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GG Bake
Department of Water Resources, Aquaculture and Fisheries Technology, School of Agric and Agric Technology, Federal University of Technology P.M.B 65 Minna, Niger, Nigeria

H Olabisi
Department of Water Resources, Aquaculture and Fisheries Technology, School of Agric and Agric Technology, Federal University of Technology P.M.B 65 Minna, Niger, Nigeria

A Abdullahi
Department of Aquaculture and Fisheries University of Ilorin. Kwara, Nigeria

DC Nwangwu
National Institute for Freshwater Fisheries Research P.M.B.6006, New-Bussa Niger, Nigeria

AO Ricketts
Department of Fisheries and Aquaculture, Federal University of Agriculture, Makurdi, Benue, Nigeria

J Samaila
Department of Food Science and Technology, School of Agric and Agric Technology, Federal University of Technology P.M.B 65 Minna, Niger, Nigeria

AB Gana
Department of Forestry and Fisheries, Kebbi State University of Science and Technology, P.M.B. 1144 Aliero, Kebbi, Nigeria

Corresponding Author:
GG Bake
Department of Water Resources, Aquaculture and Fisheries Technology, School of Agric and Agric Technology, Federal University of Technology P.M.B 65 Minna, Nigeria

Growth performance, nutrient utilization and haematological indices of hybrid catfish fingerlings fed varying inclusion levels of toasted sword beans (*Canavalia gladiata*) seed meal in concrete tanks

GG Bake, H Olabisi, A Abdullahi, DC Nwangwu, AO Ricketts, J Samaila and AB Gana

Abstract
A feeding trial was conducted to evaluate the growth performance, nutrient utilization and haematological indices of hybrid catfish fingerlings fed varying inclusion levels of toasted sword beans (*Canavalia gladiata*) seed meal (TSBM) in concrete tanks. Five 40% isonitrogenous and 10% isolipid diets were formulated with five different inclusion levels of TSBM (D1-0%, D2-10%, D3-20%, D4-30% and D5-40%). 20 fishes were stocked into each of 15 net hapas (0.5m × 0.5m × 1m) suspended in outdoor concrete tanks of 40m^3 total volume and the fishes were fed at 5% body weight daily for 10 weeks. At the end of the feeding trial fish fed D4 had the highest growth performance in term of final body weight (FWG), percentage weight gain (WG), specific growth rate (SGR) while fish fed D5 had the lowest significant value. The nutrient utilization in term of feed intake (FI), feed efficiency (FE), protein efficiency ratio (PER) and protein retention (PR) of the fish fed experimental diets also follow the same pattern as the growth performance. Whole-body proximate composition of fish fed all diets showed that inclusion of TSBM influenced moisture and lipid contents. The final haematological indices in contrast to the initial showed a range of elevated values in all the parameters measured PCV, WBC, RBC, Lymphocytes, Hb, MCHC, MCH, and MCV. It can be concluded that toasted sword beans (*Canavalia gladiata*) seed meal can be included in the diet of hybrid catfish (*hetero-clarias*) fingerlings up to 30% without any adverse effect on the growth and nutrient utilization.

Keywords: *Heteroclarias*, growth performance, *Canavalia gladiata*, feed processing

Introduction
Proper growth of fish depends largely on good nutrition and this is more pronounced with fish in an enclosure as they require adequate nutrition (Omoruwou and Edema, 2011) [36]. This poses a number of challenges to the fish farmer. Firstly, feed ingredients notably fish meal presently in use is expensive (Akinwande *et al*., 2002; Dada and Akinwande, 2005) [8, 15]. Most of the fishmeal used in the fish farming industry in Nigeria is imported resulting in drain in foreign exchange, thus there is a need for sourcing of local alternatives to reduce dependency. Fishmeal is commonly used as an animal protein source but also has some factors that are limiting its efficient use in diets such as; relatively high cost, limited supply, and variable quality.

The desire of fish farmer is to produce table sized fish within the shortest possible time, this desire is met by two popular catfishes of the genera *Clarias* and *Heterobranchus* (Ekemelu, 2010) [18]. *Clarias gariepinus* occupies a unique and prominent position in the commercial aquaculture in Nigeria because it is tasty, hardy tolerance to poor water quality condition. It is also capable of reproducing in captivity and growing to a size of 7.0 kg (Idodo-Umeh, 2003) [25]. It has an efficient feed conversion especially in the males (Nweke and Ogwumba, 2005[31]) and so attracts high market price. In a similar vein, *Heterobranchus* species are also important in growing to a size of about 14.0kg but not hardy as *Clarias* species (Idodo-Umeh, 2003) [25]. Aquaculturists have been able to harness the qualities of these two species by cross-breeding them to produce a hybrid (heteroclarias) which is hardy and grows to a large size (Miller, 2003; Keremah and Green, 2005) [29, 26].

Clarias gariepinus, Heterobranchus longifilis and their hybrids are of high aquaculture important in Nigeria. They are widely cultured owing to their high market price, fast growth rate and ability to withstand adverse conditions especially low oxygen content (Fagbenro *et al*., 2002) [20].

