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Growth Performance of *Oreochromis niloticus* fed Different Inclusion Levels of Fermented Roselle (*Hibiscus sabdariffa*) Seed Meal Diets

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Abstract: *This study evaluated the suitability of fermented Roselle Hibiscus sabdariffa seed meal as a partial replacement for soybean meal in the diets of tilapia, Oreochromis niloticus. Roselle seeds were subjected to different processing methods: boiling, fermentation, sprouting and toasting. The results for the proximate composition of Raw and Processed Roselle seeds indicated that the crude protein level was higher in Fermented Roselle (24.97 %), followed by Toasted (24.85 %), Boiled (24.75 %), Raw (24.54 %) and lowest was found in Sprouted (23.25 %). All these values were significantly different (p<0.05). Fermented meal was incorporated into four iso-nitrogenous diets at 25%, 50%, 75%, 100% and 0% control to replace soybean meal. A total of 150 Oreochromis niloticus fingerlings were randomly distributed into experimental units (10 fingerlings per bowl and replicated) and fed for 84days. The result recorded for the growth performance were significantly different (p<0.05). O. niloticus fed 25% inclusion level of fermented roselle seed meal had the highest mean weight gain of 17.16g, followed by the fish fed 100% (15.79g); 75% (8.82g), 0% control treatment (7.46g) and lowest values recorded was from the fish fed 50% inclusion level (5.99g). In conclusion Fermentation method employed in this study had significant effects on the Growth performance of O. niloticus.*

Keywords: *Hibiscus sabdariffa*, *Oreochromis niloticus*, soybean and growth performance.

INTRODUCTION

Over the past decade aquaculture has grown in response to an increasing demand for fish as a source of protein globally (Watkiss et al., 2019). This is because production from captured fisheries has reached its maximum potential possible, as the catch is dwindling with each passing day (Watkiss et al., 2019). According to FAO (2020), fish supplies from capture fisheries will therefore, be unable to meet the

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growing global demand for aquatic food. The present requirement of fish was put at 3.2 million metric tonnes according to National Biotechnology Development Agency. It further puts our production at 1.1 million metric tonnes leaving a deficit of a little over 2 million metric tonnes (Premium times, 2016). Therefore, there is the need for a viable alternative fish production that can sufficiently meet this demand, and aquaculture fits exactly into this role. As aquaculture production becomes more intensive in Nigeria, fish feed is a significant factor in increasing the productivity and profitability of aquaculture (Watkiss et al., 2019).

Fish feeds constitutes 40-60% of the total cost of aquaculture production which is expensive and led to extensive studies on replacing a costly protein especially soya bean in fish diets (Prabu et al., 2017). Similarly, Salih et al. (2021) observed that fish feed constitutes 60- 70% of the operational cost in the intensive and semi-intensive aquaculture system. The need to minimize feed cost through the use of new and cheaper sources of feed ingredients is currently receiving the attention of nutritionists and the selection of feed ingredients for use as fish feed (Salih et al., (2021). There is high competition for foodstuffs between human and domestic animals. (Prabu et al. 2017).

Experimental Site

The experiment was conducted at the wet Laboratory, Department of Fisheries and Aquaculture, Federal University Gashua (FUGA), Gashua, Yobe State, Nigeria. It is located along Nguru road in Gashua, Bade Local Government Area of Yobe State. Yobe state is located in the northern eastern region of Nigeria, between latitude $10^{o}34^{1}$ N and $13^{o}23^{1}$N and longitudes $90^{o}40^{1}$ E and $12^{o}41^{1}$ E. (ACReSAL and MTEF 2023).

Source of Roselle (*Hibiscus sabdariffa)* Seed

Roselle (*H. sabdariffa)* were purchased from Gashua market, Bade Local Government Areas, Yobe State.

