# PROCESSED CASSAVA ROOT TUBER AS MAIZE REPLACERS IN THE PRACTICAL DIET OF NILE TILAPIA, *Oreochromis Niloticus*

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## ABSTRACT

*The study investigated the effects of differently processed cassava root meal on the growth performance, nutrient digestibility, and liver pathology in the diets of Oreochromis niloticus. Cassava tubers (IITA-TMS-I982132) were conditioned to four different processing techniques namely: sun-drying (SDC), soaking (SC), solid-state fermentation (SSF), and anaerobic fermentation (AFC). Five isonitrogenous (35% crude protein) diets were formulated in which maize was replaced at 50% level by each of the processed cassava root meals. Diet 1 (CTR), Diet 2 (SDC50), Diet 3 (SSF 50), Diet 4 (SC 50), and Diet 5 (AFC 50) were fed to 120 fingerlings (3.20±0.50g) ad libitum in three replicates. At the end of a 90-day rearing period, feed conversion ratio (FCR) was significantly different ($p<0.05$) among treatments and lowest (1.49±0.20) in fish fed Diet AFC but highest (1.61±0.02) in SC. Percentage weight gain (PWG) (286.82±3.77%), protein efficiency ratio (PER) (1.94±0.24), and protein digestibility (81.85±1.50%) were significantly ($p<0.05$) better in fish fed AFC than other treatments. There was no visible distortion of the hepatocytes of the liver implying that the treatments did not affect the liver tissues. The study concluded that O. niloticus could be successfully cultured on diets containing 50% aerobically fermented cassava tuber.*

**Keywords:** Processed cassava, Fermentation, Sun drying, Nutrient digestibility, Hepatocytes

## INTRODUCTION

One of the conventional major ingredients used in commercial aquafeed is maize which is included between 10-40% by weight in feed production as an energy source. This ingredient, however, is not one in which Nigeria has a competitive production advantage. A lot of factors influence world production, the most notable of which is past climate change (FAO, 2012). A substitute crop of note in which the country has a competitive production advantage is cassava. Nigeria is the highest producer of cassava in the world with an ever-increasing capacity to produce more. There was an increase in world cassava production from 2012 till 2013. This is so because cassava production is a strategic crop cultivated in Africa both for food security and poverty alleviation (FAO, 2012). Cassava is a hardy plant, highly tolerant to adverse soil conditions, pests, and drought (Vongsamphanh and Wanapat, 2004). Its use in animal feeding also grew from 25% in 1997 to 34% in 2007. In 2010, 52% of cassava was produced in Africa, 33% in Asia, and 15% in Latin America (FAO, 2011).

Cassava's nutritional qualities make it an excellent energy substitute for corn. Cassava products are insect-resistant and simple to store due to the presence of hydrogen cyanide (HCN). Göhl (1982) found that adding 15% cassava root meal to a concentrate feed increases pest resistance. Cassava roots have a high starch content, ranging from 70 to 85 percent dry matter (DM), which increases with the harvesting stage (Ly 1998; Régnier 2011). The protein content, however, is lower than cereal grains (typically <3%) (Régnier 2011). Cassava can be used as a high-level cereal replacement in rations for all types of animals, as long as it is enriched with a nitrogen source. Cassava has a very low fiber content, which varies depending on the variety and age of the root. Its content in fresh root rarely exceeds 1.5 percent, and it rarely exceeds 4% in root flour (Gil and Buitrago, 2002), which makes cassava roots highly digestible in all livestock species. Hydrogen Cyanide content may not be a problem, owing to the current improved varieties, and processing (Sanni *et al* 2002).

Processing of products is a technique aimed at modifying the product, preserving the vital nutrients, and increasing its shelf life. There are various methods such as fermentation, drying, and soaking. Fermentation is one of the ancient methods of food preservation and processing applied to food biotechnology usually use in the production of beverages over 6,000 years (Motarjemi, 2000). Fermentation increases the nutrient contents of food through the biosynthesis of vitamins, essential amino acids, and proteins. It also improves fiber digestibility and protein quality. Biodegradation of antinutrient, availability, and utilization of macronutrients by an organism is enhanced through the fermentation process (Achinewhu *et al*., 1998).

