

RESEARCH ARTICLE

Effects of Dietary Inclusion Levels of Soaked Sunflower Seed Meal (*Helianthus annuus*) on the Growth Performance of *Clarias gariepinus* Reared in Captivity

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Abstract

A trial was conducted to evaluate the effects of substituting soaked sunflower seed meal (*Helianthus annuus*) in the diet of *Clarias gariepinus* on production performances. A total of 720 *C. gariepinus* juveniles (initial average weight: 8.45 ± 2.85 g) were randomly assigned to four dietary treatments in a completely randomized design. The treatments consisted of four rations (Ha0, Ha25, Ha50 and Ha75), corresponding to sunflower seed meal inclusion levels of 0%, 25%, 50% and 75%, respectively, with three replicates per treatment. Fish were fed twice daily at 8% of their biomass, and zootechnical performance parameters were recorded every 14 days. The results showed that survival rates increased ($p < 0.05$) with higher levels of sunflower seed meal substitution compared to the control diet (Ha0). Total length and live weight also increased ($p < 0.05$) with increasing inclusion levels of sunflower seed meal. With the exception of feed conversion ratio (FCR) and feed intake (FI), most growth performance parameters were improved by sunflower seed meal substitution, indicating enhanced feed utilisation by the juveniles. Bromatological analysis of the flesh revealed an increase ($p < 0.05$) in crude protein and lipid contents, with the highest values observed in fish fed the Ha75 diet (95.12 ± 1.28 and 20.80 ± 0.51 , respectively). Similar trends were observed for all other biochemical parameters analysed. Overall, the use of sunflower seed meal (*Helianthus annuus*) as a partial substitute for soybean meal in the diet of juvenile *C. gariepinus* proved to be both technically effective and environmentally sustainable.

Keywords: *Clarias gariepinus*, *Helianthus annuus*, Growth Performances, Meat Quality.

1. Introduction

In Cameroon, high growth rates combined with high urbanization have led to an increase in national demand for fishery products from 409.519 tonnes in 2013 to an average of 433.616 tonnes in 2015 (MINEPIA, 2013). However, almost all of the fish consumed comes from fishing (58.7%), imports (39.6%) and aquaculture (1.7%) (Brumett and Pouomogne 2008). This is why it would be wise to focus on aquaculture in general and fish farming in particular. In Cameroon, the main aquaculture species is *Clarias gariepinus*, due to its ability to adapt to a variety of environments,

its high growth rate (Biswas and Pramanik 2016), its resistance to parasites and diseases. However, in addition to reproduction problems, the main difficulty in developing its farming is the cost of feed, which is so high because of the price of fishmeal, the main source of protein in the diet of this species. To this end, alternative sources of protein in fish feed manufacturing are currently a major concern for fish farmers. This has led to research into alternative sources of protein, particularly those that are not directly usable for human consumption (Serra et al 2024).

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The use of plant-based proteins can replace up to 50% of soybean meal in the diet of carnivorous fish without adversely affecting growth performance (Al-Owafeir et Belal 1996). Among the most commonly used oilseed by-products, sunflower seed meal (*Helianthus annuus*) is rich in protein, nicotinic acid, choline, and vitamins B and C (Nambeesan et al 2015 ; Saleh 2011). However, its utilization is limited by low palatability resulting from high levels of anti-nutritional factors, including tannins, arginase inhibitors, and protease inhibitors, whose presence in fish diets generally leads to reduced growth performance (Karamac et al 2012). Several conventional processing methods, such as sun-drying, soaking in hot water, low-temperature roasting, and germination, have been reported to reduce or inactivate these anti-nutritional compounds in feed ingredients (Punia et al 2024). Ngugi et al (2001) recommended maximum inclusion levels of 25% for roasted sunflower seed meal and 15% for unprocessed sunflower seeds in the diet of *Clarias gariepinus*. However, the efficacy of these processing methods in eliminating anti-nutritional factors that may inhibit growth in *Clarias gariepinus* has been scarcely investigated (Abbass 2007). Furthermore, the physiological response to dietary anti-nutritional factors may vary depending on fish species and rearing environmental conditions. In this context, the present study was undertaken to evaluate the effects of different inclusion levels of soaked sunflower seed meal in the diet on the production performance of the African catfish (*Clarias gariepinus*).

