Research Article ISSN 2834-7854

Journal of Nutrition Food Science and Technology

# Substitution of Soya Bean (*Glycine max*) with Chia Seed (*Salvia hispanica*) Meals in the Diets of African Catfish *Clarias gariepinus* (Burchell, 1822)

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**Submitted**: 6 Apr 2026; **Accepted**: 13 Apr 2026; **Published**: 21 Apr 2026

**Citation:** Abdullahi, A. I. et al., (2026). Substitution of Soya Bean (Glycine max) With Chia Seed (Salvia hispanica) Meals in the Diets of African Catfish Clarias gariepinus (Burchell, 1822). *J N food sci tech, 7*(2):1-4. DOI : https://doi.org/10.47485/2834-7854.1059

**Abstract**

*This study was carried out to evaluate the effects of substituting toasted soybean meal with fermented chia seed meal in the diets of Clarias gariepinus fingerlings. Five iso-nitrogenous diets were formulated at 40% crude protein using Pearson's square method. Chia seed meal (CSM) was used to replace toasted soybean meal progressively at 0%, 25%, 50%, 75% and 100% respectively. A total number of one hundred and fifty fingerlings of C. gariepinus were procured. The fish were allowed to acclimatize for a week. A complete randomized design (CRD) was adopted. Ten fish were randomly assigned to a 1m Hapa net, a total of 15 Hapa nets were used in an outdoor earthen lined pond of 10×7m² with a 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 of 73.88g was recorded in the fish fed 75% level of inclusion followed by 69.22g in the fish fed 25% inclusion which were significantly different (P≤0.05), the least mean weight gain of 46.66g was recorded in the fish fed 50% inclusion level. The highest of feed conversion ratio was recorded in the 50% inclusion level with a value of 0.83 while the least (0.75) was recorded in the diet with 25%, 75% and 100% inclusion level. This study revealed that toasted soybean meal can be substituted with chia seed meal up to 75% inclusion level in C. gariepinus diets without any negative effects on the growth and nutrient utilization.*

**Keywords:** African Catfish; Chia Seed; Fermentation; Growth Performance; Soybean Meal.

## Introduction

Fish farming is a rapidly growing industry in Africa, with Nigeria being one of the largest producers of farmed fish. Fish is a vital source of animal protein for many households. World per capital fish consumption is projected to rise in 2023, with the average individual expected to consume around 21.4 kilograms of fish per year, marking a slight increase from the previous average of 20.8 kilograms per capita; this trends to attributed to factors like increase aquaculture production and stable demand (FAO, 2023). Because of its high nutritional quality and biologically active chemicals with good effects on human health, fish is consumed by a wide range of individuals, regardless of their income, age or health.

African catfish (*Clarias gariepinus*) belongs to the family Claridae, is an important commercial species and highly relished in Nigeria and other parts of west Africa for its flesh quality and nutritional value. C. gariepinus is an omnivorous species and feast on any food material aside plants and fish. It has some unique characteristics which include fast growth rate, better feed conversion rate, high resistance to disease outbreak and poor water quality condition, easy adaptability in captivity and highly acceptability by consumers.

*Salvia hispanica* Lamiaceae also known as chia, is an annual herbaceous plant, originally from Southern Mexico and Northern Guatemala. It belongs to the order Lamiales, mint family Labiate, subfamily Nepetoideae, and genus Salvia. The genus Salvia consists of approximately 900 species, which have been widely distributed for thousands of years around several regions of the world, including Southern Africa, Central America, North and South America, and South-East Asia (Grancieri *et al.*, 2019). Chia today is not only cultivated in Mexico and Guatemala, but also in Africa, Australia, Bolivia, Columbia, Peru, Argentina, America, and Europe. Nowadays, Mexico is recognized as the world's largest chia producer (Grancieri *et al*., 2019). Historical records testify that *Salvia hispanica L*. was used beside corn, bean, and amaranth by ancient Mesoamerican cultures "Aztecs and Mayas" in the preparation of folk medicines and food. In pre-Columbian societies, it was the second main crop after beans (Ullah, et al.,2016). In the Aztecs communities, chia was used for food, cosmetics, and religious rituals. The use of plant protein sources such as soya beans in the fish diets may not be profitable due

to high cost and being serve as a good sources of protein for human consumption (Abdullahi and Mohammed, 2023). It is necessary to reduce the dependence on soybeans meal by replacing it with unconventional feed ingredients. Therefore, utilization of good quality unconventional plant protein source such as Chia seed would be beneficial and improving sustainable aquaculture in reducing the cost of production. Chia seed has a great potential of replacing soybean meal in *Clarias gariepinus* diets due to its crude protein content of about 20-26%, and 24.1%, reported by Agarwal *et al*., (2023). Thus this research aims to evaluate the effects of substituting soya bean meal with chia seed meal in the diet of *C. gariepinus* fingerlings.