## MATERIALS AND METHODS

### Experimental system

The experiment was carried out in rectangular plastic tanks of 60 litres volume capacity at the hatchery facility of the Department of Aquaculture and Fisheries Management, Federal

University of Agriculture, Abeokuta. The experimental design was completely randomized. Experimental Fish *O. niloticus* fingerlings were sourced from a reputable fish hatchery in Lagos State, Nigeria. The fish were acclimatized and fed with commercial feed for two weeks before commencing them on the experimental diets.

### Experimental Diet

Cassava tubers (IITA-TMS-I982132) were procured from International Institute for Tropical Agriculture, (IITA) Ibadan, Oyo State, Nigeria, and whole cassava tubers were processed using the following methods:

Sun-dried cassava was prepared bywashing freshly harvested cassava tuber and sundried for 2 weeks. Soaked cassava was prepared by washing freshly harvested cassava tubers, soakedin water in a big plastic bowl for 72 h and the waterchanged every six hours to prevent fermentation, sundried, and stored in airtight containers. Solidstate fermentation was carried out in line with the method of Amey (1987) and Sauti *et al*. (1987) while anaerobic fermentation followed the method of Obasa *et al.* (2007).

The differently processed cassava was then analyzed for proximate composition and hydrogen cyanide level. Each of these was used to replace maize at 50% level in a diet containing 35% crude protein level. Control diet contained 100% maize and 0% cassava flour (Table 1). The diet layouts were as follows: Diet 1 contained 0% cassava root meal or Control (CTR), Diet 2, 50% sundried cassava root meal (SDC50), Diet 3, 50% solid state fermented cassava (SSF50), Diet 4, 50% soaked cassava root meal (SC50) and Diet 5, 50% anaerobically fermented cassava root meal (AFC50).

### Experimental Procedure

One hundred and fifty fingerlings (mean weight 3.20g) of *O. niloticus* were stocked into 60 liters plastic tank at 10 fish per tank with each treatment having three replicates. The fingerlings were fed experimental diet *ad-libitum* twice daily at 9.00 h and 17.00 h for a period of 90days. The fish were weighed once a week using a sensitive balance (METTLER TOLEDO, PB602). Water quality was recorded weekly for dissolved oxygen (DO) using DO meter; temperature using mercury-in-glass thermometer; pH with a pH meter (E251); and ammonia using Hach water quality analyzer

### Proximate Analysis of Experimental Fish and Diets

The proximate analyses of the various feed and carcass samples were carried out using the methods of AOAC (2000). Crude protein was assessed by the Kjeldahl method of nitrogen determination, crude fibre using Trichloroacetic Acid (TCA) method of crude fibre determination, lipid determination using Soxhlet extractionmethod, proximate and antinutritional factor (Cyanide) analysis of the experimental ingredient, cassava, proximate analysis of the experimental fishcarcass before and after each procedure.

The metabolizable energy (ME) was calculated using Atwater's calculation as described by Foster and Smith (1997). M.E (Kcal/kg) = 10[(8.5*CF) + (3.5*CP) + (3.5 NFE)]

Where CF = % Crude Fat, CP = % Crude Protein, NFE = %Nitrogen Free Extract

Growth performance was expressed as the mean weight gain (MWG), Percentage weight Gain (PWG), Daily Growth Rate (DGR) and Protein Efficiency Ratio (PER), and apparent net protein utilization estimated following the methods of Obasa *et al* (2013).

### Haematological Examination

After the feeding experiments, the haematological profile of *O. niloticus* wasexamined. Blood samples for haematological examination were taken using a sharp syringe (1ml)from the fish and placed in an EDTA vial. According to Shah and Altindag, the erythrocyte count (Red Blood Cell) and pack cell volume were measured (2004).). Leucocytes count (White Blood Cell followed the method of Mgbenka and Oluahns, (2003). Haemoglobin was according to Roberts, (1978). Mean corpuscular volume, MCV was estimated using the relationship (Blaxhall and Daisely, 1973). MCV = Pack Cell Volume × 100/ Erythrocyte Count. While the mean corpuscular haemoglobin concentration, MCHC was calculated using MCHC = Haemoglobin Concentration (g/100ml) × 100/ Pack Cell Volume (%) (Blaxhall and Daisely, 1973)

### Histopathological Examinations

The fish's liver and kidney were examined histopathologically at the Department of Veterinary Pathology, Federal University of Agriculture, Abeokuta, Nigeria. The organs were carefully removed from the fish's body and stored in a 10% formalin solution to avoid damage. The fixed tissues were routinely processed for histological analysis as described by Samuelson (2007). The necrotized areas were then photographed and read accordingly to determine the histopathological effects of processed cassava root tuber.

