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# Growth and Feed Utilization Value of Fermented *Tamarindus indica* L. Seed in the Diet of *Oreochromis niloticus* (Linnaeus, 1758)

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**Abstract**

The effect of fermented *Tamarindus indica* seed nut on the composition, growth, nutrient utilisation and carcass composition of *Oreochromis niloticus* fingerlings fed graded levels of fermented *T. indica* seed meal was investigated for 84 days. Fermentation significantly increased the crude protein and lipid content of the seeds by 10.17 and 46.62%, respectively while alkaloid, saponin and phytate content of the seeds were reduced by 59.46, 21.74 and 60.30%, respectively. Five diets were formulated to include 0, 25, 50, 75 and 100% inclusion of fermented *T. indica* seed meal. The results for growth and feed utilisation revealed that the best experimental diet was the 75% inclusion level, as it gave the best mean weight gain (8.58g), standard length gain (2.54cm), total length gain (3.12cm), specific growth rate (0.85%days), percentage weight gain (1.01) and nitrogen metabolism (194.60) compared with the other diets. Carcass composition showed that all fish fed experimental diet had an increase in carcass crude protein and ranged between 49.99-54.02% compared to the initial of 43.91%. Thus the use of *T. indica* seed at 75% replacement level of soya beans seed is recommended in the diet of *O. niloticus* fingerlings.

Keywords: Fermentation, Nile Tilapia, Tamarind seed



## Introduction

Fish is an important source of both food and income to many people in developing countries. The exponential growth of the Nigerian aquaculture sector during the past two decades is a result of the progressive intensification of production systems and use of quality feeds, which meet the nutritional requirements of cultured fish (FAO, 2006). This increase of aquaculture production must be supported by a corresponding increase in the production of designed diets for the cultured aquatic animals (Rahman, Choi & Lee, 2013).

Tilapia is not the most cultured fish in Nigeria but regionally, tilapia is the most preferred cultured fish in East Africa and are the second most important cultured fish in the world after carps (El-Sayed, 2006). Nile tilapias are relatively cheaper to feed compared to other carnivorous finfish, and this can be attributed to their low trophic feeding level and herbivorous mode of feeding.

*Tamarindus indica* L. is an important food in the tropics. It is a multipurpose tree of which almost every part finds at least some use (Kumar & Bhattacharya, 2008), either nutritional or medicinal. The seed is a by-product of the *T. indica* pulp industry. The presence of tannins and other dyeing matter in the testa make the whole seed

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unsuitable for direct consumption (Rao & Srivastava (1974) cited in Kumar & Bhattacharya, 2008). In Northern Nigeria, there is usually no use for the seed which are usually discarded after the pulp have been removed for making "kunun tsamiya". The major industrial product of *T. indica* seed is the tamarind kernel powder (TKP) which is an important sizing material used in the textile, paper, and jute industries (Kumar & Bhattacharya, 2008). *Tamarindus indica* seed is also the raw material used in the manufacture of polysaccharide (jellose), adhesive and tannin.

Processing techniques used on seed nuts for fish feeds are of various types and include; roasting, boiling, soaking and fermentation. However, fermentation of fish feed ingredient is not common in Nigeria. The different processing techniques utilized often have varied effects on the bioavailability of the nutrients because the degree at which nutrients are lost differs from one processing technique to the other (Ndidi et al., 2014). Fermented legumes have shown cases of improvement in nutritive value as a result of increase in soluble fraction of the food and are also safe for consumption (Sahlin, 1999).

In view of the overall nutrient and chemical composition, tamarind seeds may be adopted as an inexpensive alternative protein source to alleviate protein malnutrition among traditional people living in developing countries (Pugalenthi, Vadivel, Gurumoorthi & Janardhanan, 2004), but the main question is can it be used as protein source in aquaculture? Therefore, this research was aimed at evaluating the growth performance and feed utilization of *O. niloticus* fingerlings fed varying inclusion levels of fermented *T. indica* seed meal by determining the effect of fermentation on proximate and anti-nutrient composition, growth performance, feed utilization and carcass composition of *O. niloticus* fingerlings fed varying inclusion levels of fermented *T. indica* seed meal.

