet containing 75% inclusion level of blanched *L. paucicostata* meal gave the best protein, lipid, ash and carbohydrate digestibility of 92.94%, 90.62%, 52.29% and 80.56%, respectively and also gave the best growth performance and hepatosomatic index.

Keywords: Hepatosomatic Index; Digestibility; *Oreochromis Niloticus*; *Lemna paucicostata*; Growth Performance

Abbreviations: AIA: Acid Insoluble Ash; CP: Crude Protein; CRD: Completely Randomized Design; PCA: Principal Component Analysis; APD: Apparent Protein Digestibility; AAD: Apparent Ash Digestibility; ALD: Apparent Lipid Digestibility; ACD: Apparent Carbohydrate Digestibility.

Introduction

Nile tilapia (*Oreochromis niloticus)* is one of the most common cultured fish species in the world, after carp (*Cyprinus carpio*) [1]. It inhabits both freshwater and brackish water and can be easily identified by dark bands or stripes found on the body. In particular, the *Oreochromis niloticus* species has impacted aquaculture development since the 1970s and has become the preferred tilapia species for aquaculture, especially in developing countries [2]. The popularity of Nile tilapia is due to its market acceptability, fast growth rate, resistance to disease and ability to grow on a wide range of diets. It is also very tolerant to a wide range of environmental conditions, can reproduce readily in captivity and has a high prolific rate and good carcass taste [3]. The optimal growth of *Oreochromis niloticus* requires different diet formulations that include proteins, lipids, energy sources and vitamins. To achieve growth in fish, the requirement for the deposition of new body components has to be satisfied, which consists mainly of protein and lipids [4].

The most reliable and consistent estimates of nutrient digestibility were obtained using chromic oxide and crude fibre as dietary markers, while the performance of acid-washed sand and polyethylene as dietary markers was disappointing. The values of digestibility were significantly lower when using titanium dioxide instead of chromic oxide. On the other hand, Acid-insoluble ash (AIA) has also been reported as an internal marker and the marker yielded consistent and realistic apparent digestibility coefficients [5].

Duckweed is a monocotyledon, belonging to the Lemnaceae family, which consists of five genera (*Spirodela, Landoltia, Lemna, Wolffia, and Wolffiella*) and 37 species [6]. Duckweed (*Lemna paucicostata*, Hegelm) is a small, fragile, free-floating aquatic plant that grows well in static and nutrient-rich freshwater or a brackish aquatic environment [7]. Duckweed usually reproduces asexually with an extremely short cycle. The daughter plants of the duckweed are produced from the budding pouch of the mother plant. The exponential reproduction of duckweed results in a high biomass growth rate. The biomass of duckweed also doubles in 2 to 3 days under ideal conditions of nutrient availability, sunlight, pH (6.5-7.5), and temperature (20°C to 30°C) [8]. Generally, duckweed contains 6.8 to 45% crude protein (CP), 1.8 to 9.2% crude lipid (CL), 5.7 to 16.2% crude fibre, 12 to 27.6% ash, and the carbohydrate content is in the range of 14.1-43.6% on a dry matter basis [8]. The nutrient composition in each duckweed species varies depending on the condition of the water environment. *Lemna paucicostata* leaves contain a very low amount of fibre, therefore even monogastric animals can digest it and many fishes, especially herbivorous consume it readily because its cell wall of has low lignin. Thus, duckweed shows enhanced digestibility and is considered an ideal protein source of fish feed [9]. Therefore, this study aimed to evaluate the effect of dietary replacement of soybean with blanched *Lemna paucicostata* meal on digestibility, growth and hepatosomatic index of *O. niloticus*.

Materials and Methods

Experimental Site

The experiment was conducted in concrete pond of the Department of Fisheries and Aquaculture, Faculty of Agriculture, Ahmadu Bello University, Zaria which falls within latitude 11° 17'North and longitude 7° 63'East in the northern guinea savannah zone of Nigeria.

Procurement of Experimental Fish

Three hundred fingerlings of *Oreochromis niloticus* with an initial mean weight of 7.46g were procured from Kuka Farm, Gabasawa, Kano State and transported in an oxygenated polythene bag placed in 50 litres "Jerry-can".

Collection and Culture *Lemna paucicostata*

Fresh *L. paucicostata* was collected during raining season from a burrow pit at Hanwa Low-cost, Kwangila, Zaria, Kaduna State, with a hand net and transported in nylon bags. The fresh *L. paucicostata* was cultured for two months in concrete ponds at the Department of Fisheries and Aquaculture, Ahmadu Bello University, Zaria.

