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Original Research Article

Preliminary Investigation on the Inclusion of Fermented Sickle Pod *Senna obtusifolia* Seed Meal as an Ingredient in the Diet of *Clarias gariepinus* Fingerlings

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Abstract

A 56-day feeding trial was conducted to investigate the effect of varying inclusion levels of fermented *Senna obtusifolia* seed meal in the diets of *Clarias gariepinus* fingerlings. Five isonitrogenous and isolipidic diets were formulated, containing 40% crude protein and 9.5% lipid. Fermented *Senna obtusifolia* (FSOM) was included at different graded levels viz 0, 10, 20, 30 and 10% raw *Senna obtusifolia* (RSOM) and were designated as D1 (0 % inclusion), D2 (10 % inclusion), D3 (20 % inclusion) D4 (30 % inclusion) and D5 (10% RSOM inclusion) in a completely randomized design.Fifteen net hapa (0.5×0.5×1m) were suspended in two outdoor concrete ponds with the aid of kuralon twine tied to plastic poles, the concrete ponds were filled to 5/6 of its volume (40m^3) with filtered and dechlorinated tap water. Each treatment had three replicates with 20 fish were accommodated in each hapa (mean initial body weight (2. 03±0.1g) per fish. Water temperature and other water quality parameters were monitored daily. The results showed that the fish fed D3 was significantly different from the other treatments (P<0.05) in all the growth performances indices measured. However fish fed D1, D2 and D4 were not significantly different (P>0.05) from each other but were significantly higher than fish fed 10% inclusion of raw *Senna obtusifolia* seed meal (D5) (P<0.05). Fish fed D4 diet had the lowest carcass moisture and highest carcass lipid among the fish fed experimental diets and was significantly different from those fed other diets (P<0.05). Carcass protein of the experimental fish was highest in fish fed D3 diet although not significantly different from fish fed D2. Fish fed D1 and D4 were similar and not significantly different from each other, but significantly different from those fed D5 (P<0.05). This study showed that fermented *Senna obtusifolia* seed meal would be a potential suitable ingredient for *Clarias gariepinus* fingerlings and that it may be included in a diet up to 30% without any adverse effect.

Keywords

Clarias gariepinus
Fermentation
Growth performance
Seed meal
Senna obtusifolia

Introduction

The present shortage and dwindling of animal protein in Nigeria is attributed to the fact that population is continually increasing while the production of animal protein cannot cover the necessary requirement. Therefore, aquaculture farming is becoming more important. In the developing countries like Nigeria, where the problem is drastic, it is believed that aquaculture product can offer one of the solutions, especially in view of ever depletion of existing fisheries. It has been found that increasing fish production in Nigeria is feasible through the development of fish farming, this is largely due to sustainable climate, availability of cultured fish seed and water availability, hence the potential of aquaculture is very high (FDF, 2004). The growth witness in aquaculture industry is largely and ever increasingly dependent on industrially compounded feeds, hence current global demands for aqua feeds, is projected to double by 2020 (Tacon and Metain, 2008). However, as a result of unstable and declining reduction fishery landing, the use of fishmeal (FM) as a protein sources in these aqua feeds is projected to remain essentially static over the same period (Tacon and Metain 2008). To effectively minimise cost and facilitate increase production of aquatic product requiring protein dense diet, traditional FM-based feeds must be reformulated to include the maximum amount of alterative protein yielding acceptable production performance. To meet these goals, considerable effort has been expended to identify ideal candidate among existing feed stuff for FM replacement in aqua feed.

The search for alternative to fishmeal (FM) has largely been focused on conventional sources such as oil seed cakes and meal due to their higher protein content, These include soya bean (Sadiku and Tauncey, 1995) groundnut, sun flower, rapeseed (Jackson et al., 1982), and cotton seed cake (Mbahinzireki et al., 2001). However despite their usefulness, these ingredients are scarce and expensive due to high demand for livestock production and human consumption (Gabriel et al., 2007). Furthermore, their cultivation generally requires high use of input and energy subsidies (Francis et al., 2002). This makes them unaffordable, unsustainable and sometimes even conflicts with food security interests, particularly among resource-poor farmers (Atteh, 1995). 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 sources, particularly from plant products such as seeds, leave and other agricultural by-products (Olvera-Novoa et al., 1988; El-sayed, 1999; Siddhuraju and Becker, 2001; Ogunji, 2004; Bake et al., 2009 and 2013).

