



Effect of Graded Levels of Jujube (*Ziziphus mauritiana* Lam.) leaf meal on Growth Performance of the Nile Tilapia, *Oreochromis niloticus* (Linnaeus, 1758)

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ABSTRACT

Effect of graded levels of Jujube (*Ziziphus mauritiana* Lam.) leaf meal on growth performance of Nile Tilapia, *Oreochromis niloticus* (Linnaeus, 1758) was investigated to evaluate the efficiency of leaf meal on growth performance of *O. niloticus* fingerlings. Proximate composition and antinutritional factor of the Jujube leaf was conducted to ascertain its nutritional value. Four (4) different graded levels of *Z. mauritiana*; 0 (control), 5, 10, and 15% designated as diet I (DI), diet II (DII), diet III (DIII) and diet IV (DIV), respectively, were incorporated into 35% crude protein diet. Twelve (12) hapas (1m × 1m × 1m) were installed in polyethylene lined fish pond (7 × 5 × 1.2m) stocked with ten (10) *O. niloticus* fingerlings (4.62 ± 0.39g weight and 5.68 ± 0.28cm length). The Jujube leaf based-diets were allotted to the fish in hapa at random in three replications and were cultured for ten weeks (70days). The results showed that *Z. mauritiana* leaf has 25.00% crude protein, 15.11% crude fiber, 3.90% ether extract, 4.10% ash, 5.95% moisture and 51.89% nitrogen free extract. The anti-nutritional factors were alkaloid (10.75 mg/g), tannins (1.15 mg/g), oxalate (12.03 mg/g), phytate (3.33 mg/g) and saponin (24.57 mg/g). Better weight gain (92.0g) was obtained in the fish fed 5% Jujube leaf-based diet while the least weight gain was observed in fish fed 15% (60.33g) Jujube leaf-based diet. This study concludes that Jujube leaf meal can be incorporated into the diets of *O. niloticus* fingerlings up to 5% without compromising the fish growth.

Key words: Jujube leaf meal, Proximate, Anti-nutritional factors, Growth *Oreochromis niloticus*.

INTRODUCTION

The importance of fish as a valuable source of animal protein in human diets cannot be over emphasized (Ofuoku *et al.*, 2008). The demand for fish food has been on the increase with increasing human population (FAO, 2012). According to FAO (2006), fish supplies from capture fisheries will, therefore, not be able to meet the growing global demand for aquatic food. Production of fish from aquaculture is therefore seen as the only remedy to this problem since capture from the wild is dwindling day-by-day as a result of depletion in natural stock, while the population is on the increase (Akinrotimi *et al.*, 2011).

Oreochromis niloticus is the second largest fish species cultured worldwide and is mostly done via semi-intensive culture techniques in developing countries like Nigeria (FAO, 2000). The cultivation of Tilapia is becoming more and more popular due to its higher growth rate, higher fecundity, ease of manipulation, good consumer acceptance, ability to grow under suboptimal nutritional problems, and response to adverse environmental conditions such as low oxygen and high ammonia levels in the water (Nazrul *et al.*, 2011).

Ziziphus mauritiana also called Jujube, Chinese date or apple, Indian plum or Masau is a tropical fruit tree (Michel, 2002) belonging to the family Rhamnaceae. The leaves are readily eaten by camels, cattle, sheep and goats and are considered nutritious and with resistance power against different types of pathogens. The leaves are also used in the treatment of liver diseases, asthma and fever (Zhao *et al.*, 2012).

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Fish feed today, is becoming costly due to the competition between man and animal for protein source (Adeparusi and Agbede, 2005). Therefore, there is need for utilization of other and inexpensive plant sources dietary materials that are readily available and affordable thereby, improving growth. The potential and utilization of unconventional plant feed stuffs in aquaculture have been reviewed by Ugwumba and Ugwumba (2003). Their level of inclusions in aquaculture feed varied and largely depends on their availability, nutrient content, processing techniques, species of fish and fish cultural practice prevalent in the locality (Gabriel *et al.*, 2007). Nandeesh *et al.* (1991) stated that so many factors limit high inclusion level of unconventional plant feedstuffs in fish feed, such as amino acid imbalance Eyo (1998), low protein content and presence of anti-nutritional factors (Oresegun and Alegbeleye, 2001).