## Materials and Methods

### Feed stuff and Fish Analyses

Seeds were soaked for 14 hours, then thrashed mechanically with a mortar and pistil (Shlini & Siddalinga Murthy, 2015), washed thoroughly to remove seed testa and bad seeds. Then seeds were fermented for 72 hours by placing them in an airtight container, air-dried, weighed and oven dried at 60°C in a paper bag for 24 hours followed by cooling. The dried seeds were pulverized using a laboratory blender and sieved using a 0.5 mm mesh sieve (Ingweye, Kalio, Uba & Effiong, 2010). The flour was stored in screw-capped bottles at room temperature for further analyses.

The proximate analyses of fermented seeds, formulated feed and fish (before the feeding trial) were carried out according to the recommended methods of AOAC (1990).This included determination of moisture (this was calculated by subtracting the weight of dry matter from the weight of ashed fermented seed sample), dry matter (weight of ashed fish sample) lipid, ash, crude fibre, crude protein (Kjeldahl method) and nitrogen free extract levels (calculated by difference). Anti-nutrients of raw and fermented *T. indica* seeds were tested for Alkaloid, saponin, tannin, and phytate levels using standard methods described by AOAC (1980).

### Feed Formulation

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The ingredients were milled and added to replace soya bean meal at various inclusion levels (0%, 25%, 50%, 75% and 100%) using Pearson square method. The ingredients were mixed together for each diet and water was added and mixed thoroughly to form dough. The dough was pelleted with a hand pelletizer.

**Experimental Fish**

*Oreochromis niloticus* fingerlings were obtained from Songhai Nigeria Partnership Initiative LTD/GTE Funtua Branch, Katsina State. The fish were acclimatized to laboratory condition for two weeks in the Fisheries Laboratory of the Department of Biology, Ahmadu Bello University, Zaria.

**Experimental Setup**

The feeding and growth experiment was conducted in the Fisheries Laboratory of Department of Biology, Ahmadu Bello University, Zaria. Ten plastic aquaria with dimension of 50×45×35 cm were used (two aquaria/experimental diet) in a static culture system with each aquarium containing ten fish. Feeding frequency recommended by Marimuthu, Cheen, Muralikrishnan and Kumar (2010) was adopted. Experimental fish were fed thrice a day (8:00 am, 1:00 noon and 6:00 pm) at 5% body weight.

**Data Collection**

The weights of fish were determined every fortnight using an electric Mettler Zurich (Swiss made) top-loading balance model CP8201 for period of twelve weeks. The standard length of fish was measured using a measuring board calibrated in centimetre (cm).

**Growth and feed utilization determination**

Mean weight gain (MWG) = mean final weight – mean initial weight.

Mean standard length gain (MSLG) = mean final standard length – mean initial standard length.

The percentage live weight gain according to recommendation of Falayi (2009) as follows:

$$PWG = \frac{fw - iw}{iw} \ (\%)$$

Where: $fw$ = final fish weight

$iw$ = initial fish weight.

The specific growth rate was calculated as described by Aderolu and Sogbesan (2010) as follows:

$$SGR = \frac{\log_e w_t - \log_e w_0}{t - t_0} \ (\%days)$$

where: $w_t$ = weight at the time of observation

$w_0$ = initial weight

$t$-$t_0$= duration of the experiment

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*e* = the base of natural logarithm (10)

Feed conversion ratio (FCR) was calculated using this formula:

