



Research Article

Digestibility, Blood Profile and Enzyme Activity of *Clarias gariepinus* (Burchell, 1822) Fed Diets Containing Sweet Potato Peel

Abdullahi, A. I.^{1,*}, Isiyaku, M. S.², Tukur M.³, Hassan, M. Z.¹, Usman, U.¹ Shettima, H. M. and Ibrahim Y.⁴

¹Department of Fisheries, University of Maiduguri, Maiduguri, 600004, Nigeria

²Department of Fisheries and Aquaculture, Bayero University, 700241, Nigeria

³Department of Fisheries and Aquaculture, Ahmadu Bello University, Zaria, 810107, Nigeria

⁴Department of Fisheries Technology, Federal Polytechnic, Bauchi, 740231, Nigeria

*Corresponding author: aiabdullahi@unimaid.edu.ng, doi.org/10.55639/607.3848

ARTICLE INFO:

Keywords:

Enzyme activity,
Sweet Potato Peel,
Digestibility,
Clarias
Gariepinus,
Haematological indices

ABSTRACT

This study evaluated digestibility, haematological indices and enzymes activities of *Clarias gariepinus* fed sweet potato peel as a replacement for maize. Five experimental diets were formulated at a crude protein of 35% using Pearson's square method; maize was replaced by sweet potato peel in the diets at 0%, 25%, 50%, 75% and 100%. Fifteen plastic tanks of 200-litres each were used. 10 juveniles of *C. gariepinus* were introduced into the experimental tanks. The fish were fed at 5% biomass twice per day. The experiment lasted for 12 weeks. The fish fed 100% sweet potato peel gave the best digestibility coefficients contents of 43.17%, 65.44% and 95.12% for apparent ash, fat and protein digestibility, respectively. The fish fed 100% sweet potato peel recorded the highest packed cell volume of 27.75% in the blood while the least percentage of 23.21 was recorded in the fish fed 25% sweet potato peel. The lipase activity was highest (0.79U/mg) in the fish fed 100% sweet potato peel while the fish fed 25% sweet potato peel had the least (0.47U/mg). This research revealed that the enzymes activities were the main factors that activated the experimental fish to assimilate the sweet potato peel more efficiently.

Corresponding author: Abdullahi, A. I, Email: aiabdullahi@unimaid.edu.ng
Department of Fisheries, University of Maiduguri, Maiduguri, 600004, Nigeria

INTRODUCTION

Fish feeds digestibility is mostly determined by the diet chemical composition and the characteristics of the cultured fish (Yorcelis *et al.*, 2014). Fish haematological indices are being studied to establish normal value range for an excellent physiological process. Environmental and physiological factors are known to influence fish haematology, these include stress due to capturing, transportation, high stocking density and sampling (Keri-Alhadi *et al.*, 2012). Cells naturally contain enzymes for their functions and the presence or activities of enzymes can be measured as an index of cell integrity (Coppo *et al.*, 2002).

Sweet potato (*Ipomoea batatas* Lam) is a root and tuber crop mostly grown in the tropical and subtropical parts of the world. It was described as the seventh most important food crop in the world (Okorie and Onyeneke, 2012). Its peel has a proximate composition of 4.05%, 7.63%, 5.61% 2.30%, 3.05% and 77.36% for moisture, ash, crude protein, lipid, crude fibre and carbohydrate, respectively (Abdullahi *et al.*, 2022). It is also an excellent source of minerals, which are important in reducing blood cholesterol and aid digestion (Chukwu *et al.*, 2012; Effah-Manu *et al.*, 2013). For feeds quality to improve, feed producers require essential information on effects of formulated diets on digestibility, haematological parameters and enzymes activities of fish. The status of maize replaced by sweet potato peel in the diet of *C. gariepinus* has not been fully investigated. Thus, this research aimed to evaluate the digestibility, haematological indices and enzyme activity of *C. gariepinus* juvenile fed diets containing sweet potato peel as a replacement for maize.

MATERIALS AND METHODS

Experimental Location

The experiment was conducted at Fisheries Research Laboratory of the Department of Biology, Ahmadu Bello University, Zaria, located at Latitude: 11° 03' 60.00" N and Longitude: 7° 41' 59.99" E in Kaduna State, Nigeria.