Leaf meal inclusion in aquaculture feed is fast gaining global attention due to their availability, protein contents and economic feasibility (Udo and John, 2015). Inclusion of plant dietary materials in fish feed have been reported by several authors. Soliman *et al.* (1997) reported a weight gain of 12.88g in *Oreochromis niloticus* fed with diet containing black seed meal (*Nigella sativa*) for soya bean meal at 0% inclusion level. Adewolu (2008) reported a high weight gain of 2.58% in sweet potatoes (*Ipomoea batatas*) leaf meal fed to *Coptodon zilli*. Soloman and Okomoda (2012) documented a weight gain of 1.92g at 5% inclusion level of duckweed (*Lemna minor*). Weight gain of 88.26 g was recorded for Nile Tilapia fed multi-feed and NIOMR feed in a flow-through system (Yakubu *et al.*, 2014). No reports have appeared in the literature concerning the utilization of *Ziziphus mauritiana* leaf meal in fish diets. Therefore, the present study was undertaken to determine the proximate composition, anti-nutritional factors and investigate the efficacy of *Ziziphus mauritiana* leaf meal as dietary ingredient for *Oreochromis niloticus*.

MATERIALS AND METHODS

The experiment was conducted on the Teaching and Research Fish Farm of the Department of Fisheries and Aquaculture, Federal University Dutse (FUD), Jigawa State, Nigeria. It is located between latitude 11° 42° North and longitude 9° 22° East and altitude of 436m above sea level (Compass, 2018). The area falls within the Sudan Savannah. The mean relative humidity ranges from 15 to 20% (City-population, 2018). The mean annual temperature ranges between 22° and 31°C, with the hottest month being April and the coolest month being January (Climate-data, 2018). Precipitation is lowest in January, with an average of 0mm. The greatest amount of precipitation occurs in August with an average of 262mm (Climate-data, 2018).

Collection and preparation of *Ziziphus mauritiana* leaves

Ziziphus mauritiana leaves were collected from Federal University Dutse campus, Jigawa State, Nigeria and taken to the Herbarium of the Department of Forestry and Wildlife Management, Federal University Dutse for proper identification. The leaves were shade dried for three (3) days, milled using hammer mill (Model: R175A) and packaged in air tight polyethylene bag and stored at room temperature until needed.

Proximate composition and anti-nutritional factors of *Ziziphus mauritiana* leaf

The anti-nutritional factors of *Ziziphus mauritiana* leaves were conducted according to the methods described by AOAC (2000), while the proximate composition was conducted using the methods described by AOAC (2006).

Experimental diet

The feed ingredients; fish meal, toasted soybean meal and maize were procured locally and ground into powder using hammer mill (Model: R175A), weighed, mixed thoroughly. Thirty five percent (35%) crude

protein iso-nitrogenous diets were formulated with the aid of Pearson's square method using locally available ingredients.

Experimental fish

Two hundred (200) *Oreochromis niloticus* fingerlings were procured from Bagauda Fish Farm, along Kano – Jos Road, Kano State and transported to the Teaching and Research Fish Farm of the Department of Fisheries and Aquaculture, Federal University Dutse, Jigawa State in oxygenated polyethylene bag. They were acclimatized for 7 days in a plastic tank (1,500 litres) and fed commercial diet Aqualis of 35% crude protein at 5% of their body weight twice daily; morning (9:00am) and evening (5:00pm) throughout the acclimatization.

Experimental design

Four (4) graded levels of the *Z. mauritiana* leaf meal; 0 (control), 5, 10, and 15% designated as DI, DII, DIII and DIV, respectively were incorporated into the 35% crude protein diet (table 1). The mixer were made into dough and pelletized using manual pelletizer (meat mincer with 3mm dice). The pelleted feed was crushed into smaller size after air drying for 3days. It was packaged in air tight polyethylene bag, labeled and stored at room temperature.