Processing of *Lemna paucicostata* and Soybean Meals

Blanching and sun-drying methods were employed to process the cultured samples while toasting was used to process the soybean meal. Blanching was done by boiling duckweed in water for 5 minutes at 100°C as described by Abdullahi AI, et al. [10]. The blanched *L. paucicostata* was milled into a fine powder and sieved through a 0.5 mm. The second treatment involved sun drying *L. paucicostata* for three (3) days as described by Mmanda FP.

Formulation of Experimental Diets

Five iso-protenious diets were formulated using Feed Solution Software version 2022 which took into consideration the cost and the nutritive value of the ingredients. The soybean meal which serves as the control in the diets was replaced by blanched *L. paucicostata* meal at 25%, 50%, 75% and 100%, respectively. All the feed ingredients were integrated into computing, at the required quantities to make up a 100-unit quantity of the feed. Inclusion levels of each ingredient and proximate composition the experimental diets are resented in Tables 1 and 2, respectively.

Ingredients	BLP0%	BLP25%	BLP50%	BLP75%	BLP100%
Soybean meal	23.74	17.81	11.87	5.93	0
BLP	0	5.93	11.87	17.81	23.74
Fish meal	11.87	11.87	11.87	11.87	11.87
Groundnut cake	35.61	35.61	35.61	35.61	35.61
Maize	9.39	9.39	9.39	9.39	9.39
Wheat bran	9.39	9.39	9.39	9.39	9.39
Palm oil	2.5	2.5	2.5	2.5	2.5
Salt	0.5	0.5	0.5	0.5	0.5
Pre-mix	2.5	2.5	2.5	2.5	2.5
DL-Methionine	1.5	1.5	1.5	1.5	1.5
L-Lysine	2	2	2	2	2
Klinofeed	1	1	1	1	1
Chromic oxide (Cr_2O_3)	0.5	0.5	0.5	0.5	0.5

Table 1: Composition of the Experimental diets.

Parameters	BLP0%	BLP25%	BLP50%	BLP75%	BLP100%
Moisture	11.45	10.12	10.5	10.46	11.52
Crude protein	38.02	35.54	35.49	36.33	37.98
Ether extract	12.59	10.06	11.54	10.83	10.49
Ash	14.95	15.81	16.32	15.92	16.81
Crude fibre	6.98	7.01	7.04	6.96	6.85
NFE	16.01	21.46	19.11	19.5	16.35
Gross energy (Kcal)	2996	2861.34	2925.95	2912.61	2835.6

Table 2: Proximate composition of the experimental diets (%DM basis).

Experimental Design

A completely Randomized Design (CRD) was employed in this research. The experiment consisted of four treatments (BLP25%, BLP50%, BLP75%, BLP 100%) and one control (BLP0%) with three replications each. 150 *Oreochromis niloticus* was acclimatized for two weeks. After the period of acclimatization, 10 fish were randomly assigned to a 1m² Hapa net. A total of 15 Hapa nets were used in outdoor concrete pond of 5m × 3.5m (l × b) and depth of 1.5m, and the five formulated diets were fed to the experimental fish and the pond water was daily monitored.

Digestibility Determination

Indirect method using Chromic oxide (Cr_2O_3) an indigestible marker was used for the experiment. Diets were formulated to accommodate 0.5kg/100kg chromic oxide and were fed to the experimental fish. Faeces were collected by dissecting the intestine as described by Belal EH, et al. [11]. The faeces from each treatment were pooled together to have enough faeces for analysis.

Apparent digestibility coefficient of crude protein, lipid, carbohydrate and dry matter was determined according to standard formula [12].

$$ADC = 100 \times \left\{ \left[\frac{-\ \%Faecal\ nutrient}{\%Dietary\ nutrient} \times \frac{\%\ Dietary\ chromic\ oxide}{\%Faecal\ chromic\ oxide} \right] \right\}$$

Determination of Growth Performance and Nutrient Utilization Parameters

The data obtained on the growth performance and nutrient utilization of *O. niloticus* fed on the formulated diets were determined as follows:

- **Mean Weight Gain (MWG) (g)**

Mean Weight Gain (MWG) = $W2 - W1$

Where W1 = Initial mean weight (g)
W2 = Final mean weight (g)

- **Daily Weight Gain (g/day)**

$$Daily\ Weight\ Gain\ (DWG) = \frac{FMW - IMW}{T}$$

Where FMW = Final mean weight (g)
IMW = Initial mean weight (g)
T=Feeding trial period in days