## Materials and Methods

### Experimental Site

The experiment was conduct in an earthen lined pond of the Teaching and Research Fish Farm Unit, Department of Fisheries, Faculty of Agriculture, University of Maiduguri, Nigeria.

### Sources of Fish and Feed Ingredients

A total number of one hundred and fifty fingerlings of *Clarias gariepinus* was purchased from local fish farm in Maiduguri, Borno state, Nigeria. The fish were allowed to acclimatize for a week. The ingredients that were used for the formulation of experimental diets includes chia seed meal, which was procured from Potiskum main market, Yobe State, Nigeria. Toasted soya bean meal, fish meal and maize will be procured from Baga market in Maiduguri. Vitamin/mineral premix, methionine, salt, lysine, oil, will be procured from Agrovet store in Gidanmadara, Maiduguri.

### Fermentation of Chia Seed

The Chia seed was processed using fermentation method in an air-tied container for 72 hours as described by (Abdullahi *et al.*, 2022) to reduce the anti-nutritional factors.

### Experimental Diets

Five iso-nitrogenous diets were formulated at 40% crude protein using a Pearson's square method. Fermented Chia seeds was used to substitute toasted soybean meal progressively at 0%, 25%, 50%, 75%, 100%. The feed ingredient that were used in the experiment include; fish meal, (broken tilapia), chia seed, soybean meal, maize, binder, palm oil, salt, vitamin/ mineral premix, methionine and lysine as shown in Table 1.

### Experimental Design

A completely randomized design (CRD) was used. Fermented chia seeds meal was used to replace toasted soybeans meal progressively at 0%, 25%, 50%, 75% and 100% to make one control and four treatments, respectively. Each treatment was replicated three times. Ten fish were randomly assigned to 1×1 hapa net. A total of 15 hapa nets was used in an outdoor earthen lined pond. The treatments will include: Control diet (100% soya beans as protein source)

Diet 1 (25% chia seeds and 75% soya beans as protein source)
Diet 2 (50% chia seeds and 50% soya beans as protein source)
Diet 3 (75% chia seeds and 25% soya bean as protein source)
Diet 4 (100% chia seeds as a protein source). See Table 1.

**Table 1:** Composition of the Experimental Diets

| **Percentage of processed Chia seed** | | | | | |
|---|---|---|---|---|---|
| **Ingredients** | **0%** | **25%** | **50%** | **75%** | **100%** |
| **FM (%)** | 26.90 | 26.90 | 26.90 | 26.90 | 26.90 |
| **SBM (%)** | 53.80 | 40.35 | 26.90 | 13.45 | 0.00 |
| **CSM (%)** | 0.00 | 13.45 | 26.90 | 40.35 | 53.80 |
| **WM (%)** | 9.30 | 9.30 | 9.30 | 9.30 | 9.30 |
| **Premix (%)** | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| **Lysine (%)** | 2 | 2 | 2 | 2 | 2 |
| **Methionine (%)** | 2 | 2 | 2 | 2 | 2 |
| **Salt (%)** | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| **Palm oil (%)** | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| **Binder (%)** | 1 | 1 | 1 | 1 | 1 |
| **Total** | **100** | **100** | **100** | **100** | **100** |

**Key:** CSM= Chia seeds meal, FM = fish meal, SBM= soybean meal, WM = white maize.

### Proximate Analysis of the Experimental Diet

Proximate analysis of the experimental diet for each of the sample was carried out according to AOAC (Association of Official Analytical Chemistry) method, (2006).

### Growth Parameters

The data obtained on the growth response and nutrients utilization of C. *gariepinus* fed on the formulated diets were determined as described by Abdullahi *et al*., (2023).

