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Response of African Catfish, Clarias gariepinus; (Burchell, 1822) to Diets of African Yam Bean, Sphenostylis stenocarpa Subjected to Two Processing Methods

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Abstract

Response of Clarias gariepinus to diets of African yam bean (Sphenostylis stenocarpa) (AYB) subjected to two processing methods was assessed. Mature AYB was boiled, fermented and processed into meals. Seven diets were formulated to contain 44.07 ±0.48% crude protein and 19.03±0.05 kJ g^{-1} gross energy respectively. Fishmeal in the diets was substituted with each of the two processed AYB meals at 40%, 45% and 50% levels. Nine fingerlings (initial average weight 1.36±0.02g) were stocked per experimental tank. Experimental diets were fed to triplicate groups of catfish fingerlings at 10% body weight for 56 days. Results showed that specific growth rate (SGR) and protein production value (PPV) were highest at 45% replacement of fermented AYB (3.32±0.20; 49.30±17.94) compared to control (3.17±0.44; 38.89±12.49). Mean values for haematological parameters (PCV, HB, WBC and RBC) significantly increased ($P<0.05$) above the initial status and control group. Haematological values for fish fed 40% inclusion level of fermented and boiled AYB were the highest. This study shows that AYB processed by fermentation and boiling were effective in enhancing fish growth. However, based on SGR and PPV results Fermented AYB should not be used in Clarias gariepinus diets beyond 45% inclusion level.

Key Words: African Catfish, Alternative Protein Sources, African Yam Beans, Haematology

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Introduction

Thorarinsdottir et al. (2011) indicated that the aquaculture industry is the fastest growing food production industry in the world and approximately 50% of all fish consumed by humans is from aquaculture. They however observed that the costliest factor in the aquaculture production process is that of feed. Corroborating this fact Ogunji et al. (2008a) reported that the high prices of fishmeal in world markets have necessitated the search for another protein sources. According to Tacon and Metian (2008) fishmeal has been adjudged the most important and expensive protein ingredient used in aquafeeds. Fishmeal has been replaced with cheap plant proteins (Jackson et al., 1982; Tacon and Jackson, 1985; Webster et al., 1992; Ogunji and Wirth, 2001). One of the major local feed stuffs that meet the protein needs of most species is soybean meal (Ogunji, 2004). This feed ingredient has also become relatively expensive on account of its competitive value in fish and livestock feeds and as well as in human nutrition.

African yam bean (AYB) is one of the tropical legume seeds that have been scarcely used in fish feed production in spite of its relatively high crude protein content. The plant is found growing wild throughout tropical Africa, and most commonly in central and western Africa, especially in southern Nigeria. It is also reported to be cultivated in Ivory Coast, Ghana, Togo, Gabon, Congo, Ethiopia and parts of East Africa(Ref?). The African yam bean (AYB) has attracted research interest due to its nutrient content. Amino acid analysis indicates that lysine and methionine levels in the protein are equal to or better than those of soybeans (Obatolu et al., 2001).

However, like other legume beans, its nutritive value is masked by the occurrence of antinutritional factors (ANFs) such as alkaloids,

flavonoids and saponins (Asuzu and Undie, 1986). ANFs are known to have negative effects on fish growth and general physiology. As such, the removal of ANFs using different processing methods is important to reduce the concentration of those factors (Ogunji et al., 2008b). This strengthens the position of Uwaegbute et al. (2012) that quality of foodstuffs may be improved by processing. The objective of this study therefore, was to determine the effect(of feed produced by using AYB processed by boiling and fermentation) on the growth performance and haematology of the African catfish, Clarias gariepinus.

Materials and Methods

The experiment was carried out at the Department of Fisheries and Aquaculture, Ebonyi State University, Abakaliki Nigeria. Mature African yam bean was purchased from a local farmer. The yam bean was visually inspected and defective ones discarded. The yam bean was subjected to two processing methods: Boiling and Fermentation respectively to detoxify anti-nutrient present. The method described by Obatolu et al. (2001) was used.