- **Percentage Weight Gain (%)**

$$Percentage\ weight\ gain\ (PWG\ \%) = \frac{FMW - IMW}{FW} \times 100$$

Where FMW = Final mean weight (g)
IMW = Initial mean weight (g)

- **Specific Growth Rate (SGR %/day)**

$$SGR\ \% = \frac{log\ of\ W2 - log\ of\ W1}{T2 - T1} \times 100$$

Where W1 = Initial mean weight (g)
W2 = Final mean weight (g)
T1 = Initial time (g)
T2 = Final time (g)

- **Condition Factor (CF)**

$$CF = \frac{100\ (Weight\ gain)(g)}{(Final\ Length)3\ (cm)}$$

- **Survival Rate (%)**

$$SR = \frac{Number\ of\ fish\ that\ remain\ at\ the\ end\ of\ the\ experiment}{The\ initial\ number\ of\ fish\ stocked} \times 100$$

Daily Feed Intake (g)

$$Daily\ Feed\ intake\ (DFI) = \frac{Quantity\ of\ feed\ fed\ (g)}{Number\ of\ days}$$

- **Protein Efficiency Ratio (PER)**

$$PER = \frac{Total\ weight\ gain\ (g)}{Crude\ protein\ fed\ (g)}$$

- **Feed Conversion Ratio (FCR)**

$$FCR = \frac{Total\ weight\ of\ diet\ fed\ (g)}{Total\ weight\ of\ fish\ (g)}$$

- **Apparent Net Protein Utilization (ANPU)**

$$ANPU = \frac{Final\ carcass\ protein\ (g) - Initial\ carcass\ protein\ (g)}{Protein\ fed\ (g)} \times 100$$

- **Net Nitrogen Retention (NNR)**

$$NNR = \frac{Initial\ body\ protein\ (g)}{Final\ body\ protein\ (g)} \times 100$$

- **Mortality**

$$M = \frac{Number\ of\ fish\ dead\ at\ the\ end\ of\ experiment}{The\ initial\ number\ of\ fish\ stocked} \times 100$$

Somatic Indices

Somatic indices were used to know the condition of the experimental fish by determining the Viscerosomatic index (VSI) and Hepatosomatic index (HSI) according to Kubiriza GK, et al. [13] as follows:

$$Viscerosomatic\ Index\ (VSI) = \frac{FVM}{FBM} \times 100$$

Where FVM = Fish visceral mass (g)
FBM = fish body mass (g)

$$Hepatosomatic\ Index\ (HSI) = \frac{LM}{BM} \times 100$$

Where LM = liver mass (g)
BM = body mass (g)

Data Analysis

All data collected from the experiment were subjected to one-way analysis of variance to test for significant differences among treatment means using XLSTAT version 2022, followed by Duncan pairwise comparisons which was used to separate significantly different means at a confidence interval of 95%. The level of significance set for treatments was P≤ 0.05. Principal component analysis (PCA) was carried out to establish the relationship between the digestibility and growth performance.

Results

Apparent Digestibility Coefficients of Blanched *Lemna paucicostata* Meal in the Diet of *Oreochromis Niloticus*

The apparent digestibility coefficients of blanched *L. paucicostata* meal as a replacement for soybean meal in the diets of *O. niloticus* are presented in Table 3. There was significant difference (P≤0.05) in the apparent protein digestibility coefficient among the treatments and the control. Highest apparent protein digestibility coefficient of 92.94% was recorded in the diet containing 75% blanched *L. paucicostata* meal while the least value of 86.86% was obtained in the diet with 100% *L. paucicostata* meal.

Parameters	Treatments				
	BLP0%	BLP25%	BLP50%	BLP75%	BLP100%
AAD	34.56±3.05[c]	43.24±3.03[b]	50.32±3.03[a]	52.29±3.03[a]	34.48±3.03[c]
APD	88.38±2.97[c]	88.22±2.97[c]	91.73±2.97[b]	92.94±2.97[a]	86.86±2.97[d]
ALD	83.06±3.53[b]	80.20±3.53[b]	88.37±3.53[b]	90.62±3.53[a]	78.16±3.53[b]
ACD	63.11±4.17[e]	66.36±4.17[d]	78.48±4.17[b]	80.56±4.17[a]	60.57±4.17[d]

Table 3: Apparent digestibility coefficients of the experimental diets for *Oreochromis niloticus*.