Procurement of Fish

A total number of two hundred (200) juveniles of *Clarias gariepinus* were procured from Umfatas Ventures Farm, Dagace Zaria, Kaduna State, Nigeria for the experiment. The juveniles were acclimatized to laboratory conditions for 2 weeks.

Collection and processing of the sweet potato peel

The sweet potato peels were obtained from restaurateurs in ABU Zaria main campus. The fresh sweet potato peels were washed thoroughly, sun-dried under hygienic condition and winnowed. The peels were then milled to form a fine powder and sieved with a 0.5 mm mesh screen.

Formulation of Experimental Diets

Five experimental diets were formulated at a crude protein (CP) level of 35% using Pearson's square method in a way that maize was progressively replaced by sweet potato peel at 0%, 25%, 50%, 75% and 100% respectively. The feed ingredients used in the formulation include; fish meal, soybean meal, maize, sweet potato peel, bone meal, salt, palm oil, vitamin premix, lysine, methionine and Chromic oxide (Cr₂O₃) (Table 1). All the ingredients were processed and milled separately to fine particle size and mixed together for pelleting, then feed was sun-dried and stored in a cool dry place.

Table 1: Composition of the Experimental diets

Ingredients	SP0%	SP25%	SP50%	SP75%	SP100%
Maize	15.16	11.37	7.59	3.79	-
Sweet potato peel	-	3.79	7.58	11.37	15.16
Fish meal	24.96	24.96	24.96	24.96	24.96
Soya bean meal	49.89	49.89	49.89	49.89	49.89
Bone meal	1	1	1	1	1
Palm oil	3.4	3.4	3.4	3.4	3.4
Salt	0.8	0.8	0.8	0.8	0.8
Min/Vit premix	0.7	0.7	0.7	0.7	0.7
Lysine	1.5	1.5	1.5	1.5	1.5
Methionine	2	2	2	2	2
Chromic oxide (Cr ₂ O ₃)	0.5	0.5	0.5	0.5	0.5

SP- Sweet potato peel

EXPERIMENTAL DESIGN

The experiment was set in a laboratory using fifteen (15) plastic tanks with a water holding capacity of 200-litres each. The experimental tanks were allotted to five treatments as SP0%, SP25%, SP50%, SP75% and SP100%, respectively with three replications each. For the feeding trails, 10 *C. gariepinus* juveniles were weighed and introduced into the experimental tanks. The fish were fed at 5% biomass twice per day, morning (8:00am) and evening (5:00pm). The experimental period lasted for three (3) months.

Monitoring of physicochemical parameters of experimental ponds

Physicochemical parameters were taken weekly, before feeding. Water temperature was measured using mercury in-glass thermometer calibrated in degree centigrade. pH was determined with a pH meter (pH-009 model) while dissolved oxygen was determined using a digital oxygen meter.

Digestibility Determination

The indirect method which involves the use of an indigestible marker was used for the

experiment. Chromic oxide (Cr₂O₃) was used as an indigestible marker. It is assumed that all the chromic oxide consumed will pass through the digestive tract and appear in the faeces. Analysis of the difference of chromic oxide percentages in feed and faeces was used to calculate the digestibility coefficients. Diets were formulated to accommodate 0.5kg/100kg chromic oxide and were fed to the experimental fish for 14 days. Faeces were collected by dissecting two (2) fish per tank as described by Belal (2005). Faeces were collected 10-11hours after feeding by dissecting the distal end of the intestine close to the anus, after which the faeces were gently squeezed out. Faeces from each treatment were pooled together to have enough faeces for analysis. Faeces were stored in labelled petri-dishes and frozen at -4 °C.

Digestibility of the different experimental diets was estimated to determine bioavailability of nutrients. The Apparent digestibility coefficient of crude protein, lipid, carbohydrate and dry matter was determined according to standard formula (Forster, 1999).

$$ADC = 100 \times \left\{ 1 - \left[\frac{\% \text{Faecal nutrient}}{\% \text{Dietary nutrient}} \times \frac{\% \text{Dietary chromic oxide}}{\% \text{Faecal chromic oxide}} \right] \right\}$$