Some of the ingredients that may have potential include product from *Senna obtusifolia* seed. *Senna obtusifolia*, a leguminous seed, has considerable potential as an ingredient in feeds for animal, including fish. It contains 19-29% protein; 2-8% lipid, 45-51% nitrogen free extract (NFE) and 19-32kjg^{-1} gross energy (Ingweye et al., 2010; Dasuki et al., 2014).

Catfish which belongs to the family Claridae are the most cultured freshwater fish in Nigeria. They are characterized by the ability to grow on a wide range of artificial and natural food, and they grow fast and have high yield potential, hardness and tolerance to dissolve oxygen in other aquacultural routine (Oresegun et al., 2007). The African catfish (*Clarias gariepinus*) are of great importance as esteemed food fishes especially to the rural populace in West Africa especially Nigeria. Hence, emphasis has been on the increase of how to improve productivity of catfish.

However, the extent to which legume seed could be potential sources of protein and energy in 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). With recent technological advancement in feedstuff processing techniques which has the ability to boost and improve nutrient digestibility and utilization of these plants based protein sources by altering their nutritional content and reducing their anti-nutritional factors. Different processing techniques have evolved these include fermentation techniques.

Fermentation has long been used to prepare healthy foods for both humans and livestock (Lee, 1998; Kim et al., 1999). Fermentation is a unique process which will improve the nutritional value of feed ingredients and tremendously reduce the anti-nutritional factors and fibre content in the plant based feed ingredients. More so, fermentation hold promise for growth enhancement and immunostimulants in aquaculture (Mukhopadhyay and Ray, 2001; El-sayed, 2003; Bairagi et al., 2004; Ramachandran and Ray, 2007). Fermentation also increases the availability of certain vitamins *viz.*, riboflavin, cyanogobalamine, thiamine, niacin, B6, B12 and folic acid levels in some feed ingredients. Furthermore, fermentation process has the ability to remove a substantial portion of the glycinin and β-conglycinin (Helm et al., 2000; Rickert et al., 2004; Deak et al., 2006) which are potential antigenic and allergenic compounds (Holzhauser et al., 2009).

Although data about the potential and nutrient composition of *Senna obtusifolia* are available, the data regarding the inclusion levels of fermented *Senna obtusifolia* seed meal in the diet of *Clarias gariepinus* fingerlings is still limited. Therefore, it is in this view that the current experiment was conducted to evaluate the growth performance, nutrient utilization and proximate composition of *Clarias gariepinus* fingerlings fed FSOM-based diet.

Materials and methods

Ingredients and diet formulation

Soybean meal (SMB): Raw soybean was purchased from the Bosso market Minna (Niger state). The soybean was processed by toasting the soybean in frying pan at 80°C for 60 min until the colour changes 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 as shown in Table1.

Fish meal: 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 as shown in Table 1.

Senna obtusifolia seed meal: Senna obtusifolia seed pods were collected manually during the dry season from Rafin yashi, area of Bosso local government, Minna Niger state. It was manually crushed to get the seed. The fermentation of the seeds was carried out by mixing the *S. obtusifolia* seed with water in the ratio 2:1 (1 part of *S. obtusifolia* seed to 2 parts of water); 0.25ml of cultured *Aspergillus niger* which was collected from the Department of Microbiology laboratory of Federal University of Technology Minna, was pipette and mixed with the water. The mixture was packed in a plastic container, firmly sealed with cotton wool before being kept in a room at ambient temperature of 25°C. The sample was fermented for five days. The fermented sample was then washed and spread on a polythene sheet in a room and dried for six (6) days up to about 90% of the dry matter. The seed was grinded into powder using hammer mill. Crude protein and lipid contents of FSOM were 33.18% and 4.39%, while RSOM were 22.15% and 3.19% respectively as shown inTable1.