### Weight Gain (WG)

WG = Final Weight (g) −Initial Weight (g)

### Specific Growth Rate (SGR)

$$\text{SGR (\%/day)} = \frac{\log of\ W2 - \log of\ W1}{T2 - T1} x100$$

### Survival Rate (%)

$$\text{SR} = \frac{final\ number\ of\ fish}{initial\ number\ of\ fish} x100$$

### Condition Factor (K)

$$\text{K} = \frac{W}{L^3} x100$$

### Nutrient Utilization Parameters

### Feed Conversion Ratio (FCR)

$$\text{FCR} = \frac{total\ weight\ of\ diet\ fed\ (g)}{total\ weight\ of\ fish\ (g)}$$

### Protein Efficient Ratio (PER)

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

### Data Analysis

Data obtained were analyzed using one-way analysis of variance (ANOVA) to test for significant differences among treatments means using XLSTAT version 2022, followed by LSD pair wise comparison was used to separate significantly different means at a confidence interval of 95%.

## Results

Table 2 shows the growth performance parameters of the fingerlings. Significantly highest value of mean weight gain was observed in T4 (73.89g) followed by T2 (69.23g), T1 (59.89g), T5 (55.08g) while the least was recorded in T3 (41.21g). The highest mean daily weight gain was recorded. Similarly, SGR followed the same trend, with T2 (1.90%/ day) and T4 (1.87%/ day) showing superior, while the lowest value (1.47%/ day) was recorded in T3. Condition factor (K) ranged between 1.05 and 1.20, indicating that the fish were in good condition across the treatments. The survival rate was generally high (93.33-100%), showing that the experimental diets were not toxic to the fish. The Initial weight, Survival rate there is no significant difference (P>0.05) and the Initial length, Final weight, Final length, mean weight gain, Specific growth rate, Condition factor was significantly difference (P≤0.05).

**Table 2:** Growth response of Clarias gariepinus fed experimental diets

| | Inclusion level of fermented Chia seed meal | | | | |
|---|---|---|---|---|---|
| **Parameters** | **CSM0%** | **CSM25%** | **CSM50%** | **CSM75%** | **CSM100%** |
| **IW(g)** | 5.99 ± 0.11$^{a}$ | 5.85 ± 0.11$^{a}$ | 6.16 ± 0.11$^{a}$ | 6.07 ± 0.11$^{a}$ | 5.87 ± 0.11$^{a}$ |
| **IL(cm)** | 8.83 ± 0.08$^{b}$ | 9.13 ± 0.08$^{a}$ | 8.73 ± 0.08$^{b}$ | 8.83 ± 0.08$^{b}$ | 8.80 ± 0.08$^{b}$ |
| **FW(g)** | 65.89 ± 1.44$^{c}$ | 75.31 ± 1.44$^{b}$ | 46.66 ± 1.44$^{e}$ | 80.49 ± 1.44$^{a}$ | 60.66 ± 1.44$^{d}$ |
| **FL(cm)** | 18.10 ± 0.15$^{b}$ | 18.18 ± 0.15$^{b}$ | 16.70 ± 0.15$^{c}$ | 19.73 ± 0.15$^{a}$ | 17.70 ± 0.15$^{b}$ |
| **MWG(g)** | 59.89 ± 1.30$^{c}$ | 69.23 ± 1.30$^{b}$ | 41.21 ± 1.30$^{e}$ | 73.89 ± 1.30$^{a}$ | 55.08 ± 1.30$^{d}$ |
| **SGR(%)** | 1.73 ± 0.02$^{b}$ | 1.90 ± 0.02$^{a}$ | 1.47 ± 0.02$^{c}$ | 1.87 ± 0.02$^{a}$ | 1.90 ± 0.02$^{b}$ |
| **CF** | 1.11 ± 0.01$^{b}$ | 1.20 ± 0.01$^{a}$ | 1.05 ± 0.01c$^{d}$ | 1.05 ± 0.01$^{d}$ | 1.09 ± 0.01b$^{c}$ |
| **SR(%)** | 96.67 ± 2.98$^{a}$ | 100.00 ± 2.98$^{a}$ | 96.67 ± 2.98$^{a}$ | 96.67 ± 2.98$^{a}$ | 93.33 ± 2.98$^{a}$ |

Means with the same superscript across the same row were not significantly different (P>0.05) Key: CSM = Chia seed meal, IW = Initial weight, IL = Initial Length, FW = Final weight, FL = Final length, MWG = Mean weight gain, SGR = Specific growth rate, CF = Condition factor, SR = Survival rate

Table 3 presents the nutrient utilization parameters of the experimental diets. The data include: weight gain, final length, protein efficiency ratio (PER), and feed conversion ratio (FCR). Nutrients utilization parameters there was significant difference in the protein efficiency ratio values, highest value of 3.72 was recorded in the fish fed 75% inclusion level of chia seed meal followed by 3.47 in the fish fed 25% inclusion level of the chia seed, the significantly lowest value of 3.08 was obtained in the fish fed 50% chia seed meal. The highest feed conversion ratio was recorded in 50% inclusion level with a value of 0.83 while the least 0.75 was recorded in the diet with 25%, 75% and 100% inclusion level. The protein efficiency ratio and feed conversion ratio there is no any significant difference among the treatments and the control.