Determination of haematological parameters

At the end of the feeding trials, 3 fish per tank were taken for haematological analysis. Blood samples were taken using 0.5 ml syringes from the dorsal regions. The blood was emptied into ethylene diamine tetra acetate (EDTA) treated bottles to prevent coagulation. After which the blood was analyzed according to standard

$$MCV (FL) = \frac{\text{packed cell volume}}{RBC (106 \mu L^{-1})} \times 10$$

$$MCH (pg) = \frac{Hb (gdL^{-1})}{RBC (106 \mu L^{-1})} \times 10$$

$$MCHC (\%) = \frac{Hb (gdL^{-1})}{\text{packed cell volume}} \times 100$$

Determination of enzymes activities

Three fish per tank were randomly selected for the enzyme activities determination. The entire digestive tract was removed and adipose tissue thoroughly cleaned. The samples were then rinsed, weighed and homogenized (using ceramic mortar and pestle) with 5ml of ice cold phosphate buffer solution pH 8 (Furné *et al.*, 2008).

Amylase activity

Amylase activity was assayed according to the method of Vega-Villasante *et al.* (1993). One unit of amylase activity was defined as the amount of enzyme that produced 1 μmol of maltose per min

Lipase activity

Triacylglycerol lipase activity was assayed according to Versaw *et al.* (1989), with β-naphthyl caprylate as substrate (100 mM in DMSO).

Protease activity

Alkaline protease activity of the samples was determined according to García-Carreño (1992), using azocasein (2.0% Tris-HCl 100 mM, pH 9) as substrate.

Data analysis

The data collected were subjected to one-way analysis of variance (ANOVA) to test for

haematological procedures as described by Dacie and Lewis (2001).

The mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were calculated as described by Dacie and Lewis (2001).

significant difference among treatment means using XLSTAT version 2022. Duncan pairwise comparisons was used to separate significantly different means at a confidence interval of 95%. The level of significance for treatments was set at P ≤ 0.05. Principal component analysis (PCA) was carried out to establish the relationship among the digestibility, haematological profile and enzymes activities.

RESULTS AND DISCUSSION

Physicochemical parameters

The physicochemical parameters (temperature, dissolved oxygen and hydrogen ion concentration) monitored during the experimental period as shown in Table 2, were not affected by the experimental diet, all the variables measured did not differ significantly (p>0.05) among the experimental tanks. The dissolved oxygen ranged from 4.93 – 5.81mg/L, the temperature ranged from 24.80°C – 25.70°C while the hydrogen ion concentration (pH) ranged from 7.92 – 8.87. Ayoola and Fedrick (2012) stated that 3 – 8mg/L of dissolved oxygen is recommended for freshwater fish culture. The physicochemical parameters of water used for the culture of *C. gariepinus* during the experimental period were within the

range recommended for African catfish culture (Olurin *et al.*, 2006).

Table 2: Physicochemical Parameters of Experimental Water

Parameters	Inclusion levels				
	SP0%	SP25%	SP50%	SP75%	SP100%
DO (mg/L)	5.59±0.60 ^a	5.81±0.60 ^a	5.21±0.60 ^a	5.00±0.60 ^a	4.93±0.60 ^a
T (°C)	25.50±0.58 ^a	24.80±0.58 ^a	25.01±0.58 ^a	24.90±0.58 ^a	25.70±0.58 ^a
pH	8.86±0.54 ^a	8.11±0.54 ^a	8.31±0.54 ^a	7.92±0.54 ^a	8.87±0.54 ^a

Means with the same superscripts within the same row are not significantly different (P>0.05)

Legend: SP-Sweet potato peel; DO-Dissolved oxygen; T-Temperature

Apparent digestibility coefficients of the experimental diets

The apparent digestibility coefficients of the diets of are shown in Table 3. The apparent ash digestibility coefficient was significantly high (P≤0.05) in the diet containing 100% sweet potato peel with a value of 43.17% while significantly low in the diet containing 25% sweet potato peel which recorded 30.22%. There was no significant difference (P>0.05) in the apparent ash digestibility coefficients of the diets containing 50% and 75% sweet potato peel with a values of 38.75% and 39.76%, respectively. The apparent protein digestibility coefficient differed significantly difference (P≤0.05) between the treatments and the control diets, the highest value of 95.12% was recorded in the diet containing 100% sweet potato peel, followed by the diet containing 75% sweet potato peel which gave 90.24% while the diet containing 25% sweet potato peel obtained the lowest value of 75.43%. The diet containing 100% sweet potato peel had significantly high apparent fat digestibility coefficient with a value of 65.44% while the diet containing 25% sweet potato peel had significantly low apparent fat digestibility coefficient with a value of 57.39%. The control diet recorded 60.47% which was not significantly different (P>0.05) with the value (61.71%) obtained in the diet containing 50% sweet potato peel. There was a significant difference (P≤0.05) in the apparent carbohydrate digestibility coefficient between the treatments