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

Experimental diets

Based on the nutritional requirements of *Clarias gariepinus* fingerlings (NRC 1993), five isonitrogenous and isolipid diets were formulated at 40 % protein and 9.5 % lipids, containing 10-30% fermented *Senna obtusifolia* seed meal at different levels of inclusion and 10% inclusion of raw *Senna obtusifolia* seed meal as shown in Table 3.

Experimental system and fish

The experimental fish, pure- bred *C. gariepinus* fingerlings, with an initial mean weight of (2.02 - 2.04g) were purchased from Sauki fish farm limited 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 (coppense feed) at 40% crude protein once a day before the experiment commenced.

The fish were subsequently fed with 40% iso-nitrogenous diet and 9.5% lipid, containing different inclusion level of fermented *Senna obtusifolia* meal, designated as D1 (0% inclusion), D2 (10% inclusion), D3 (20% inclusion), D4 (30% inclusion) and D5 (10% raw *Senna obtusifolia* seed meal) for 56 days. Fifteen net hapa (0.5×0.5×1m) were suspended in two outdoor concrete tanks (8m×5m×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 hapa, Photoperiod depends on the natural light, and water temperature was monitored daily. The water quality parameters in the system were monitored weekly, the temperature ranged between 24ºC-29ºC while the concentration of dissolved oxygen ranged between 5.94-7.82 mg/L and the pH values of the treatments ranged from 7.18-7.60. No critical values were detected for nitrite and nitrate. Two replicates of each treatment using 20 fish per hapa were reared on each of the four diets. The feed was manually administered and the fish were fed three times daily at 5% of body weight at 09:00 am, 12:00noon and 04:00pm. 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. Five fish were randomly sampled on weekly basis, and weights were measured using a digital electronic weighing balance (*CITIZEN MP-300*) model.

Biochemical analysis

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). Moisture content was determined by drying samples at 105±2°C 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 solvent. Crude protein content was calculated by using nitrogen content obtained by Kjeldahl method. A conversion factor of 6.25 was used for calculation of protein content according to AOAC (2000). Anti-nutritional factors of the seeds; tannins and trypsin inhibitor activity (TIA) were analyzed by modifying the procedures of AOAC (1984). Phytic acid was determined by the method of Latta and Eskin (1980).

Evaluation of growth parameters

Growth performance and diet nutrient were analyzed 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)/Initial weight (g)] × 100

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 analyzed 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 8-week feeding period, no significant differences were observed in the water-quality indices between the experimental treatments. The water temperature ranges from 27.5-30.3°C, Dissolved oxygen from 6.1-7.4 mg/*l*, pH from 6.8-7.2 and ammonia from 0.26-0.29 mg/*l*.

Table 1. Proximate composition of the major ingredients used in the formulation of the experimental diet for *C. gariepinus* fingerlings.

Ingredients	Fish meal	Soybean meal	Maize meal	Millet meal	RSOM	FSOM
Proximate composition						
Moisture (%)	5.79	3.09	4.66	3.22	3.19	4.78
Crude protein (% d.b.*1)	65.34	43.63	9.32	12.86	22.15	33.18
Crude lipid (% d.b.*1)	11.4	7.00	4.20	4.36	3.98	4.39
Ash (% d.b.*1)	14.34	8.15	3.22	2.33	12.35	7.34
Crude fibre (% d.b*1)	0.06	5.00	3.40	2.60	9.82	6.54

*d.b = dry basis.

Table 2. Effect of fermentation treatment on anti-nutritional factors in *Senna obtusifolia* seed meal.