2. Materials and Methods

2.1 Study Area

The study was conducted from 1st March to 31st July 2025 at the Application and Research Farm (FAR-UDS) of the University of Dschang, located in the Menoua Department, West Region of Cameroon.



Figure 1. Farming structures

2.5 Experimental Rations

Four experimental diets were formulated based on a basal feed. The selection of these diets was guided

The site lies between latitudes 5°36' and 5°44' N and longitudes 9°85' and 10°06' E.

2.2 Animal Material

A total of seven hundred and twenty (720) juveniles *Clarias gariepinus*, with an initial average weight of 8.45 ± 2.85 g and a total average length of 10.51 ± 1.03 cm, were used in the experiment. The juveniles were obtained through artificial reproduction at the Application and Research Farm of the University of Dschang (FAR-UDS), using broodstock sourced from the city of Douala. Prior to the experiment, the juveniles were acclimatized for 14 days in 2 m³ fastanks and fed twice daily (08:00 and 17:00 h) with the control diet (T0) at 5% of their total biomass.

2.3 Plant Material

Sunflower seed meal (*Helianthus annuus*) was produced from *Funtua* variety sunflower seeds supplied by the IRAD (Agricultural Research and Development Institute) Dschang office. The seeds were dehulled using a local melon seed crusher and winnowed. They were then soaked in plain water for 12 hours and sun-dried for three days. The dried seeds were ground using a milling machine to obtain a fine powder, which was transported to the Agricultural Engineering Laboratory for oil extraction using a press machine, yielding the oilcake.

2.4 Rearing Structure

The feeding trial was conducted in two 6 m³ fastanks ($2.90 \times 1.90 \times 1.10$ m), each containing six 0.5 m³ hapas ($0.7 \times 0.7 \times 1$ m), suspended on all four sides from a dry, white-painted wooden support. Each tank was equipped with a water supply and drainage system, consisting of a 32 mm diameter pressure pipe connected to a borehole water source. The hapas were clearly labelled according to the dietary treatments.

by the nutritional requirements of *Clarias gariepinus*. Each diet was prepared using ingredients purchased from the same feed store in the town of Dschang.

Sunflower seed meal was included at four different levels: 0%, 25%, 50%, and 75%, following the inclusion rates used by Akintayo and Alasoadura (2001) for *C. gariepinus* growth trials.

All ingredients were first ground into fine particles. The formulated and moistened diets were then granulated using a manual granulator with a 2 mm mesh, appropriate for the growth stage of the fish,

and subsequently sun-dried to constant weight prior to use. A 100 g sample of each diet was collected and sent to the Animal Nutrition and Feeding Laboratory at the University of Dschang for proximate analysis. The analyses of the bromatological composition of the experimental diets were performed according to the method described by the AOAC in 2000, and the results are presented in Table 1.

Table 1. Experimental rations for *Clarias gariepinus*

Ingredients	Rations			
	Ha0	Ha25	Ha50	Ha75
Fish meal	23	23	23.4	23.8
Sunflower seed meal	0	24.5	30.5	40
Soybean meal	42	10.5	11.5	11
Maize meal	22	20.5	12	16.4
Wheat bran	2	2	3	3
Palm oil	5	3	3	2
Meat and bone concentrate	3.5	2	2	2
Salt	0.5	0.5	0.5	0.5
Shell meal	2	3	2	2
Total	100	100	100	100
Calculated proximate composition				
Crude protein (% DM)	55.32	58.79	57.21	57.21
Lipid (% DM)	20.47	14.44	20.71	20.80
Organic matter (% DM)	86.84	86.18	88.65	87.81
Ash (% DM)	13.16	13.82	11.34	12.18
Dry matter (% DM)	88.88	87.90	88.30	88.39
Metabolizable energy	4625	4617	4524	4514
Moisture (% DM)	5.09	4.88	4.02	4.71
Analysed proximate composition				
Dry matter (%)	92.5	91.78	91.48	92.32
Moisture (%)	7.94	8.21	8.52	7.06
Ash (%)	17.7	17.08	13.46	18.51
Organic matter (%)	82.26	82.92	86.49	81.48
Crude protein (%)	26.42	29.06	31.52	29.79
Lipid (%)	14.06	15.14	14.78	12.80
Crude fibre (%)	4.83	3.45	5.03	5.66
Gross energy (kcal/kg DM)	4492.08	4626.24	4811.32	4469.885

Ha0: control diet; Ha25: diet with 25% substitution of sunflower seed meal; Ha50: diet with 50% substitution of sunflower seed meal; Ha75: diet with 75% substitution of sunflower seed meal.