### Statistical analysis

The data obtained were subjected to a one-way analysis of variance (ANOVA) to determine whether or not there were significant differences among the means of the various treatments. Duncan Multiple Range Test was used to separate the means further where there were significant differences.

## RESULTS

Table 1 shows the gross composition (%) of the experimental diets, while the results of the Proximate and antinutritional composition of differently processed whole cassava root meal are presented in Table 2. The highest crude proteinlevel, 3.99% was recorded for solid state fermentation (SSF) and was significantly different ($P<0.05$) from the lowest 2.83% recorded for anaerobic-fermented (AFC) method. The highestash content 0.1% was found in AFC and SC and wassignificantly different ($P<0.05$) from 0.05% recorded for SSF. The crude fibre was highest (0.04%) in AFC and was significantly different ($P<0.05$) from the lowest (0.00%) found in SSF andSDC. The highest cyanide content was found (3.02%) in DC and was significantly different ($P<0.05$) to 2.19% found in SSF. The highest (2.00%) ether extract was recorded for AFC and was significantly different ($P<0.05$) from the lowest (0.5%) recorded for SSF.

The results of the proximate composition of experimental diets are presented in Table 3. The crude protein contents of the diets ranged from 34.98% in AFC to 34.90% with no significant difference ($P>0.05$); fat content ranged from 8.00% in SSF and was significantly different ($P<0.05$) to 6.00% in SDC and control; crude fibre ranged from 3.45% in Control and was significantly different ($P<0.05$) to 3.10% in SC; while the ash content ranged from 8.00% in SC and was significantly different ($P<0.05$) to 7.35% in SDC.

The carcass composition of the experimental fish fed with a differently processed cassava root meal-based diet is shown in Table 4. Crude protein level was highest (57.99%) in AFC50 and lowest (57.25%) in SC50. The ether extract values showed that fat was highest (11.65%) in SC50 but lowest (10.35%) in AFC50. The ash content was highest (17.65%) in SC50 but lowest (15.50%) in the control which was significantly ($p<0.05$) different.

The results of the growth performance, nutrient utilization, and survival of *O. niloticus* fed with a differently processed cassava root meal-based diet are presented in Table 5. The highest mean weight gain was observed in the fish fed anaerobic fermented cassava root meal while the lowest weight gain was observed in the treatment fed the control diet which was significantly different ($P<0.05$). The mean feed intake was highest (13.86±0.12g) in the SSF50 and was significantly different ($p<0.05$) from fish fed other rations. The feed conversion ratio, FCR, was lowest (1.49±0.20) in AFC50 and was significantly different ($P<0.05$) from the highest (1.61±0.02) observed in SC50. The apparent net protein utilization (ANPU), was highest (86.85± 0.45%) in AFC50 and significantly different ($p<0.05$) from SC50 which had the lowest (73.83±3.16%). The highest protein efficiency ratio (1.94) was observed in fish fed diet AFC50 while the lowest (1.78) was observed in fish fed diet SC50 which was significantly ($p<0.05$) different. Fish fed with AFC50 had the highest (81.85±1.50%) protein digestibility value and was significantly different from SC50 with lowest (73.55±1.75%) digestibility.

The results of the haematological parameters of fish fed with differently processed whole cassava root meal-based diet are presented in Table 6. Packed cell volume, heamoglobin, erythrocyte and leukocytes values were statistically higher in fish fed diet SSF50 while lymphocyte was statistically higher in fish fed diet SDC50. Mean corpuscular heamoglobin and mean corpuscular heamoglobin concentration were statistically similar in all groups fed the experimental diets.