Table 1: Composition and proximate analysis of the experimental diets

Ingredients	Jujube leaf inclusion levels (%)			
	0	5	10	15
Fishmeal	23.76	23.76	23.76	23.76
Toasted soy bean	23.76	23.76	23.76	23.76
White maize	21.25	21.25	21.25	21.25
Wheat offal	21.25	21.25	21.25	21.25
Methionine	0.5	0.5	0.5	0.5
Lysine	0.5	0.5	0.5	0.5
Min –vit Premix	0.5	0.5	0.5	0.5
Common salt	0.5	0.5	0.5	0.5
Ascorbic acid	1.0	1.0	1.0	1.0
Dicalcium phosphate	1.0	1.0	1.0	1.0
Cassava starch	5.0	5.0	5.0	5.0
Vegetable oil	1.0	1.0	1.0	1.0
Jujube leaf	0	5	10	15
Total	100	105	110	115
Proximate Composition (%)				
Dry matter	90.61	90.61	90.61	90.61
Crude protein	35.00	35.00	35.00	35.00
Crude fiber	4.86	4.86	4.86	4.86
Ether extract	10.30	10.30	10.30	10.30
Ash	8.40	8.40	8.40	8.40
NFE	41.44	41.44	41.44	41.44
ME (Kcal/kg)	3530.42	3530.42	3530.42	3530.42

Keys: NFE = Nitrogen free extract; ME = Metabolizable energy

Twelve (12) hapas (1m × 1m × 1m) were installed in polyethylene lined fish pond (7 × 5 × 1.2m) and stocked randomly each with ten (10) *O. niloticus* fingerlings (4.62 ± 0.39g weight and 5.68 ± 0.28cm length). The Jujube leaf based-diets were allotted to the fish in hapa at random in three replications. Prior to the commencement of the experiment, fish were starved for 48hours to increase the appetite of the fish. Fish weight and length were recorded using top loading sensitive digital scale (Model: SF - 400) and fish measuring board, respectively. The fish were fed *Z. mauritiana* based diet at 5% of their body weight for a period of ten weeks (70 days) twice daily; morning (9:00am) and evening (5:00pm). The fish were weighed weekly and quantity of feed was adjusted appropriately.

At the end of the experiment, final weight (g), final length (cm), survival and feed dispensed were recorded. The following growth parameters were determined for each treatment using the following formulae:

- i) Mean weight gain (MWG) = $W_2 - W_1$, where W_2 = final average weight (g), W_1 = initial average weight (g).
- ii) Average daily weight gain ($ADWG$)(g/day) = MWG/T , where T= culture period (days)
- iii) Specific growth rate (SGR)(%/day) = $[(\log W_2 - \log W_1) \times 100]/T$.
- iv) Feed conversion ratio (FCR) = W/WG , W = Weight of dry feed dispensed (g).
- v) Apparent protein efficiency ratio ($APER$) = WG/API , where API = Apparent Protein intake (g)
- vi) Apparent protein intake (API) = $FI \times CP$, where FI = Total feed intake 5% body weight of fish per day, CP = Crude protein 35% in diet.
- vii) Condition factor (K) = $W_2/L_2^3 \times 100$, where L_2 = Average total length (cm)
- viii) Percentage Survival (%) = $(S_2/S_1) \times 100$, where S_2 = Final number of fish, S_1 = Initial number of fish.

Monitoring of water quality

Water quality parameters; dissolved oxygen, pH and temperature were recorded weekly using dissolved oxygen analyzer meter (Model: JPB-507 potable) and pH/temperature pen type (Model: pH-009), respectively, throughout the trial.

Data analysis

The data obtained from the study were subjected to One-Way Analysis of Variance (ANOVA). The differences between the means were determined using Least Significant Difference (LSD) at 5% confidence (P = 0.05) level with aid of Statistix 8.0.

RESULTS

Proximate composition and anti-nutritional factor of *Ziziphus mauritiana* leaf

The mean proximate composition and anti-nutritional factor of *Ziziphus mauritiana* leaf is shown in table 1. *Ziziphus mauritiana* leaf contain 25.00% crude protein, 15.11% crude fiber, 3.90% ether extract, 4.10% ash, 5.95% moisture and 51.89% nitrogen free extract. The mean anti-nutritional factors of *Ziziphus mauritiana* leaf is presented in Table 2. *Z. mauritiana* leaf has alkaloid 10.75mg/g, tannins 1.15mg/g, oxalate 12.03mg/g, phytate 3.33mg/g and saponin 24.57mg/g.

Growth Performance of *Oreochromis niloticus* fingerlings fed diets with *Ziziphus mauritiana* leaf meal

The growth performance parameters of *Oreochromis niloticus* fingerlings fed *Ziziphus mauritiana* leaf meal (ZMLM) is shown in Table 3. The final length (FW) and weight gain (WG) was higher in the fish fed 5%, followed by 10, 0 and 15%, respectively. The FW and WG of the fish fed 5% (136.67 and 92.0g) were significantly better (P<0.05) than those fed 0, 10 and 15%. However, there was no significant (P>0.05)

variation among the treatments. The daily weight gain (DWG) was higher in the fish fed 5%, followed by 10, 0 and 15%, respectively. The DWG of the fish fed 5% diet had better value compared to those of the fish fed with 10, 0 and 15%. However, there was no significant ($P>0.05$) variation among the treatments.