2.6 Experimental Procedure

The 720 *Clarias gariepinus* juveniles described above were randomly divided into four groups of comparable weight and size, with three replicates per group, distributed across 12 hapas. Each group was randomly assigned to one of the experimental diets.

The average stocking density was 60 fish per 400 litres (Suresh et al 2013).

Ha0: control diet; Ha25: diet with 25% substitution of sunflower seed meal; Ha50: diet with 50% substitution of sunflower seed meal; Ha75: diet with 75% substitution of sunflower seed meal.

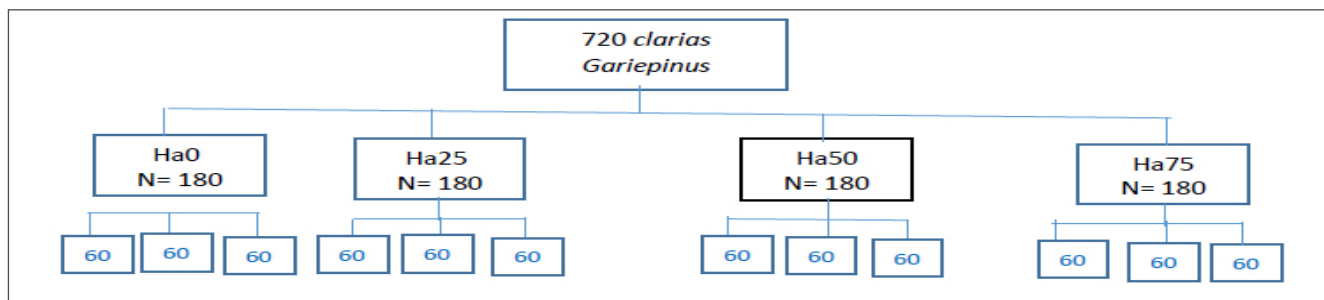


Figure 2. Experimental design

Ha0: control diet; Ha25: diet with 25% substitution of sunflower seed meal; Ha50: diet with 50% substitution of sunflower seed meal; Ha75: diet with 75% substitution of sunflower seed meal.

During the trial, fish were fed at 8% of their biomass per day, provided in two daily meals at fixed times (08:00–09:00 and 16:00–17:00). Feed quantities were adjusted every 14 days based on sampling catches. During these control samplings, fish from each group were individually weighed using an SF-400 electronic scale (capacity: 10 kg; accuracy: 1 g) and measured for total and standard length using a 1 mm precision graduated ichthyometer to assess growth performance.

2.7 Parameters Evaluated and Data Collection

2.7.1 Growth and Survival Parameters

Survival rate

This was assessed by the number of fish alive at the end of the experiment period compared to the number at the start of the experiment, using the following formula:

$SR = (N_f/N_i) \times 100$. Where N_f is the final number of fish and N_i is the initial number of fish

Feed consumption (FC)

Amount of feed ingested over a given period. It was calculated using the following formula: $FC = (\text{Amount of feed} \times \text{number of days}) / \text{number of fish}$

Feed conversion ratio (FCR)

This is a criterion used in animal husbandry to measure the efficiency of feed conversion into a given production. Its formula is:

$FCR = \text{Amount of feed served} / \text{Weight gain}$

Weight gain

This allows the weight gain of fish over a given period to be assessed. It was calculated using the following formula: $\text{Weight gain (g)} = \text{Final weight (g)} - \text{Initial weight (g)}$



Figure 3. Weight measurement

Average daily gain (ADG)

Average daily gain (ADG) or daily growth rate (DGR) represents the average daily weight gain achieved during the rearing period. It was calculated as follows: $(P_{mf} - P_{mi}) / \Delta t$. Where P_{mf} = final average weight, P_{mi} = initial average weight, Δt = duration of the trial (days).

