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Research Article

Effects of Sun-Dried Sicklepod (Senna Obtusifolia) as a Replacement for Soybean (Glycine Max) in the Diets of African Catfish (*Clarias gariepinus*) Juveniles

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Abstract

This study was carried out to evaluate the effects of sun-dried sicklepod as a replacement for toasted soybean meal in the diets of *Clarias gariepinus* juveniles. Five iso-nitrogenous diets were formulated at 35% crude protein using Pearson's square method. Sun-dried sicklepod (SSM) was use to replace toasted soybean meal progressively at 0%, 25%, 50%, 75% and 100% respectively. A total number of one hundred and fifty juveniles of *Clarias gariepinus* with an average mean weight of 31.19g were procured. The fish were allowed to acclimatize for a day. A complete randomized design (CRD) was adopted. Ten fish were randomly assigned to a $1m^2$ Hapa net, a total of 15 Hapa nets were used in an outdoor earthen lined pond of 10m × 7m (l × b) and depth of 1.5m, and the five formulated diets were fed to the experimental fish at 5% body weight twice daily and the pond water was monitored. The experiment lasted for 8 weeks. Highest value of mean weight gain was observed in 25% level of inclusion (141.20g) followed by 0% (124.50g), 50% (114.80g) and 75% (108.33g) inclusion level, while the least mean weight gain of 106.00g was recorded in the fish fed 100% inclusion level. The highest of feed conversion ratio was recorded in the control diet with a value of 0.10 while the least (0.07) was recorded in the diet with 25% inclusion level. Highest carcass crude protein of 61.03g/100g was recorded the fish fed 25% inclusion level while the least (58.58g/100g) was obtained in 100% inclusion level. This study revealed that toasted soybean meal can be replaced with sun-dried sicklepod meal up to 25% inclusion level in *Clarias gariepinus* diets without any negative effects on the growth and nutrient utilization.

Keywords: Iso-Nitrogenous diets; Mean Weight Gain; Feed Conversation Ratio; Carcass Composition; Catfish

Introduction

African catfish (*Clarias gariepinus,* Teugel, 1986) is the most important fish species cultured in Nigeria. It belongs to the family Clariidae and genus *Clarias*. There are over 60 species in the genus *Clarias* found throughout Africa [1]. *Clarias gariepinus* has high economic importance in many countries of the world [2]. It can tolerate adverse water quality conditions, it grows fast and feeds on a large variety of agricultural by-products, and can be raised in high densities [1].

Fish feeds in sustainable intensive fish culture system account for about 40-70% of the total cost of production which to a larger extent determines the profitability and viability of fish farming enterprise. In order to attain more economical, sustainable, and viable fish production, research interest has been directed towards the evaluation and use of non-conventional plant protein sources [3]. Studies in fish nutrition are aimed at exploring alternative, cheaper protein sources for use as fishmeal and soybean replacers in aqua feeds. The decrease in global production of soybean clearly demonstrates that the sustainability of this industry will depend on the sustained supply of plant proteins for aqua feeds [4]. The failure of aquaculture to meet the challenge of closing the widening gap between fish supply and demand in Nigeria, results from high cost of feed and underutilizations of the locally available feed ingredients to formulate a good quality diets in commercial quantities. Better growth of fish is only possible through provision of high quality feed to sustain the increased demand for quality feed [5]. According to Hecht [6], poor financial circumstances of the farmers within Sub-Saharan Africa are one of the main problem impeding fish farming.

Senna obtusifolia is a leguminous plant belonging to the family Fabaceae. It is an annual or perennial plant [7]. It can grow to about one meter high [8]. It is a pan-tropical plant species that is characterized by alternate compound leaves. The proximate composition of *S. obstifolia* revealed high crude protein (29.50%) and ash content (38.00%), but low ether extract, crude fibre and nitrogen free extract values. *S. obstifolia* seeds have high

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concentrations of calcium (960 mg/100 g), potassium (1,200 mg/100 g), phosphorus (810 mg/100 g), sodium (600 mg/100 g), magnesium (640 mg/100 g), iron (234.60 mg/100 g), zinc (53.12 mg/100 g) and copper (10.48 mg/100 g) but low in molybdenum, cobalt, chromium, selenium, sulphur and fluorine [9].