Growth Performance of *Oreochromis Niloticus* Fed Experimental Diets

The growth performance parameters of *O. niloticus* fed experimental diets are presented in Table 4. There was no significant difference (P>0.05) in the initial weight and initial length among all the treatments and the control. The fish fed diet containing 75% blanched *L. paucicostata* meal recorded significantly highest (P≤0.05) mean final weight of 468.01g followed by the fish fed with 50% blanched *L. paucicostata* meal with 453.68g, the fish fed 100% blanched *L. paucicostata* meal recorded significantly lowest (P≤0.05) value of 401.54g. There was significant difference in the mean final weight among all the treatments and the control (P≤0.05) diet.

Parameters	Treatments				
	BLP0%	BLP25%	BLP50%	BLP75%	BLP100%
IW (g)	7.48±0.06[a]	7.43±0.06[a]	7.50±0.06[a]	7.42±0.06[a]	7.51±0.06[a]
IL (cm)	7.79±0.07[a]	7.75±0.07[a]	7.87±0.07[a]	7.78±0.07[a]	7.86±0.07[a]
FW (g)	416.88±56.90[c]	425.57±56.90[b]	453.68±56.90[ab]	468.01±56.90[a]	401.54±56.90[d]
FL (cm)	27.07±0.43[a]	27.19±0.43[a]	27.68±0.43[a]	27.72±0.43[a]	26.72±0.43[b]
MWG (g)	409.40±56.92[c]	418.14±56.92[b]	446.18±56.92[ab]	460.59±56.92[a]	394.03±56.92[d]
DWG (g)	2.27±0.31[c]	2.32±0.31[b]	2.48±0.31[ab]	2.55±0.31[a]	2.19±0.31[d]
PWG (%)	98.17±0.27[b]	98.25±0.27[ab]	98.31±0.27[a]	98.33±0.27[a]	98.12±0.27[b]
SGR (%)	0.97±0.03[ab]	0.97±0.03[ab]	0.98±0.03[a]	0.99±0.03[a]	0.96±0.03[b]
CF	2.10±0.24[a]	2.12±0.24[a]	2.13±0.24[a]	2.18±0.24[a]	2.10±0.24[a]
SR	96.66±2.48[b]	96.66±0.24[b]	100.00±0.24[a]	96.66±0.24[b]	96.66±0.24[b]

Table 4: Growth performance and survival of *Oreochromis niloticus* fed experimental diets.

Hepatosomatic Index and Feed Conversation Ratio of the Experimental Fish

The results of hepatosomatic index and feed conversation ratio of *O. niloticus* fed experimental diets are presented in Table 5. There was significant difference (P≤0.05) in the hepatosomatic index, feed conversion ratio, feed intake, protein efficiency ratio, protein productive value and viscerosomatic index among all the treatments and the control. The principal component analysis of the digestibility and growth performance of the experimental fish is presented in Figure 1.

Parameters	Treatments				
	BLP0%	BLP25%	BLP50%	BLP75%	BLP100%
DFI (g)	42.11±4.12[ab]	42.61±4.12[ab]	44.17±4.12[a]	44.44±4.12[a]	41.67±4.12[b]
PER	10.77±1.55[b]	11.76±1.55[b]	12.57±1.55[a]	12.67±1.55[a]	10.37±1.55[b]
HIS	0.65±0.11[b]	0.68±0.11[b]	0.88±0.11[a]	0.95±0.11[a]	0.63±0.11[b]
VSI	7.21±1.12[b]	7.48±1.12[b]	9.77±1.12[a]	9.90±1.12[a]	6.99±1.12[b]
FCR	1.99±0.19[a]	1.91±0.19[ab]	1.82±0.19[b]	1.82±0.19[b]	2.10±0.19[a]
ANPU	34.96±1.27[c]	39.08±1.27[b]	43.14±1.27[a]	44.23±1.27[a]	33.65±1.27[c]
NNR	77.09±1.10[b]	76.31±1.10[b]	74.50±1.10[bc]	73.57±1.10[c]	77.78±1.10[ab]
PPV	1.53±0.43[c]	1.65±0.43[b]	1.69±0.43[b]	1.66±0.43[b]	1.51±0.43[c]

Table 5: Hepatosomatic index and feed conversation ratio of the experimental fish.