Anti nutritive factors	RSOM	FSOM	(%) decrease of anti nutritive factors after fermentation
Phytate (mg/100g)	260.07	101.24	61.07
Hydrocyanic acid (mg/kg DM)	9.45	3.24	65.71
Saponin (mg/100g)	175.92	70.34	60.02
Tannin (g/100g)	358.54	147.12	58.97
Oxalate	74.46	12.65	83.01
Alkaloid	240.74	115.22	52.14
Phytohaemaglutinin (Hu/g)	1240.65	350.25	71.77

Table 1 showed the proximate composition of the major feed ingredients used in formulating the experimental diets. Fishmeal has the highest crude protein and lipid content (69.34% and 11.76%), followed by soybean meal (43.07% and 7.0%) while, the crude protein and lipid content of fermented *Senna obtusifolia* seed meal was 33.18% and 4.39% respectively. The proximate composition of the experimental diets (Table 2) showed the anti-nutritional factor composition of both the untreated raw *S. obtusifolia* (RSOM) and the treated fermented *S. obtusifolia* (FSOM). All the anti-nutritive factors parameters measured were lower in the treated FSOM ingredient as compared to RSOM. Table 3 also showed that the crude protein of the diets were similar and ranged between 37.43% and 38.85%. Similarly the lipid, ash and moisture content of the diets were also close and ranged between 8.38 and 8.88%, 9.27 and 10.73%, and 5.25 and 5.95% respectively.

Table 3. Formulation of the experimental diet and proximate composition of the experimental diet for *C. gariepinus* fingerlings (g/kg).

Ingredients	D1	D2	D3	D4	D5
FM	529.30	478.50	427.80	376.90	495.40
SBM	100.00	100.00	100.00	100.00	100.00
FSOM	0.00	100.00	200.00	300.00	0.00
RSOM	0.00	0.00	0.00	0.00	100.00
MM	50.00	50.00	50.00	50.00	50.00
Millet	50.00	50.00	50.00	50.00	50.00
Starch	50.00	50.00	50.00	50.00	50.00
Vitamin premix	15.00	15.00	15.00	15.00	15.00
SBO	24.30	25.70	27.20	28.60	23.80
Cellulose	166.40	115.80	65.00	14.50	100.80
Mineral	15.00	15.00	15.00	15.00	15.00
Total	1000.00	1000.00	1000.00	1000.00	1000.00
Moisture (%)	5.25	5.56	5.82	5.95	5.64
Crude protien (% d.b.^{*1})	38.12	38.25	38.85	38.24	37.43
Crude lipid (% d.b.^{*1})	8.38	8.46	8.75	8.88	8.55
Ash (% d.b.^{*1})	9.27	10.33	10.72	10.73	10.53
Crude fibre (% d.b.*1)	4.14	4.25	5.26	5.43	5.53
*d.b = dry basis					

It was observed that there was no feed rejection by the fish fed the experimental diets, and they vigorously ingested the experimental diets. The change in weight per week, growth performance and nutrient utilization data of *Clarias gariepinus* fingerlings fed the experimental diets for 56 days are summarized and presented in Fig.1 and Table 4 Significant differences were observed among *Clarias gariepinus* fingerlings fed experimental diets(p<0.05). Table 3 showed that fish fed 20% inclusion of fermented *Senna obtusifolia* seed meal (D3) had the highest values of all growth performances indices measured and was significantly different from the other treatments (p<0.05). However fish fed 10% and 30% inclusion of fermented *Senna obtusifolia* seed meal (D2 and D4) and fish fed 0% inclusion of fermented *Senna obtusifolia* seed meal (D1) were not significantly different (p>0.05) from each other but were significantly higher than fish fed 10% inclusion of raw *Senna obtusifolia* seed meal (D5) (p<0.05).