Soybean meal is the most important protein source used to feed farm animals. It represents two-third of the world output of protein feedstuffs. The use of soybean meal in the fish diet may not be profitable because it is very expensive and serves as a good source of protein for human and other domestic animals [10]. It is necessary to reduce the dependence on soybean meal by partial or total replacement with less popular wild legume seeds. However, the over-dependence has already caused a hike in the price of soybean meal; therefore, utilization of other inexpensive plant protein source would be beneficial in reducing the fish feed cost [11]. Thus, this research aimed to evaluate the effects of sun-dried sicklepod (*Senna obtusifolia*) as a replacement for soybean (*Glycine max*) in the diets of African catfish (*Clarias gariepinus*) juveniles

Materials and Methods

Experimental site

The experiment was conducted in an earthen lined pond of the Department of Fisheries, Faculty of Agriculture University of Maiduguri, Nigeria. It is located at latitude $11^0$15`N and longitude $13^0$15E.

Source of feed ingredients: The ingredients used for the formulation of the experimental diets includes sun-dried sicklepod meal, which was procured from Gombe Main Market, Gombe State, Nigeria. Toasted soybean meal, fish meal and maize were procured from Monday Market in Maiduguri. Vitamin/mineral premix, methionine, salt, lysine, oil, were procured from Agrovet store in Bama-road Maiduguri.

Processing of sicklepod and feed ingredients: The sickle pod was dried under sun for three days using the method of sun drying described by Abdullahi *et al.* [12] before it was ground into fine particles using domestic hammer mill and sieved with 1mm mesh screen and kept in an airtight container until required. All the other feed ingredients were also ground separately.

Experimental diet

Five iso-nitrogenous diets were formulated at 35% crude protein using a Pearson's square method. Sun-dried sicklepod meal (SSM) was use to replace toasted soybean meal progressively at 0%, 25%, 50%, 75% and 100% respectively. The feed ingredients that were used in the experiment include; fish meal (broken tilapia), sicklepod, soya bean meal, maize, binder, palm oil, salt, vitamin/mineral premix, methionine and lysine (Table 1). All the ingredients were separately processed and milled to fine particles and mixed together for pelleting, the feed was dried after pelleting, and it was stored in a cool dry place.

Experimental design

A total number of one hundred and fifty juveniles of *Clarias gariepinus* with an average mean weight of 31.19g were purchased from Maiduguri Fish Farm, Borno State, Nigeria. The fish were allowed to acclimatize for a day. A complete randomized design (CRD) was adopted. Sun-dried sicklepod meal was used to replace toasted soybean meal at 0%, 25%, 50%, 75% and 100% to make one control and four treatments, respectively. Each treatments and the control were replicated. Ten fish were randomly assigned to a $1m^2$ Hapa net. A total of 15 Hapa nets were used in an outdoor earthen lined pond of 10m × 7m (l × b) and depth of 1.5m, and the five formulated diets were fed to the experimental fish and the pond water was daily monitored.

Feeding trials: The fish were fed at 5% body weight twice daily, morning (8:00 – 9:00 a.m.) and evening (5:00 – 6:00 p.m.). Fish in each experimental net was collectively weighed and both the total and standard lengths were measured biweekly using weighing balance and measuring board respectively, throughout the experimental period. The experiment lasted for 8 weeks.

Determination of nutrient content: The proximate composition of sicklepod and carcass composition of the

Table 1: Composition of the experimental diets.