Processing Methods of Roselle *Hibiscus sabdariffa* Seeds according to Ahmed et al. (2012)

i**.** Five hundred (500) grams of Roselle seeds were thoroughly cleaned, milled and tagged Raw *Hibiscus sabdariffa* meal (RHSM)

ii. Five hundred (500) grams of Roselle seeds were Boiled for 30 minutes, milled and tagged Boiled *Hibiscus sabdariffa* meal (BHSM)

iii. Five hundred (500) grams of *Hibiscus Sabdariffa* seeds were boiled at 1:3 seed to water for 30 minutes, the water was drained and allowed to cool. The boiled seeds were kept in an air tight sack for 72 hours to ferment (solid fermentation) and tagged Fermented *Hibiscus sabdariffa* meal (FHSM)

iv. Five hundred (500) grams of Roselle seeds were cleaned, washed and soaked in water for 24 hours and kept in sack to sprout, dry and mill, then tagged Sprouted *Hibiscus sabdariffa* meal (SHSM)

v. Five hundred grams of Roselle seeds were Toasted for 30 minutes, milled and tagged Toasted *Hibiscus sabdariffa* meal (THSM).

Experimental Diets Formulation

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Five iso-nitrogenous diets were formulated using the best processed method (Fermented) *Hibiscus sabdariffa* seeds meal. A 35% crude protein diet was formulated; the control diet (0%) consists of soybean without Roselle seed meal. The fermented *H. sabdariffa* seed meal was used to replace soybean at inclusion levels of 25%, 50%, 75%, and 100%. The ingredient composition of the experimental diets as shown in Table 1.

Table 1. Composition of the Experimental Diets

INGREDIENTS (g/100g)	0%	25%	50%	75%	100%
Soya bean (43%)	52.0	39.0	26.0	13.0	0.00
H. sabdariffa (24.97%)	0.00	13.0	26.0	39.0	52.0
Fish meal (50%)	20.0	20.0	20.0	20.0	20.0
Yellow Maize (10%)	23.0	23.0	23.0	23.0	23.0
Vitamin/Mineral premix	1.5	1.5	1.5	1.5	1.5
Lysine	1.0	1.0	1.0	1.0	1.0
Methionine	1.0	1.0	1.0	1.0	1.0
Oil	0.5	0.5	0.5	0.5	0.5
DCP	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

DCP=Dicalcium phosphate

Proximate Analysis

Proximate composition of raw and differently processed *Hibiscus sabdariffa* seeds meal and feed formulated were carried out according to Association of Official Analytical Chemists International (AOAC, 2002) methods.

Experimental Design

A completely randomized design was used, were 150 fingerlings of *O. niloticus* were allocated to 10 fingerlings per plastic bowls and replicated. Fifteen (15) plastic bowls of 20 liters'capacity were used

Data Collection

The initial weight and length of each fish in each treatment were taken. The growth performance was measured weekly for 12 weeks. The quantity of feed fed was adjusted weekly based on the biomass.

Growth *Performance*

At the end of 12 weeks, the following parameters was computed and analyzed.

Weight gain (g)

The total and mean weight gains was calculated for each replicate and treatment as follows (Busacker et al. 2012) :

Weight gain / fish (g/fish) = $(W_f - W_I)$

Mean weekly weight gain (g/week) = $\frac{W_f - W_I}{\quad}$

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n

Where:
W_f =final weight of fish at the end of the experiment
W_I=Initial weight of fish at the beginning of the experiment
n=Number of weeks.

Relative growth rate (RGR)

This is the percentage ratio of the weight gained to the initial body weight and was determined as follows:

$$RGR\ (\%) = \frac{W_f - W_I}{W_I} \times 100$$ Ahmed et al. (2012)

Specific growth rate (SGR %/day)

This is the percentage of daily weight gain and was computed according to the formula below:

$$SGR\ (\%/day) = \frac{Log\ Wf - Log\ Wi}{t} \times 100$$ Ahmed et al. (2012)

Where:
Log W_f = Logarithm of the fish final weight
Log W_I = Logarithm of the fish initial weight
t = Experimental period in days

Condition factor (K)

This expresses the health status of fish as a result of the experimental treatment and was computed at the beginning and end of the experiment (K1 and K2) using the Fulton's conditor factor formular as expressed by Bagenal (1978) as:

$$K = \frac{100W}{L^3}$$

Where:
W = Weight of fish
L = Length of fish

Survival (%)

$$SR\ (\%) = \frac{N_f}{N_i} \times 100$$

Where:
N_i = Number of cultured fish stocked at the beginning of the experiment
N_f = Number of fish alive at the end of the experiment

Feed conversion ratio (FCR)

This is a numerical value used to measure the utilization of feed for growth. Feed conversion ratio was calculated following Aderolu, et al. (2010) as shown below.