Specific growth rate

This coefficient is used to evaluate the weight gained by the fish each day as a percentage of its live weight.

$SGR (\%/day) = \ln(\text{final weight}) - \ln(\text{initial$

$\text{weight})] \times 100 / \text{Duration of the experiment in days.}$

Weight-length relationship

The relationship between the total length of fish and their weight is generally exponential. This relationship allows growth to be assessed.

$TW = a TL^b$, (where a = regression constant, b = allometry coefficient, TL = total length (cm) and TW = total weight (g).

2.7.2 Condition Factor K

The condition factor or coefficient K is defined as the ratio between the weight and size of the fish. It is given by the formula (Tesch, 1971; Lalèyè et al 1995b):

$K = (TW / TL^b) \times 100$. Where TW = total fish weight (g), TL = total fish length (cm) and b = allometric coefficient.

2.7.3 Carcass Composition

At the end of the trial, five individuals per treatment were randomly selected from each experimental unit, weighed and measured, then killed with a sharp blow to the skull in order to assess the bromatological and biochemical characteristics of the flesh after taking 100 g of dorso-ventral muscle samples. The analyses were performed according to the method described by the AOAC in 2000.

2.8 Statistical Analysis

The data collected were subjected to one-way analysis of variance (ANOVA). In the event of significant differences between treatments, Duncan’s test was

applied to separate the means at a significance level of 5%. SPSS20.0 statistical software (Statistical Package for Social Science, 2020) was used for data analysis.

3. Results

3.1 Effect of the Incorporation Rate of Soaked Sunflower Seed Meal on the Survival and Growth Characteristics of *Clarias gariepinus* Juveniles

3.1.1 Survival Rate of *Clarias gariepinus* Juveniles

Figure 3 illustrates the effect of the incorporation rate of soaked sunflower seed meal on the survival rate of *Clarias gariepinus* juveniles. It shows that the animals fed with ration Ha25 recorded the highest value, which was statistically higher ($p < 0.05$) than those of the fish fed with the other three rations, whose values were comparable to each other ($p > 0.05$).

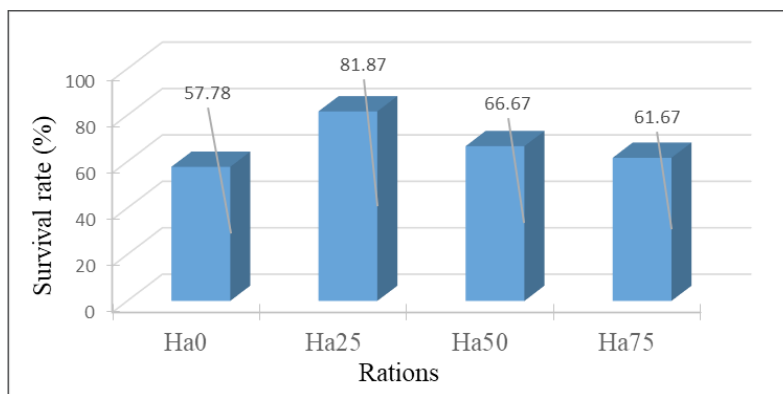


Figure 4. Effect of the incorporation rate of soaked sunflower seed meal on the survival rate of *Clarias gariepinus* juveniles

Ha0: control diet; Ha25: diet substituted with 25% sunflower meal; Ha50: diet substituted with 50% sunflower meal; Ha75: diet substituted with 75% sunflower meal.

3.1.2 Effect of the Incorporation Rate of Soaked Sunflower Seed Meal on Growth Characteristics in *Clarias gariepinus* Juveniles

rates of soybean meal substitution with soaked sunflower seed meal on the growth performance of *Clarias gariepinus* juveniles.