Ingredients	SSM0%	SSM25%	SSM50%	SSM75%	SSM100%
SBM	49.44	39.55	24.72	9.89	-
Sicklepod	-	9.89	24.72	39.55	49.44
Maize	15.84	15.84	15.84	15.84	15.84
Fish meal	24.75	24.72	24.72	24.72	24.72
Premix	0.7	0.7	0.7	0.7	0.7
Methionine	2	2	2	2	2
Lysine	2	2	2	2	2
Salt	0.8	0.8	0.8	0.8	0.8
Palm oil	3.5	35	35	35	35
Binder	1	1	1	1	1
Total	100	100	100	100	100
SBM	49.44	39.55	24.72	9.89	-

experimental fish were determined using the methods of the AOAC [13].

a) Moisture content: A clean crucible was dried to a constant weight in an air oven at 110°C, cooled in a desiccator and weighed (W1). 2 g of finely pulverized sample was weighed in the crucible and then re-weighed (W2). The crucible and its content were dried in an oven to a constant weight (W3). The percentage moisture was calculated thus %

Moisture content = {(W2–W3)/(W2–W1)} × 100

b) Ash content: The porcelain crucible was dried in an oven at 100 °C for 10 minutes, cooled in a desiccator and weighed (W1). 2 g of finely pulverized sample was weighed (W2) into the previously weighed clean crucible which was ignited in the muffle furnace at 550 °C for 1 hour and cooled in a desiccator. The crucible and its content were transferred into the muffle furnace and the temperature was gradually increased until it reached 550 °C. The sample was left in the furnace for 8 hrs to ensure proper ashing. The crucible containing the ash was allowed to cool to 200 °C, the crucible was removed and cooled in a desiccator until constant weight is obtained (W3).

% Ash content = {(W2–W3)/(W2–W1)} × 100

c) Crude lipid content: Four grams of sample was weighed (W1) into a clean, dried 500 mL round bottom flask containing few anti-bumping granules was weighed (W2) and 300 mL of petroleum ether (40 °C - 60 °C) for the extraction was poured into the flask fitted with soxhlet extraction unit. The round bottom flask and a condenser were connected to the soxhlet extractor, and cold water circulation was put on. The heating mantle was switched on and the heating rate adjusted until the solvent was refluxing at a steady rate. Extraction was carried out for 6 hours. The solvent will be recovered and the oil was dried in the oven at 70 °C for 1 hour. The round bottom flask and oil were cooled and then weighed (W3).

% Crude Content = {(W2–W3)/(W2–W1)} × 100

d) Crude fibre: Two grams of finely pulverized sample was weighed into an extraction apparatus, fat was extracted with liquid petroleum spirit (40 °C - 60 °C) the extracted was removed and dried at 105 °C for 30 minutes. Two grams of the defatted sample was weighed into a dry 600 cm round bottom flask. 100 cm^3 of (0.023M) sulphuric acid was added and the mixture boiled under reflux for 30 minutes. The hot solution was quickly filtered under suction. The insoluble matter was washed several times with hot water until it is acid free. This was quantitatively transferred into the flask and 100 cm^3 of hot (0.312) sodium hydroxide solution was added and the mixture boiled under reflux for 30 minutes and quickly filtered under suction. The insoluble residue was washed with boiling water until it was base free. It was dried to constant weight in the oven set at 100 °C, cooled in a desiccator and weighed (C2). The weighed residue was incinerated in a muffle furnace at 550 o C for 2 hours, cooled in a desiccator and reweighed (C3).

The loss in weight on ashing (incineration) = C2 – C3

Weight of original sample = W

% Crude Fibre = {C2–C3)/W} × 100

e) Crude protein: Two grams of the sample was weighed into 100 cm^3 Kjeldahl digestion flask and about l g of catalyst mixture (K_2SO_4 and $CuSO_4$) was added to speed up the reaction. 25 mL of concentrated sulphuric acid was added into the flask. The content in the Kjeldahl digestion flask was heated slowly at first in Kjeldahl heating unit frotting subsides and then more vigorously with occasional rotation of the flask to ensure even digestion and avoid over heating of the content. The heating continued until a clear solution is obtained. After cooling, the solution was transferred into 100 cm3 volumetric flask and diluted to mark with distilled water. 10 mL aliquot of the diluted solution or digest was pipette into Markham semi macro nitrogen steel and 10 cm^3 of 40% sodium hydroxide solution was added. The liberated ammonia was trapped in a 100 cm^3 conical flask containing l0 cm^3 of 40% boric acid and 2 drops of methyl red indicator. Distillation was allowed to continue until pink colour of the indicator turn green. The content of the conical flask was titrated with 0.1M HCl, with end point indicated by a change from green to pink colour. The volume of the acid used for the distillate as well as the blank was noted.