Experimental Diets: Fish meal and African yam bean meal were used as the major dietary protein sources in the diets. Seven diets were formulated to contain 44.07 ±0.48% crude protein (Mean ± SD) and 19.03±0.05 kJ g^{-1} gross energy (Mean ± SD) respectively (Table 1).

Table 1: Composition of fermented and boiled experimental diets fed Clarias gariepinus

Ingredients	FD1	FD2	FD3	BD1	BD2	BD3	Control
Fishmeal	34	33	32	34	33	32	41
African Yam Bean	40	45	50	40	45	50	0
Maize	9.5	5.5	1.5	9.5	5.5	1.5	42.5
Soy Bean	15	15	15	15	15	15	15
Mineral/Vitamin[1] Mix	1	1	1	1	1	1	1
Cod-liver Oil	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100	100	100

F = fermented; B = boiled

[1]Min/vitamin premix: Vit. A., 15,000,000 iu; Vit B., 4,400,000 iu; Vit. E., 2500 iu; Vit. K., 4,350 mg; Vit. B2, 4,350 mg; Vit. B6, 2,350 mg; Vit. B12, 11,350 mcg; Vit. C, 1,000 mg; Nicotinamide, 16,700mg; Calcium Pantothenate, 87,000 mg; Sodium Sulphate, 50,000 mg; Magnesium Sulphate, 12,000 mg; Copper sulphate, 12,000 mg; Zinc Sulphate, 12,000 mg; Managanese Sulphate, 12,000 mg; Excipients Q.S., 1,000 mg.

Fishmeal in the diets was substituted with each of the two processed AYB meals (Fermented – F; Boiled – B) at 40%, 45% and 50% levels. Control diet did not contain AYB (Table 1). The dry diet component including vitamin C and oil were thoroughly mixed. Water was added and the feed was pressed into pellets of 2 mm diameter. Locally fabricated machine was used to pellet the feed. The pelleted feed was sun dried to reduce moisture content. This was done to enhance quality and was stored in refrigerator until use (Ogunji et al., 2008b).

Experimental fish: A total of 189 catfishes (initial average weight 1.4±0.0g) were acclimatized for seven days. They were weighed and distributed among 21experimental tanks at a rate of nine fish per aquarium tank with 10 litres of water. Test diets were randomly assigned using completely randomized design to triplicate tanks. The fish were fed a restricted ration of 10% body weight per day in two portions for 56 days in static water. Quantity of feed was adjusted forth nightly after batch-weighing of experimental fish. The aquaria were cleaned and water completely replaced by siphoning every other day to avoid fouling. Water temperature, dissolved oxygen, nitrate and pH were monitored. Temperature was maintained at 28 ± 0.2 ^{o}C, dissolved oxygen between 7.6±0.9 mg L^{-1}, nitrate 0.00 mg L^{-1} and pH between 7.6±0.7. No critical values were detected in any of the tanks. Feedstuffs were analyzed prior to diet formulation, while analysis of experimental data and samples of fish were carried out at the end of experiment.

Striking time was determined by noting the time it took the first fish to pick feed particle (Eyo and Ezechie, 2004). This was assessed to know the degree of acceptability of the experimental diets by fish. Striking time (1/time) was calculated according to (Sogbesan and Ugwumba 2006).

Biochemical and haematological analysis: Blood samples were collected at the commencement, and at the end of the experiment from the caudal vein into an EDTA litium tubes. The blood was analyzed to determine the packed cell value (PCV) with microhaematocrit using heparnized capillary tube (25mm). Red blood cell (RBC) and white blood cell (WBC) counts were determined as described by Blaxhal and Diasley (1973). Hemoglobin (Hb) concentration was determined by the methods described by Wedemeyer and Yasutake (1977).