and the control diets, the diet containing 25% sweet potato peel recorded the highest value of 88.27% while the diet containing 100% sweet potato peel had the significantly lowest value of 60.88%. There was no significant difference (P>0.05) in the apparent carbohydrate coefficients of the diets containing 50% and 75% sweet potato peel. The apparent digestibility of nutrients and energy differs from one fish species to another and even within an individual fish depending on age, sex, species, diet composition and water temperature (NRC, 2011). However, variations in the quantity and quality of dietary nutrients influence the apparent digestibility in fish (Montoya-Mejía *et al.*, 2017). In all the experimental diets, apparent ash digestibility (AAD) was in the range of 34.56-43.17%, which is lower than the range of 38.00-62.90% reported for *Oreochromis niloticus* fed fishmeal-based diets (El-shafai *et al.*, 2004). The lower values in this study could be attributed to the higher percentages of plant ingredients in the dietary treatments. All the experimental diets showed a good apparent protein digestibility of greater than 75.43%. The apparent fat digestibility (AFD) showed a large variation among the experimental diets and it was within the range for the best feed digestibility of *Clarias gariepinus*. The highest apparent fat digestibility (ACD) value of 65.44% obtained in the fish-fed 100% sweet potato peel could be attributed to the high lipase activity observed in the treatment. Moreover, the highest

apparent carbohydrate digestibility (ACD) value of 88.27% obtained in the fish-fed 25% sweet potato peel among all the treatments and the

control diet could be attributed to the high amylase activity observed in the treatment.

Table 3: Apparent digestibility coefficients of the experimental diets for *Clarias gariepinus*

Parameters	Treatments				
	SP0%	SP25%	SP50%	SP75%	SP100%
AAD	34.56±3.05 ^b	30.22±3.05 ^b	38.75±3.05 ^{ab}	39.76±3.05 ^{ab}	43.17±3.05 ^a
APD	80.44±4.97 ^b	75.43±4.97 ^b	87.89±4.97 ^{ab}	90.24±4.97 ^a	95.12±4.97 ^a
AFD	60.47±1.93 ^b	57.39±1.93 ^{bc}	61.71±1.93 ^{ab}	64.62±1.93 ^a	65.44±1.93 ^a
ACD	74.99±4.27 ^{ab}	88.27±4.27 ^a	65.53±4.27 ^b	64.78±4.27 ^b	60.88±4.27 ^{bc}

Means with the same superscripts within the same row are not significantly different (P>0.05)

Legend: SP-Sweet potato peel, AAD-Apparent ash digestibility, APD-Apparent protein digestibility, AFD-Apparent fat digestibility, ACD-Apparent carbohydrate digestibility.

Haematological indices of *Clarias gariepinus* fed experimental diets

The haematological indices of *Clarias gariepinus* fed experimental diets are presented in Table 4. There was significant increase (P≤0.05) in the packed cell volume values between the control and the experimental groups. The fish fed 100% sweet potato peel had highest packed cell volume value of 27.75 while the fish-fed 25% sweet potato peel had a least value of 23.21%. The red blood cell ranged from 2.33×10⁶mm³/l to 2.88×10⁶mm³/l. There was a significant increase (P≤0.05) in the mean corpuscular haemoglobin concentration between the treatments and the control which ranged from 29.30% to 34.44%. The highest (34.44%) value was obtained in the fish-fed 75% sweet potato peel while the lowest value (29.30%) was recorded in the control. The fish fed the control diet had the highest mean corpuscular volume of 99.66% followed by the fish fed 25% sweet potato peel with a value of 99.61%. The least value of 90.49% was obtained in the fish-fed 75% sweet potato peel. There was a significant difference (P≤0.05) between the treatments and the control.