Table 2 summarises the observed effect of increasing

Table 2. Effect of the incorporation rate of soaked sunflower seed meal on growth characteristics in *Clarias gariepinus* juveniles

Growth characteristics	Rations				SE	P
	Ha0	Ha25	Ha50	Ha75		
TL	15.95±0.50c	16.23±0.57c	18.70±0.60b	20.08±0.58a	0.53	0.001
BW	47.33±3.68c	53.16±2.75b	53.88±2.22b	67.61±2.37a	2.34	0.001
WG	39.16±2.75c	44.49±4.76b	45.83±1.00b	59.35±3.59a	2.44	0.001
SGR	0.84±0.12	0.97±0.11	1.48±0.08	1.64±0.01	0.36	0.909
ADG	0.32±0.09c	0.36±0.04b	0.38±0.07b	0.49±0.05a	0.07	0.001
CF	1.31±0.18a	1.10±0.03b	0.82±0.11c	0.83±0.04c	0.06	0.002
FC	156.36±6.57	132.65±9.39	180.18±12.13	118.52±3.15	0.38	0.952
FCI	4.41±0.39	3.68±0.47	4.28±1.05	2.98±0.82	0.24	0.151

a, b and c: averages marked with the same lowercase letters on the same line are not significantly different ($p > 0.05$); p: probability; Ha0: control ration; Ha25: ration substituted with 25% sunflower meal; Ha50: ration substituted with 50% sunflower meal; Ha75: ration substituted with 75% sunflower meal. FC = feed consumption, BW = body weight, TL = total length, WG = weight gain, ADG= average daily gain, SGR = specific growth rate, FCI = feed conversion index, CF = condition factor.

Table 2 shows that the incorporation rate of soaked sunflower seed meal had no effect ($p>0.05$) on specific growth rate, feed intake and feed conversion ratio. The values for live weight (67.61 ± 2.37), weight gain (59.35 ± 3.59), total length (20.08 ± 0.58) and average daily gain (0.49 ± 0.05) of animals fed the Ha75 ration were the highest and statistically superior ($p<0.05$) to those of animals fed the other three rations.

The K factor of animals fed the control ration (1.31 ± 0.18) was the highest and statistically higher ($p<0.05$) than that of animals fed the Ha25 ration (1.10 ± 0.03), which was also statistically higher ($p<0.05$) than that of animals fed the other two rations.

Table 3. Weight-length relationship in *Clarias gariepinus* according to the incorporation rate of sunflower seed meal

Rations	Equation	R ²	A	B	Growth type
Ha0	$P = 0.0478LT^{3.4826}$	0.4014	0.0478	3.4826	Positive allometry
Ha25	$P = 0.0011LT^{4.008}$	0.817	0.0011	4.008	Positive allometry
Ha50	$P = 0.0122LT^{3.0545}$	0.7419	0.0122	3.0545	Positive allometry
Ha75	$P = 0.0154LT^{3.9344}$	0.7503	0.0154	3.9344	Positive allometry

Ha0: control ration; Ha25: ration substituted with 25% sunflower meal; Ha50: ration substituted with 50% sunflower meal; Ha75: ration substituted with 75% sunflower meal.

3.2 Effect of the Incorporation Rate of Soaked Sunflower Seed Meal on the Bromatological and Biochemical Composition of the Carcass

The effect of incorporating soaked sunflower seed meal on the bromatological characteristics of *Clarias gariepinus* flesh reveals that only crude protein and fat content were statistically influenced ($p<0.05$). The animals in the control group (55.32 ± 0.96) produced the lowest protein content, which was significantly lower ($p<0.05$) than that of the animals in the other three groups. The same observation was made in

3.1.3 Relationship between Weight and total Length of *Clarias gariepinus* Juveniles as a Function of the Incorporation Rate of Sunflower Seed Meal

The influence of the level of incorporation of sunflower seed meal in the ration on the weight-length relationship of *Clarias gariepinus* juveniles (Table 3) shows that the allometry coefficient b was greater than 3 for the Ha25 ration and equal to 3 for the Ha0, Ha50 and Ha75 rations. However, the weight of juvenile *Clarias gariepinus* is highly correlated with total length, with R² close to 1.

animals fed the Ha25 ration (14.44 ± 0.21) with regard to fat content.