The amino acid and proximate analyses of feed stuff and feed samples were carried out. Amino acid in samples was determined spectorophotometrically using ninhydrin chemical reaction (Schroeder et al., 1990). Protein (N x 6.25) was determined by the Kjeltec System (Tecator) and crude fat by Soxtec System HT (Tecator) using petroleum ether. Ash was determined by burning in a muffle furnace at 550^{o}C for 10 hours. Gross energy was calculated using the following factors: crude protein = 23.9 kJ g^{-1}, crude lipids = 39.8 kJ g^{-1} and NFE = 17.6 kJ g^{-1} (Schulz et al. 2005).

Statistical and growth analysis: At the end of the experiment, all the fish was weighed and data obtained from triplicate tanks were used to calculate weight gains, specific growth rate (SGR) and percentage body weight. Weight gain = final weight – initial weight, SGR = (LnW_2 - LnW_1)/(T_2-T_1)100 where W_1 and W_2 = initial and final weight of fish and T_1 and T_2 = time in days.

Percentage body weight (% BW or PBWG (-%) = $\left(W_2 - W_1 \middle/ T_2 - T_1\right) \times 100$; Where: W_2 = final weight of fish, W_1 = initial weight of fish and (T_2-T_1) = time (day).

Nitrogen retention efficiency (NRE) (Singh et al., 2011) or Protein production value (PPV) (Slawiski et al., 2013) is the nitrogen deposition with respect to ingested nitrogen. This variable was calculated for each treatment from the initial nitrogen content of the fish as stocked and the final nitrogen content of fish in each treatment. It was calculated as follows: 100 ×[(crude protein final fish × biomass final tank weight) - (crude protein initial fish × biomass initial tank weight)] / (crude protein diet × total feed intake)

All growth and heamatological data were subjected to one way analysis of variance (ANOVA). The significance of difference between means was determined by Duncan's Multiple Range test ($p<0.05$) using SPSS for windows (version 17). Values were expressed as means ±SE.

Result

The proximate and amino acid composition of feed stuffs and experimental diets are presented on Tables 2, 3, 4 and 5. Results of the amino acid showed that processing AYB by fermentation increased amino acid values while boiling process decreased the content. Similar observation was made in the proximate analysis in comparison with raw AYB.

The growth response of C. gariepinus fed boiled and fermented African yam bean meals at varying levels of dietary incorporation is shown in (Table 6). With respect to the values of PPV and SGR best growth response was obtained at 45% inclusion levels of fermented yam bean meal. SGR values were not significantly different from fish fed control diet and BD2 (Boiled Diet 2). PPV values were not significantly different in all the groups. Values of fish fed FD3 (50% inclusion) were the lowest for SGR and PPV.

The results of analysis of Clarias gariepinus (whole fish) fed fermented and boiled African yam bean are presented in Table 7. The protein content of fish fed boiled African yam bean (BAYB) meal at 45% inclusion was significantly ($P<0.05$) higher than all other feeding groups. Fish fed control diet accumulated less body protein. The protein content of the carcass of fish fed BAYB meal at 50% inclusion did not differ from the initial carcass but differed from all other feeding group. Protein contents of fish fed FAYB meal at 40% and 45% inclusion levels were not different but differed from other feeding groups. Fat content of all the different feeding groups were significantly different from one another. Fish fed diet with 45% BAYB meal inclusion accumulated the highest fat content. The energy content of all the feeding group were not significantly different from one another and from the control.

Table 8 shows the mean value and standard error (SE) of all blood parameters for each feeding group. The blood indices in each treatment varied significantly ($P<0.05$) and were higher than control and initial. Among the treatment groups, PCV, Hb, WBC and RBC content of fish fed fermented diet, at 40% inclusion (FD1) was significantly higher ($P<0.05$).

Table 2: The proximate composition (%) of feed ingredients.