FCR = Feed Intake

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Weight gain (g)

Feed intake (FI)
This was taken as the addition of the amount of feed supplied during the experimental period.

Protein intake (PI)
This is the numerical value of the quantity of protein present in the feed that was fed to the fishes during the experimental period and was determined following Ayoola et al. (2012) as shown below:
Protein Intake = Feed Intake x Crude protein

Protein efficiency ratio (PER)
This index uses growth as a measure of nutritive value of dietary protein as:

$$PER = \frac{\text{Mean weight gain (g)} \quad (x)}{\text{Mean Protein Intake (g of protein in 100g of diet/fish)}}$$

Ahmed et al. (2012)

Statistical Analysis
Data obtained from this study were subjected to One-way Analysis of Variance (ANOVA). Differences between the means were determined using Least Significant Difference (LSD) at 5% confidence level (P = 0.05) with the aid of SPSS statistical package.

RESULTS AND DISCUSSION

Proximate Composition of differently Processed Roselle (*Hibiscus sabdariffa*) seeds.
The proximate composition of differently processed *Hibiscus sabdariffa* seeds as shown in Table 2. The Crude protein ranged from 23.25-24.97 % with the highest value of (24.97) recorded from fermented *Hibiscus sabdariffa* seeds, followed by toasted with (24.85%), boiled (24.75 %) and raw recoded (24.54 %) recorded and the lowest (23.25%) was recorded from soaked *Hibiscus sabdariffa* seeds. There was significant different. ($p<0.05$) in the crude protein composition of differently processed *H.* sabdariffa seeds. Crude fibre content ranged from 18.45- 19.01% with the highest value of (19.01%) recorded from soaked followed by (18.67 %) recorded from toasted (18.66 %) recorded from raw, (18.57%) from boiled and the lowest (18.45%) was recorded in fermented. There was significant different ($p<0.05$) from the experimental treatments. Ether extract ranged from 16.54-18.02 %. The highest value of (18.02%) was recorded from raw, followed by toasted, boiled (18.01 %) (17.98 %). (17.87%) was recorded from fermented and the lowest value of (16.54 %) was recorded from soaked. There was significant different ($p<0.05$) between the raw, boiled, fermented and soaked. Toasted did not differ significantly ($p>0.05$) with raw.

Table 2: Proximate Composition of Differently Processed Roselle (*Hibiscuss sabdariffa*) Seeds

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Nutrients	Raw	Boiled	Fermented	Soaked	Toasted
Crude Protein	24.54±0.01[d]	24.75±0.01[c]	24.97±0.01[a]	23.25±0.01[e]	24.85±0.01[b]
Crude Fibre	18.66±0.05[b]	18.57±0.01[c]	18.45±0.01[d]	19.01±0.01[a]	18.67±0.05[b]
Either Extract	18.02±0.01[a]	17.98±0.01[b]	17.87±0.41[c]	16.54±0.01[d]	18.01±0.01[ab]
Ash	6.86±0.01[c]	7.01±0.01[b]	7.16±0.01[a]	5.57±0.01[e]	5.95±0.01[d]
NFE	25.23±0.01[d]	26.35±0.01[c]	24.56±0.01[e]	29.88±0.03[a]	27.35±0.01[b]
Moisture	6.68±0.01[b]	5.34±0.01[d]	6.97±0.01[a]	5.75±0.01[c]	5.16±0.01[e]
Dry Matter	93.31±0.005[d]	94.66±0.01[b]	93.02±0.01[e]	94.25±0.01[c]	94.83±0.01[a]

Means on the same row with the same superscripts are not significantly different ($p<0.05$)