The blood biochemical parameters of animals fed the Ha75 ration were the statistically highest ($p<0.05$) compared to those of animals fed the other rations. The lowest values in terms of total protein (2.31 ± 0.01), albumin level (0.74 ± 0.15) and globulin level (1.60 ± 0.26) were recorded in animals fed the Ha25 ration. Furthermore, animals fed the control ration produced the lowest values for total cholesterol (69.23 ± 1.07) and HDL cholesterol (25.80 ± 0.25).

Table 4. Effects of the incorporation rate of sunflower seed meal in the diet on the bromatological and biochemical characteristics of *C. gariepinus* meat

Bromatological and biochemical characteristics	Rations				SE	P
	Ha0	Ha25	Ha50	Ha75		
Bromatological characteristic						
DM (%)	94.91±0.89	95.12±1.28	95.98±0.41	95.29±2.35	0.37	0.814
CP (%DM)	55.32±0.96 ^b	58.79±0.89 ^a	57.21±0.88 ^a	57.21±0.88 ^a	0.50	0.012
FM (%DM)	20.47±0.20 ^a	14.44±0.21 ^b	20.71±0.06 ^a	20.80±0.51 ^a	0.81	0.001
Ash (%DM)	13.16±0.51	13.82±1.61	11.34±1.55	12.18±2.03	0.47	0.285
OM (%DM)	86.84±0.51	86.18±1.61	88.65±1.55	87.81±2.03	0.47	0.285
Humidity (%)	5.09±0.89	4.88±0.28	4.02±0.41	4.71±2.35	0.37	0.814
Biochemical characteristic						
TP (g/dl)	2.75±0.26 ^b	2.31±0.01 ^b	2.64±0.02 ^b	4.41±0.04 ^a	0.25	0.001
Albumin (g/dl)	0.8±0.17 ^b	0.74±0.15 ^b	0.68±0.04 ^b	1.23±0.1 ^a	0.07	0.003
Globulin (g/dl)	1.96±0.05 ^b	1.60±0.26 ^c	1.93±0.06 ^b	3.14±0.05 ^a	0.17	0.001

TC (mg/dl)	69.23±1.07 ^c	71.07±0.86 ^b	70.35±0.17 ^b	81.70±1.89 ^a	1.53	0.001
HDL (mg/dl)	25.80±0.25 ^d	28.27±0.05 ^c	35.76±0.05 ^b	54.82±0.01 ^a	3.43	0.001
TGS (mg/dl)	149.76±0.46 ^b	141.79±0.20 ^c	139.44±0.44 ^d	231.87±0.02 ^a	11.57	0.001

a, b, c and d: averages with the same lowercase letters on the same line are not significantly different ($p > 0.05$). p=Probability Ha0: control ration; Ha25: ration substituted with 25% sunflower meal; Ha50: ration substituted with 50% sunflower meal; Ha75: ration substituted with 75% sunflower meal. DM = dry matter; CP = crude protein, FM = fat, OM = organic matter; TP = total protein, TC= total cholesterol, HDL = high-density lipoprotein, TGS = triglycerides.

4. Discussion

The results of this study show that the total length (TL), live weight (LW), weight gain (WG) and average daily gain (ADG) of the fish increased significantly with the incorporation rates of sunflower meal, reaching their maximum values at 75% substitution. This result suggests that the treatment applied (soaking) reduced the load of antinutritional factors and improved the digestibility of protein and energy. Similar results were reported by Akintayo and Alasoadura (2001), who showed that the incorporation of toasted sunflower seeds into the feed of *Clarias gariepinus* did not negatively affect growth up to 25%. Similarly, El-Saidy and Gaber (2002) observed that sunflower meal could replace soybean meal in tilapia at levels of 25–50% without compromising growth performances, especially when supplemented with lysine. In African catfish, Azaza and Assad (2013) had already shown that technological processing of plant ingredients (soaking, cooking) reduced tannins and phytates, thereby promoting better nitrogen utilization.

Unlike growth parameters, the condition factor (K) decreased significantly as the substitution rate increased. This suggests that fish fed sunflower meal have a more elongated morphology, probably related to lower body fat content. This result is consistent with the observations of Nwakaji et al (2021), who reported that the use of low-lipid ingredients in *Clarias gariepinus* diets led to a reduction in fat deposition. The prior extraction of oil from sunflower meal therefore explains this decrease in the condition index.