	FAYB	BAYB	MAIZE	SOYBEAN	FISH MEAL	RAW AYB
Dry matter	90.06±0.01	85.27±0.01	91.72±0.01	90.84±0.01	93.65±0.01	91.13±0.01
Crude protein	23.14±0.02^{d}	20.78±0.02^{b}	10.91±0.03^{a}	46.43±0.05^{e}	67.83±0.02^{f}	22.31±0.04^{c}
Crude fat	6.59±0.01^{f}	4.66±0.01^{b}	3.93±0.01^{a}	5.05±0.01^{d}	6.39±0.01^{e}	4.85±0.01^{c}
Fibre	2.28±0.01^{c}	4.96±0.01^{e}	1.95±0.01^{b}	4.17±0.01^{d}	0.00±0.00^{a}	6.17±0.01^{f}
Ash	4.23±0.01^{c}	4.05±0.01^{b}	1.08±0.01^{a}	7.51±0.01^{e}	14.37±0.01^{f}	5.77±0.01^{d}
NFE[2]	66.01±0.02^{c}	70.52±0.03^{e}	84.03±0.02^{f}	41.02±0.08^{b}	11.42±0.02^{a}	67.07±0.06^{d}
Energy[3]	19.72±0.00^{d}	19.23±0.01^{c}	18.89±0.07^{a}	20.32±0.00^{e}	20.76±0.02^{f}	19.07±0.00^{b}

[1.] Values are mean of duplicate determination ± SE;
[2.] NFE = 100 – (%protein + %fat +%ash);
[3.] Calculated by: crude protein = 23.9 kJ g^{-1}, crude lipids = 39.8 kJ g^{-1} and NFE = 17.6 kJ g^{-1} (Schulz et al. 2005).

Table 3: Proximate composition (% dry matter) of experimental diets[1] (n = 3)

	Fermented			Boiled			Control
	40%	45%	50%	40%	45%	50%	0%
Dry matter	92.84±0.01	93.05±0.01	92.91±0.01	91.73±0.01	91.67±0.01	91.72±0.01	93.54±0.01
Crude protein	44.34±0.03	44.63±0.03	44.72±0.02	43.62±0.02	43.62±0.02	43.72±0.04	43.82±0.03
Crude fat	4.55±0.01	4.66±0.01	4.61±0.01	4.27±0.01	4.33±0.01	4.24±0.01	4.40±0.01
Ash	13.47±0.01	13.39±0.01	13.57±0.01	12.85±0.01	12.96±0.01	13.06±0.01	13.56±0.01
NFE[2]	37.64±0.01	37.32±0.04	37.10±0.02	39.26±0.02	39.19±0.03	38.98±0.06	38.23±0.04
Fibre	3.37±0.01	3.25±0.01	3.30±0.01	3.16±0.01	3.22±0.01	3.13±.0.01	3.58±0.01
Energy[3]	19.04±0.00	19.09±0.00	19.06±0.00	19.04±0.00	19.02±0.00	18.99±0.00	18.95±0.00

1. Values are mean of triplicate determination ± standard error. 2. NFE = 100 – (% protein + % fat +% ash) 3. Gross energy = crude protein = 23.9 kJ g^{-1}, crude lipids = 39.8 kJ g^{-1} and NFE = 17.6 kJ g^{-1} (Schulz et al. 2005).

Table 4: Amino Acid Composition (% Dry Matter) of Raw and Processed African Yam Beans (AYB) Samples[1]

AMINO ACIDS	FERMENTED AYB	BOILED AYB	RAW AYB
Alanine*	1.88	1.26	1.67
Arginine*	2.97	2.21	2.78
Aspartic Acid	4.06	3.18	3.89
Cysteine	0.61	0.37	0.53
Methionine *	0.54	0.18	0.42
Glutamic Acid	7.63	5.39	6.35
Glycine	1.96	1.58	1.79
Histidine *	1.67	1.36	1.51
Isoleucine *	1.85	1.52	1.66
Leucine *	3.13	2.24	2.98
Lysine *	2.82	2.53	2.67
Phenylalanine *	2.49	2.11	2.34
Proline	2.23	1.96	2.09
Serine	2.17	1.65	2.05
Threonine *	1.57	1.18	1.39
Tryptophan *	0.45	0.23	0.37
Tyrosine	1.65	1.39	1.58
Valine *	2.06	1.64	1.88

*Essential Amino Acids. [1]Values are mean of duplicate determinations ± SE.