The haematological variables measured in this study revealed stable and normal values, showing the non-harmful effect of the sweet

potato peel in *Clarias gariepinus* diets. Haematological indices are used to recognize the probable nutritional effects of feed on the health of aquatic animals. The pack cell volume (PCV) range (23.21 – 27.75%) observed is within the range of 21.00 – 29.00% reported by Bello and Nzeh (2013). An increase in the concentration of the pack cell volume in the blood usually suggests that the types of blood are free of any toxic factors which have an adverse effect on blood formation. The improved red blood cell (RBC) values observed in this study indicated that the fish were free of anaemia as a result of the experimental diet fed. The inclusion of sweet potato peel at 100% in the diets of *Clarias gariepinus* improved haematological parameters when compared with the other treatments and the control in this study. Therefore, it assumed that dietary sweet potato peel could positively meliorate most of the blood indices in fish as a result of improved immunity. White blood cell (WBC) is one of the defence cells of the body. Douglass and Janes (2010), confirmed that the amount of white blood cells (WBC) has implications for immune responses and the ability of the animal to fight infection. The higher white blood cell count observed in the fish fed 25% sweet potato peel could be due to stress. Anyanwu *et al.* (2011) stated that there

are usually wide fluctuations associated with white blood cell values which may be due to endogenous factors such as experimental conditions, diet and anti-nutrients. The fish-fed diet containing 25% sweet potato peel recorded the lowest value (7.21g/100ml) of haemoglobin (Hb) among the control and other treatments. The reduction in the Hb concentration could

imply that the diet contained low-quality protein. Therefore, results in poor transportation of oxygen from the respiratory organs to the peripheral tissue (Robert *et al.*, 2000). The mean corpuscular volume (MCV) observed in this study recorded its highest value in the fish-fed control diet which is comparable with the value ranges reported by Anyanwu *et al.* (2011).

Table 4: Haematological indices of *Clarias gariepinus* fed experimental diets

Parameters	Treatments				
	SP0%	SP25%	SP50%	SP75%	SP100%
PCV(%)	26.01±0.62 ^{ab}	23.21±0.62 ^{bc}	25.11±0.62 ^b	25.52±0.62 ^b	27.75±0.62 ^a
RBC×10 ⁶ mm ³ /l	2.61±0.45 ^a	2.33±0.45 ^a	2.74±0.45 ^a	2.82±0.45 ^a	2.88±0.45 ^a
WBC×10 ³ mm ³ /l	17.71±0.32 ^a	17.85±0.32 ^a	17.52±0.32 ^a	17.28±0.32 ^a	17.25±0.32 ^a
Hb(g/100ml)	7.62±0.51 ^b	7.21±0.51 ^b	7.93±0.51 ^b	8.79±0.51 ^a	9.42±0.51 ^a
MCH(pg)	29.19±0.71 ^{ab}	30.90±0.71 ^{ab}	28.90±0.71 ^b	31.17±0.71 ^a	32.71±0.71 ^a
MCHC(%)	29.30±0.31 ^b	31.06±0.31 ^b	31.58±0.31 ^b	34.44±0.31 ^a	33.95±0.31 ^a
MCV(fl)	99.66±1.22 ^a	99.61±1.22 ^a	91.64±1.22 ^b	90.49±1.22 ^b	96.35±1.22 ^{ab}

Means with the same superscripts within the same row are not significantly different (P>0.05)

Legend: PVC-Packed cell volume, RBC-Red blood cell, Hb-Haemoglobin, WBC-White blood cell, MCV-mean corpuscular volume, MCH-Mean corpuscular haemoglobin, MCHC-Mean corpuscular haemoglobin concentration, pg-picograms, fl-femtoliters.

Enzymes activities of *Clarias gariepinus* fed experimental diets

The enzyme activities of *Clarias gariepinus* fed experimental diets are presented in Table 5. The lipase activity was significantly increased in the fish fed 100% sweet potato peel with a value of 0.79 U/mg followed by the fish fed 75% sweet potato peel gave 0.68 U/mg. The least lipase activity value of 0.47 U/mg was obtained in the fish-fed 25% sweet potato peel which was not significantly different (P>0.05) from the fish-fed control diet and 50% sweet potato peel which had 0.51 U/mg and 0.55U/mg, respectively. There was a significant increase (P≤0.05) in the lipase activity between the treatments and the control. The amylase activity value ranged from 3.85 U/mg to 6.68U/mg. The fish fed 25% sweet potato peel recorded the highest (6.68) while the fish fed 100% sweet potato peel had the lowest value (3.85). However, there was a significant