The development of commercial aquatic feeds has been traditionally based on Fishmeal as the main protein source because of its high protein content and balanced essential amino acid (EAA) profile. Fishmeal is also an excellent source of essential fatty acids, digestible energy, minerals, and vitamins (Deng *et al*., 2011) [16]. Fishmeal is the conventional source of animal protein in the fish diet and it has been valued for its balanced amino acid. Protein is one of the most expensive components of aquaculture diets. Animal protein sources, especially fishmeal, have relatively high cost, limited supply, and variable quality. Therefore, it is no surprise that fishmeal is the most expensive protein source in animal and aquaculture feeds (Tacon and Hassan, 2007) [42]. However, despite their usefulness, these ingredients are scarce and expensive due to high demand for livestock production and human consumption (Gabriel *et al*., 2007) [24]. The cost of fishmeal has made scientists to suggest the possibility of replacing animal protein feedstuff in fish feed production to reduce the cost of producing the feed and the cost per kilogram of produced fish weight (Falayi, 2003) [22]. Therefore, in order to attain a more economically sustainable, environmentally friendly and viable production, research interest has been redirected towards the evaluation and use of unconventional protein source, particularly from plant products such as seeds, leaves and other agricultural by-products (Bake *et al*., 2009 and 2013) [12, 13]

Several attempts have therefore been made to find adequate substitutes for fishmeal in fish diets. Unfortunately attempts to use protein sources of plant or animal origin as complete replacements for the fishmeal component in fish diets showed varying success. Ogunji and Wirth (2000) [33] summarized some of the factors which may have contributed to the variation in the results obtained like protein composition and amino acid profile of alternative feeds; apparent digestibility of feeds; phosphorus content of alternative feeds; anti-nutritional factors in alternative feeds (especially in protein sources of plant origin) and palatability/acceptability of alternative feeds.

Since the fish available isn't even enough to feed the timing population and still out of these unlimited supplies we still set aside some for feed formulation. This brings about the search for other available and cheaper source of protein to substitute for or for partial replacement of the fishmeal for other protein sources.

Canavalia gladiata usually called sword beans is a domesticated plant species in which the leaves look like a sword. The fruits are eaten as a vegetable in Nigeria especially in the northern part of the country (amongst the Nupes and Gbagis), it's a legume (*Fabaceae*) family. However, the extent to which legume seed could be potential sources of protein and fish feed is limited due to the presence of anti-nutritional factors (ANFs), deficiencies in some sulphur-containing amino acids and the presence of high level of non-starch polysaccharides (NSPs) (Francis *et al*., 2001; Fagbenro *et al*., 2004) [21]. Like other grain legumes, anti-nutrition factors such as phytin, tannin, Canavalia, con-canavalia-A, gibberellins, hydro cyanide (cyanogenic glycosides), trypsin inhibitors to mention but a few, have been reported in raw sword beans (Akinmutimi, 2003) [7]. This then call for toasting the sword beans which detoxifies it before usage. As a result of the need to cut the cost of aquaculture feed production (fishmeal) and the increase in the price of soybean and other conventional feedstuffs. In this view, unconventional feed sources such as seeds and leguminous plants could be used as alternatives to expensive feedstuffs to cut down the expense on feed.

Though sword beans (*Canavalia gladiata*) is readily available and less expensive plant protein, much work on the nutritional properties of the seed as a potential aqua feed ingredient had not been reported by scientists. It is in the light of this, unconventional feed sources can be used as alternatives to expensive feedstuffs to cut down the expense on feed as a result of this; the research is based on the inclusion of the sword beans in fish diet.

Therefore, the aim of the research work is to evaluate the effect of toasted sword beans seed meal (TSBM) on the growth performance and nutrient utilization of hetero-clarias fingerlings.

Materials and Methods

Ingredients and diet formulation

The fishmeal used in this experiment was obtained from the Sauki Fisheries store, 15km along Maikunkele - Zungeru road Minna Niger State Nigeria. The crude protein and lipid content of fishmeal were 65.34% and 11.36% respectively. Raw soybeans were purchased from the Bosso market Minna (Niger State, Nigeria). The soybean was processed by toasting in a frying pan at 80 °C for 60 minutes until the colour changed to golden brown and allowed to cool before milling with the aid of a grinding machine. Crude protein and lipid contents of SMB were 43.63% and 7.00%, respectively. Raw sword beans were purchased from a local farmer in Minna metropolis. The sword bean was subjected to toasting at a temperature of 80 ºC for 30mins until the colour changes to a golden brown then allowed to cool and the coats were peeled before grinding into powder using a hammer mill. Crude protein and lipid contents of TSBM were 27.68% and 4.28%, while RSOM was 22.15% and 3.19% respectively as shown in Table1.

All the ingredients were separately milled and mixed with warm water to form a consistent dough, which was then pelleted, sun-dried, packed in polyethylene bags and stored. The feed composition table is shown in Table 2.

Based on the nutritional requirements of freshwater catfish fingerlings (NRC 2011) [32], Five isonitrogenous and isolipid diets were formulated at 40% protein and 10% lipids, containing 10-40% toasted *Canavalia gladiata* seed meal at different levels of inclusion and were designated as D1 (0% inclusion), D2 (10% inclusion), D3 (20% inclusion), D4 (30% inclusion) and D5 (40% inclusion) Table 3.