The results of the histopathology of the experimental fish fed differently-processed whole cassava root meal-based diet are presented in Plates 1-5. All groups fed the experimental diets (Plates 1 – 5) showed hepatocytes with no visible lesions seen except, fish ted diet SDC50 (Plate 2) which in addition showed hepatocytes with few large extensive areas of hepatic vacuolations which distorted the cell shapes.

## DISCUSSION

The Physico-chemical parameters of the water recorded showed that the condition in the experimental tanks was favorable for the culture of *O. niloticus.* According to Chuapoehuk (1999), fish grows best in warm water with a temperature between $25^{o}$-$35^{0}$C while Verreth *et al* (1992) reported that the optimum temperature for optimal feed conversion of *O. niloticu*s was $27.75^{o}$C. Dissolved oxygen (D.O) recorded in this study was above the critical concentration recommended by Chuapoehuk (1999). The pH range recorded in this study was also within the normal range noted by Chuapoehuk (1999).

The high survival percentage recorded in this study indicated that feeding *O. niloticus* fingerlings with anaerobically fermented cassava meal did not negatively affect the fish mortality. Although FCR in fish fed Diet SDC50 was better, however, protein digestibility was significantly ($p < 0.05$) higher in fish fed Diet AFC50. These findings were consistent with those of many other researchers, such as Refstie *et al*. (2005), who found that Atlantic Salmon, Salmon salar, performed better when fed fermented white flakes than when fed unfermented white flakes. This was equally in agreement with the works of Ogunji *et al.* (2014) who found out that catfish, *C. gariepinus*, fed fermented African yam bean *Sphenostylis stenocarpa* at 45% level performed better than the control which had no fermented portion. Likewise, Skrede *et al.* (2002) reported that the apparent digestibility of lipid, starch, and energy was increase significantly in the diets of Atlantic salmon when fermented lactic acid was used to replace unfermented cereals.

The considerably superior (p 0.05) growth performance in fish given anaerobically fermented feed was predicted in this investigation. This, according to Mehta *et al* (2012), is becauseanaerobic fermentation has been observed to contribute several advantages to food which includethe addition of new tastes, flavours, aromas, enhancement of the nutritional value of food by increasing digestibility and production of vitamins and elimination of toxic substances. This position was also corroborated by Ali *et al.* (2003) who statedthat fermentation is one of the processes that decrease the level of antinutrient in food and increases starch digestibility, protein digestibility, and nutritive value.

The growth performance, feed efficiency, digestibility, and non-specific immune response of fish could be enhanced with the use of fermented vegetable products even in terrestrial animals (Min *et al*., 2009; Cho *et al.*, 2007; Yang *et al*., 2007; Kim *et al*., 2007). Therefore, the nutritional composition of plant protein sources can be improved through fermentation and as an alternative component of fish feed (Ashida and Okimasu, 2005).

The values in the haematological parameters indicated that there was a slight increase in the values of PCV, Hb, and RBC in the experimental group when compared with the control group. There was, however, a higher value observed in WBC in the fish fed control diet over the dietary test. Erythrocytes (RBC) count range in the studied *O. niloticus* for all groups were lower than what was reported by Ighwela *et al.* (2012) in *O. niloticus* when fed varying dietary levels of maltose. This was equally lower than the range reported by Khalafalla (2013) in *O. niloticus* fed diets containing digestion-1 as a feed additive. However, this result is higher than the range reported by Agbebi *et al* (2013) in *C. gariepinus* fed feed wastes and similarly higher than the range given as a baseline range for rainbow trout (*Salmo gairdneri*) as reported by McCarthy *et al.* (1971). It, however, fell almost within the range reported by Hrubec *et al.* (2000) as the reference intervals of haematology for cultured Tilapia (*O. niloticus* x *O. mossambicus* x *O. aureus*) except for the fish fed a solid-state fermented diet that had a higher RBC count.

The differences observed in these values as variously reported could be as a result of differences in culture conditions, sizes of fish used for experimental studies. The reduction in the WBC values among the experimental dietary treatments compared to the control might be an indication that the effect of processing on the cassava root meal imparted a level of detoxification to make it safer for utilization. Various factors have been reported to influence the haematological parameters of fish which include age, species, physiological status, size, environmental conditions, food quality and quantity, protein sources, dietary ingredients (Houston, 1997; Lim *et al*., 2000; Osuigwe *et al*., 2005).