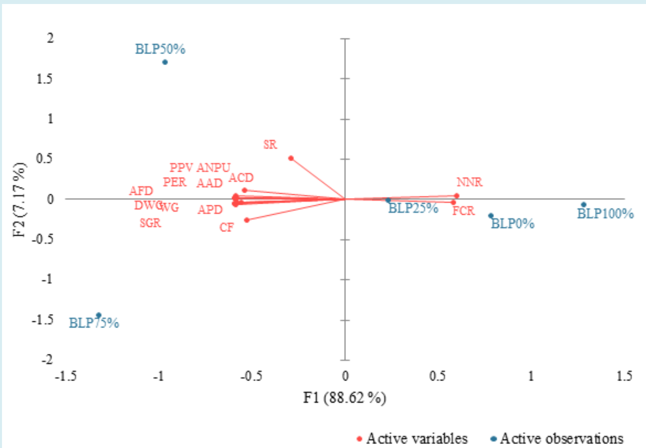

Figure 1: Principal component analysis (PCA) biplot (axes F1 and F2: 95.78%) of the relationship between digestibility and growth performance of the experimental fish.

Discussion

In all the experimental diets good values were obtained for the apparent digestibility coefficients. Differences in the quantity and quality of dietary nutrients influence the apparent digestibility in fish [14]. However, the apparent digestibility of nutrients varies from one fish species to another and even within an individual fish depending on sex, age, species, diet composition and water temperature [15]. Apparent Protein Digestibility (APD) is a key factor in the determination of the quality of a diet for fish and the potential of the diet to synthesize new tissues. All the experimental diets revealed a high APD (>86.86%). A high apparent protein digestibility in *O. nilotucus* fed feed ingredients of different origin has also been reported by Maina JG, et al. [16]; Köprücü K, et al. [17]. The range of the APD (86.86%~92.94%) obtained in this research is higher than the range of APD (75.90%~79.00%) and (46.30%~92.40%) in *O. niloticus* reported by El-shafai SA, et al. [18] and Mmanda FP, et al. [19], respectively. The blanched *L. paucicostata* meal used in this study had a higher protein content and a lower fibre content than previously reported by El-shafai SA, et al. [18] and Mmanda FP, et al. [19], which might explain the higher apparent protein digestibility obtained in this study. The protein content of *L. paucicostata* meal could vary widely depending on plant age, nutrient content of the aquatic environment and water temperature. In all the experimental diets, apparent ash digestibility (AAD) was in the range of 34.48-52.29%, which is lower than the range of 38.00%-62.90% reported for *O. niloticus* fishmeal-based diets, which included 20% and 40% of dry duckweed [18]. The lower values in this study could be attributed to the higher percentages of plant ingredients in the treatments. The apparent lipid digestibility (ALD) showed a large variation among the experimental diets and it was below the range of values reported for apparent lipid digestibility coefficients of the treatment diets for *O. niloticus* by El-shafai SA, et al. [18]. The variation could be explained by different lipid contents in the experimental diets used in this study and that of the previous authors. The highest apparent carbohydrate digestibility (ACD) value of 80.56% obtained in the treatment 75% blanched *L. paucicostata* meal among all the treatments and the control diet could be attributed to the high amylase activity observed in the treatment.

The growth performance of *O. niloticus* fed varying inclusion levels of blanched *L. paucicostata* meal as a replacement for soybean revealed that the initial mean weight (7.41g – 7.51g) and initial mean length (7.75cm – 7.87cm) were not significantly different (P>0.05) among the experimental treatments and the control showing uniformity in their sizes at onset of the experiment which indicated the accuracy of randomization process employed.