Ash content ranged from 5.57 % -7.16 %; the highest value of (7.16 %) was recorded in the fermented, followed by (7.01 %) in boiled and (6.86 %) was recorded in raw while (5.95%) was recoded in toasted and the lowest value of (5.57 %) was recorded in soaked. There was significant different ($p<0.05$) in the ash content of differently processed *H. sabdariffa* seed. The Nitrogen free extract (NFE) ranged from 24.56-29.88 % with the highest value of (29.88 %) was recorded from soaked, followed by (27.35 %) from toasted (26.35 %) was recorded from boiled while (25.23 %) was recorded from raw and the lowest value of (24.56 %) was recorded from fermented. There was significant ($p<0.05$) different in the Nitrogen free extract composition of differently processed H. sabdariffa seeds. Moisture content ranged from 5.16-6.97 % with the highest value of (6.97%) recorded from fermented, followed by (6.68 %) from raw (5.75 %) was recorded from soaked while (5.34%) was recorded from boiled and lowest value of (5.16 %) was recorded from the toasted. There was significant different ($p<0.05$) from the moisture content of differently processed *Hibiscus sabdariffa* seed. Dry matter content of differently processed *Hibiscus sabdariffa* seed ranged from 93.02-94.83 % with the highest value of (94.83 %) was recorded from toasted, followed by (94.66%) from boiled (94.25 %) from soaked while (93.31 %) from raw and the lowest value of (93.02%) was recorded from fermented. There was significant difference ($p<0.05$) in the dry matter content differently processed *H. sabdariffa* seeds.

The crude protein (CP) of the fermented *H. sabdariffa* seed recorded from this study was higher (24.97 %) compared to the value of (21.74 %) reported by Angbulu et al. (2019). The increase in protein content following fermentation might be attributed to microbial activity, whereby microorganisms utilize carbohydrates as an energy source while synthesizing microbial protein and reducing anti-nutritional factor, resulting in an increasing the relative protein concentration of the seed. Similar findings were reported by Olaoye et al. (2025), who reported that fermentation enhance nutrient availability and reduced anti-nutritional compounds. However, the crude protein values from this study were higher compared to the results reported by Owosibo et al. (2018). Likewise, the crude protein values reported from different processing methods from this study were also similar to the values reported by Usman et al. (2023). The lowest crude protein values were recorded from soaked which is in agreement with the findings reported by Olaoye et al. (2025), who attributed that the reduction in protein content after soaking was probably due to the leaching of soluble nitrogenous compounds into soaking medium. The crude fibre (FC) content recorded from this study was higher than to the result reported by Usman et al. (2023) and Yunusa Aliyu

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et al. (2023). In contrast, Angbulu et al. (2019) reported lower (6.0 %) CF value from raw (control) and (6.28 %) from soaked *H. sabdariffa* seeds, which are considerably lower than the values recorded from this study. Conversely, Taofik et al. (2018) reported higher CF contents of (27.26 %) and (26.22 %) from raw (control) and processed fermented *H. sabdariffa* seed meal (FHSSM), respectively, exceeding the values recorded from this study. However, the crude fiber values reported by Hainida et al. (2008), 17.89 % and 18.35 %, was comparable to those recorded from this study, indicating a closer agreement between the findings. The ether extract (EE) values recorded from this study for unprocessed and processed *H. sabdariffa* seeds was higher than 5.27 % and 5.73 % EE values reported for raw and soaked *H.sabdariffa* seed by Igwebuike et al. (2010). Toafik et al. (2018) recorded lower (15.92 and 9.22 %) EE value for raw and processed HSSM than the value reported from this study. Angbulu et al. (2019) recorded higher values of (26.79 and 22.22 %) from raw and processed HSSM than the value recorded from this study. In contrast, higher value was reported by Olaoye et al. (2025) than the value recorded from this study. Ash contents recorded from this study is higher than value reported by Usman et al. (2023). Equally, the ash value recorded from this study was also higher than the value reported by Olaoye et al. (2025). However, the Ash contents reported by Owosibo et al. (2018) is lower than the value recorded from this study. The value of ash content recorded from this study favorably aligned with 8 - 12% recommended for optimal fish growth, Condey, (2012) The nitrogen free extract (NFE) values recorded from this study were lower than the value of (29.27-56.36 %) reported by Olaoye et al. (2025). The variation might be attributed to differences in the processing methods used for roselle seeds. In this study, the roselle seeds were fermented for 72hrs and soaked for 24hr whereas (Olaoye et al., 2025) soaked the seeds for only 12hr. Differences in processing time can influence the carbohydrate composition and overall nutrient profile of plant-based feed ingredients. Furthermore, the moisture content recorded from this study was lower than the values of 8.07-8.77 % reported by Owosibo et al. (2018), but was comparable to the range 5.61 - 6.09 % reported by Usman et al. (2023). Similarly, the dry matter contents recorded from this study exceeded the values of 89.44-91.87 % recorded by Angbulu et al. (2019). However, it was closely comparable to the range of 93.91-94.11 % reported by Usman et al. (2023), while higher than the values of 85.50- 91.91 % reported by Yunusa Aliyu et al. (2023).