The absence of eosinophils and basophils in the WBC of the fish might be a result of the possibility of their being absent in the WBC analysed. This was in agreement with the report of Weinreb (1958) in rainbow trout *Salmon gairdneri.* He reported that eosinophils and basophils wereonly occasionally seen. The monocytes found in fishfed diets SC50 and SSF50 were much lower than the range reported by Agbebi *et al.* (2013) but fell within 10% of the total WBC production as reported by Kelly (1979).

The result of the histopathology revealed that except for Treatment 2, sundried cassava root meal which revealed a few large extensive areas of hepatic vacuolations which distorted the cell shapes, there were no visible lesions in the other groups. Their melano-macrophage centres were well developed. The reason for the distortion of the hepatocytes as observed in SDC50 could be due to only sun drying of cassava which was not subjected to any other form of processing. Some other endogenous antinutrients in addition to cyanide might have impacted this form of distortion observed.

## CONCLUSION

At the end of the experiment, the result shows that the replacement of maize with sun drying (SDC), soaking (SC), solid state fermentation (SSF), and anaerobic fermentation (AFC) as a carbohydrate source was successful. However, this study concluded that *O. niloticus* could be successfully cultured on diets containing 50% aerobically fermented cassava tuber without any negative effect on the growth, nutrient utilization, haematological, and histopathology of the fish.

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**Table 1: Gross Composition (%) of Experimental Diet 1.**

| INGREDIENTS | CONTROL | SDC50 | SSF50 | SC50 | AFC50 |
|---|---|---|---|---|---|
| Fish meal | 13.14 | 13.56 | 13.52 | 13.60 | 13.60 |
| Soya Bean Meal | 26.28 | 27.12 | 27.04 | 27.20 | 27.20 |
| Groundnut Cake | 26.28 | 27.12 | 27.04 | 27.20 | 27.20 |
| Maize | 26.8 | 12.35 | 12.45 | 12.30 | 12.30 |
| Processed Cassava Meal | Nil | 12.35 | 12.45 | 12.30 | 12.30 |
| Methionine | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Salt | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Fish Premix | 1 | 1 | 1 | 1 | 1 |
| Vegetable Oil | 5 | 5 | 5 | 5 | 5 |
| Dicalcium Phosphate | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Total | 100 | 100 | 100 | 100 | 100 |

**Table 2: Proximate and antinutritional composition of differently processed whole cassava root meal**

| Parameters (%) | SDC | SSF | SC | AFC |
|---|---|---|---|---|
| Moisture | 11.00±1.25 | 11.50±2.14$^{a}$ | 11.50±2.04$^{a}$ | 11.50±1.66$^{a}$ |
| Ether extract | 1.00±0.01$^{b}$ | 0.50±0.01$^{c}$ | 1.00±0.00$^{b}$ | 2.00±0.05$^{a}$ |
| Ash | 0.09±0.01$^{a}$ | 0.05±0.01$^{b}$ | 0.10±0.01$^{a}$ | 0.10±0.01$^{a}$ |
| Crude fibre | 0.00±0.00$^{c}$ | 0.00±0.00$^{c}$ | 0.01±0.01$^{b}$ | 0.04±0.01$^{a}$ |
| Crude protein | 3.38±0.01$^{b}$ | 3.99±0.01$^{a}$ | 2.91±0.01$^{c}$ | 2.83±0.02$^{d}$ |
| Cyanide | 3.02±0.03$^{a}$ | 2.19±0.02$^{d}$ | 2.45±0.01$^{c}$ | 2.55±0.02$^{b}$ |
| Nitrogen free extract | 81.51±2.50$^{b}$ | 81.76±2.65$^{c}$ | 82.03±3.40$^{a}$ | 80.98±3.20$^{b}$ |
| Metabolizable energy | 305.08±3.20$^{b}$ | 304.38±2.65$^{b}$ | 305.8±3.20$^{b}$ | 310.34±4.50$^{a}$ |

Means with different superscripts along the rows were significantly different at ($p<0.05$)