Table 1: Mean Proximate and anti-nutrient composition of *Ziziphus mauritiana* leaf meal

Nutrients	Constituent (%)	Antinutritional factor	Constituents (mg/g)
Crude protein	25.00	Alkaloid	10.75 ± 0.19
Crude fiber	15.11	Tannins	1.15 ± 0.05
Ether extract	3.90	Oxalate	12.03 ± 0.72
Ash	4.10	Phytate	3.33 ± 0.17
Moisture	5.95	Saponin	24.57 ± 0.16
NFE	51.89		

Key: NFE = Nitrogen free extract

The specific growth rate (SGR) was higher in the fish fed 5%, followed by 10, 0 and 15%, respectively. SGR of the 5% diet had better SGR (0.88%/day) compared to those fish fed 15% (0.79%/day). However, there was no significant ($P>0.05$) variation among the treatments.

The feed conversion ratio (FCR) was lower in the fish fed 5%, followed by 10, 0 and 15%, respectively. The FCR of the fish fed 5% diet had significantly ($P<0.05$) lower FCR (2.87) compared to those fish fed 15% (3.67). However, there was no significant ($P>0.05$) variation among the treatments.

Table 3: Mean growth performance of *O. niloticus* fingerlings fed graded level of *Z. mauritiana* leaf meal

Parameters	Inclusion levels (%)				SEM
	0	5	10	15	
IL (cm)	5.43	5.87	5.73	5.70	0.22 ^{NS}
FL (cm)	8.63 ^b	10.87 ^a	9.63 ^b	9.13 ^b	0.66
IW (g)	46.67	44.67	49.33	44.00	3.06 ^{NS}
FW (g)	117.33	136.67	121.67	106.33	15.07 ^{NS}
WG (g)	70.67	92.00	72.33	60.33	15.44 ^{NS}
DWG (g/day)	1.01	1.31	1.03	0.86	15.13 ^{NS}
SGR (%/day)	0.83	0.88	0.85	0.79	0.12 ^{NS}
FCR	3.30	2.87	3.23	3.67	0.40 ^{NS}
API	75.48	75.95	72.10	72.57	15.50 ^{NS}
APER	0.93 ^{bc}	1.21 ^a	1.00 ^b	0.83 ^c	0.05
K	2.04 ^a	2.75 ^c	2.15 ^b	1.53 ^b	0.22
SR (%)	66.67	73.33	66.67	63.33	8.50 ^{NS}

a, b, c and d = mean values within the same row with different superscript differ significantly ($P < 0.05$)

Keys: SEM = standard error of means; NS = no significant ($P > 0.05$); IL = initial length; FL = final length; IW = initial weight; FW = final weight; WG = weight gain; DWG = daily weight gain; SGR = specific growth rate; FCR = feed conversion ratio; PI = protein intake; PER = protein efficiency ratio; K = condition factor; SR = survival rate.

The Apparent protein intake (API) was higher in the fish fed 5%, followed by 0, 15 and 10%, respectively. The API of the fish fed 5% was better (75.95) compared to those fish fed 10% (72.10). However, there was no significant difference ($P>0.05$) between the PI values for the entire treatments. The Apparent protein efficiency ratio (APER) was higher in the fish fed 5%, followed by 10, 0 and 15%, respectively. The APER

of the fish fed 5% diet was significantly ($P < 0.05$) better compared to those of the fish fed 15% (0.83). However, 5% is statistically ($P < 0.05$) different from 10, 15 and 0%.

The condition factor (K) was higher in the fish fed 5%, followed by 10, 0 and 15% respectively. The K of the fish fed 5% was better compared to those of the fish fed with 15%. However, 10 and 15% are statistically ($P < 0.05$) different from 0 and 5%. The survival rate (SR) was higher in the fish fed 5%, followed by 10, 0 and 15%, respectively. The SR of the fish fed 5% diet had better SR (73.33%) compared to that with 15% (63.33%) inclusion level. However, there was no significant ($P > 0.05$) variation among the treatments.