% Nitrogen = {(0.014 × M × (V1–V0)}/ {weight of test sample} × 100

where M = actual molarity of acid; V1 = volume of HCl required for 10 mL sample solution,

V0 = volume of HCl required for the blank.

Atomic weight of nitrogen = 0.014 % Crude = % Nitrogen (N2) × 6.25

f) Nitrogen free extract: The total carbohydrate content was determined by difference. The sum of the percentage moisture, % ash, % lipid, % crude protein and % crude fibre was subtracted from 100.

NFE = 100 – (ash+ crude lipid + crude protein + crude fibre)

Determination of growth performance and nutrient utilization parameters: The data obtained on the growth response and nutrient utilization of *Clarias gariepinus* fed experimental diets were determined as following the method of Abdullahi *et al.* [14].

Mean Weight Gain (MWG) (g) Mean Weight Gain (MWG) = W2 - W1

Where W1 = initial mean weight (g)

W2 = Final mean weight (g)

- **Specific Growth Rate (SGR%/day)**

$$SGR\ \% = \frac{\log of\ W2 - \log of\ W1}{T2 - T1} X 100$$

Where W1 = initial mean weight (g)

W2 = Final mean weight (g)

T1 = initial time (g)

T2 = Final time (g)

- **Condition Factor (CF)**

$$CF = \frac{100\,(\text{Weight gain})(g)}{(Final\,Length)3\,(cm)}$$

- **Survival Rate (%)**

$$SR = \frac{Number\,of\,Fish\,that\,remain\,at\,the\,end\,of\,the\,experiment}{the\,initial\,number\,of\,fish\,stock} X\,100$$

- **Protein Efficiency Ratio (PER)**

$$PER = \frac{\text{Total weight gain(g)}}{Crude\,Protein\,fed\,(g)}$$

- **Feed Conversion Ratio (FCR)**

$$FCR = \frac{Total\,weight\,of\,diet\,fed(g)}{Total\,weight\,of\,\,fish(g)}$$

- **Mortality**

$$M = \frac{Number\,of\,\,fish\,dead\,at\,the\,end\,of\,experiment}{The\,initial\,number\,of\,\,fish\,stocked} X\,100$$

Water quality parameters

Water quality parameters were determined weekly, before feeding the fish. The dissolved oxygen level of the water was measured using a digital water dissolved oxygen meter (Smart Sensor AR8210 model) while pH and temperature were measured using a digital pH/Temperature meter (HI-98127 model).

Data Analysis

All data collected from the experiment were subjected to one-way analysis of variance to test for significant differences among treatment means using XLSTAT version 2022, followed by Duncan pairwise comparisons which was used to separate significantly different means at a confidence interval of 95%.

Results

Proximate composition of sicklepod

The result of proximate composition of sun-dried sicklepod meal is shown in Table 2. The raw seed had high values of moisture, crude fibre, ether extract and nitrogen free extract of 4.59%, 25.29%, 19.82, and 42.32%, respectively. While the sun-dried seed had high values of crude protein and ash content of 29.50% and 5.89%, respectively. There was significant difference (P≤0.05) between the raw and sun-dried seed in terms of ether extract, nitrogen free extract, ash content, crude protein and crude fibre.

Means with the same superscript across the same row were not significantly different (P>0.05)

Table 2: Proximate composition of sicklepod meal (g/100g DM).

Parameters	RSM	SSM
Moisture content	4.59±0.60[a]	3.72±0.60[b]
Crude protein	25.29±1.52[b]	29.50±1.52[a]
Crude fibre	11.90±0.41[a]	9.59±0.41[b]
Ether extract	19.82±1.01[a]	13.21±1.01[b]
Ash content	46.32±3.20[a]	38.00±3.20[b]
Nitrogen free extract	3.98±1.11[b]	5.89±1.11[a]