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

The GFCE is the reciprocal of the FCR expressed as a percentage, it was calculated as follows:

$$GFCE = \frac{1}{FCR} \times 100$$

Protein efficiency ratio was calculated using formula described by Aderolu and Sogbesan (2010) as follows:

$$PER = \frac{Weight\ gain\ (g)}{Protein\ intake\ of\ fish\ (g)}$$

Net Protein Utilization (NPU) was calculated using the formula recommended by Balogun, Auta, Abdullahi, and Agboola (2004) as follows:

$$NPU = \frac{Fish\ protein\ gain}{Protein\ fed} \times 100 \quad (\%)$$

The values of nitrogen metabolism (Nm) was calculated using the formula of Dabrowski (1977) as follows:

$$\%\ Nitrogen = \frac{(0.54)(b-a)h}{2}$$

Where: *a* = initial weight of fish (g)

*b* = final weight of fish (g)

*h* = Experimental period in days

**Data Analyses**

Student's t-test was used to determine if there was significant difference ($P \leq 0.05$) between the proximate and anti-nutritional content of the raw and fermented *T. indica* seed nut. One way ANOVA was adopted to determine if there was significant difference ($P \leq 0.05$) between the growth performance, feed utilization and carcass composition of *O. niloticus* fed varying inclusion levels of fermented *T. indica* seed meal. Duncan's multiple range test (DMRT) was used to rank means where significant. All analyses were carried out using SAS 9.1.3 software package.

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## Results

The proximate composition of *T. indica* seed is presented in Table 1. The fermented seed had higher values for dry matter (94.27%), crude protein (21.44%), lipid (6.73%) and nitrogen free extract (64.12%), and lower crude fibre (3.99%) and ash content (3.73%) compared to the raw seed. While the raw seed had higher crude fibre (5.09%) and ash contents (6.84%), low values for dry matter (94.18%), crude protein (19.46%), lipid (4.59%) and nitrogen free extract (64.02%). There was significant difference ($P$<0.05) in the level of crude protein, lipid and ash content of the two seeds. Fermentation significantly increased the crude protein and lipid content of the seeds by 10.17 and 46.62%, respectively.

The results of anti-nutrient composition of *T. indica* seed is presented in Table 1. The values for alkaloid content of raw (3.70 mg/g$^{-1}$) and fermented (1.50 mg/g$^{-1}$) samples differed significantly ($P$<0.05). The values of the saponin content of raw and fermented samples (2.30 mg/g$^{-1}$ and 1.80 mg/g$^{-1}$, respectively) differed significantly ($P$<0.05). The values of the tannin content of raw and fermented samples (2.37 mg/g$^{-1}$ and 4.22 mg/g$^{-1}$, respectively) differed significantly ($P$<0.05). Phytate content for the raw (6.75 mg/g$^{-1}$) was significantly higher ($P$<0.05) than the fermented (2.68 mg/g$^{-1}$).

Growth performance of *O. niloticus* fed varying inclusion levels of fermented *T. indica* seed meal is presented in Table 2. The highest weight gain (12.40 g) was recorded in the 0% inclusion level while 100% inclusion level of fermented *T. indica* seed meal had the least weight gain (2.25 g). All growth parameters varied significantly ($P$<0.05).

The highest final standard length (8.93 cm), standard length gain (2.81 cm), final total length (11.20 cm) and total length gain (3.58 cm) were observed in fish fed 0% inclusion level of fermented *T. indica* seed meal. Whereas, the lowest final standard length (7.52 cm), standard length gain (0.70 cm), final total length (9.40 cm) and total length gain (0.72 cm) were observed in those fed 25% inclusion level of fermented *T. indica* seed meal. All growth parameters varied significantly ($P$<0.05).

The highest value for SGR (1.05%days) was observed in fish fed 0% inclusion level of fermented *T. indica* seed meal, followed by 75% (0.85%days), 25% (0.55%days), 50% (0.37%days) and 100% (0.25) inclusion levels of fermented *T. indica* seed meal, respectively. There was significant difference ($P$<0.05) in the percentage weight gain of fish fed varying inclusion levels of fermented *T. indica* seed meal, with 100% inclusion levels of fermented *T. indica* seed meal having the least (0.23) and 0% inclusion levels of fermented *T. indica* seed meal having the highest (1.42).