difference (P≤0.05) between the treatments and the control. The protease activity value ranged from 0.16U/mg to 0.19U/mg. There was no significantly different (P>0.05) in the protease activity between the treatments and the control. The activities of enzymes (lipase, amylase and protease) observed in this study were the main factors that helped the experimental fish to digest sweet potato peel efficiently, without reducing the digestibility of the experimental diets. Thus, the best digestibility and haematological profile could be associated with the improved enzyme activities observed in this research. Pérez-Jiménez (2009) stated that enzymes play a significant role in the utilization of diets, with the activities of enzymes affecting the efficiency of nutrient absorption, and their performance provides key information on the digestive ability of fish to hydrolyze protein, lipid, and carbohydrate in diets. In this study,

amylase activity was reduced in *Clarias gariepinus* fed the diet containing 100% sweet potato peel when compared to the fish fed the control diet and other treatments. Also, according to the observed enzymatic profile and considering the amylase activity in this study, the results suggest that the digestive tract of *Clarias gariepinus* is well adapted to carbohydrate digestion. This confirms that the digestive physiology of *Clarias gariepinus* is proximate to that of omnivorous species.

Various studies have demonstrated that amylase activity is greater in herbivorous and omnivorous fish than in carnivorous fish, this has been related to the digestion of diets rich in carbohydrates and proteins, respectively (Chan *et al.*, 2004; Abolfathi *et al.*, 2012). Higher activities of these enzymes observed in this study showed enhanced digestibility in *Clarias gariepinus* fed the sweet potato peel-based diets, which indicated that the consumed diet was utilized more efficiently.

Table 5: Enzymes activities (U/mg) of *Oreochromis niloticus* fed experimental diets

Enzymes (U/mg)	Treatments				
	SP0%	SP25%	SP50%	SP75%	SP100%
Lipase	0.51±0.04 ^b	0.47±0.04 ^b	0.55±0.04 ^b	0.68±0.04 ^a	0.79±0.04 ^a
Amylase	5.91±0.57 ^a	6.68±0.57 ^a	5.42±0.57 ^a	4.63±0.57 ^b	3.85±0.57 ^a
Protease	0.17±0.01 ^a	0.16±0.01 ^a	0.18±0.01 ^a	0.19±0.01 ^a	0.19±0.01 ^a

Means with the same superscripts within the same row are not significantly different (P>0.05)

The principal component analysis of the digestibility, haematological indices and enzyme activity is presented in Fig. 1. The principal component analysis of the digestibility coefficient, haematological indices and enzymes activities as shown in Figure 1 revealed that a strong correlation exists among mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), lipid (LIP), haemoglobin (HB) and packed cell volume (PCV); mean corpuscular

volume (MCV), apparent carbohydrate digestibility (ACD) and white blood cell (WBC); apparent protein digestibility (APD), apparent ash digestibility (AAD), protease (PROT), red blood cell (RBC) and apparent fat digestibility (AFD); only amylase (AMY) was observed to have no correlation with any of active variables in this study. Principal Component Analysis (PCA) F1 (88.80%) and F2 (6.03%) combined to give the biplot axes of 92.40%.