Experimental setup and biochemical analysis

The experimental fish, hetero-clarias fingerlings, with an initial mean weight of (1.80 - 1.84g) were purchased from Tagwai fish hatchery of Ministry of livestock and fisheries development Minna, Niger State. The fish were transferred in a well-oxygenated water plastic container from the hatchery to the Department of Water Resources, Aquaculture and Fisheries Technology experimental fish farm, Federal University of Technology, Minna Bosso campus, where the feeding trial was conducted. Upon arrival, they were acclimatized in a transitional tank in the farm for four days and were fed commercial feed (Coppens feed) at 40% crude protein once a day before the experiment commenced. The fish were subsequently fed the formulated experimental diets, Fifteen net hapa (0.5x0.5x1m) were suspended in two outdoor concrete tanks (8m x 5m x 1.5m) with the aid of kuralon twine tied to plastic poles. The concrete tanks were filled to 5/6 of its volume (40m^3) with filtered and dechlorinated tap water, 20 fish were accommodated in each hapa. Each treatment was randomly allocated to three hapas, Photoperiod depends on the natural light, and the water temperature was monitored daily. The water quality parameters in the system were monitored weekly, the temperature ranged between 25.5 ºC-30.3 ºC while the concentration of dissolved oxygen ranged between 6.4-7.6 mg/L and the pH values of the treatments ranged from 6.4-7.8. No critical values were detected for nitrite and nitrate. The feed was manually administered, and the fish were fed three times daily at 5% of body weight at 09:00 am, 12:00 pm and 16:00 pm. Feeding rate was subsequently adjusted according to their growth rates per hapa. The uneaten and faecal matters were siphoned out of the hapa every morning before feeding, and 45 minutes after the fish have been fed. The fish were denied feed 24 h prior to sampling. Ten fish were randomly sampled on a weekly basis, and weights were measured using a digital electronic weighing balance (*OHAUSLS 2000*) model.

About 10g initial sample and 15g of final samples from each hapa were pooled separately and then homogenized using laboratory mortar and pestle. The major ingredient used for the diet; the formulated diet and the fish body samples were subjected to chemical analysis. The proximate composition analysis was determined according to AOAC procedures (2000) [11]. Moisture content was determined by drying samples at 105±2 ℃ until a constant weight was obtained. Dried samples were used for determination of crude fat, protein and Ash contents. Crude fat was measured by solvent extraction method in a soxhlet system where n-hexane was used as a solvent. Crude protein content was calculated by using nitrogen content obtained by the Kjeldahl method. A conversion factor of 6.25 was used for calculation of protein content according to AOAC (2000) [11]. Anti-nutritional factors of the seeds; tannins and trypsin inhibitor activity (TIA) were analyzed by modifying the procedures of AOAC (1984) [10]. Phytic acid was determined by the method of Latta and Eskin (1980) [28].

Evaluation of growth parameters

Growth performance and diet nutrient were analysed in terms of Weight Gain (WG), Feed Efficiency (FE), Specific Growth Rate (SGR), Feed Intake (FI), Protein Efficiency Ratio (PER) and Protein Retention (PR). The following formulas were used:

Weight gain (%) = (final weight (g) – initial weight (g) × 100 / initial weight (g)

Feed efficiency (%) = (weight gained (g) / feed fed (g)) × 100

Specific growth rate (%) = (In final weight (g) – In initial weight (g) / feeding period (day) × 100

Feed intake (mg/fish/day) = dry feed (mg) given / number of fish / feeding period (day)

Protein efficiency ratio = wet body gain × 100 / protein intake (g)

Protein retention (%) = protein gain ×100 / protein fed.

Statistical analyses

Data were analysed using one-way analysis of variance (ANOVA) using Statistica 8.0 (Stat-Soft, Inc., Oklahoma, USA). Differences between treatments were compared by Tukey's test. Level of significance was tested at P<0.05.

Results

Over the 70 days feeding period, no significant differences were observed in the water-quality indices between the experimental treatments. The water temperature ranges from 25.5-30.3 ℃, Dissolved oxygen from 6.4-7.6 mg/ *l*, pH from 6.4 -7.8 and ammonia from 0.22-0.28 mg/ *l*.

The proximate composition of the feedstuff used in the formulation of the experimental diet is shown in Table 1. The lipid and crude protein contents (11.36 and 65.34%) of the fishmeal were the highest among all the ingredients used for the formulation, followed by soybean meal (7.00 and 43.63%) while toasted sword bean meal had 9.22 and 30.86% of lipid and crude protein contents, respectively.

Table 2 shows the effect of toasting on the ANFs present in sword bean (*Canavalia gladiata*). Among phytate, oxalate, tannin and saponin, saponin had the lowest reduction of 51.27% while oxalate was the highest with a 62.11% reduction.

The ingredient profile and proximate composition of the formulated experimental diets are shown in Table 3. All experimental diets were similar in both formulation and nutrient composition.

The growth parameters and the nutrient utilization indices measured are shown in Table 4. The fish fed D4 had the highest value and was significantly different (P<0.05) from all other fish fed other experimental diets in all the growth performance indices measured (FWG, WG and SGR) while fish fed D5 had the lowest significant value. There was no significant difference in the growth performance indices among fish fed D1, D2 and D3 however they were significantly higher than fish fed D5. The nutrient utilization indices measured in term of FIW, FE, PER and PR of the fish fed experimental diets also follow the same trend as the growth performance. The survival rate for Hetero-clarias fingerlings fed D1-D4 was higher and significantly different (P<0.05) from D5.

The proximate composition profile of whole-body Heteroclarias fingerlings (wet basis) fed experimental diets for 70 days is given in Table 5. The whole body composition of the fish fed the experimental diets revealed that there was no significant difference in the crude protein and the ash composition of the fish fed experimental diets however the inclusion levels of TSBM influenced the moisture and carcass lipid composition of the whole body of the fish fed the experimental diets. D5 had the highest significant carcass lipid, Fish fed D1 had the lowest however it was not significantly different from fish fed D2. The carcass lipid increased with increase in the inclusion level of TSBM, while the moisture reduced with an increase in the inclusion level of TSBM.