Growth Performance of *Oreochromis niloticus* fed Different Inclusion levels of Fermented *Hibiscus Sabdariffa* Seed meal diet.

Growth Performance of *O. niloticus* fed Different inclusion levels of fermented *H. sabdariffa* seed meal diet is presented in Table 3. Total initial weight ranged from (11.43 g - 11.46 g). The highest value of (11.46 g) was recorded from T2 and T3(25 % and 50 %) FHSSM diet meal, followed by 11.43 g from fish fed T4 and T5 (75 %, 100%) and the control (0 %). There was no significant difference (p>0.05) among all the treatments. Mean initial weight recorded was 1.14 g across all the five treatments. There was no significant difference (p>0.05) among them. Total final weight recorded ranged from 32.20 g-47.13 g. The highest value of (47.13 g) was recorded from the control (0%) inclusion level, followed by (42.80-39.96 g) from fish fed 25%--50% inclusion levels and (38.70 g) from fish fed with 75 % inclusion level, while the lowest value of (32.20 g) from fish fed 100 % inclusion level. There was no significant difference (p>0.05) between fish fed with 25-50% inclusion levels. Whereas, there was significant different (p<0.05)

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between the fish fed with 0, 50, 75 and 100 % inclusion levels. Total weight gain ranged from 20.77 g to 35.70 g, the highest value of (35.70 g) was recorded from the control treatment (0 %), followed by (31.36 g) from fish fed with 25 % inclusion level and (28.50 g) from fish fed with 50 %, while (27.26 g)

Table 3. Growth Performance of *Oreochromis niloticus* fed Different inclusion levels of fermented Roselle *(Hibiscus sabdariffa)* Seeds meal.

Parameters	T1	T2	T3	T4	T5
TIW(g)	11.43 ± 0.05^{a}	$11.46\pm0.0\ 5^{a}$	11.46 ± 0.05^{a}	11.43 ± 0.05^{a}	11.43 ± 0.05^{a}
TFW (g)	47.13 ± 2.65^{a}	42.80 ± 1.50^{b}	39.96 ± 011^{bc}	38.70 ± 3.12^{c}	32.20 ± 1.45^{d}
TWG (g)	35.70 ± 2.69^{a}	31.34 ± 1.40^{b}	28.50 ± 0.10^{bc}	27.27 ± 3.06^{c}	20.77 ± 1.50^{d}
MIW (g)	1.14 ± 0.005^{a}	1.14 ± 0.005^{a}	1.14 ± 0.005^{a}	1.14 ± 0.005^{a}	1.14 ± 0.005^{a}
MFW (g)	8.60 ± 3.53^{dc}	18.30 ± 21.39^{a}	7.13 ± 0.75^{e}	9.96 ± 1.98^{c}	16.93 ± 13.16^{b}
MWG (g)	7.46 ± 2.81^{d}	17.16 ± 15.76^{a}	5.99 ± 0.56^{e}	8.82 ± 1.24^{c}	15.79 ± 8.49^{b}
MWWG	0.62 ± 0.22^{a}	1.43 ± 0.12^{b}	0.49 ± 0.10^{bc}	0.74 ± 0.23^{c}	1.32 ± 0.09^{d}
MIL (cm)	5.90 ± 0.10^{b}	6.03 ± 0.20^{a}	5.93 ± 0.11^{ab}	5.93 ± 0.15^{ab}	5.83 ± 0.15^{c}
MFL (cm)	9.33 ± 0.15^{a}	8.86 ± 0.15^{ab}	8.63 ± 0.23^{bc}	8.20 ± 0.26^{c}	8.20 ± 0.43^{c}
RGR (%)	654.3 ± 312.26^{d}	1505.26 ± 1839.16^{a}	525.43 ± 63.84^{e}	773.68 ± 176.94^{c}	1385.08 ± 1157.14^{b}
SGR (%)	1.04 ± 0.48^{d}	1.49 ± 1.30^{a}	0.92 ± 0.12^{e}	1.12 ± 0.23^{c}	1.42 ± 0.86^{b}
K	1.05 ± 0.43^{e}	2.63 ± 0.11^{b}	1.10 ± 0.02^{d}	1.80 ± 0.39^{c}	3.07 ± 0.66^{a}
SR(%)	60.00 ± 20.00^{a}	53.33 ± 37.85^{b}	56.66 ± 5.77^{b}	40.00 ± 10.00^{c}	26.66 ± 15.27^{d}