**Table 3. Proximate composition of Experimental Diets**

| Parameters (%) | (CTR) | SDC50 | SSF50 | SC50 | AFC50 |
|---|---|---|---|---|---|
| **Moisture** | 10.51±0.06$^{a}$ | 10.48±0.05$^{a}$ | 10.62±0.06$^{a}$ | 10.55±0.06$^{a}$ | 10.53±0.06$^{a}$ |
| **Fat** | 6.00±0.82$^{c}$ | 6.00±0.68$^{c}$ | 8.00±1.10$^{a}$ | 7.50±0.65$^{b}$ | 7.20±1.22$^{b}$ |
| **Crude fibre** | 3.45±0.12$^{a}$ | 3.21±0.21$^{b}$ | 3.19±0.24$^{c}$ | 3.10±0.32$^{d}$ | 3.11±0.22$^{d}$ |
| **Ash** | 7.50±0.92$^{c}$ | 7.35±0.73$^{d}$ | 7.75±0.33$^{b}$ | 8.00±0.67$^{a}$ | 7.55±1.10$^{c}$ |
| **Crude protein** | 34.95±0.20$^{a}$ | 34.90±0.24$^{a}$ | 34.98±0.22$^{a}$ | 34.96±0.32$^{a}$ | 34.98±0.22$^{a}$ |

Means with the same superscripts along the rows were not significantly different at ($p>0.05$)

**Table 4. Proximate composition of *O. niloticus* fed differently processed cassava root meal based diet**

| Parameters | Initial | CTR | SDC50 | SSF50 | SC50 | AFC50 |
|---|---|---|---|---|---|---|
| Moisture | 9.50±0.64 | 9.80±0.50 | 10.25±0.34 | 9.85±0.32 | 10.50±0.44 | 10.65±0.55 |
| Fat | 9.50±0.44$^{b}$ | 10.50±0.66$^{a}$ | 10.85±0.40$^{a}$ | 10.95±0.42$^{a}$ | 11.65±0.74$^{a}$ | 10.35±0.62$^{a}$ |
| Crude fibre | 2.75±0.02 | 2.95±0.07 | 2.88±0.06 | 3.14±0.04 | 2.98±0.05 | 2.97±0.05 |
| Ash | 10.40±1.80$^{c}$ | 15.50±1.55$^{ab}$ | 15.75±1.85$^{ab}$ | 16.10±1.90$^{b}$ | 17.65±2.45$^{a}$ | 16.50±1.88$^{b}$ |
| Crude protein | 53.45±3.50$^{b}$ | 57.30±2.01$^{a}$ | 57.33±1.76$^{a}$ | 57.51±2.30$^{a}$ | 57.25±3.45$^{a}$ | 57.99±2.40$^{a}$ |

Means with the same superscripts along the rows were not significantly ($p>0.05$) different.

**Table 5: Growth response of *O. niloticus* fed differently processed whole cassava root meal**

| Parameters | CTR | SDC50 | SSF50 | SC50 | AFC50 |
|---|---|---|---|---|---|
| Initial mean weight( g) | 3.14±0.53 | 3.25±0.50 | 3.20±0.37 | 3.20±0.30 | 3.29±0.78 |
| Final mean weight (g) | 11.57±1.06$^{d}$ | 12.14±1.02$^{b}$ | 11.97±0.15$^{c}$ | 11.57±0.14$^{d}$ | 12.48±1.78$^{a}$ |
| Mean weight gain (g) | 8.43±1.36$^{c}$ | 8.88±0.53$^{b}$ | 8.75±0.25$^{bc}$ | 8.37±0.27$^{c}$ | 9.19±1.22$^{a}$ |
| Mean feed intake (g) | 12.96±0.16$^{c}$ | 13.22±0.24$^{ab}$ | 13.86±0.12$^{a}$ | 13.43±0.30$^{b}$ | 13.55±0.13$^{bc}$ |
| Feed conversion ratio | 1.57±0.28$^{b}$ | 1.49±0.06$^{c}$ | 1.59±0.05$^{b}$ | 1.61±0.02$^{a}$ | 1.49±0.02$^{c}$ |
| Weight gain (%) | 277.47±60.40$^{b}$ | 275.80±27.19$^{b}$ | 274.46±36.91$^{b}$ | 263.41±34.10$^{c}$ | 286.82±61.87$^{a}$ |
| Protein efficiency ratio | 1.86±0.31$^{b}$ | 1.92±0.08$^{ab}$ | 1.81±0.06$^{bc}$ | 1.78±0.02$^{c}$ | 1.94±0.25$^{a}$ |
| Daily growth rate (%) | 0.12±0.02$^{b}$ | 0.13±0.01$^{a}$ | 0.13±0.01$^{a}$ | 0.12±0.00$^{b}$ | 0.13±0.02$^{a}$ |
| Survival rate (%) | 96.67±5.77$^{b}$ | 96.67±5.77$^{b}$ | 100.00±0.00$^{a}$ | 100.00±0.00$^{a}$ | 100.00±0.00$^{a}$ |