Table 4. Growth performances and nutrient utilization of *C. gariepinus* fingerlings fed experimental diets for 56 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	2.03±0.02	13.70±0.02c	574.71±11.00c	98.81±1.14a	3.41±0.21c	15.24±0.38c	0.77±0.06b	2.01±0.23b	37.92±0.28b
D2	2.04±0.01	14.72±0.21b	621.73±24.59b	98.90±1.02a	3.53±0.34b	16.27±0.45b	0.78±0.04b	2.04±0.16b	38.62±0.91b
D3	2.02±0.04	16.75±0.33a	729.37±32.54a	98.73±1.07a	3.78±0.26a	17.64±0.52a	0.84±0.12a	2.15±0.18a	40.71±0.32a
D4	2.04±0.02	13.73±0.24c	572.88±42.11c	98.75±1.05a	3.40±0.18c	15.23±0.44c	0.77±0.11b	2.01±0.24b	37.93±0.43b
D5	2.05±0.03	10.63±0.18d	426.07±42.11d	97.42±1.16b	2.96±0.29d	13.09±0.35d	0.66±0.14c	1.76±0.28c	33.14±0.44c

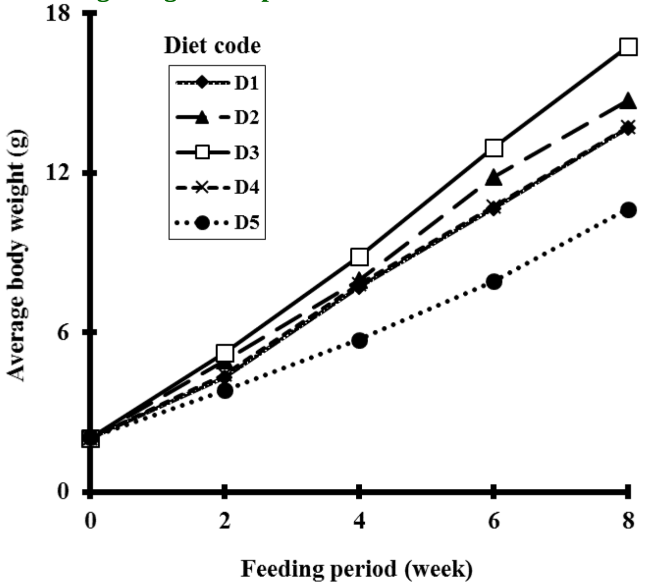
Values in the same column with different superscript letters are significantly different ($p<0.05$) from each other.

Table 5. Proximate composition analyses of whole body *C. gariepinus* (wet basis) fed experimental diets for 56 days.

Component (%)	Initial	Final*1				
		D1	D2	D3	D4	D5
Moisture	78.43	$74.60±1.8^{a}$	$74.55±0.5^{a}$	$73.13±1.7^{c}$	$72.22±1.1^{d}$	$74.44±1.8^{b}$
Protein	14.94	$18.20±1.5^{b}$	$18.52±1.3^{ab}$	$18.23±1.1^{a}$	$18.01±1.2^{b}$	$18.02±1.5^{c}$
Lipid	2.57	$4.31±0.7^{d}$	$4.32±0.5^{d}$	$4.95±0.5^{b}$	$6.55±0.4^{a}$	$4.46±0.7^{c}$
Ash	2.16	2.37±0.3	2.38±0.4	2.39±0.1	2.35±0.3	2.36±0.3

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

Fig. 1: Average body weight increase of *Clarias gariepinus* fingerlings fed experimental diet for 8 weeks.



The WG, SGR and the total feed intake (FI) of the *Clarias gariepinus* fingerlings fed with experimental diets followed the same pattern as the final body weight. There was no significant difference in the percentage survival among all the fish fed with the experimental diets except fish fed with D5 which was significantly lower than that fish fed with other experimental diets (p<0.05). Fish fed with D3 showed the highest nutrient utilization parameters measured and was significantly higher than other fish fed other experimental diets(p<0.05), however fish fed D1, D2 and D4 did not show any significant difference from each other (p>0.05), they were significantly higher and different from fish fed D5 (p<0.05).