Means on the same row with the same superscripts are not significantly different ($p<0.05$) TIW- Total initial weight; MIW- mean initial weight; TFW- Total final weight; MFW- mean final weight; TIL- Total initial length; MFL- mean final length; TWG-Total weight gain; MWG- mean weight gain; MWWG- mean weekly weight gain; RGR- relative growth rate; SGR- specific growth rate; K- condition factor; SR- survival rate.

was recoded from fish fed 75 %, the lowest value of (20.76 g) was recorded from fish fed 100 % inclusion level. Significant different ($p<0.05$) was recorded from fish fed 0,25,75 and 100 %, but there was no significant difference ($p<0.05$) between fish fed 50 % and 75 % inclusion levels. Mean final weight values among the five treatments ranged from 7.13 g-18.30g, with the highest value of (18.30 g) was recorded from fish fed 25% inclusion level, followed by (16.93 g) from fish fed with 100 %, (9.96 g) from fish fed with 75 % inclusion levels. While (7.13 g) was recorded from fish fed with 50 % inclusion level, and the lowest (8.60 g) was recorded from control (0 %) inclusion level. There was significant difference ($p<0.05$) between fish fed with 25, 50, 75 and 100% inclusion levels, but there was no significant different ($p>0.05$) between fish fed with 75% and 0% inclusion levels. Mean weight gain ranged from 5.99 g-17.16 g, the highest value of (17.16 g) was recorded from fish fed 25 % inclusion level, followed by (15.79 g) from fish fed 100 % and (8.82 g) from fish fed 75 % inclusion level, while (7.46 g) was recorded from fish fed 0 % inclusion level and the lowest value of (5.99 g) was recorded from fish fed 50 % inclusion level.

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There was significant different (p<0.05) among the treatments. Mean weekly weight gain ranged from 1.43 g to 0.49 g, the highest value of (1.43 g) was recorded from fish fed 25 %, followed by (1.32 g) from fish fed 100 % and (0.74 g) from fish fed 75 % inclusion level, while (0.49 g) was recorded from fish fed 50 % and the lowest value of (0.62 g) was recorded from fish fed 0 % inclusion level. There was no significant different (p>0.05) between fish fed 25, 50 and 75 %, but there was significant different (p<0.05) among fish fed 0, 25, 75 and 100 % inclusion levels.

The mean initial length ranged from 5.83 g-6.03 g, with highest length of 6.03 g was recorded from fish fed with 25 % inclusion level, followed by 5.93 g recorded from the control treatment at (0 %) and (5.90 g) recorded from fish fed with 50 and 75 % inclusion levels. While the lowest length of (5.83 g) was recorded from fish fed with 100 % inclusion level. There was no significant different (p>0.05) in mean initial length between fish fed with 50 % and 75 % inclusion levels, however, significant different (p<0.05) was recorded between fish fed with 0,25 and 100 % inclusion levels. Mean final length ranged from 8.20-9.33 g, with the highest value of (9.33 g) was recorded from the control treatment (0 %), followed by (8.86 g and 8.83 g) recorded from fish fed with 25 % and 50 % inclusion levels. While, the lowest value of (8.20 g) was recorded from both fish fed with 75 % and 100 % inclusion levels. The relative growth rate (RGR) ranged from 525.43 % to 1505.26 %, the highest value of (1505.26%) was recorded from fish fed 25 % inclusion level, followed by (1385.08 %) from fish fed 100 % and (773.68 %) from fish fed 75 % inclusion level, while (654.3 %) was recorded from 0 % and the lowest value of (525.43 %) was recorded from fish fed 50 % inclusion level. There was significant different (p<0.05) among the treatments. Specific growth rate (SGR) values ranged from 0.92 % to 1.49 %, the highest value of (1.49%) was recorded from fish fed 25% inclusion level, followed by (1.42 %) from fish fed 100 % and (1.12 %) from fish fed 75 %, while (1.04%) was recorded from control treatment, the lowest value of (0.92 %) was recorded from fish fed 50 % inclusion level. There was significant different (p<0.05) among the treatments. Condition factor (K) ranged from 1.05-3.07, the highest value of (3.07) was recorded from fish fed 100 % inclusion level, followed by (2.63) from fish fed 50 % and (1.80) was recorded from fish fed 75 % inclusion level, while (1.10) was recorded from fish fed 50 % and the lowest value of (1.05) was recorded from fish fed 0 % inclusion level. There was significant different (p<0.05) between the fish fed 75, 100 and 25 % inclusion levels, but there was no significant (p>0.05) between the fish fed 0 % and 50 % inclusion levels. Survival rate (SR) values ranged from 26.66 - 60.00 %, the highest value of (60.00 %) was recorded from the control treatment (0 %), followed by (56.66 %) from fish fed 50 % and (53.33 %) was recorded from fish fed 25 % inclusion level, while (40.0 0%) was recorded from fish fed 75 % inclusion level and the lowest value of (26.66 %) was recorded from fish fed 100 % inclusion level. There was significant different (p<0.05) between from fish fed 0, 50, 75 and 100 % inclusion levels, but there was no significant between (p>0.05) the fish fed 25 % and 50 % inclusion levels.