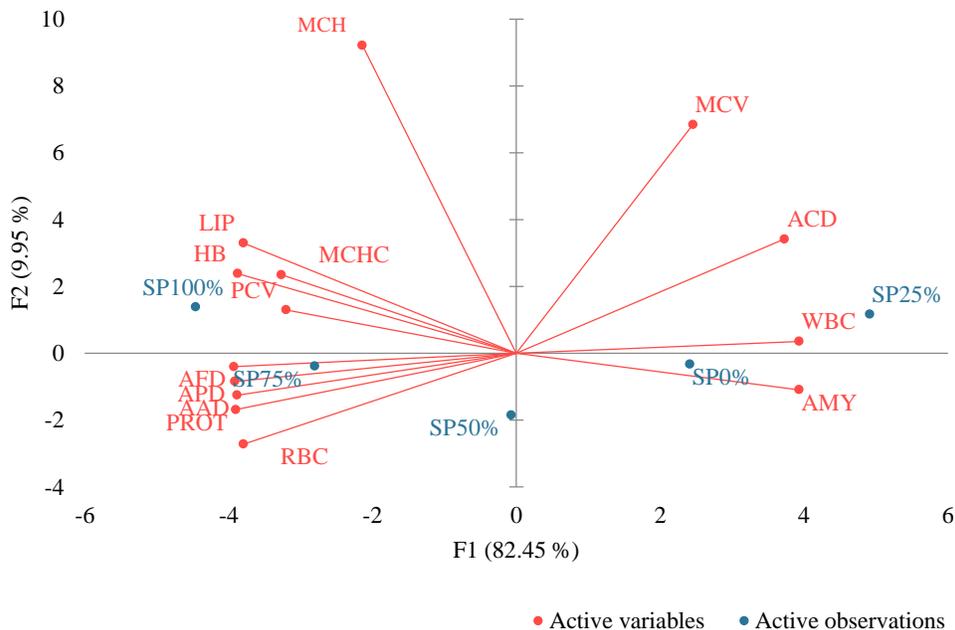


Figure 1: Principal component analysis (PCA) biplot (axes F1 and F2: 92.40%) of the relationship between haematological indices and enzymes activities

SP-Sweet potato peel, AAD-Apparent ash digestibility, APD-Apparent protein digestibility, AFD-Apparent fat digestibility, ACD-Apparent carbohydrate digestibility, PCV-Packed cell volume, RBC-Red blood cell, WBC-White blood cell, Hb-Haemoglobin, MCH-Mean corpuscular volume, MCHC-Mean corpuscular volume concentration, PROT-Protease, AMY-Amylase, LIP-Lipase.

CONCLUSION

In conclusion, the fish-fed diet containing a 100% inclusion level of sweet potato peel gave the best digestibility coefficients contents of 43.17%, 65.44% and 95.12% for apparent ash, fat and protein digestibility coefficients, respectively. The haematological indices in this study revealed that all the variables recorded were within the range required for the good health condition of *Clarias gariepinus*, showing the non-harmful effect of the sweet potato peel in the diets. The fish-fed diet containing a 100%

sweet potato peel had the best concentration of the packed cell volume (27.75%) in the blood while a poor concentration of 23.21% was recorded in the fish-fed 25% sweet potato peel. The enzymes activities were the main factors that activated the experimental fish to assimilate the sweet potato peel more efficiently.

ACKNOWLEDGEMENTS

The authors acknowledge the efforts of laboratory technologists who assisted in all analyses carried out during this study.

REFERENCES

Abdullahi, A. I., Bawa B. S., & Abdullahi, S. A. (2022). Effects of Dietary Replacement of Maize with Sweet Potato Peel in the Diet of African Catfish *Clarias gariepinus* (Burchell, 1822). *Journal of*

Fisheries Science, 04 (02): 15-24. DOI: <https://doi.org/10.30564/jfs.v4i2.4705>.
 Abolfathi, M., Abdolmajid H., Rasool G., & Abbas, Z. (2012). Effect of starvation and refeeding on digestive enzyme activities in juvenile roach, *Rutilus*