Proximate body composition

The proximate carcass composition of the initial and final groups of the fish fed with the experimental diets is given in Table 5. Except for moisture, all the final carcass proximate compositions were higher than the initial. Fish fed D4 diet had the lowest carcass moisture among the fish fed experimental diets and was significantly different from those fed other diets (p<0.05). While fish fed D1 had the highest moisture content, it was not significantly different from those fed D2 (p>0.05), however they were significantly higher than fish fed D3 and D5 diets (p<0.05). Furthermore the carcass moisture of fish fed D5 was significantly higher than those fed D3 (p<0.05).

Carcass protein of the experimental fish fed changed significantly among the treatments, and was highest in fish fed D3 diet although not significantly different from fish fed D2. Fish fed D1 and D4 were similar and not significantly different from each other, but significantly different from those fed D5 (p<0.05). Fish fed D4 accumulated the highest carcass lipid composition and was different from those fed other experimental diets (p<0.05). With exception of fish fed D2; fish fed D1 had the lowest carcass lipid and was significantly different from those fed other experimental diets (p<0.05). There was no significant difference in the ash composition of all the fish fed experimental diet.

Discussion

The results showed that the values of water quality parameters throughout the experimental period did not vary significantly with each other, and these water quality parameters values were within the acceptable and optimum range for African catfish *(Clarias gariepinus)* culture (Omitoyin, 1995; Madu et al., 2001; Swann, 2006).

The quality and quantity of Protein in fish diet is of paramount importance since it plays decisive role in influencing the growth rate of fish, provided all other physiological requirements are satisfied (Sogbesan et al., 2006).The proximate composition of both RSOM and FSOM meal in this present study revealed that the crude protein content was 24.15% and 33.18 respectively while the lipid was 3.98 and 4.39% (Table 2). The value of RSOM in this study was lower than the values reported by Ingweye et al. (2010) but was higher than the values reported earlier by Sudi et al. (2011) and Dasuki et al. (2014), however FSOM value was higher than those previously reported by Ingweye et al. (2010), Sudi et al. (2011) and Dasuki et al. (2014). The differences might be attributed to differences in environmental conditions such as soil types, harvesting time and the processing conditions. Mukhopadhyay and Ray (2001), El-Sayeed (2003), Poveda and Emorales (2004) and Ramachandran, and Ray (2007) reported that the fermentation process significantly improves in nutritive value, acceptability, digestibility and eliminates anti-nutritional factors in plant based ingredients. Our results tend to agree with their report hence substantial amount of anti-nutritional factors were greatly reduced as a result of fermentation processing method used as shown in Table 2.

In the present study, there was no feed rejection during the experimental period, the suitability of inclusion of alternative ingredient in a fish diet in terms of growth performance and nutrient utilization has been reported to vary highly among fish species and experimental conditions (El-Sayed, 1999; Bake et al., 2009; Bake et al., 2013). From the present study the percentage survival was excellent throughout the experimental period and there was no significant difference among all the treatment except for the fish fed D5; this could be attributed to good handling, good water quality management, proper processing and the suitability of FSOM meal inclusion in the diet of *C. gariepinus* fingerlings, however the little mortalities recorded among the treatments could be as a result of handling stress during and after sampling. Diet produced with poor quality raw materials and under adverse processing conditions have inferior nutritive value and adverse effects on fish health and survival (Tomas-Vidal et al., 2010; Fapohunda et al., 2012; Bake et al., 2013).

The growth performance and nutrient utilization as shown in table 4 indicated that *C. gariepinus* fingerlings fed D3 gave a better growth performance and nutrient utilization than the other treatments. This may likely be due to the fermentation method used in the processing of the *Senna obtusifolia* in the diet, although generally all the fish fed the experimental diets accepted the feeds acceptability of the diets however differs among the treatment. This agrees with earlier reports (Riche et al., 2001; Riche and Garling Jr., 2004; Ahmad, 2008) suggesting that when alternative protein sources especially plant protein sources are used in fish diet, palatability and attractiveness of the diets are usually affected. In the context of this study, *Senna obtusifolia* is a leguminous plant protein sources used at varying inclusion levels the experimental diets. As suggested by Watanabe et al. (1987) proper utilization of dietary protein is dependent on the good quality or amino acid balance of the protein sources.