Key: RSM= Raw sicklepod meal; SSM= Sun-dried sicklepod meal

Proximate composition of the experimental diets

3 shows the proximate composition of the compounded feed containing sun-dried sicklepod meal. The moisture content, crude protein, ash content decreased with the increase incorporation of sun-dried sicklepod meal in the diets. While the crude fibre, nitrogen free extract, ether extract increased with increase in the inclusion level of sun-dried sicklepod meal. The diet with 25% inclusion level had the highest value of crude protein (51.22%) followed by the control diet with a value of 50.27%, the least crude protein content of 45.68% was recorded in the diet with 100% inclusion level of sicklepod which was not significantly different (P>0.05) with diet containing 75% inclusion. The moisture content in the experimental diets ranges from 6.73 to 9.23%, the highest was recorded in the diet with 25% inclusion while the least was recorded in the diet with 100% inclusion level of sun-dried sicklepod meal. The diets with 50% inclusion level of sun-dried sicklepod recorded the highest value (20.70%) of ether extract followed by 100%, 0%, 75% and 25% with values of 19.74, 19.17, 17.36 and 15.30%, respectively.

Means with the same superscript across the same row were not significantly different (P>0.05)

Key: SSM= Sun-dried sicklepod meal

Growth response of *Clarias gariepinus* fed experimental diet

The growth response of *C. gariepinus* fed experimental diets is shown in Table 4. There was decreased in final weight, mean weight gain, mean final length, daily weight gain, percentage weight gain, specific growth rate, condition factor and survival rate with the increase in the level of sun-dried sicklepod meal in the diets. Significantly highest value of mean weight gain was observed in 25% level of inclusion (141.20g) followed by 0% (124.50g), 50% (114.80g) and 75% (108.33g) inclusion level, while the least mean weight gain of 106.00g was recorded in the fish fed 100% inclusion level. The highest mean daily weight gain of 2.51g was obtained in the fish fed 25% inclusion level and the least (1.88g) was recorded in the fish fed 100% inclusion level. The significantly highest mean final length was recorded in 25% level of inclusion (27.83cm) followed by 0% (27.00cm), 100% (26.33cm), 75% (25.46cm) while the 50% inclusion level

Table 3: Proximate composition of the experimental diets.

Parameters (g/100g DM)	Inclusion levels of sun-dried sicklepod meal				
	SSM0%	SSM25%	SSM50%	SSM75%	SSM100%
Moisture	7.22±1.24^{c}	9.23±1.24^{a}	8.64±1.24^{b}	7.33±1.24^{c}	6.73±1.24^{d}
Crude protein	50.27±1.47^{ab}	51.22±1.47^{a}	47.19±1.47^{b}	45.84±1.47^{c}	45.68±1.47^{c}
Ether extract	19.17±0.90^{b}	15.30±0.90^{d}	20.70±0.90^{a}	17.36±0.90^{c}	19.74±0.90^{b}
Crude fibre	3.52±0.47^{a}	2.42±0.47^{c}	2.62±0.47^{c}	3.02±0.47^{ab}	3.41±0.47^{a}
Ash	8.79±1.22^{a}	8.06±1.22^{a}	8.15±1.22^{a}	5.75±1.22^{b}	5.45±1.22^{b}
Nitrogen free-extract	11.03±2.10^{d}	13.77±2.10^{c}	12.70±2.10^{cd}	20.70±2.10^{a}	18.99±2.10^{b}

Table 4: Growth response of Clarias gariepinus fed experimental diet.