The haematological indices of the experimental fish fed different inclusion levels of TSBM are shown in Table 6. There was no significant difference (P>0.05) in the PCV value among the fish fed D1, D2 and D3 however they were significantly (P<0.05) higher than those fed D4 and D5. The WBC was highest in the fish fed D5 and was significantly different from each other fish fed experimental diets while fish fed D1 and D2 recorded the lowest WBC and were significantly different from fish fed other experimental diets. Although the RBC values of Heteroclarias fingerlings fed D1, D2, D3 was not significantly different (P>0.05) from each other, they were significantly higher than fish fed D4 and D5.

The haemoglobin count for all diets was higher than the initial and fish fed D1-D4 were not significantly different ($P>0.05$) from each other but were significantly higher than fish fed D5 ($P<0.05$). There was no significant difference among all the fish fed experimental diets in the lymphocytes value. Except for fish fed D5 which was significantly ($P>0.05$) lower in the MCHC value, there was no significant difference among fish fed D1-D4. The same pattern is seen in the MCH results

Discussion

The crude protein (30.86%) of toasted sword bean meal (TSBM) is an indication to the protein-rich nature of sword bean (*Canavalia gladiata*) and the potential of its use in the reduction of overdependence on fishmeal for aquaculture feed production (Table 1). Although sword bean (*Canavalia gladiata*) like many other plant sources of protein has some antinutritive factors (compounds) that can affect its metabolism and utilization by fish or any animal this study shows that toasting as a processing method can significantly reduce ANFs in sword bean (*Canavalia gladiata*) as seen in Table 2. This aligns with various reports on the effect of processing on ANFs in plant-based protein sources (Vadivel *et al*., 2010; Bake *et al*., 2014; Tiamiyu *et al*., 2006) [46, 14, 44].

The growth performance of Hetero-clarias fingerlings in this study showed good tolerance and utility of TSBM at substitution level as high as 30% (D4), beyond which a decline in growth performance was observed. Although the survival rate was high for all test diets D5 (40% TSBM) had the lowest significantly survival rate and performed poorest in all measured growth parameters. D4 (30% TSBM) had the highest Final Body Weight. The poor growth response in D5 (40% TSBM) is similar with the findings of (Ebeniro and Orji 2012; Siddhuraju and Becker, 2001) [17, 40] who reported that higher inclusion rate of processed *Mucuna* seed meal significantly reduced growth performance. This is because of the increased presence of ANFs that cause growth depression. The FE was highest in fish fed D4 (30% TSBM) which outperformed the control DI (0% TSBM). The result obtained for 40% inclusion of TSBM may be due to the degree of the anti-nutrients which might have resulted in poor feed efficiency and nutrient utilization. (Ebeniro and Orji 2012; Kian, *et al*., 2004) [17, 27].

Dietary constituents of fish feed, as well as their response to stress, can influence the typical physiological regime and health condition of the fish body. Many studies have shown that the effect of nutrition on Hb, PCV and Erythrocytes are very reliable indicators of stress. Potential feed toxicity due to the presence of ANFs in feed can influence haematological stress indicators. (Rainza Paiva, *et al*., 2000; Osuigwe *et al*., 2007; Oyawoye and Ogunkunle, 1998) [39, 37, 38].

The final PCV (haematocrit) ranged from 29.98 to 32.56 for D5 (40% TSBM) and D1 (control) respectively. The result from this study is within the normal range for African Catfish which has been reported to range between 20 to 35% and rarely above 50% (Erondu *et al*., 1993; Adeyemo *et al*., 2014; Tiamiyu *et al*., 2019) [19, 4, 43]. The reduction in PCV was inversely proportional to increase in inclusion levels of TSBM this can be attributed the fact that more ANFs would be available in the feed with higher inclusion levels of TSBM.

WBC and lymphocytes contribute significantly to the immune system and responses of living organisms. Whereas the Lymphocyte count did not vary in this study, the WBC count in this study was highest ($9.44 \pm 0.49 \times 10^3$ mm^3) in D5 (40%TSBM), there was a corresponding increase in WBC count with increasing inclusion levels of TSBM, increase in the WBC is an indication of a natural defensive response to the presence of antibodies. (Ajani and Awogbade 2012) [6] reported an increase in WBC count of *Clarias gariepinus* when induced by Diuron. The WBC in results from this study were within the range described by Adesina (2017) [3] when juveniles of *Clarias gariepinus* were fed graded levels of sunflower seed meal and lower than the WBC count reported by (Tiamiyu *et al*., 2019) [43] who Studied Some haematological and serum protein of *Clarias gariepinus* juveniles fed with *Chromoleana odorata* as feed additives. High WBC count is usually linked with microbial infection or the incidence of foreign body or antigen in the blood (Oyawoye and Ogunkunle, 1998) [38].

The RBC count declined with increased inclusion of TSBM in the experimental diet of Hetero-clarias fingerlings. In this study the final RBC of D4 (30% TSBM) and D5 (40% TSBM) were significantly lower than the rest, however, the results were similar to the report of many authors on the RBC of *Clarias gariepinus*, *Heterobranchus longifilis* and their hybrid (Olapade and Kargbo, 2015; Afia and Ofor, 2016; Adesina *et al*., 2017; Tiamiyu *et al*., 2019) [34, 5, 2, 43].