Means with different superscripts are significantly different ($p<0.05$).

**Table 6: Haematological Parameters of *O. niloticus* fed differently processed whole cassava root meal based diet.**

| Parameters | CTR | SDC50 | SSF50 | SC50 | AFC50 |
|---|---|---|---|---|---|
| Pack cell volume (%) | 29±0.67$^{c}$ | 34±4.04$^{b}$ | 38±0.88$^{a}$ | 33±0.67$^{b}$ | 31±0.88$^{bc}$ |
| Heamoglobin (g/dl) | 9.7±0.47$^{c}$ | 10.6±1.01$^{b}$ | 11.3±0.49$^{a}$ | 10.8±0.20$^{b}$ | 10.3±0.12$^{bc}$ |
| Erythrocyte (mil/mm$^{3}$) | 2.4±0.33$^{c}$ | 2.8±0.15$^{b}$ | 3.2±0.15$^{a}$ | 2.8±0.15$^{b}$ | 2.6±0.21$^{c}$ |
| Leukocyte (No/mm) | 17.0±0.35$^{a}$ | 12.9±1.38$^{c}$ | 16.4±1.31$^{a}$ | 16.9±1.40$^{a}$ | 14.8±1.73$^{b}$ |
| Mean corpuscular volume | 1208.33±2.0$^{a}$ | 1214.28±2.0$^{a}$ | 1187.5±0.4$^{b}$ | 1178.57±1.50$^{b}$ | 1192.31±0.30$^{ab}$ |
| Mean corpuscular heamoglobin | 4.04±0.20$^{a}$ | 3.79±0.55$^{a}$ | 3.53±0.14$^{a}$ | 3.86±0.28$^{a}$ | 3.96±0.70$^{a}$ |
| Mean corpuscular heamoglobin concentration | 33.48±0.86$^{a}$ | 31.18±0.90$^{a}$ | 29.74±0.74$^{a}$ | 32.73±0.40$^{a}$ | 33.23±0.51$^{a}$ |
| Nuetrophil (%) | 44±1.20 $^{a}$ | 35±1.00$^{ab}$ | 27±3.53 $^{b}$ | 37±2.91 $^{ab}$ | 40±7.67 $^{ab}$ |
| Lymphocyte (%) | 60±2.91$^{bc}$ | 68±0.00$^{a}$ | 62±00$^{b}$ | 61±2.91$^{b}$ | 59±7.00$^{c}$ |
| Eosenophil (%) | 0±0.00 | 0±0.00 | 0±0.00 | 0.±0.00 | 0±0.00 |
| Monocyte (%) | 0±0.00$^{b}$ | 01±0.07$^{a}$ | 01±0.03$^{a}$ | 0±0.00$^{b}$ | 0±0.00$^{b}$ |
| Basophil (%) | 0±0.00 | 0±0.00 | 0±0.00 | 0±0.00 | 0±0.00 |

Means with different superscripts are significantly different ($p<0.05$).