Parameters	Inclusion levels of sun-dried sicklepod meal				
	SSM0%	SSM25%	SSM50%	SSM75%	SSM100%
IW (g)	30.16±1.63^{a}	29.63±1.63^{a}	31.66±1.63^{a}	33.00±1.63^{a}	31.50±1.63^{a}
IL (cm)	11.33±0.18^{a}	11.00±0.18^{a}	11.00±0.18^{a}	11.00±0.18^{a}	11.66±0.18^{a}
FW (g)	155.00±4.14^{b}	170.33±4.14^{a}	146.46±4.14^{c}	141.33±4.14^{d}	137.50±4.14^{e}
FL (cm)	27.00±0.86^{a}	27.83±0.86^{a}	25.16±0.86^{b}	25.46±0.86^{b}	26.33±0.86^{ab}
MWG (g)	124.50±5.14^{b}	141.20±5.14^{a}	114.80±5.14^{c}	108.33±5.14^{d}	106.00±5.14^{d}
DWG (g)	2.21±0.98^{b}	2.51±0.98^{a}	2.04±0.98^{c}	1.92±0.98^{d}	1.88±0.98^{e}
PWG (%)	80.33±2.02^{b}	82.84±2.02^{a}	78.38±2.02^{c}	76.65±2.02^{d}	77.09±2.02^{d}
SGR (%)	3.73±0.43^{a}	3.83±0.43^{a}	3.67±0.43^{c}	3.62±0.43^{c}	3.16±0.43^{d}
CF	1.64±0.86^{a}	1.52±0.86^{b}	0.73±0.86^{c}	0.68±0.86^{c}	0.59±0.86^{d}
SR (%)	100±2.97^{a}	100±2.97^{a}	96.66±2.97^{b}	96.66±2.97^{b}	96.66±2.97^{b}

had the least value of 25.16cm. The value of specific growth rate decreased with the increase in the levels of inclusion at 0%, 25%, 50%, 75%, and 100% with the value of 3.73, 3.83, 3.67, 3.62, and 3.61% respectively.

Means with the same superscript across the same row were not significantly different (P>0.05)

Key: SSM= Sun-dried sicklepod meal, IW=Initial weight, IL=Initial length, FW=Final weight, FL=Final length, MWG=Mean weight gain, DWG=Daily weight gain, PWG=Percentage weight gain, SGR=Specific growth rate, CF=Condition factor, SR=Survival rate.

Nutrient utilization of *Clarias gariepinus* fed experimental diet

nutrient utilization parameters are presented in Table 5. There was significant difference in the protein efficiency ratio values, highest value of 4.03 was recorded in the fish fed 25% inclusion level of sun-dried sicklepod meal followed by 3.55 in the fish fed control diet, the significantly lowest value of 3.02 was obtained in the fish fed 100% sun-dried sicklepod meal. The highest of feed conversion ratio was recorded in the control diet with a value of 0.10 while the least (0.07) was recorded in the diet with 25% inclusion level. The highest mean value of apparent nutrient protein utilization (25.30) was in 100% inclusion level, followed by 25% (25.24), 75% (20.51), 0% (19.66) and 50% (18.93) had the least value. The mean weight gain, final weight, feed conversion ratio, apparent net protein utilization and net nitrogen retention differed significantly (P<0.05) among the treatments and the control.

Means with the same superscript across the same row were not significantly different (P>0.05)

Key: SSM= Sun-dried sicklepod meal, PER=Protein efficiency ratio, FCR=Feed conversion ratio, ANPU=Apparent net protein utilization, NNR=Net nitrogen retention

Carcass composition of *Clarias gariepinus* fed experimental diet

The carcass composition of *Clarias gariepinus* fed experimental diet is shown in Table 6. Highest value of carcass crude protein was of 61.03g/100g was recorded the fish fed 25% inclusion level of sun-dried sicklepod meal, followed by 0%, 50%, 75% and 100% with mean values of 52.25, 59.30, 58.58 and 54.49g/100g, respectively. All the mean crude protein values obtained in the final carcass differed significantly (P>0.05) with initial carcass crude protein. There was significant increase in the values of ether extract with the increase in the inclusion levels of sun-dried sicklepod meal which ranged between 13.16 to18.26g/100g.

Means with the same superscript across the same row were not significantly different (P>0.05)

Key: SSM= Sun-dried sicklepod

Table 5: Nutrient utilization of Clarias gariepinus fed experimental diet.