Haemoglobin is necessary for transporting oxygen to the tissues for the oxidation of digested food nutrients for the release of energy (Ugwuene, 2011) [45]. The final haemoglobin count in this experiment marginally declined from D1 through to D4 but did not differ significantly, however at 8.79±0.37 D5 was significantly lower than the other diets. This suggests that the inclusion of TSBM as high as 40% in the diet of Heteroclarias juvenile can negatively influence haemoglobin in the blood thereby limiting the transportation of oxygen to the tissues and removal of carbon dioxide (Ugwuene 2011; Omiyale *et al*., 2012; Soetan *et al*., 2013) [45, 35, 41]. The haemoglobin recorded in the study were lower than the study of (Afia and Ofor, 2016) [5] which reported a range of 11.33 to 13.07 for haemoglobin of Hetero-clarias fed at various feeding levels, (Olapade and Kargbo, 2015) [34] reported very low values of haemoglobin in the juvenile of catfish fed *Terminalia catappa* the result of this study were higher but similar to the report of (Tiamiyu *et al*., 2019) [43] that stated a range of 7.40 to 9.60g/dl for haemoglobin of African catfish fed *Chromoleana odorata* as feed additives.

The mean corpuscular volume (MCV), or the average volume of erythrocytes expressed in cubic microns or fl, the mean corpuscular haemoglobin (MCH), or the haemoglobin content of the erythrocytes expressed in microns or pg; and mean corpuscular haemoglobin concentration (MCHC), were calculated from obtained haematological data. Although the mean corpuscular volume (MCV) did not differ significantly, the range reported in this study was higher than 79.20 to 100.47 fl recorded for Hetero-clarias (Anyanwu, *et al*., 2015) [9].

The mean corpuscular haemoglobin concentration (MCHC) of 30.62-31.48 recorded in this study similar to the reports for *C. gariepinus* juveniles fed with *Chromoleana Odorata* by (Tiamiyu *et al*., 2019) [43] and 30.70% reported for *C. gariepinus* from Asejire dam (Adedeji and Adegbile 2011) [1] and also the reported range of 30 to 66% by (Mohan and Senthilkumar, 2016) [30].

The MCH values obtained in this study was higher than the range 20.82 to 23.80 pg reported for Hetero-clarias fed *Microdesmis puberula* leaf meal incorporated feed (Anyanwu *et al*., 2015) [9].

Table 1: Proximate composition (on dry-matter basis) of the major ingredients used

Ingredients	Fishmeal	Soybean meal	Maize meal	Millet meal	RCGM	TCGM
Proximate composition						
Moisture (%)	5.79	3.09	4.66	3.22	7.64	5.54
Crude protein (% d.b.*1)	65.34	43.63	9.32	12.9	29.58	30.86
Crude lipid (% d.b.*1)	11.36	7.00	4.20	4.36	9.44	9.22
Ash (% d.b.*1)	14.34	8.15	3.22	2.33	3.96	3.66
Crude fiber (% d.b.*1)	0.06	5.00	3.40	2.60	6.94	6.58

[a] Means of two replicate analyses
* RCGM = Roasted *Canavalia gladiata* Seed Meal; TCGM = Toasted *Canavalia gladiata* Seed Meal

Table 2: Effect of fermentation treatment on anti-nutritional factors in Raw and Toasted *Canavalia gladiata* seed meal (TCGM)

Anti-nutritive factors	RCGM	TCGM	(%) decrease of anti-nutritive factors after fermentation
Phytate (mg/g)	21.55	9.08	57.87
Oxalate(mg/g)	2.85	1.08	62.11
Tannin (mg/g)	0.05	0.02	60.00
Saponin (g/100g)	5.50	2.68	51.27

*RCGM = Roasted *Canavalia gladiata* Seed Meal; TCGM = Toasted *Canavalia gladiata* Seed Meal

Table 3: Formulation profile and proximate composition of experimental diets (g/kg)

Ingredients	D1	D2	D3	D4	D5
FM (clupied)	573.30	526.20	479.00	431.90	384.80
SBM	50.00	50.00	50.00	50.00	50.00
Toasted sword bean meal	0.00	100.00	200.00	300.00	400.00
MM	25.00	25.00	25.00	25.00	25.00
Millet	25.00	25.00	25.00	25.00	25.00
starch	45.00	45.00	45.00	45.00	45.00
Vitamin premix	20.00	20.00	20.00	20.00	20.00
SBO	36.00	31.70	27.00	22.60	18.10
Mineral	20.00	20.00	20.00	20.00	20.00
Cellulose	205.70	157.10	109.00	60.50	12.10
Total	1000.00	1000.00	1000.00	1000.00	1000.00
Moisture (%)	4.66	4.54	4.48	4.63	4.36
Crude protein (% d.b.*1)	37.20	37.25	37.30	37.32	37.27
Crude lipid (% d.b.*1)	9.51	9.47	9.38	9.45	9.18
Ash (% d.b.*1)	9.15	9.29	9.32	9.27	9.48
Crude fibre (% d.b.*1)	6.14	6.25	6.47	6.33	6.57
AIA (% d.b.*1)	4.75	4.78	4.85	4.35	5.12
FM=Fish meal; SBM= Soybean meal; TSBM =Toasted Sword bean meal; MM= Yellow maize meal; SBO Sheabutter oil					

**: Premix composition: vitamin and mineral premix (IU or mg / kg of premix). Vitamin A: 4800 IU; Cholecalciferol (vitamin D): 2400 IU; Vitamin E: 4000 mg; Vitamin K: 800 mg; Vitamin B1: 400mg; Riboflavin: 1600 mg; Vitamin B6: 600 mg, Vitamin B12: 4 mg; Pantothenic acid: 4000 mg; Nicotinic acid: 8000mg; Folic acid: 400 mg; Biotin: 20 mg, Manganese: 22000 mg; Zinc: 22000 mg; Iron: 12000 mg; Copper: 4000 mg; Iodine: 400 mg; Selenium: 400mg; cobalt: 4.8 mg.