Table 5: Amino Acid Composition (% Dry Matter) of Experimental Diets[1]

Amino Acids	FD1	FD2	FD3	BD1	BD2	BD3	CONTROL
Alanine *	1.26	1.28	1.31	1.17	1.21	1.24	1.19
Arginine *	1.37	1.39	1.34	1.29	1.33	1.31	1.27
Aspartic Acid	2.98	3.04	3.07	2.50	2.54	2.52	2.48
Cysteine	0.33	0.36	0.39	0.29	0.34	0.31	0.30
Methionine *	0.28	0.34	0.31	0.25	0.28	0.30	0.27
Glutamic Acid	5.28	5.32	5.30	5.02	4.97	5.07	5.06
Glycine	1.34	1.36	1.32	1.26	1.24	1.29	1.22
Histidine *	1.22	1.25	1.27	1.18	1.16	1.21	1.17
Isoleucine *	1.49	1.46	1.51	1.37	1.43	1.39	1.35
Leucine *	2.48	2.45	2.53	2.26	2.34	2.29	2.31
Lysine *	1.47	1.49	1.52	1.39	1.45	1.43	1.41
Phenylalanine *	1.36	1.38	1.34	1.23	1.27	1.25	1.21
Proline	1.79	1.83	1.81	1.59	1.61	1.55	1.57
Serine	1.68	1.70	1.70	1.51	1.48	1.51	1.46
Threonine *	1.18	1.21	1.21	1.05	1.03	1.07	1.01
Tryptophan *	0.23	0.27	0.25	0.15	0.13	0.17	0.13
Tyrosine	1.22	1.18	1.25	1.09	1.07	1.05	1.08
Valine *	1.57	1.64	1.61	1.28	1.31	1.25	1.27

*Essential Amino Acids. [1] Values are mean of duplicate determinations ± SE.

Discussion

African Yam Bean (AYB) used for diet formulation in this study was subjected to two different processing methods to remove the anti-nutrients present. Results showed that food consumption by fish throughout the experiment was good. A mean striking time of 0.7±0.1 showed no difference in feed acceptability of diets with different dietary inclusion levels of AYB processed using the two methods of boiling and fermentation. This could be due to the presence of flavonoids which enhanced the palatability of the diets irrespective of the presence of alkaloids. Johnson (2001) reported that flavonoids are a large and complex group of phenolic compounds that contribute to the flavour and colour of vegetables and fruits, and account for most of the dissolved solids in beverages such as tea, coffee and wine.

Fermenting process improved crude protein and fat content of AYB while boiling decreased the crude protein and fat content. This is contrary to the report of Ogunji et al. (2008b) that most proteins of plant origin are nutritionally improved by heat treatment. Osuigwe et al. (2005) observed inferior performance of fish fed boiled Jack Beans Seed Meal (JBSM) relative to those fed the control diet. This was attributed to the effect of heat treatment which reduced the protein of JBSM by destroying some amino acids. Bressani et al. (1987) reported that heat treatment not only reduced the level of lysine but also destroyed methionine (both essential amino acids) in Jack Bean, thus reducing the biological value of JBSM protein.