Feed intake, feed conversion ratio and specific growth rate were not influenced ($p > 0.05$) by the treatments, indicating that sunflower meal has no negative effect on the palatability of the ration. These results are consistent with those of Olvera-Novoa et al (2022), who showed that fish could maintain their feed efficiency when local vegetable proteins partially replaced soybean meal, provided that the essential amino acid profile remained balanced.

Bromatological analysis of the meat showed that partial substitution of soybean meal with soaked

sunflower meal improved crude protein content, with a peak observed at 25% substitution rate (58.79% DM) compared to 55.32% for the control. This increase can be attributed to the high sulphur amino acid content of sunflower, which promotes muscle growth, and is consistent with the observations of Ngugi et al (2001). In contrast, the lipid content decreased at R25% (14.44%) but remained high at R50% and R75% (20–21%), reflecting good energy density linked to the presence of polyunsaturated fatty acids (Turchini et al 2009). Ash and organic matter levels did not vary significantly, confirming that the substitution did not affect the overall mineral content of the rations. These results suggest that soaked sunflower meal may be an attractive protein alternative, particularly at levels of 25 to 50%, which maximise the balance between protein and energy.

Total protein, albumin and globulin levels increased to 75% of the replacement level (4.41 g/dl; 1.23 g/dl and 3.14 g/dl respectively), revealing better protein assimilation and increased hepatic stimulation, as well as improved humoral immunity thanks to the natural polyphenols and antioxidants contained in sunflower seeds. The same observation was made with lipid parameters, in terms of total cholesterol and triglyceride levels (81.7 mg/dl and 231.9 mg/dl), accompanied by a favourable increase in HDL cholesterol (54.8 mg/dl). This situation reflects both good lipid regulation and possible metabolic overload when the substitution rate is too high.

5. Conclusion

This study shows that incorporating sunflower meal (*Helianthus annuus*) in the diet of *Clarias gariepinus* juveniles improves most growth performance and survival rates compared to the control diet. This incorporation also improves the crude protein content of the flesh and tends to reduce the fat content, as well as all beneficial biochemical parameters. It would be wise to take this research further by evaluating the effect of different levels of sunflower meal (*Helianthus annuus*) incorporation in adult diets on the health, reproductive performance and meat quality of *Clarias gariepinus*.