Parameters	Inclusion levels of sun-dried sicklepod meal				
	SSM0%	SSM25%	SSM50%	SSM75%	SSM100%
FW (g)	155.00±4.14^{b}	170.33±4.14^{a}	146.46±4.14^{c}	141.33±4.14^{d}	137.50±4.14^{e}
MWG (g)	124.50±5.14^{b}	141.20±5.14^{a}	114.80±5.14^{c}	10 8.33±5.14^{d}	106.00±5.14^{d}
PER	3.55±0.93^{b}	4.03±0.93^{a}	3.27±0.93^{b}	3.08±0.93^{b}	3.02±0.93^{b}
FCR	0.10±0.37^{a}	0.07±0.37^{b}	0.08±0.37^{b}	0.08±0.37^{b}	0.09±0.37^{a}
ANPU	19.66±1.22^{b}	25.24±1.22^{a}	18.93±1.22^{c}	20.51±1.22^{b}	25.30±1.22^{a}
NNR	60.69±2.55^{c}	70.40±2.55^{a}	64.84±2.55^{b}	61.93±2.55^{c}	55.82±2.55^{d}

Table 6: Carcass composition (g/100g DM) of Clarias gariepinus fed experimental diet.

Parameters	Inclusion levels of sun-dried sicklepod meal					
	Initial	SSM0%	SSM25%	SSM50%	SSM75%	SSM100%
Moisture	10.23±1.17^{a}	7.52±1.17^{c}	6.53±1.17^{c}	7.67±1.17^{c}	8.80±1.17^{b}	8.62±1.17^{b}
Crude protein	51.16±2.70^{d}	59.30±2.70^{b}	61.03±2.70^{a}	58.58±2.70^{b}	54.49±2.70^{c}	52.25±2.70^{d}
Ether extract	13.99±0.54^{d}	18.26±0.54^{a}	13.16±0.54^{d}	17.50±0.54^{b}	18.34±0.54^{a}	16.97±0.54^{c}
Ash	15.37±1.29^{a}	9.52±1.29^{d}	10.98±1.29^{c}	11.51±1.29^{b}	11.95±1.29^{b}	10.69±1.29^{c}
Nitrogen free-extract	9.25±1.39^{b}	5.38±1.39^{d}	8.28±1.39^{b}	4.73±1.39^{d}	6.39±1.39^{c}	11.46±1.39^{a}

Water quality parameters of culture medium

Summary of the mean values of the water quality parameters of the culture medium are presented in Figure 1. There was no significant difference (P>0.05) in the physico-chemical parameters observed in this study. The temperature ranged from 29.55 to 32.38°C, the pH ranged from 5.70 to 6.16, while the dissolved oxygen ranged from 4.99 to 5.85mg/L.

Discussion

This research revealed that the crude protein of sicklepod increased from 25.29% to 29.50% after sun drying, this proved that sun drying as one of the processing methods had a positive effect on crude protein content of sicklepod meal. The crude protein content of the sun-dried sicklepod meal obtained in this study is similar to the crude protein contents of 29.54% and 29.07% reported by Ingweye [15], and Rabiu [16], respectively. Angustine *et al.,* [17] also reported similar value of 29.54%. The crude protein content of sun-dried sicklepod obtained in this study was higher than the crude protein content reported by Yusuf [18], who reported 22.87% as the crude protein content of boiled sicklepod (*Senna obtusifolia*) meal, the discrepancy could be as a result of different processing method employed the mentioned author. Sicklepod has the potential of being plant protein source in fish diets as it contains more than 20% crude protein content. Sun-dried sicklepod showed higher values for crude protein and ash, while ether extract, moisture, crude fibre and carbohydrate were lower when compared among the proximate composition parameters obtained from this study. Difference was also observed in the report of Bake [19], who fermented sicklepod (*S. obtusifolia*). He obtained crude protein, crude fibre, Ash, ether extract, NFE and moisture to be 33.18, 6.54, 7.34, 4.39, 43.77 and 4.78%, respectively. The moisture content reported by Bake [19], and that of this study did not differ significantly, but significant difference was observed among all the other proximate parameters. The discrepancy in proximate composition observed from both studies is probably due to difference in the processing method employed and inter species levels. Since variation in proximate composition could also be observed at inter species levels.