Feed utilization parameters for this study is presented in Table 2. The feed conversion ratio (FCR) and gross feed conversion efficiency (GFCE) value did not vary significantly ($P$>0.05) for all inclusion levels of fermented *T. indica* seed meal. PER obtained in this study varied significantly ($P$<0.05). 0% inclusion levels of fermented *T. indica* seed meal had the highest (0.14), while the least (0.03) was recorded in 100% inclusion levels of fermented *T. indica* seed meal. Net protein utilisation (NPU) values for this study ranged between 0.09-0.22% and did not vary significantly ($P$>0.05).

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There was great significant difference (*P*<0.05) in the nitrogen metabolism (Nm) obtained in this study, which ranged between 281.24 - 50.92. 0% inclusion levels of fermented *T. indica* seed meal had the highest (281.24) while 100% inclusion levels of fermented *T. indica* seed meal had the lowest (50.92).

Table 3 shows the carcass composition of *O. niloticus* fed the experimental diets. Fish fed the diet with 0% inclusion level of fermented *T. indica* seed meal had the highest carcass crude protein (54.02%) followed by the diet with 75% inclusion level of fermented *T. indica* seed meal (53.07%). 100% inclusion level of fermented *T. indica* seed meal gave the least carcass crude protein (49.99%). However, all formulated feeds significantly increased the crude protein content of *O. niloticus*. Dry matter, crude fibre and lipid contents did not vary significantly (*P*>0.05) for both initial fish and fish fed varying inclusion levels of fermented *T. indica* seed meal.

## Discussion

Fermentation significantly increased (*P*<0.05) the lipid content of the seed by 46.62%. Ouoba, Cantor, Diawara, Traore and Jakobsen (2003a) reported significant lipolysis of legumes by fermentation which yielded predominantly oleic, linoleic and linolenic acids which are essential fatty acids that are mostly not synthesized by many animals. Nwanna, Fagbenro and Olanipekun (2004) reported lipid content value of 0.35% for raw *T. indica* seed nut in Ondo State, Nigeria, which is lower than that observed in this study.

Soluble low molecular weight peptides and amino acids that contribute to enhanced acceptability and consumption of feed evidenced by improved growth in this study are produced through the enzymatic breakdown of proteins (Ouoba et al., 2003b) as a result of fermentation. The values for crude protein are higher than the crude protein value of *T. indica* seed nut (15.4%) reported by Heuze and Tran (2015).

Most legumes contain large amounts of non-digestible carbohydrates, which may include arabinogalactan, stachyose, sucrose and raffinose (Achi, 2005). These carbohydrates are associated with abdominal distention and flatulence in animals (Naczk, Amarowicz & Shashidi, 1997; Chicago: Encyclopædia Britannica, 2014b). The value for both samples are higher than that of the carbohydrate value of roasted and soaked *T. indica* seed nut (58.08% and 56.24%) reported by Akajiaku, Nwosu, Onuegbu, Njoku and Egbeneke (2015). The values of the proximate composition obtained from this research are higher than those reported by Heuze and Tran (2015) in India except for ash and fibre contents, which could be as a result of difference in geographical locations in which the seeds were obtained.

Alkaloid containing grain legumes, such as lupins (*Lupinus albinus*), are otherwise ideally suited as feedstuff in aquafeeds because of high digestible protein content (Kumar et al., 2012). The low level of alkaloid in the fermented sample could be due to the extended hours spent during soaking of the seed sample to remove the seed coat and fermentation process. Alkaloids are removed from seed materials by aqueous extraction and treatment (Kumar et al., 2012).

Saponins increase the digestibility of carbohydrate rich foods. However, simultaneous consumption of saponin and tannin results in the loss of individual toxicity because the formation of tannin-saponin complexes inactivates the separate biological activity of both tannin and saponins.

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Anti-nutritional effects of tannins include interference with digestion by binding to proteins or minerals. The higher level of tannin in the fermented sample could be due to the extended hours spent during soaking of the seed sample to remove the seed coat and fermentation process which made the hydrolysable tannin content more available within the seed. The decrease in phytate content by soaking (fermentation: keeping of the seed for longer hours in water), cooking of pre-soaked bean or germination may be due to leaching out of this compound in water (Osman, 2007).