- rutilus caspicus*. *Comparative Biochemistry and Physiology*, 161A: 166-173.
- Anyanwu, D. C., Udedibie, A. B., Osuigwe, D. I., & Ogwu, V. O. (2011). Haematological Responses of hybrid of *Heterobranchus bidorsalis* and *Clarias gariepinus* fed dietary levels of *Carica papaya* leafmeal. *World Rural Observations*, 3 (1): 9-12.
- Belal, E. H., (2005). A review of some fish nutrition methodologies. *Bioresource Technology*, 96:395-402.
- Bello, N. O., & Nzeh, G. C. (2013). Effects of varying levels of *Moringa oleifera* leaf meal diet on growth performance, haematological indices and biochemical enzymes of African catfish *Clarias gariepinus* (Burchell 1822). *Elixir Aquaculture*, 57A: 14459-14466.
- Chan, A. S., Horn, M. H., Dickson, K. A., & Gawlicka, A. (2004). Digestive enzyme activities in carnivores and herbivores: comparisons among four closely related prickle back fishes (*Teleostei: Stichaeidae*) from a California intertidal habitat. *Journal of Fish Biology*, 65: 848–858.
- Chukwu, O., Nwadike, N., & Nwachukwu, N. G. (2012). Effect of cooking and frying on antioxidants present in sweet potato (*Ipomoea batatas*). *Academic Research International*, 2, 2.
- Coppo, J. A., Mussart N. B., Fioranelli S. A. (2002). Physiological variations of enzymatic activities in blood of Bullfrog, *Rana catesbeina* (Shaw, 1802). *Review in Veterinary*, 12(13): 22-27.
- Dacie, J. V. & Lewis, S. M. (2001). *Practical Haematology* 9 ed. Churchill Livingstone, London. Pp: 633.
- Douglass, J. W. & Janes, K. W. (2010). In: *Schalm's Veterinary Haematology*. John Wiley and Sons. Blackwell publishing Ltd., Pp: 1232.
- Effah-Manu, L., Oduro, I., & Addo, A. (2013). Effect of Dextrinized Sweet potatoes on the physicochemical and Sensory. *Journal of Food Processing and Technology*, 4, 5.
- El-Shafai, S. A., El-Gohary, F. A., Nasr, F. A., ven der Steen, N. P., & Gijzen, H. J. (2004). Chronic ammonia toxicity to duckweed-fed tilapia (*Oreochromis niloticus*). *Aquaculture*, 232, 117-127.
- Forster, (1999). A note on the method of calculating digestibility coefficients of nutrients provided by single ingredients to feeds of aquatic animals. *Aquaculture Nutrition*, 5 (2), 143-145.
- Furné, M., García-Gallego, M., Hidalgo, M. C., Morales, A. E., Domezain, A., Domezain, J., & Sanz, A. (2008). Effect of starvation and refeeding on digestive enzyme activities in sturgeon (*Acipenser naccarii*) and trout (*Oncorhynchus mykiss*). *Comparative Biochemistry and Physiology*. 149 (4): 420-5. doi: 10.1016/j.cbpa.2008.02.002.
- García-Carreño, F. L. (1992). Protease inhibition in theory and practice. *Biotechnology Education*, 3: 145-150.
- Keri-Alhadi, I., Aziz Bin, A., & Abol-Munati, A. B. (2012). Haematological changes in Nile Tilapia (*Oreochromis niloticus*) fed with varying dietary maltose levels. *World Journal of Fish and Marine Science*. 4(4): 376-381.
- Montoya-Mejía, M., García-Ulloa, M., Hernández-Llamas, A., Nolasco-Soria, H., Rodríguez-González, H., (2017). Digestibility, growth, blood chemistry, and enzyme activity of juvenile *Oreochromis niloticus* fed isocaloric diets containing animal and plant byproducts. *Revista Brasileira de Zootecnia*, 46 (12), 873-882.
- NRC (National research Council)., (2011). *Nutrients requirement of fish and shrimp* (Paula T. Whitacre (ed.); 500th ed.). The National Academies Press.
- Okorie, S. U., & Onyeneke, E. N. (2012). Production and quality evaluation of baked cake from blend of sweet potatoes and wheat flour. *Journal of Natural and Applied Science*, 3, 2.
- Olurin, K. B., Olojo, E. A. A., Olukoya, O. A. (2006). Growth of African catfish *Clarias gariepinus* fingerlings, fed different levels of cassava. *International*

- Digital Organization for Scientific Information*, 1 (1): 54-56.
- Pérez-Jiménez, A. (2009). Digestive enzymatic profile of *Dentex dentex* and response to different dietary formulations. *Comparative Biochemistry and Physiology*. 154A: 157-164. <https://doi.org/10.1016/j.cbpa.2009.05.126>.
- Roberts, K. M., Daryl, K. G., Peter, A. M., & Victor, W. R. (2000). Mayer's Biochemistry, 25th edition, Mc Graw Hill, New York, 25: 763-765.
- Vega-Villasante, F., Nolasco, H., & Civera, R. (1993). The digestive enzymes of the Pacific brown shrimp *Panaeus californiensis*: Properties of the amylase activity in the digestive tract. *Comparative Biochemistry and Physiology B*, 106: 547-550.
- Versaw, W. K., Cuppet, S. L., Winters, D. D., & Williams, L. E. (1989). An improved colorimetric assay for bacterial lipase in nonfat dry milk. *Journal of Food Science*, 54: 1557-1558.
- Yorcelis, C., Claudia, K., Walter, V., & Carsten, S. (2014). Digestibility coefficients of sun-dried and fermented aquatic macrophytes for Cachama blanca, *Piaractus brachypomus* (Cuvier, 1818). *Original Article*, 18-2.