Water quality parameters

The mean water quality parameters during the growth trial are presented in Table 4. The mean dissolved oxygen ranged from 7.70 to 7.92mg/l. The highest was recorded in 15%, followed by 10, 0 and 5%. Fish fed 5% *Z. mauritiana* leave meal had significantly ($P < 0.05$) lower DO value compared to those treated with 0, 10 and 15%. The mean temperature ranged from 24.9 to 25.37°C. The highest was obtained in 10%, followed by 15, 0 and 5%. Fish fed 0 and 5% had significant ($P < 0.05$) lower temperature values compared to the rest of the treatments. The mean pH values ranged from 6.27 to 6.43. However, there was no significant ($P > 0.05$) variation between the pH among the entire treatments.

Table 4: Mean water quality parameters during feeding trials

Parameter	Inclusion levels (%)				SEM
	0	5	10	15	
DO (mg/l)	7.70 ^a	7.60 ^a	7.84 ^a	7.92 ^b	0.14
T (°C)	24.97 ^b	24.97 ^b	25.43 ^a	25.37 ^a	0.12
pH	6.27 ^a	6.43 ^a	6.30 ^a	6.37 ^a	0.15 ^{NS}

a, b, c and d = mean values within the same row with different superscript differ significantly ($p < 0.05$)

Keys: SEM = standard error of means; NS = not significant ($P > 0.05$). DO = Dissolved oxygen T =Temperature

DISCUSSIONS

Proximate Composition of *Ziziphus mauritiana* leaf meal

The mean crude protein (CP) content recorded was 25%. This value was much higher than the 12.5 – 16.9 range, 15.4, 14.21, 14.8 and 11.16% reported by Morton (1987), Orwa *et al.* (2009), Azim *et al.* (2011), Njidda and Olatunji (2012) and Gidado *et al.* (2013), respectively. However, it was lower than 28.18% documented by Akinsola *et al.* (2016). The variation in CP level recorded could be attributed to differences in ecological zone which could have different soil fertility, stage growth and ratio of stem to leaves (Abdu *et al.*, 2007). The mean crude fiber (CF) studied was 15.11%. It was within the 13.9 – 17.10% range reported by Morton (1987). However, it was slightly and much lower than 15.8 and 26.60% documented by Orwa *et al.* (2009) and Azim *et al.* (2011), respectively.

The mean ether extract (EE) in this study was 3.90%. This value was higher than 2.41% reported by Azim *et al.* (2011). However, it was much lower than the 11.5 – 12.7 range, 7.53 and 10.7% documented by Morton (1987), Gidado *et al.* (2013) and Akinsola *et al.* (2016), respectively. The mean ash content value obtained was 4.10%. The value obtained was much lower than the 10.2 – 11.7 range, 11.8, 13.94, 8.14 and 8.0% reported by Morton (1987), Azim *et al.* (2011), Njidda and Olatunji (2012), Gidado *et al.* (2013) and Akinsola *et al.* (2016), respectively. The ash content of 4.10% indicates that the leaves are rich in mineral elements. The mean moisture content analyzed was 5.95%. This value is comparable to 6.0% reported by Akinsola *et al.* (2016). The low moisture content of the leaves would hinder the growth of micro-organism and storage life would be high (Akinsola *et al.*, 2016).

The mean nitrogen free extract (NFE) recorded was 51.89%. The value obtained was higher than 44.90 and 44.05% reported by Azim *et al.* (2011) and Akinsola *et al.* (2016), respectively. However, it is lower than the 55.3 – 56.7% range documented by Morton (1987).

Anti-nutritional Factors in *Ziziphus mauritiana* leaf meal

Njidda and Ikhimiya (2012) stated that the ultimate effect of high condensed tannin concentrations is to make the animal both energy and protein deficient, which thereby leads to reduced growth or weight loss and poor reproduction. The tannins recorded in this study was higher than the 0.38% documented by Njidda and Olatunji (2012) and (0.207%) by Gidado *et al.* (2013). Njidda and Ikhimiya (2012) affirmed that saponin have effect on erythrocyte haemolysis, reduction of blood and liver cholesterol, depression of growth rate, and bloat (ruminant), inhibition of smooth muscle activity, enzyme inhibition and reduction in nutrient absorption. Also, it alters cell wall permeability and therefore produces some toxic effect when ingested. The saponin recorded in this study was higher compared to the value 4.20% obtained by Gidado *et al.* (2013) in their study on assessment of anti-nutritive factors and nutrient composition of some selected browse plants. The oxalate value obtained in this study was higher than 5.04% reported by Njidda and Olatunji (2012). The phytate obtained in this study was higher than 4.08% reported by Njidda and Olatunji (2012). The alkaloid recorded in this study was higher than 0.01705% reported by Gidado *et al.* (2013).