Pretreatments such as soaking, soaking and boiling, effected significant reduction of the anti-nutrients concentrations and toxicants present in *Mucuna pruriens* (Velvet Beans) seeds (Nwaoguikpe, Braide & Ujowundu, 2011).

Weight gain and SGR decreased with increase in inclusion level of fermented *T. indica* seed meal. However, SLG and TLG increased with increase in inclusion level. The 0% inclusion level had the best growth response, followed by 75% inclusion level of fermented *T. indica*. The growth response in respect to weight gain and SGR are in conformity with the findings of Agbo, Madalla and Jauncey (2011) who reported decrease in growth rate with increase in the level of cotton seed meal in the diet of *O. niloticus*. However, SLG and TLG in this study are contrary to their findings. Khan, Siddique and Zamal (2013) also reported decrease in growth performance of *O. niloticus* with increase in inclusion level of rice polish. The general slow gain in weight might be due to the fact that fish were fed exclusively the formulated feeds with no access to natural feed as may be found in pond or riverine condition (Amisah, Oteng & Ofori, 2009) and reared under laboratory condition.

The high values recorded for FCR suggests indigestibility of the diet and can be attributed to high crude fibre in the diet (Aderolu & Sogbesan, 2010). A number of studies opined that low level of FCR is an indicator of feed utilization efficiency of formulated feed (Kader, Hossain & Hossain, 2003; Khan, Siddique & Zamal, 2013; Shipton & Hecht, 2013 and RIAS Inc., 2016). The values for NPU from this study reveals that the fishes were able to convert the amino acids supplied by the diets since value greater than 0 depicts conversion of nitrogen supplied to protein. Nm and PER decreased with increase in inclusion level of fermented *T. indica* seed meal and all varied significantly ($P$<0.05). PER increased with the quantity of protein fed. The high value for Diets $D_1$ and $D_4$ can be attributed to their higher cost of feeding.

Obaroh, Haruna and Ojibo (2015) reported that protein, lipids and moisture contents are the major constituents when evaluating nutritive value of fish. All experimental diets significantly increased the protein and lipid contents of experimental fish. This result implies that there was synthesis and increased tissue protein production (Yusuf, Umar, Micah & Akpotu, 2016). Increase in lipid content of the carcass can be due to accumulation of fat (Bekibele, 2005) which has contributed to increase in weight. Carbohydrate content increased with increase in inclusion level and must have resulted in $D_5$ having the least WG, SGR, GFCE, PWG, PER, NPU and Nm. Also, Pantazis (2005) reported that high dietary carbohydrate level has significant protein sparing effect in fish.

## Conclusion

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Fermentation significantly ($P$<0.05) increased the nutritive content of *T. indica* seed nut and also significantly decreased the anti-nutrients of the seed except for tannin content. The growth performance of *O. niloticus* fed 75% inclusion level of fermented *T. indica* seed meal varied significantly ($P$<0.05) compared to those fed other inclusion levels, and also maximally utilized fermented *T. indica* seed meal at 75% inclusion level compared to the rest. However, the low values for PER indicates that the fishes were not able utilize the protein in the diet efficiently. All inclusion levels significantly ($P$<0.05) increased the carcass composition of *O. niloticus*. 75% inclusion level gave the best crude protein.

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**Table 1.** Proximate and anti-nutrients composition of *Tamarindus indica* Seed