Growth parameters such as weight gain (WG) and specific growth rate (SGR) are usually considered the most important measurement of productivity of diet Oyetnji et al. (2021) and a good indication of a marketable product. The fact that growth was recorded from all experimental diets, indicated that the fish were able to convert the protein in the feed to muscles development. This observation is consistent with the findings of Sogbesan et al. (2008), who reported that fish can effectively convert dietary protein into body tissues when provided with nutritionally balanced diets. The growth performance and nutrients utilization of fish fed with fermented *H. sabdariffa* seeds meal (FHSSM), significantly differed ($p<0.05$) among the dietary treatments. Fish fed raw *H. sabdariffa* seed meal diet exhibited superior weight gain compared with those receiving FHSSM-based diets. However, the 25 % inclusion level produced the better growth performance, followed by the 50 % inclusion level. This study has agreed with result from Sogbesan et al. (2008), who reported improved growth performance in fish diets containing fermented Sunflower meal diet at moderate inclusion levels.

This study reported differences in acceptability of the diets among treatments which is in line with the works from Bake et al. (2015); Riche et al. (2001). They reported that when alternative protein sources especially from plant protein are incorporated in the fish diet, the palatability and attractiveness of the diets are usually affected. Nguyen et al. (2009) reported that the weight gain (WG) of young fish is a reliable indicator of nutritional efficiency. This study showed that fermentation and inclusion levels both affected the weight gained, this agrees with the findings of Nguyen et al. (2009); Samtiya et al. (2020), who reported that one of the major limitations of using alternative plant protein sources in fish feeding is the changes in palatability and the presence of anti- nutritional factors in the ingredient. The reduction in feed intake due to the unpalatability may lead to deterioration in growth performance and feed utilization. This reduction recorded could be attributed to the presence of anti-nutritional factors. The declaration is in line with the findings of Siddhuraju et al. (2003); Wang et al. (2021) that higher inclusion levels of most plant protein source base meals resulted in poor growth and nutrient utilization.

The result for weight gained (WG), Feed Conversion Ratio (FCR) and Specific growth rate (SGR) is in line with report from El-Sayed (2020), who reported that growth performance and feed conversion efficiency are related but are independently influenced by feed intake, nutrient digestibility, dietary composition, and metabolic utilization. Similarly, NRC (2011), reported that FCR reflects the efficiency with which consumed feed is converted into fish biomass and should therefore be interpreted together with feed intake and weight gain to provide a comprehensive assessment of fish growth performance. The Protein Efficiency Ratio (PER) is known to be regulated by the non-protein energy input of the diet and is a good measure of the protein-sparing effect of lipids and/or carbohydrate as reported by Jabeen et al. (2004) and Ochang et al. (2007). The general well-being of the fish fed fermented *H. sabdariffa* meal diets is expressed by the condition factor (K). The condition factor values recorded from this study were above 1.0 and agreed with the report from Tibbetts et al. (2005) reported that increased inclusion level resulted in decreased survival rate and this might be due to the levels of ant nutrients in the diets or extraneous factors which agreed with Jamabo et al. (2020), who reported that mortality might not be necessary due to the anti-nutrients in the diets only but also to any other extraneous factors such as stress resulting from handling.