Table 4: Growth performances and nutrient utilization of hybrid catfish fingerling fed experimental diets for 70 days.

Diet code	Body weight (g)		Weight gain (%)	Survival rate (%)	Specific growth rate (%)	Total feed intake (g)	Feed efficiency	Protein efficiency ratio	Protein retention (%)
	Initial	Final							
D1	1.84±0.04	17.68±0.31^b	860.69±17.67^b	98.50±2.14^a	3.23±0.51^b	20.68±1.52^b	0.77±0.41^b	2.06±0.57^b	37.56±0.27^b
D2	1.84±0.06	17.65±0.22^b	859.06±26.51^b	98.66±2.21^a	3.23±0.36^b	20.67±1.24^b	0.76±0.88^b	2.05±0.24^b	37.28±0.42^b
D3	1.82±0.07	17.88±0.52^b	882.23±15.48^b	98.52±2.12^a	3.26±0.24^b	20.98±0.96^b	0.77±0.62^b	2.05±0.45^b	37.39±0.76^b
D4	1.82±0.02	20.54±0.64^a	1028.75±22.55^a	98.42±2.15^a	3.46±0.48^a	23.29±0.98^a	0.80±0.39^a	2.16±0.26^a	39.15±0.26^a
D5	1.82±0.04	16.10±0.64^c	784.43±24.33^c	95.22±2.37^b	3.11±0.48^c	19.09±0.72^c	0.75±0.39^c	2.01±0.26^c	36.75±0.34^c

Values in the same column with different superscript letters are significantly different ($p<0.05$) from each other.

Table 5: Proximate composition analyses of whole-body hybrid catfish (wet basis) fed experimental diets for 70 days

Component (%)	Initial	Final*1				
		D1	D2	D3	D4	D5
Moisture	77.42	73.55±1.2^a	73.18±0.8^a	72.52±1.4^b	72.11±1.5^b	71.25±0.4^c
Protein	13.12	17.71±1.5^a	17.65±1.3^a	17.68±1.1^a	17.71±1.2^a	17.70±1.5^a
Lipid	4.11	4.35±0.5^c	4.91±0.4^c	5.45±0.6^b	5.84±0.4^b	6.65±0.4^a
Ash	3.86	4.32±0.2^a	4.24±0.3^a	4.25±0.1^a	4.31±0.3^a	4.37±0.3^a

*1 Values in the same row with different superscript letters are significantly different ($p<0.05$) from each other (n=3).

Table 6: Haematological parameters of Hybrid catfish *fingerling* fed experimental diets for 70 days

Blood Parameter	Initial	Final*1				
		D1	D2	D3	D4	D5
PCV (%)	20.28	32.56±0.36^a	31.69±0.38^a	31.54±0.40^a	30.92±0.49^b	29.98±0.52^c
WBC (10^3 mm^{-3})	5.06	6.35±0.35^c	6.75±0.60^c	8.23±0.52^b	8.26±0.40^b	9.44±0.49^a
RBC (10^3 mm^{-3})	1.86	3.23±0.80^a	3.15±0.18^a	3.06±0.20^a	2.98±0.32^b	2.85±0.40^b
Hb (g/100 ml)	6.24	9.89±0.43^a	9.82±0.17^a	9.62±0.40^a	9.38±0.20^a	8.79±0.37^b
LYMPH (100)	60.44	61.49±0.54^a	61.72±0.20^a	61.98±0.37^a	61.45±0.89^a	61.23±0.78^a
MCHC (%)	30.77	30.37±0.20^a	30.97±0.50^a	30.50±0.74^a	30.34±0.29^a	29.34±0.44^b
MCH (pg)	33.55	30.62±0.18^b	31.16±0.39^a	31.44±0.27^a	31.48±0.45^a	30.84±0.29^b
MCV (fl)	109.03	100.80±0.16^b	100.60±0.53^b	103.07±0.76^a	103.76±0.50^a	105.19±0.60^a

PCV, packed cell volume; WBC, white blood cell; RBC, red blood cell; Hb, haemoglobin; LYMPH, lymphocyte; MCHC, mean corpuscular haemoglobin concentration; MCH, mean corpuscular haemoglobin concentration; MCH, mean corpuscular haemoglobin; MCV, mean corpuscular volume.

*1 Values in the same row with different superscript letters are significantly different ($p<0.05$) from each other (n=3).

Conclusion

The findings of this study revealed that the optimum inclusion level of toasted *Canavalia gladiate* seed meal in the diet of hybrid catfish is 30% and beyond this would bring about a decline in growth performance. Also, toasting substantially decresed anti-nutritive factors in *Canavalia gladiata* seed meal. Therefore, 30% inclusion level is recommended for optimum growth performance and nutrient utilization of Hetero-clarias catfish fingerlings without any adverse effect on their health and morphological structure. Furthermore, a longer feeding trial, other processing techniques and more research work on the amino acid profile of *Canavalia gladiata* seed meal should be carried out on other viable aquacultural fish species.

