



Research Article

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# Silkworm (*Bombyx mori*) Feces Inclusion in Diets of Nile Tilapia (*Oreochromis niloticus*) On Water Quality, Morphometric Parameters, Growth and Carcass Performances in Aquaculture System in Ziway, Southern Ethiopia



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## Abstract

Feces from silkworm (*Bombyx mori*) fed on mulberry leaf was fed to Nile Tilapia and growth performance evaluated (Ziway, Ethiopia). 192 fishes (5.2±1.6g) were randomly distributed to four diets (T1-T4), each replicated four times and fed at 10% of body weight for 90 days. T1= basal diet (Bone and meat meal +wheat flour + roasted soybean +noug cake), T2= 95% basal diet + 5% SWF, T3= 90% basal diet + 10% SWF and T4 = 85% basal diet + 15% SWF. T1, T2, T3 and T4 had 29.41, 29.84, 30.52 and 30.54%CP; and 3377, 3305, 3179 and 3104 kcal ME/kg, respectively. Change in BW (0.12, 0.10, 0.10 and 0.07g/d) and body length (0.47, 0.44, 0.49 and 0.33cm/15d) among T1, T2, T3 and T4, respectively, were not different (p>0.05). Feed conversion ratio was <0.3. T1 had slightly higher (4.19) protein efficiency ratio followed by T2 (4.14), T3 (1.87) and T4 (1.58). CP content of fillet of fish (54.78, 55.64, 55.75 and 56.28%CP) for T1, T2, T3 and T4, respectively and Fulton's condition factor index were not significantly different (p>0.05). SWF could be included up to 15% in *O. niloticus* diets with no noticeable side effects in fish growth and health.

**Key words:** Aquarium; Mulberry; *Oreochromis niloticus*; Silkworm

## Introduction

Nile tilapia (*O. niloticus*) dominates fresh water aquaculture. This species is preferred due to its rapid growth rates, high tolerance to low water quality, efficient feed conversion, ease of spawning, resistance to disease and good meat taste [1].

Aquaculture output has been growing at a high pace for decades. According to data published by the FAO, in 2007, 49% of fish and fishery products (excluding fish meal) consumed as food were farmed. Fish demand has risen worldwide as populations have grown and incomes have increased; thus fish are highly likely to continue becoming more expensive over the next two decades. Consequently the use of supplementary feeds in fish culture is therefore expected to increase. An investigation on the development of alternative low-cost feeds suitable for small-scale farmers have become a priority in many developing countries, including sub-Saharan Africa. Some of cheap feed stuffs are; agro-industrial by-products and excrements of

one animal can be a source of nutrient to others in integrated livestock farming systems [2]. Protein represents about 50% of feed cost in intensive culture. The major challenge facing tilapia nutritionists in developing countries is the development of commercial, cost effective tilapia feeds using locally available, cheap and nonconventional resources [3].

Aquaculture is relatively new to Ethiopia and has been limited to stocking of water bodies with fingerlings. On the other hand, the limited production of fish from the capture fishery cannot fulfil the rapidly growing demand of the population [4].

The sericulture center found in ALAGE ATVET College is under the administration of Ministry of Agriculture [5]. In the college, among agricultural activities being conducted includes fisheries but the resources are not being used efficiently by integration. Silkworms are monophagous and nutrients in their feces are directly coming from the feed. Even if this is the fact the

college is not using the feces in any sector of its farming. This study was therefore designed to evaluate the effect of mixing graded level of silkworm feces with locally available feeds on the growth and carcass performances of Nile tilapia (*Oreochromis niloticus*).