**Table 3:** Nutrient Utilization Parameters of the Fish Fed Experimental Diets

| **Parameters** | **CSM0%** | **CSM25%** | **CSM50%** | **CSM75%** | **CSM100%** |
|---|---|---|---|---|---|
| **WG (g)** | 59.89 ± 1.30 | 69.23 ± 1.30 | 41.21 ± 1.30 | 73.89 ± 1.30 | 55.08 ± 1.30 |
| **FL (cm)** | 18.10 ± 0.15$^{b}$ | 18.18 ± 0.15$^{b}$ | 16.70 ± 0.15 | 19.73 ± 0.15$^{a}$ | 17.70 ± 0.15$^{b}$ |
| **PER** | 3.24 ± 0.03$^{ab}$ | 3.47 ± 0.03$^{a}$ | 3.08 ± 0.03$^{b}$ | 3.72 ± 0.03$^{ab}$ | 3.39 ± 0.03$^{ab}$ |
| **FCR** | 0.79 ± 0.10$^{a}$ | 0.75 ± 0.10$^{a}$ | 0.83 ± 0.10$^{a}$ | 0.75 ± 0.10$^{a}$ | 0.75 ± 0.10$^{a}$ |

Means with the same superscript across the same row were not significantly different (P>0.05)
Key: CSM = Chia seed meal, WG = weight gain, FL = Final length, PER = Protein efficiency ratio, FCR = Feed conversion ratio

## Discussion

The superior performance observed at 75% inclusion level can be attributed to the balanced nutrient profile of chia seed meal at this substitution rate. At this level, the diet likely provided an optimal balance of high-quality protein, essential amino acids (lysine and methionine supplementation), and omega-3 fatty acids, which enhanced growth and feed utilization. The improved fatty acid profile of chia may also have boosted metabolic efficiency and nutrient assimilation, supporting higher weight gain and growth. This finding is consistent with reports that higher inclusion of plant-based protein sources enriched with essential nutrients can improve growth when well-balanced in the diet. On the other hand, the 50% inclusion level resulted in the poorest performance. This could be due to a dietary imbalance at this substitution ratio. At half replacement, there may have been a suboptimal balance of soybean protein and chia seed protein, leading to reduced digestibility or amino acid imbalance.

The best growth occurred at 75% inclusion level of chia seed meal (final weight = 80.49g; weight gain = 73.89g), whereas the 50% inclusion level produced the lowest growth (46.66g and weight gain 41.21g). Specific growth rate peaked at 25% and 100% inclusion (1.90% $d^{-1}$) during the research. Similar findings were reported in Nile tilapia, where chia seed supplementation improved growth at moderate levels but showed no additional benefit at very high levels.

Feed conversion was most efficient at (25%, 75% and 100% inclusion level of fermented chia seeds with 0.75 and 0.83 in 50% inclusion level). This is because the lower the value of FCR the better the feed utilization by the fish (Hassan et al., 2015). This is consistent with studies showing moderate chia inclusion improves feed efficiency, and aligns with reviews noting that amino acid imbalances and anti-nutritional factors limit efficiency when plant proteins dominate diets. Protein efficiency values, highest value of 3.72 was recorded in the fish fed 75% inclusion level of chia seeds meal followed by 3.47 in the fish fed 25% inclusion level, the significantly lowest value of 3.08 was obtained in the fish fed 50% inclusion level this is align with Abdullahi et al., (2023) who reported the highest PER of 4.03 and the lowest of 3.02. Condition factor (K) ranged between 1.05 and 1.20, indicating that the fish were in good condition across treatments. The survival rate (93–100%) were high across treatments during the research.

## Conclusion

In conclusion this study revealed that fermented chia seeds meal is a good source of plant protein for fish and can be used to effectively substitute soya bean meal in the diets of *Clarias gariepinus* fingerlings at 75% inclusion level without any deleterious effect on growth and nutrient utilization.

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