References

1. Adedeji O, Adegbile A. Comparative haematological parameters of the Bagrid catfish (*Chrysichthys nigrodigitatus*) and African catfish (*Clarias gariepinus*) from Asejire Dam Southwestern Nigeria. Journal of Applied Sciences Research. 2011; 7(7):1042-1046.
2. Adesina SA, Falaye AE, Ajani EK. Evaluation of haematological and serum biochemical changescin *Clarias gariepinus* juveniles fed graded dietary levels of boiled sunflower (*Helianthus Annuus*) seed meal replacing soybean meal. Ife Journal of Science. 2017; 51-68.
3. Adesina S. Haematological and Serum Biochemical Profiles of *Clarias gariepinus* juveniles fed diets containing different inclusion levels of mechanically extracted sunflower (*Helianthus annuus*) seed meal. Applied Tropical Agriculture. 2017; 22(2):24-35.
4. Adeyemo B, Obande RA, Solomon S. Haematological reference ranges of cultured *Clarias gariepinus* in the Lower Benue River Basin, Nigeria. Comparative Clinical Pathology. 2014; 23(2):361-366.
5. Afia OE, Ofor CO. Haematological indices of the *Clarias gariepinus x Heterobranchus longifilis* (hybrid catfish - heteroclarias) reared at different feeding levels. Nigerian Journal of Agriculture, Food and Environment. 2016; 12 (3):6-11.
6. Ajani F, Awogbade AA. Haematological Changes of the Africa catfish *Clarias gariepinus* (Burchell, 1822) Juveniles Induced by Diuron. British Biotechnology Journal. 2012; 2(4):247-256.
7. Akinmutimi AH. Effect of processing on metabolisability of energy content of Sword beans (*Canavalia gladiata*) using broiler chicks (starter phase). Proceedings of the 28th Network Service Access Point, (NSAP'03), Ibadan, Nigeria, 2003, 194-196.
8. Akinwande AA, Ugwumba AAA, Ugwumba OA. Effects of replacement of fish meal with maggot meal in the diet of *Clarias gariepinus* (Burchell 1822) fingerlings. The Zoologist. 2002; 1(2):41-46.
9. Anyanwu D, Udedibie A, Osuigwe D, Offor J. Haematological responses of heteroclarias fed dietary levels of *Microdesmis puberula* leaf meal. International Journal of Bioassays. 2015, 4272-4275.
10. AOAC. Official Methods of Analysis. 14th Edition, Association of Official Analytical Chemists, Arlington, VA, 1984.
11. AOAC. Official Methods of Analysis. 17th Edition, The Association of Official Analytical Chemists, Gaithersburg, MD, USA, 2000.
12. Bake GG, Endo M, Akimoto A, Takeuchi T. Evaluation of recycled food waste as a partial replacement of fishmeal in the diets for first feeding Nile tilapia (*Oreochromis niloticus*). Journal of Aquaculture and Fisheries Science. 2009; 75:1275-1283.
13. Bake GG, Endo M, Satoh S, Sadiku SOE, Takeuchi T. Nitrogen and mineral budget of Nile tilapia fry fed recycled food wastes materials supplemented with lysine and methionine in a closed recirculating fish culture system. Continental Journal of Fisheries and Aquatic Science. 2013; 7(1):18-31. ISSN: 2141–4246.
14. Bake GG, Elizabeth IM, Sadiku SOE. Nutritional evaluation of varying levels of cooked flamboyant seed meal (*Delonix regia*) on the growth performance and body composition of Nile Tilapia (*Oreochromis niloticus*) fingerlings. Agriculture, Forestry and Fisheries. 2014; 3(4):233-239.
15. Dada AA, Akinwande AA. Effect of meal frequencies on growth performance and food conversion of *Heterobranchus bidorsalis* fingerlings. Journal of Aquatic Sciences. 2005; 20(2):75-79.
16. Deng J, Zhang X, Bi B, Kong L, Kang B. Dietary protein requirement of juvenile Asian red-tailed catfish *Hemibagrus wyckioides*. Animal feed science and Technology. 2011; 170(3):231-238.
17. Ebeniro L, Orji R. Growth response of *Heterobranchus longifilis* Fingerlings To *Mucuna pruriens* Seed Meal Based Diets. Journal of Agriculture and Social Research. 2012; 12(2):67-73.
18. Ekemelu JK. Differential growth patterns of *Clarias gariepinus*, *Heterobranchus bidorsalis* and Hybrid Heteroclarias fed commercially prepared diets. Agriculture and Biology Journal of North America. 2010; 1(4):658-661.