This finding corroborates with Akinsola *et al.* (2016) who reported the presence of tannin, saponin and alkaloid in the leaves of *Z. mauritiana*. The results of this study supported the findings of Sameera and Mandakini (2015) who confirmed the presence of alkaloids and tannins in the leaves of *Z. mauritiana*. Kumar *et al.* (2017) affirmed the presence of tannins in the leaves of *Z. mauritiana* which is similar with this study. The result of this study is in line with the findings of Yusof and Saat (2017) who reported that leaves of *Z. mauritiana* contain tannin, saponin and alkaloid. The variation in the anti-nutritional factors (ANFs) could be due to different environmental conditions but within the range documented by Anwa *et al.* (2007).

The tolerable level of tannins by fish is 5g/kg (Buyukcapar *et al.*, 2011). Kumar *et al.* (2012) reported the tolerant level of phytate in fish diet is 2mg/100g. The dietary saponins above a level of 1.5g/kg can retard growth and damage intestinal mucosa in fish (Francis, 2002). He further revealed that saponins may also affect protein availability by forming sparingly digestible saponin-protein complexes. However, these anti-nutritional factors in *Z. mauritiana* leaves are within tolerable range for *O. niloticus*.

Effect of *Ziziphus mauritiana* leaf meal on growth of *Oreochromis niloticus*

The mean weight gain observed in this study was higher than those observed by Soliman *et al.* (1997) for fish fed cottonseed meal based diet, Nwanna (2003) when fed fish with 60% of tamarind seed meal, Diyaware *et al.* (2009) when fed fish with 50% CP diet, Agbo *et al.* (2011) when fed fish with black seed meal and Solomon and Okomoda (2012) when fed fish with 5% duckweed, respectively.

The specific growth rate (SGR) (0.88%/day) observed in this study was higher than those observed by Abdel-Halim (2009) for *O. niloticus* fed 75% of alfalfa meal. However, it is lower than 1.06 and 1.75%/day reported by Moustafa (1993) when fed fish with 35% CP and Olvera-Novoa (1990) when fed *O. mossambicus* with 35% alfalfa meal, respectively.

The feed conversion ratio (FCR) obtained in this study had no variation among the treatments. This is similar to the reports Hanafy (2004), Abdel-Halim (2009), Agbo *et al.* (2011) who fed fish with linseed,

copra, cotton seed and sunflower meal, respectively. However, the FCR recorded in this study was higher compared to that reported by Olude *et al.* (2008) when fed fish with 30% copra meal

The apparent protein efficiency ratio (APER) recorded in this study was higher compared to that by Olude *et al.* (2008) when fed fish with copra meal. However, it was lower than 2.02, 2.70 and 2.45 reported by Soliman *et al.* (1997) when fed fish with 10% black seed meal, Hanafy (2004) when fed fish with 100% linseed meal, respectively.

The condition factor (K) recorded in this study was lower than the range 1.71-1.81 reported by Opiyo *et al.* (2014), Soliman *et al.* (1997) when fed fish with 15% black seed meal, respectively. The survival rate (SR) recorded in this study was lower compared to that reported by Olude *et al.* (2008) when fed fish with 45% copra meal. However, it was within the range observed by Diyaware *et al.* (2009) when fed fish with different levels of dietary crude protein level.

Water quality parameters

The mean dissolved oxygen 7.70 to 7.92mg/l, temperature 24.9 to 25.37°C and pH 6.27 to 6.43 (table 4) recorded during this experiment are within the recommended ranges by Viveen *et al.* (1985), Boyd (1998), UNEP (1999) and Swann (2007) for fish culture.

Conclusion

The study revealed that *Ziziphus mauritiana* leaf meal contained good crude protein, tolerable levels of anti-nutritional factors. *Ziziphus mauritiana* can be utilized as fish feed stuff in the diets of *O. niloticus* fingerlings up to 5% inclusion level without compromising the fish growth.

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