Fish groups fed fermented yam bean at 45% level (FD2) performed better than the control. Reported values were not however, significantly different (P>0.05). Specific growth rate (SGR) was higher (3.3±0.2) compared to control (3.2±0.4). Similarly PPV was 49.30±17.94 and control 38.89±12.49. At 40% of FAYB (FD1) the three dietary inclusions of boiled yam bean, values were not significantly different also. At 50% inclusion of FAYB, fish performance was the poorest. Same poor performance was also observed with PPV. Commenting on the importance of different processing methods for legumes, Mubarak (2005) posits that cooking improves the protein quality by either destroying or inactivating heat labile anti-nutritional factors. Removal of undesirable components is essential for the enhancement and effective utilization of plant nutrients in animal feed (Ogunji et al., 2008b). This also may have influenced the improved protein composition of the fish carcass and haematological values above the control in this study (Table 7 and 8). Ates et al. (2008) report that decreases in erythrocyte, haemoglobin, and hematocrit values can be an indicator of anaemia with the subsequent result of

Table 6: Growth performance of Clarias gariepinus fingerlings fed diets with fermented and boiled African yam bean at varying levels of incorporation[1]

	Fermented			Boiled			
	FD_1	FD_2	FD_3	BD_1	BD_2	BD_3	Control
Inclusion level	40%	45%	50%	40%	45%	50%	0%
Initial weight(g)	1.38 ± 0.00^{b}	1.34 ± 0.00^{a}	1.37 ± 0.00^{ab}	1.37 ± 0.01^{ab}	1.36 ± 0.01^{ab}	1.37 ± 0.01^{ab}	1.36 ± 0.0^{ab}
Final weight (g)	6.02 ± 0.65^{ab}	8.26 ± 0.89^{b}	4.40 ± 1.34^{a}	5.06 ± 1.22^{ab}	4.86 ± 0.45^{ab}	6.96 ± 0.62^{ab}	8.48 ± 1.86^{b}
Weight gain (g)	4.63 ± 0.65^{ab}	6.91 ± 0.89^{b}	3.03 ± 1.34^{a}	3.69 ± 1.20^{ab}	3.50 ± 0.46^{ab}	5.59 ± 0.62^{ab}	7.12 ± 1.86^{b}
Specific growth rate (SGR % day^{-1})[2]	2.61 ± 0.19^{ab}	3.32 ± 0.20^{a}	1.91 ± 0.56^{b}	2.20 ± 0.49^{b}	2.26 ± 0.17^{ab}	2.88 ± 0.16^{ab}	3.17 ± 0.44^{a}
Protein production value (PPV)[3]	42.70 ± 3.23^{a}	49.30 ± 17.94^{a}	19.43 ± 12.51^{a}	47.63 ± 9.55^{a}	49.36 ± 11.49^{a}	44.90 ± 8.89^{a}	38.89 ± 12.49^{a}
Percentage body weight gain (%)	335.91 ± 47.89^{ab}	516.39 ± 68.26^{a}	220.72 ± 97.37^{b}	268.29 ± 85.78^{ab}	258.96 ± 36.71^{ab}	406.79 ± 44.96^{ab}	524.12 ± 138.99^{a}

[1.] Values (mean ±SE) on the same horizontal line with different superscript letters are significantly different ($P<0.05$) from each other. SE is standard error.

[2.] $SGR = (LnW_2 - LnW_1)/(T_2-T_1)100$

[3.] PPV= 100 ×[(crude protein final fish × biomass final tank weight) - (crude protein initial fish × biomass initial tank weight)] / (crude protein diet × total feed intake)

Table 7: Proximate whole body composition (% dry weight) of Clarias gariepinus fingerlings fed experimental diets[1] (n = 3)