## Materials and methods

### Description of the study area

The experiment was conducted at Ziway Fisheries Resource Research Center (ZFRRC) which is located in the Great East African Rift Valley and located at 160km South of Addis Ababa on the way to Hawassa in Batu Town, Oromia Regional State, Ethiopia. The center is situated on Western shore of Lake Ziway within the mid Ethiopian Rift Valley system at 7.9 °N and 37.7 °E and altitude of 1638 meter above sea level. The mean annual maximum and minimum temperature is 27.3 °C, 14.2 °C respectively and the area receives a mean annual rainfall about 720.2mm (Ziway Metrology unpublished data, 2015)

### Feed ingredients collection and diets formulation

Niger seed cake, wheat grain and soybean were purchased from Ziway (Batu) city local market. Bone and meat meal was purchased from Addis Ababa Kaliti municipal slaughter house (Kera) waste processing. The silkworm feces were collected from Alage ATVET college sericulture center which is located in the Great East African Rift Valley, 214 km south of Addis Ababa. The silkworms were fed with leaves of two varieties of mulberry namely Kanva2 and S13 [5].

The proportion of the ingredients in experimental diets is shown in Table 1. Feed ingredients and SWF were dried, ground and sieved. After mixing ingredients, water was added and boiled at 800C until it becomes thick dough. The final mixtures were made into moist pellets using electrical pelletizing machine and semi-dried by sunlight then manually crushed into 1-2mm size with 1/8 inch sieve size on the pelleting machine. Then it was further sun dried and kept in plastic buckets.

**Table 1:** Treatment diets containing graded level of silkworm feces.

Ingredients	Treatment diets (%)			
	T-1	T-2	T-3	T-4
Bone and meat meal	31	35	40	43
Wheat flour	44	40	35	32
Roasted Soybean	20	15	5	0
Noug cake	5	5	10	10
Silkworm feces	0	5	10	15

## Measurements and observations

### Stock origin, experimental design and management

More than 200 mixed-sex juvenile Nile Tilapia were collected from ZFRRC experimental pond (fishes originally from Lake Chamo) by using beach seine with a stretched mesh size of 30 mm. Immediately after capture, appropriate size fishes were selected (handpicked) and weighed using mobile sensitive balance (sensitivity of 0.1gm.) and were placed in plastic buckets and moved to experimental room (laboratory). Then, fish having body weight ranging between 1.5 to 9g were selected for the experiment and the rest turned back to the pond. These batches of fish were stocked into 16 plastic aquaria (52.5cm diameter × 35cm height) which hold 75.8 liters of water and stocked with 12 fishes per aquaria and were replicated 4 times per treatment in CRD. Then, the fish were allowed to acclimatize for 7 days and were fed for 90 days. The culture system used is recirculation aquaculture system (RAS) and all dead and weak fishes, feces and feed residues were removed daily; while the water in each aquarium was circulating continuously. The experimental fish were fed two times a day at 10:00 am and 4:00 pm and daily feed offered (DFO) was about 10% of their body weight and DFO was calculated using the average body weight (ABW), the total number of fishes in an aquarium (N) and the feeding rate per day (FRd-1) using the following formula:  $DFO = ABW \times N \times (FRd-1)$  [6]. When feed is offered, water circulation of the aquaria was stopped for 30 to 40 minutes to keep the pellets floating. During the experiment, the water quality was regularly monitored throughout the experiment such as dissolved oxygen (DO) by DO meter, ammonia, nitrite, nitrate and pH were measured 3 to 4 times a week using Api Freshwater test kit (Chromatography test), while water temperature was measured daily by a thermometer.

### Chemical analysis of ingredients, experimental diets and fillet

Dry matter (DM) and ash were according to [7]. Nitrogen (N) was quantified by the standard micro-Kjeldahl method [8] and crude protein was calculated by multiplying N with 6.25. Ether extract (EE) and crude fiber (CF) were determined according to [8]. Nitrogen free extracts (NFE) were estimated by difference ( $NFE = DM - CP - EE - CF - Ash$ ).

### Data collection

Body weight change was recorded at fifteen days interval. Growth performance of fish was determined by subtracting initial from final weight (g). Total length was expressed as the distance from the tip of the snout to the end of the caudal fin. Rates of survival (%), daily growth rates (DGR) and Fulton's condition factor (FCF) were computed. Feeding behavior was also registered throughout the experiment by visual observation. Growth parameters were calculated following standard equations [9]:  $DGR (g/day) = \frac{\text{final weight (g)} - \text{initial weight (g)}}{\text{culture period}}$ ;  $\text{survival rate (\%)} = \frac{\text{number of fish harvested}}{\text{total number of fish}} \times 100$

$\times 100$  / number of fish stocked;  $FCF = (TW \times 100) / TL3$ , where TW is total body weight in g, TL total length in cm; Food Conversion Ratio (FCR) = total diet fed (g) / total weight gain (g); protein efficiency ratio (PER) = total weight gain (g)/amount of protein offered (g).