Fagbenro (1999), Francis et al. (2001), Siddhuraju and Becker (2003) reported that proper processing of feed ingredient increases the palatability of diets hence it is suggested that the texture and palatability of a diet is related to the level of plant materials incorporated. In the context of this study it was observed that fish fed D3 had the highest feed intake and also better nutrient utilization while fish fed D2 and D4 were comparable to the fish fed D1, hence the result obtained from this study tend to be in agreement of these authors. Cho and Watanabe (1988) stated that the weight gain (WG) of young fish is a reliable indicator of nutritional efficiency; from this present study it showed that fermentation and inclusion levels both affect the weight gain. This agrees with the findings of Rodriguez-Serna et al. (1996), Fagbenro (1999), Francis et al. (2001) and Siddhuraju and Becker (2003) that one of the major limitation of using alternative plant protein source in fish feeding is the changes in palatability and the presences of anti-nutrition factor in the ingredient, this clearly is evident in the inclusion of untreated raw *Senna obtusifolia* at10% in the diet which gave a lower growth and nutrient utilization value as compared to the fermented *Senna obtusifolia* which gave a higher values even at a higher inclusion level. This may likely be the reflection of the presence of the antinutritive factors in the raw seed which was effectively reduce by the fermentation of the seed meal.

The reduction in feed intake due to the unpalatability may lead to deterioration in growth performance and feed utilization. A reduction in growth and nutrient utilization in fish fed D5 was observed; this reduction observed could be attributed, not only to dietary amino acid profile of the ingredient, but also to the presence of anti-nutritional factors. This accession is in line with the findings of Davies et al. (2000), Jimoh and Aroyehun (2011), Bake et al. (2012) and Bake et al. (2013) that higher inclusion levels of most plant protein source base meals resulted in poor growth and nutrient utilization. Francis et al. (2001) and Bake et al. (2013) further reported that at a lower level of inclusion, a physiological mechanism exists in fish that could balance and compensate for the presence of the anti-nutrients; hence their negative effect may not be felt. However, at higher levels of inclusion the negative effects of the anti-nutrients would manifest hence there is need to treat or process this plant protein source base meals, this may likely explains why the fish fed fermented *Senna obtusifolia* at varying inclusion levels in the diet were comparable to that of control both in the growth and nutrient utilization. Proximate composition of whole body of the fish fed experimental diet in this study indicated that except for ash other proximate parameters; moisture, lipid and protein content of carcass of fish feed the experimental diets were affected by the varying inclusion levels of FSOM; hence, there was a significant difference in crude protein among treatments and highest value was recorded in the fish fed D3. This observation is in line with the findings of Deyab and Amal (2011) and, Cheng and Hardy (2002).

In terms of the carcass lipid it was closely and inversely related to the body moisture content, an increase in the inclusion level of FSOM in the diet also led to an increase the carcass lipid in the fish fed experimental diets. This result in agreement with the findings of Serrano et al. (1992), Yildirim et al. (2003) and Bake et al. (2012, 2013). Despite a little suppressed growth, by the fish fed D4, the fish fed D4 had the highest carcass lipid. The increase in the carcass lipid in the fish fed D4 led us to conclude that like tilapia a fresh water fish *C. gariepinus* may have the ability to store significant quantities of lipid in carcass or viscera but may not utilize this as energy source to improve its growth as postulated by Hanley (1991).

Conclusion

This study showed that fermentation processing method substantially in activated several anti-nutritive factors in *Senna obtusifolia* seed and 10-30% inclusion of FSOM meal improved the growth performance and nutrient utilization of *C. gariepinus* fingerlings without any adverse effect on their health and morphological structure. The increase in the inclusion level *Senna obtusifolia* in the diet may also have contributed to a higher accumulation of carcass lipid. A longer feeding trial and further research work on the amino acid profile should be look into.

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