Dietary treatment	Crude protein	Crude fat	Moisture	Dry matter	NFE[2]	Energy[3] kJ/g
Initial carcass	53.71±0.03^{c}	6.28±0.01^{g}	6.45±0.02a	93.55±0.02^{h}	25.81±0.03^{d}	19.21±0.07^{a}
FD1	54.64±0.03^{d}	5.88±0.01^{e}	8.63±0.01^{e}	91.37±0.01^{d}	24.76±0.03^{c}	19.17±0.06^{a}
FD2	54.73±0.02^{d}	5.77±0.01^{d}	8.56±0.02^{d}	91.45±0.02^{e}	24.69±0.03^{c}	19.14±0.06^{a}
FD3	53.17±0.02^{b}	5.41±0.01^{b}	8.69±0.01^{f}	91.31±0.01^{c}	27.37±0.04^{f}	18.90±0.08^{a}
BD1	55.93±0.02^{e}	6.02±0.01^{f}	8.49±0.01^{c}	91.51±0.01^{f}	22.91±0.03^{b}	19.34±0.05^{a}
BD2	57.82±0.02^{f}	6.57±0.01^{h}	8.28±0.03^{b}	91.73±0.03^{g}	19.80±0.02^{a}	19.69±0.02^{a}
BD3	53.74±0.03^{c}	5.57±0.01^{c}	8.82±0.02^{g}	91.18±0.02^{b}	26.53±0.03^{e}	19.01±0.07^{a}
Control	52.79±0.07^{a}	4.41±0.01^{a}	9.74±0.02^{h}	90.26±0.02^{a}	30.75±0.04^{g}	18.68±1.09^{a}

[1]Values are mean of triplicate determination ± SE; Values on the same row with different superscript are significantly different from each other; [2] NFE = 100 – (%protein + %fat +%ash); [3]Calculated by: crude protein = 23.9 kJ g^{-1}, crude lipids = 39.8 kJ g^{-1} and NFE = 17.6 kJ g^{-1} (Schulz et al. 2005).

Table 8: Haematological parameters of Clarias gariepinus fingerling fed experimental diets*.

Experimental diets	PCV (gd l^{-1})	HB (%)	WBC x (10^3 cells mm^{-6})	RBC x (10^3 cells mm^{-3})
BD1	26.5±0.29^{e}	8.70±0.17^{e}	18.70±230.9^{f}	11.47±0.09^{e}
BD2	24.0±0.00^{c}	8.07±0.03^{c}	17.70±57.7^{c}	11.17±0.03^{c}
BD3	25.0±0.00^{d}	8.27±0.03^{cd}	18.15±28.9^{de}	11.27±0.03^{cd}
FD1	27.5±0.29^{f}	9.17±0.03^{f}	19.15±28.9^{g}	11.70±0.06^{f}
FD2	26.0±0.00^{e}	8.40±0.00^{d}	18.35±28.9^{ef}	11.40±0.06^{de}
FD3	24.5±0.29^{cd}	8.17±0.15^{cd}	17.90±230.9^{cd}	11.27±0.09^{cd}
Control	21.5±0.29^{b}	7.27±0.03^{d}	15.35±28.9^{b}	8.47±0.03^{b}
Initial	14.5±0.29^{a}	4.87±0.09^{a}	10.45±28.9^{a}	5.77±0.03^{a}

*Values represent treatment mean ±SE; Values on the same column with different superscript letters are significantly different (P<0.005) from each other. PCV = packed cell volume, Hb = haemoglobin, WBC = white blood cell count, RBC =Red blood cell count.

inhibition of erythropoiesis in the hemopoietic organism. Ogunji et al. (2007) also confirm that stressful conditions in fish and in mammals are associated with decreased growth, haematocrit (packed cell volume) and haemoglobin values. In this study, processing of African Yam Bean could have subdued the effect of the anti nutritional factors (stressor) and thus improved haematological values rather than bring about any decrease.

The high PPV values in all experimental groups except FD3 gave credibility to the effectiveness of the processing methods used in this study. Steffens (1989) confirmed that a higher value of PPV is indicative of good protein utilization. According to Machiels (1987) from the use of high quality protein of good digestibility and high level of dietary energy in the form of fats and or carbohydrate, PPV valves between 50 and 60 for the catfish, Clarias gariepinus could be obtained under favourable conditions. Based on PPV values and growth performance, it is observed that fermentation and boiling are good methods for processing African Yam Bean for Clarias gariepinus diets. However, inclusion level of fermented AYB in the African catfish diet should not exceed 45%.

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