| Parameters | Raw *T. indica* Seed | Fermented *T. indica* Seed | Soya Bean (Van Eys *et al.* 2004) |
|---|---|---|---|
| Crude Protein | 19.46 ± 0.07[b] | 21.44 ± 1.01[a] | 37.08 |
| Crude Fibre | 5.09 ± 0.27[a] | 3.99 ± 2.17[b] | 5.12 |
| Lipid | 4.59 ± 1.39[b] | 6.73 ± 1.07[a] | 18.38 |
| Ash | 6.84 ± 0.62[a] | 3.73 ± 0.65[b] | 4.86 |
| Nitrogen Free Extract | 64.02 ± 1.11[a] | 64.12 ± 2.88[a] | 44.20 |
| Anti-nutrients (mg/g-1) | | | |
| | Raw *T. indica* Seed | Fermented *T. indica* Seed | % Reduction |
| Alkaloid | 3.70 ± 0.10[a] | 1.50 ± 0.05[b] | 59.46 |
| Saponin | 2.30 ± 0.10[a] | 1.80 ± 0.12[b] | 21.74 |
| Tannin | 2.37 ± 0.02[b] | 4.22 ± 0.16[a] | -43.84 |
| Phytate | 6.75 ± 0.15[a] | 2.68 ± 0.09[b] | 60.30 |

Means with the same superscript along rows do not vary significantly (*P*>0.05). "[a]" is assigned to the higher value while "[b]" is assigned to the lower value.

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**Table 2.** Growth performance and feed utilization of *Oreochromis niloticus* fed varying inclusion levels of fermented *Tamarindus indica* seed meal

| Parameters | Inclusion Levels | | | | |
|---|---|---|---|---|---|
| | 0% | 25% | 50% | 75% | 100% |
| IW (g/fish) | 9.38 ± 2.36$^{a}$ | 8.39 ± 0.37$^{a}$ | 9.39 ± 1.44$^{a}$ | 8.96 ± 2.44$^{a}$ | 9.63 ± 2.90$^{a}$ |
| FW (g/fish) | 21.78 ± 2.03$^{a}$ | 13.15 ± 0.58$^{b}$ | 12.58 ± 0.11$^{b}$ | 17.54 ± 1.76$^{ab}$ | 11.88 ± 3.68$^{b}$ |
| WG (g/fish) | 12.40 ± 0.33$^{a}$ | 4.77 ± 0.92$^{c}$ | 3.19 ± 1.54$^{c}$ | 8.58 ± 0.68$^{b}$ | 2.25 ± 0.78$^{c}$ |
| ISL (cm/fish) | 6.12 ± 1.49$^{a}$ | 6.82 ± 0.09$^{a}$ | 6.80 ± 0.13$^{a}$ | 5.61 ± 0.39$^{a}$ | 6.38 ± 0.53$^{a}$ |
| FSL (cm/fish) | 8.93 ± 0.28$^{a}$ | 7.52 ± 0.12$^{b}$ | 8.0 ± 0.60$^{ab}$ | 8.15 ± 0.15$^{ab}$ | 7.61 ± 0.31$^{b}$ |
| SLG (cm/fish) | 2.81 ± 1.76$^{a}$ | 0.70 ± 0.03$^{c}$ | 1.21 ± 0.48$^{b}$ | 2.54 ± 0.24$^{a}$ | 1.24 ± 0.22$^{b}$ |
| ITL (cm/fish) | 7.62 ± 0.10$^{a}$ | 8.68 ± 0.10$^{a}$ | 8.23 ± 0.65$^{a}$ | 7.18 ± 0.44$^{a}$ | 8.15 ± 0.58$^{a}$ |
| FTL (cm/fish) | 11.20 ± 0.20$^{a}$ | 9.40 ± 0.10$^{b}$ | 10.11 ± 0.90$^{ab}$ | 10.30 ± 0.30$^{ab}$ | 9.51 ± 0.30$^{ab}$ |
| TLG (cm/fish) | 3.58 ± 1.80$^{a}$ | 0.72 ± 0.00$^{c}$ | 1.88 ± 0.24$^{b}$ | 3.12 ± 0.14$^{a}$ | 1.37 ± 0.32$^{b}$ |
| SGR (%days) | 1.05 ± 0.20$^{a}$ | 0.55 ± 0.12$^{ab}$ | 0.37 ± 0.20$^{b}$ | 0.85 ± 0.22$^{ab}$ | 0.25 ± 0.01$^{b}$ |
| PWG | 1.42 ± 0.39$^{a}$ | 0.58 ± 0.14$^{ab}$ | 0.37 ± 0.22$^{ab}$ | 1.01 ± 0.41$^{ab}$ | 0.23 ± 0.01$^{b}$ |
| FCR | 1.82 ± 0.32$^{a}$ | 2.29 ± 0.27$^{a}$ | 2.73± 0.56$^{a}$ | 1.92 ± 0.17$^{a}$ | 2.78 ± 0.08$^{a}$ |
| GFCE | 56.70 ± 9.97$^{a}$ | 44.36 ± 5.14$^{a}$ | 36.63 ± 5.28$^{a}$ | 52.08 ± 2.65$^{a}$ | 36.01 ± 1.04$^{a}$ |
| PER | 0.14 ± 0.14$^{a}$ | 0.07 ± 0.02$^{b}$ | 0.06 ± 0.01$^{b}$ | 0.12 ± 0.02$^{a}$ | 0.03 ± 0.00$^{b}$ |
| NPU | 0.12 ± 0.01$^{a}$ | 0.12 ± 0.01$^{a}$ | 0.22 ± 0.13$^{a}$ | 0.13 ± 0.03$^{a}$ | 0.09 ± 0.03$^{a}$ |
| Nm | 281.24 ± 7.5$^{a}$ | 108.07 ± 20.8$^{c}$ | 72.35 ± 34.9$^{c}$ | 194.60 ± 15.43$^{b}$ | 50.92 ± 17.58$^{c}$ |