19. Erondu E, Nnubia S, Nwanukwe F. Haematological studies on four catfish species raised in a freshwater pond in Nigeria. Journal of Applied Ichthyology. 1993; 9(3, 4):250-256.
20. Fagbenro OA, Smith MAK, Amoo AI. Acha (*Digitaria exilis* Staaf) meal compared with maize and sorghum meals as a dietary carbohydrate source for Nile tilapia (*Oreochromis niloticus* L.). Israeli Journal of aquaculture. 2002; 52:3-10
21. Fagbenro OA, Akinbulumo MO, Ojo SO. Aquaculture in Nigeria past experience, present situation and future outlook (history, status and prospects). World Aquaculture. 2004; 35(2):23-26.
22. Falayi BA. Techniques in fish feed manufacture. Proceedings of the Joint Fisheries Society of Nigeria/National Institute for Freshwater Fisheries Research/FAO-National Special Programme for Food Security National Workshop on Fish Feed Development and Feeding Practices in Aquaculture, September 15-19, National Institute for Freshwater Fisheries Research, New Bussa, 2003, 43-55.
23. Francis G, Makkar HPS, Becker K. Antinutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. Aquaculture. 2001; 199:197-227.
24. Gabriel UU, Akinrotimi OA, Bekibele DO, Onunkwo DN, Anyanwu PE. Locally produced fish feed: Potentials for aquaculture development in Sub Saharan Africa. African Journal of Agricultural Research. 2007; 2(7):287-295.
25. Idodo-Umeh G. Freshwater Fishes of Nigeria (Taxonomy, Ecological Notes, Diets and utilization) Idodo Umeh Publishers Ltd. Benin City. 2003, 232.
26. Keremah RI, Green HJ. Effect of Replacing Fish meal with Graded levels of Fish Offal on Growth and Survival hybrid Catfish fingerlings. In Proceedings of the 20th Annual Conference of the Fisheries Society of Nigeria (FISON) Port–Harcourt, 2005; 144-149.
27. Kian A, Yong S, Mustafa S, Rahman R. Use of enriched live prey in promoting growth and maturation of Tiger Shrimp, (Penaeus monodon). NAGA, World Fish Center Quarterly. 2004; 27(12):55-59.
28. Latta M, Eskin M. A simple and rapid colorimetric method for phytate determination. Journal of Agricultural and Food Chemistry. 1980; 28(6):1313-1315.
29. Miller J. Private Sector Aquaculture Feed Development in Nigeria. In Fish Feed Development and Feeding practices in Aquaculture (ed. A.A. Eyo) A National work- shop, organised by FISON/NIFFR/FAO – NSPFS. 2003, 114.
30. Mohan A, Senthilkumar D. Assessment of the haematological and serum biochemical parameters of three commercially important freshwater fishes in river Cauvery Velur, Namakkal district, Tamil Nadu, India. International Journal of Fisheries and Aquatic Studies. 2016; 4(1):155-159.
31. Nweke SI, Ugwumba AA. Effects of Replacement of Fishmeal with Duckweed (*Lemna paucicostata*) meal on the Growth of *Clarias gariepinus* (Burchell, 1822) fingerlings. In Proceedings of the 20th Annual Conference of the Fisheries Society of Nigeria (FISON) Port-Harcourt, 2005, 163-167.
32. NRC (National Research Council). Nutrient Requirements of Fish. National Academy Press, Washington, DC. 2011, 114.
33. Ogunji JO, Wirth M. Effect of dietary protein content on growth, food conversion and body composition of *Oreochromis niloticus* fingerlings, fed fish meal diet. Journal of Aquaculture in the Tropics. 2000; 15(4):381-389.
34. Olapade OJ, Kargbo M. Effect of *Terminalia catappa* on Growth and Haematology of *Clarias gariepinus* juveniles. Journal of Aquaculture Feed Science and Nutrition. 2015; 7(1-3):1-5.
35. Omiyale C, Yisa A, Ali-Dunkrah L. Haematological characteristics of Yankasa sheep fed fonio (*Digitaria iburua*) straw-based diets. Proceedings of 37th Annual Conference of Nigerian Society for Animal Production. 2012, 87-89.
36. Omoruwou PE, Edema CU. Growth Response of Heteroclarias Hybrid Fingerlings Fed on Maggot Based Diet. Nigerian Journal of Agriculture, Food and Environment. 2011; 7(1):58-62.
37. Osuigwe D, Nwosu C, Ogunji J. Preliminary Observations on some Haematological Parameters of Juvenile *Heterobranchus longifilis* fed different dietary Levels of Raw and Boiled Jackbean (*Canavalia ensiformis*) Seed Meal. Conference on International Agricultural Research for Development. Tropentag University of Kassel-Witzenhausen and University of Göttingen, 2007, 1-6.
38. Oyawoye E, Ogunkunle M. Physiological and biochemical effects of raw Jack beans on broilers. Proceedings Annual Conference; Nigerian Society of Animal Production. 1998, 141-142.
39. Rainza Paiva M, Ishikawa C, Dostiras A, Felizando N. Haematological raised in a freshwater pond in Nigerian. Journal of Applied Ichthyology. 2000; 9:250-256.
40. Siddhuraju P, Becker K. Rapid reversed-phase high-performance liquid chromatographic method for the quantification of L-Dopa (L-3,4-dihydroxylphenylalanine) non-methylatedandmethylatedtetra hydroquinoine compounds from Mucuna beans. Food Chemistry. 2001, 389-394.
41. Soetan K, Akinrinde A, Ajibade T. Preliminary studies on the haematological parameters of cockerels fed raw and processed guinea corn (*Sorghum bicolour*). Proceedings of 38th Annual Conference of Nigerian Society for Animal Production. 2013, 49-52.
42. Tacon AGJ, Hasan MR. Global synthesis of feeds and nutrients for sustainable aquaculture development. In: M. R. Hasan, T. Hecht, S. S. De Silva, and A. G. J. Tacon (Eds.), Study and analysis of feeds and fertilizers for sustainable aquaculture development. FAO fisheries technical paper. 2007; 497:3-17.
43. Tiamiyu A, Olatoye I, Adedeji O. Study of Some Haematological and Serum Protein of African Catfish (*Clarias Gariepinus*) Juveniles Fed with Chromoleana Odorata as Feed Additives. International Journal of Oceanography & Aquaculture. 2019; 3(2):000167.
44. Tiamiyu LO, Solomon SG, Oketa EJ. Effects of different boiling time of soyabean (*Glycine Max* (L) Merril) on growth performance of tilapia (*Oreochromis niloticus*). Journal of Aquatic Sciences. 2006; 21(1):15-18.
45. Ugwuene M. Effect of Dietary Palm Kernel Meal for Maize on the Haematological and Serum Chemistry of Broiler Turkey. Nigerian Journal of Animal Science. 2011, 93-103.

46. Vadivel V, Doss A, Pugalenthi M. Evaluation of nutritional value and protein quality of raw and differentially processed sword bean [*Canavalia gladiata* (Jacq.) dc.] seeds. African Journal of Food, Agriculture, Nutrition and Development. 2010; 10(7):2850-2865.