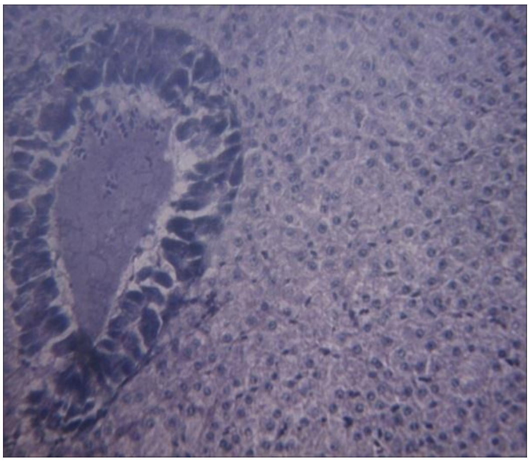

Plate 1.Section of liver of *Oreochromis niloticus* fed Control Diet

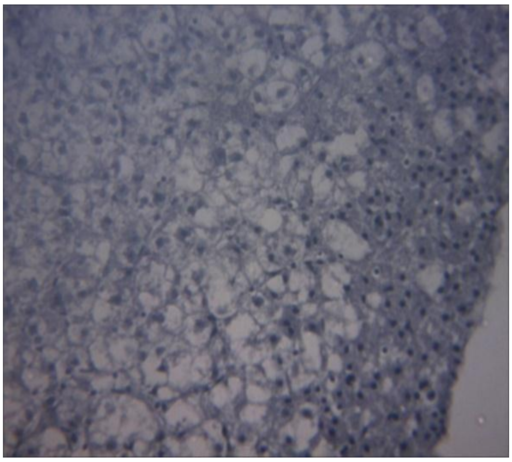

Plate 2. Section of liver of *Oreochromis niloticus* fed sundried cassava root meal, SDC50

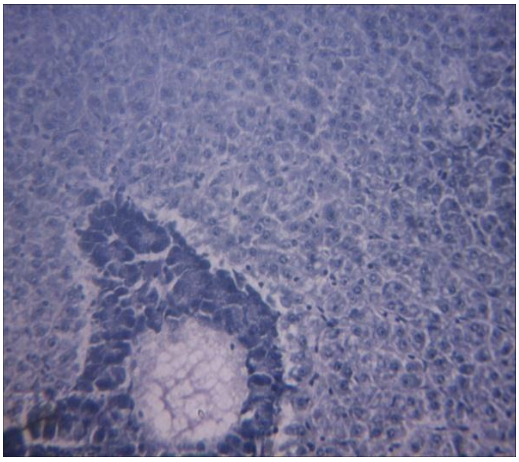

Plate 3. Section of liver of *Oreochromis niloticus* fed solid state fermented cassava root meal, SSF50

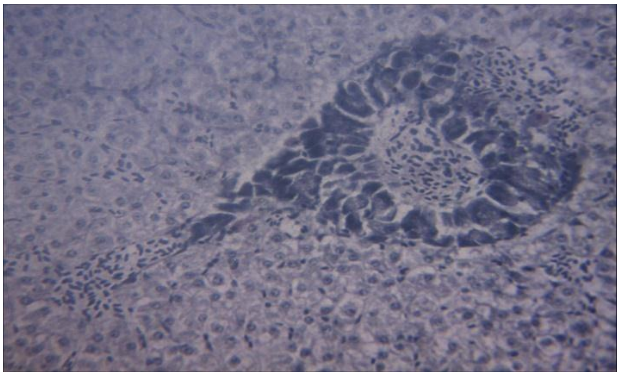

Plate 4. Section of liver of *Oreochromis niloticus* fed soaked cassava root meal, SC50

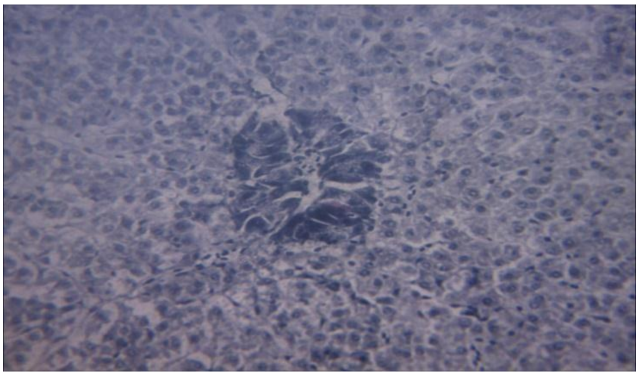

Plate 5. Section of liver of *Oreochromis niloticus* fed Anaerobically-fermented cassava root meal, AFC50