Means with the same superscripts along rows do not vary significantly ($P$>0.05). Means are ranked in descending order by assigning "$^{a}$", "b" and "$^{c}$".

**Note:** Initial Weight (IW), Final Weight (FW), Weight Gain (WG), Initial Standard Length (ISL), Final Standard Length (FSL), Standard Length Gain (SLG), Initial Total Length (ITL), Final Total Length (FTL), Total Length Gain (TLG), Specific Growth Rate (SGR), Percentage Weight Gain (PWG), Feed Conversion Ratio (FCR), Gross Feed Conversion Efficiency (GFCE), Protein Efficiency Ratio (PER), Net Protein Utilization (NPU) and Nitrogen Metabolism (Nm).

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**Table 3.** Carcass composition of *Oreochromis niloticus* fingerlings fed varying inclusion levels of fermented *Tamarindus indica* seed meal

| P | Initial | Inclusion levels after feeding trial | | | | |
|---|---|---|---|---|---|---|
| | | 0% | 25% | 50% | 75% | 100% |
| CP | $43.91 \pm 0.29^{d}$ | $54.02 \pm 0.08^{a}$ | $52.61 \pm 0.30^{b}$ | $52.77 \pm 0.27^{b}$ | $53.07 \pm 0.13^{b}$ | $49.99 \pm 0.01^{c}$ |
| EE | $8.56 \pm 0.17^{a}$ | $9.91 \pm 0.48^{a}$ | $8.78 \pm 0.78^{a}$ | $9.79 \pm 0.27^{a}$ | $10.15 \pm 0.90^{a}$ | $9.95 \pm 0.33^{a}$ |
| Ash | $13.03 \pm 0.05^{c}$ | $14.31 \pm 0.25^{ab}$ | $13.81 \pm 0.07^{ab}$ | $13.64 \pm 0.36^{ab}$ | $14.76 \pm 0.37^{a}$ | $13.98 \pm 0.13^{ab}$ |
| NFE | $34.51 \pm 0.07^{a}$ | $21.77 \pm 0.81^{c}$ | $24.81 \pm 1.14^{bc}$ | $24.69 \pm 1.52^{bc}$ | $22.04 \pm 1.39^{c}$ | $26.09 \pm 0.45^{b}$ |

Means with the same superscripts along rows do not vary significantly ($P$>0.05). Means are ranked in descending order by assigning "a", "b", "c" and "d".

**Note:** Parameters (P), Crude Protein (CP), Lipid (EE) and Nitrogen Free Extract (NFE).