6. References

- 1 Abbass F E 2007 Effect of dietary oil sources and levels on growth, feed utilization and whole body chemical composition of Common Carp, *Cyprinus carpio* L. *Fingerlings. J. Fish. Aquat. Sci.*, 2(2): 140-148.
- 2 Akintoyo O T and Alasoadura T A 2001 Dietary protein requirements of clariid catfish hybrid, *Clarias gariepinus x Heterobranchus bidorsalis*, fry fed practical diets. *Journal of Applied Aquaculture*, 11(4): 93–101.
- 3 Al-Owafeir M A and Belal H E I 1996 Replacing palm oil for soybean oil in tilapia, *Oreochromis niloticus* {L.}, feed. *Aquaculture Research*, 27(4): 221-224.
- 4 AOAC 2000 Méthodes officielles d'analyse (17^e édition). North Frederick Avenue Gaithersburg, Maryland, États Unis: Association of Official Analytical Chemists.
- 5 Azaza A and Assad W 2013 Effets de la densité d'élevage sur la croissance, l'hétérogénéité de la taille et de la variation interindividuelle de la consommation alimentaire chez les mono sexes mâles du tilapia du Nil. *Animal*, 7(11) :1865-1874. Doi : 10.1017/S1751731113001493.
- 6 Biswas J and Pramanik S 2016 Evaluation de la qualité de l'environnement aquatique à l'aide de Gyrodactylus sp.comme sonde vivante : biosurveillance parasitaire de la santé des écosystèmes. *J.AdviEnviron.Health Res.* 4 : 219-226. Doi: 10.22102/jaehr.2012.45840.
- 7 Brumett R E and Pouomogne V 2008 Small-scale aquaculture business planning in Cameroon. In Elghobashy H, Fitzsimmons K and Diab A S (eds.), *Proceeding of the 8th International Symposium of Tilapia in Aquaculture*, October 2008, Vol.1, P: 679-691.
- 8 El-Saidy D M S D and Gaber M M A 2002 Complete replacement of fish meal by soybean meal with dietary L-lysine supplementation for Nile tilapia (*Oreochromis niloticus* L.) fingerlings. *Journal of the world Aquaculture Society*, 33(3): 297-306.
- 9 Karamac M, Kosinska A, Estrella I, Hernandez T and Duenas M 2012 Activité antioxydante des composés phénoliques identifiés dans les graines de tournesol. *European Food Research Technology*, 235 :221-230. DOI : 10.1007/s00217-012-1751-6.
- 10 Lalève P, Philippart J C and Poncin P 1995b Biologie de la reproduction de deux espèces de Chrysichthys (Suliformes, Bagridae) du lac Nokoué et de la lagune de Porto-Novo au Bénin. *Revue de Zoologie Africaine*, 109:213-224.
- 11 MINEPIA 2013 Plan de développement durable de l'Aquaculture au Cameroun, Yaoundé. Ministère de l'Élevage, des pêches et des Industries Animales, *minipia.cm*, p55.
- 12 Nambeesan S U, Mandel J R, Bowers J E, Marek L F, Ebert D, Corbi J, Rieseberg L H, Knapp S J and Burke J M 2015 Association mapping in sunflower reveals independent control of apical vs basal branching. *BMC plant Biology*, 15:84. <https://doi.org/10.1186/s12870-015-0458-9>
- 13 Ngugi W K, Lim P K and Sidek H 2001 The influence of dietary lipid source on growth, muscle fatty acid composition and erythrocyte osmotic fragility on hybrid tilapia. *Fish Physiol. Biochem.*, 25: 301-310.
- 14 Nwakaji S, Aliu B S and Nwose F O 2021 Effect of dietary lipid sources on feed utilization, growth efficiency and carcass composition of *Clarias gariepinus* juveniles. *Asian Journal of Fisheries and Aquatic Research*, 15(3):1-9.
- 15 Olvera-Novoa M A, Olivera-Castillo L and Martínez-Palacios C A 2022 Sunflower seed meal as a protein source in diets for Tilapia rendalli fingerlings. *Aquaculture Research*, 33(3): 223–229. <https://doi.org/10.1046/j.1365-2109.2002.00666.x>.
- 16 Punia N, Singh D and Priyanka 2024 Approaches to use anti-nutritional factors containing plant-based protein-rich aquafeeds. *Uttar Pradesh Journal of Zoology*, 45(7): 72-82. <https://doi.org/10.56557/UPJOZ/2024/v45i73977>.
- 17 Saleh K 2011 Metabolism, interactions, requirements and functions of vitamin E in fish. *Aquaculture Nutrition*, 17(1), 98–115. <https://doi.org/10.1111/j.1365-2095.2010.00738.x>
- 18 Serra V, Pastorelli G, Tedesco D E A, Turin L and Guerrini A 2024 Alternative protein sources in aquafeed:current scenario and future perspectives. *Veterinary and Animal Science*, 25: 100381. <https://doi.org/10.1016/j.vas.2024.100381>
- 19 Suresh K M, Biswajit D, Pattnaik P, Anbarasu M and Joseph I 2013 Effet de la densité d'élevage sur la croissance et la survie des alevins de bar asiatique, Lates calcarifer(Bloch), élevés en éclosérie en conditions de captivité. *Indian Journal of Fisheries*, 60(1):71-75.
- 20 Tesch F W 1971 Age and Growth.In : Methods for Assessment of Fish production in Fresh waters.IBP Handbook No.3. *Blackwell Scientific Publicatons,Oxford*, 98-130.
- 21 Turchini G M and Francis D S 2009 Fatty acid metabolism (desaturate, elongation and b-oxidative) in rainbow trout fed fish oil or linseed oilbased diets. *British journal of Nutrition*, 102(1):69-81, DOI:10.1017/S0007114508137874.