Nutrient Utilization of *Oreochromis niloticus* fed Different inclusion levels of fermented *Hibiscus sabdariffa* Seeds meal.

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Nutrient Utilization of *Oreochromis niloticus* fed Different inclusion levels of fermented *Hibiscus sabdariffa* Seeds meal is shown in Table 4. Feed conversion ratio (FCR) values ranged from 2.60-3.45, the highest value of (3.45) was recorded from fish fed 100 % inclusion level, followed by (2.85) from fish fed 75 % and (2.79) from fish fed 0 %, while (2.68) was recorded from fish fed 25 % and the lowest value of (2.60) was recorded from fish fed 50 % inclusion level. There was significant difference ($p<0.05$) between fish fed with 0, 75, and 100 % inclusion levels, but there was no significant different ($p>0.05$) from fish fed 0, 25 and 50 % inclusion levels. Feed intake ranged from 71.60 - 99.53, with the highest value of (99.53) was recorded from the control treatment (0 %), followed by (84.23) from fish feed with 25 % inclusion level and (77.63) was recorded from fish fed 75 %, while (74.10) was recorded from fish fed 50 % and the lowest

Table 4. Nutrient Utilization of *Oreochromis niloticus* fed Different inclusion levels of fermented *Hibiscus sabdariffa* Seeds meal.

Parameters	T1	T2	T3	T4	T5
Inclusion levels	(0 %)	(25 %)	(50 %)	(75 %)	(100 %)
FCR	$2.79{\pm}0.06^{c}$	$2.68{\pm}0.07^{c}$	$2.60{\pm}0.35^{c}$	$2.85{\pm}0.35^{b}$	$3.45{\pm}0.10^{a}$
FI	$99.53{\pm}5.53^{a}$	$84.23{\pm}1.70^{b}$	$74.10{\pm}10.11b^{c}$	$77.63{\pm}1.72b^{c}$	$71.60{\pm}3.10^{c}$
PI	$34.83{\pm}1.93^{a}$	$26.95{\pm}0.54^{b}$	$22.23{\pm}3.03^{c}$	$21.73{\pm}0.47^{c}$	$17.90{\pm}0.77^{d}$
PER	$0.18{\pm}0.77^{c}$	$0.41{\pm}0.49^{a}$	$0.16{\pm}0.23^{d}$	$0.25{\pm}0.43^{b}$	$0.42{\pm}0.35^{a}$

Means on the same row with the same superscripts are not significantly different ($p<0.05$)
Key: FCR- feed conversion ratio; FI-feed intake; PI- protein intake; PER- protein efficiency ratio;
value of (71.60) was recorded from fish fed 100 % inclusion level. There was no significant different ($p>0.05$) between fish fed 50 % and 75 % inclusion levels, but there was significant different($p<0.05$) from fish fed 0, 25 and 100 % inclusion levels. Protein intake (PI) ranged values from 17.90-34.83, the highest value of (34.83) was recorded from the control treatment (0 %), followed by (26.95) recorded from fish fed 25 % and (22.23) was recorded from fish fed 50 % inclusion level, while (21.73) was recorded from fish fed 75 % and lowest value of (17.90) was recorded from fish fed 100 % inclusion level. The fish fed with 0 % inclusion level was significantly different ($p<0.05$) from the fish fed 25, 50 and 100 % inclusion levels, whereas, there was no significant different ($p>0.05$) between the fish fed 50 % and 75 % inclusion levels. Protein efficiency ratio (PER) ranged from 0.16-0.42, the highest value of (0.42) recorded from fish fed 100 % inclusion level, followed by (0.41) recorded from fish fed 25 % and (0.25) was recorded from fish fed 75 % inclusion level, while (0.18) was recorded from fish fed 0 % and the lowest value of (0.16) was recorded from fish fed 50 % inclusion level. There was significant different ($p<0.05$) in protein efficiency ratio among all the treatments.

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CONCLUSION

The results from this study clearly indicated that fermentation is an effective processing method for improving the nutrient quality of *H. sabdariffa* (roselle) seed meal by enhancing its nutrient composition and reducing anti-nutritional factors that could otherwise limit nutrient utilization and digestibility in fish. These improvements increased the potential of fermented roselle seed meal as a viable alternative plant protein source for aquaculture feed formulation at 50% inclusion level with desirable performance.

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