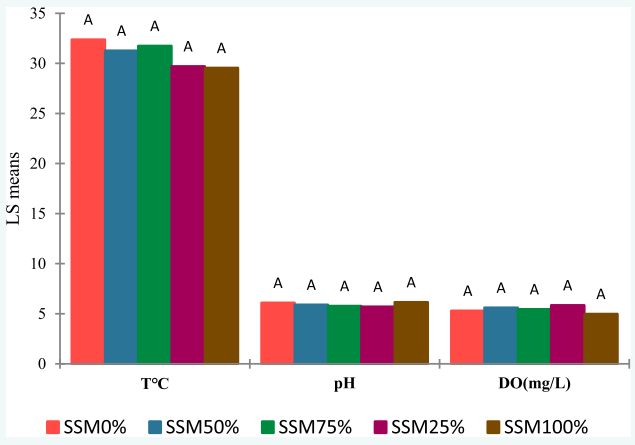

Figure 1 Water quality parameters of culture medium.
Key: SSM= Sun-dried sicklepod

There was significant difference (P≤0.05) in the moisture content of the experimental diets used in this study but was observed to be less than 12%, which was an excellent for a well dried feed materials with a longer shelf-life and can be easily stored without any spoilage. The crude protein content of the experimental diets was up to the level required by *Clarias gariepinus* (35%-55%) for a better growth performance and good health condition. The highest diet crude protein content was obtained from 25% inclusion level and the lowest was recorded in 100% level. There was significant difference in crude protein

content of experimental diets (P≤0.05), this could be attributed to level of inclusion of sun-dried sicklepod meal in the experimental diets; also soybean meal has higher in crude protein when compared to the sun-dried sicklepod meal. The crude protein and ash content decreased with increase in inclusion levels of the sun-dried sicklepod meal and this showed high significant differences (P≤0.05).

This study revealed that the growth performance and nutrient utilization parameters decreased with the increase in the inclusion levels of sun-dried sicklepod meal. This could be due to presence of anti-nutrient in the sun-dried sicklepod meal which may hinder the absorption of some essential nutrients and less palatability of the meal. Tukur *et al.* [20], reported that increase in the inclusion levels of *Moringa oliefera* (which is also a plant protein source) in fish diets decreased growth performance and feed utilization of the cultured fish, which might be due to negative effect of some anti-nutrient (in *Moringa oliefera*). The result of this study revealed similarity with that finding of Samkelisiwe and Ngonidzashe [21]. According to Eusebio *et al.* [22], the presence of anti-nutrient in fish diets may hinder the digestibility and utilization of dietary nutrients. Furthermore, Espe *et al.* [22], stated that plant based feed ingredient may reduce the fish growth due to decrease in feed intake. The reduction in the specific growth rate in the treatments could be due to different in the level of inclusion of sun-dried sicklepod meal which decreases with increase in inclusion levels. The survival rate of obtained in this study was high. This is an indication that the sicklepod meal may not be toxic to the fish, the highest mortality record was in 100% inclusion level this may be due to stress associate with the well being of fish in the culture media as most of it occur after sampling which tend to reduce dissolve oxygen level toward the end of the production period. The growth respond and nutrient utilization experimental fish feed with different inclusion level of sun-dried sicklepod meal revealed that highest mean weight gain (141.20g) in the fish fed 25% inclusion level, while the least mean weight gain (106g) was recorded in the fish fed 100% inclusion level of sun-dried sicklepod meal.

The Carcass composition of C. *gariepinus* fed sun-dried sicklepod meal revealed that all the parameters (i.e moisture content, crude protein, ether extract and nitrogen free extract) differ significantly (P≤0.05) after the feeding trials with the initial carcass, and also diet with 25% level of inclusion had the highest value of crude protein (61.03%) and the diet with 100% level of inclusion had a lowest value (52.25%). The experimental fish carcass for all dietary treatment were higher that the initial carcass protein, indicating that there was synthesis and increase tissue protein production as reported by Abdullahi *et al.* [24]. The results revealed that the values of the water quality parameters throughout the experimental period did not differ significantly with each other, and these physico-chemical parameters values were within the acceptable and optimum range for African catfish (*Clarias gariepinus*) culture.

Conclusion

In conclusion, this study revealed that toasted soybean meal can be replaced with sun-dried sicklepod meal up to 25% inclusion level in *Clarias gariepinus* diets without any negative effects on the growth and nutrient utilization.

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