The high mean weight gain observed in the 75% blanched *L. paucicostata* meal and 50% blanched *L. paucicostata* meal was an indication that the fish were able to assimilate the diet more efficiently than the other treatments and the control diet. While the least mean weight gain obtained in 100% blanched *L. paucicostata* meal could be due to low feed consumption as a result of less palatability of the diet. Since it was observed that the fish were not actively responding to the diet during feeding when compared to the response in the other treatments and the control. The decrease in mean weight gain as a result of less palatability of the diet had been reported by Welker AM, et al. [20]. Daily weight gain, percentage weight gain and specific growth rate also revealed a similar trend with the mean weight gain. The best growth performance was observed in the fish fed diet containing 75% blanched *L. paucicostata* meal contradicts the findings of Effiong BN, et al. [21] who reported that the inclusion of duckweed at 10% in the diet of *Heterobranchus longifilis* fingerlings gives better results as compared to diets containing duckweed at 20% and 30%. Olaniyi CO, et al. [22] reported that the substitution of duckweed meal for 25% fish meal promotes higher growth performance than feeding only fish meal as the main source of protein in the Nile tilapia fish. These authors added that the growth performance of the fish that were fed the control diet was higher than those that received 50%, 75% and 100% duckweed meal. However, Oyas AA, et al. [23] replaced duckweed with fish meal in the diet of *Cyprinus carpio* fingerling at 0%, 15%, 30% and 45% inclusion levels and concluded that duckweed inclusion level at a lower level (15%) gives better results compared with higher inclusion levels (30% and 45%). The discrepancy observed between the results of this study and those of the mentioned authors could be due to the differences in experimental fish in relation to species, type of duckweed used, processing methods employed in treating antinutrients in the duckweed, the ingredient that was replaced in the diet, culture system (indoor or outdoor) used for the experiment, age and stage of the fish development and water quality management. The condition factors (2.06-2.18) which are the useful index for monitoring feeding intensity, age and growth rates in fish observed in this study were not significantly different among the treatments and the control indicating that all the experimental fish were in good condition. The survival rate of *O. niloticus* fed the experimental diets showed similar values (96.66% - 100.00%) among the experimental treatments and the control as no significant difference was observed.

The hepatosomatic index, feed conversion ratio and protein productive value of *O. niloticus* fed diets containing different dietary levels of blanched *L. paucicostata* meal showed significant differences ($P \leq 0.05$) among the experimental fish and the control. The lowest feed conversion ratio (1.82) observed in the fish fed 50% blanched *L. paucicostata* meal and 75% blanched *L. paucicostata* meal could be a result of the activation of digestive enzymes by the high mineral concentrations present in the blanched *L. paucicostata* meal. The best feed conversion ratio obtained in this research is in line with the findings of Sogbesan OA, et al. [24] and Ibrahim WM, et al. [25] who reported best feed conversion ratios of 1.85 and 1.95, respectively. Apparent net protein utilization differed significantly ($P<0.05$) among the experimental fish and the control. The highest ANPU (44.23) was recorded in the fish fed 75% blanched *L. paucicostata* meal while the least ANPU of 33.65 was obtained in the fish fed 100% blanched *L. paucicostata* meal, this could be due high weight gain (460.59g) obtained in the fish fed 75% blanched *L. paucicostata* meal and least weight gain (394.03g) obtained in the fish fed 100% blanched *L. paucicostata* meal, this observation revealed that high ANPU value will be obtained if the weight gain is high.

The assessment of nutrient utilization can be carried out using the morphometric characterization of the fish as described by Vatandoust S, et al. [26] using organ and tissue indices of a particular fish. The organ indices commonly used are the Viscerosomatic Index (VSI), Hepatosomatic Index (HSI), Gonadosomatic Index (GSI) and Spleenosomatic Index (SSI) as cited by Sudaporn T, et al. [27] and Babalola OA, et al. [28] described viscerosomatic and hepatosomatic indices as the ratio of organs to body weight measured in relation to body mass which can be used as indices of changes in nutritional and energy status. According to Gumus E, et al. [29], the assessment of viscerosomatic and hepatosomatic (organosomatic indices) plays a significant role in the secretion of digestive enzymes, digestion and absorption of food items as well as metabolism in fishes. The mean viscerosomatic index (6.99g - 9.90g) and hepatosomatic index (0.63g-0.95g) of *O. niloticus* fed with the experimental diets observed in this study, increase with the increase in mean weight gain, feed intake, protein efficiency ratio and protein productive value among the treatments and the control, this indicated that the fish were able to utilize the blanched *L. paucicostata* meal in the diet by converting it into muscle tissues.

The principal component analysis of the digestibility coefficient and growth performance as shown in Figure 1 revealed that a strong correlation exists among apparent ash digestibility, apparent protein digestibility, apparent lipid digestibility, apparent carbohydrate digestibility, mean weight gain, daily weight gain, percentage weight gain, specific growth rate, condition factor and survival rate, while net nitrogen retention and feed conversion ratio are strongly correlated. Component Analysis (PCA) F1 (88.63%) and F2 (7.17%) combined to give the biplot axes of 95.78%.

Conclusion

The digestibility, growth performance and hepatosomatic index of the experimental fish increased with the increase in the inclusion levels of blanched *L. paucicostata* meal up to 75% inclusion. The fish fed diet containing 75% inclusion level of blanched *L. paucicostata* meal gave the best protein, lipid, ash and carbohydrate digestibility of 92.94%, 90.62%, 52.29% and 80.56%, respectively and also gave the best growth performance and hepatosomatic index.

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