### Statistical analysis

All data were subjected to a one-way ANOVA, using the general linear model procedure of SPSS 16.1 and means were separated using Duncan's multiple range test and declared significant at  $p < 0.05$ . The model used for analysis of biological

data was  $Y_{ij} = \mu + \tau_i + \epsilon_{ij}$  where  $Y_{ij}$  = observation  $j$  in  $i$ th treatment;  $\mu$  = the overall mean;  $\tau_i$  = the fixed effect of  $i$ th treatment; and  $\epsilon_{ij}$  = random error.

## Results and discussion

### Chemical composition of experimental feeds

The levels of major nutrients in the feed ingredients and diets are shown in Table 2. Treatment diets had comparable DM, CP, EE and CF contents. The ash was lower but NFE and ME contents higher in T1 and T2 than in T3 and T4.

**Table 2:** Chemical composition of the feed ingredients and experimental diets (% DM basis).

Parameters	Nutrients (% DM)						ME (kcal/kg DM)
	DM (%)	CP	EE	CF	Ash	NFE	
Silk worm feces	67.42	9.21	2.91	15.4	20.1	46.78	3433
Bone and meat meal	94.17	52.25	18.77	1.7	21.21	0.24	3849
Nuge cake	92.02	29.92	10.81	18.78	10.54	21.97	3197
Wheat flour	90.39	11.57	3.05	1.89	1.51	72.37	2735
Soybean roasted	92.62	33.14	17.67	4.61	3.28	33.92	2207
T1	92.09	29.41	11.24	6.28	8.42	39.8	3377
T2	92.33	29.84	11.13	6.39	10.05	37.56	3305
T3	92.58	30.52	10.83	6.69	12.24	34	3179
T4	92.78	30.54	10.56	6.78	13.67	32.48	3104

CF=crude fiber, CP=crude protein, DM=dry matter, EE=ether extract, ME=metabolizable energy, NFE=nitrogen free extract, T1=31% bone and meat meal + 44% wheat flour + 20% roasted soybean + 5% noug cake, T2=35% bone and meat meal + 40% wheat flour + 15% roasted soybean + 5% noug cake + 5% silkworm feces, T3=40% bone and meat meal + 35% wheat flour + 5% roasted soybean + 10% noug cake + 10% silkworm feces, T4=43% bone and meat meal + 32% wheat flour + 0% roasted soybean + 10% noug cake + 15% silkworm feces

The CP content of ingredients play major role in formulating Tilapia diet. According to their description variation in CP content of SWF might be due to variation in race of silkworm (*Bombyx Mori*), or due to varietal differences in the mulberry fed to the silkworms and also due to influence of season on mulberry and silkworms. In this study the soybean was roasted to minimize the effect anti-nutritional factors. Variation in protein quality among soybean products is due to the protein and amino acid (AA) concentrations and bioavailability in the product and variation in AA bioavailability could be due to either insufficient or excessive heat processing [10].

**Table 3:** Morphometric measurements and feed utilization parameters (Number of fishes = 192).

Parameters	Treatments			
	T1	T2	T3	T4
Initial weight (g)	5.2	5.6	4.7	5.6
Final weight (g)	16.4	13.7	11.9	11.6
Initial length (cm)	6.7	6.3	6.1	6.7
Final length (cm)	10.5	9.4	8.7	8.7
Weight gain (g)	11.2	8.1	7.2	6
Weight gain (g/15d)	1.57	1.36	1.24	0.97
Daily growth rate (g/d)	0.12	0.09	0.08	0.07
Change in length (cm/15 d)	0.47	0.44	0.49	0.33

### Morphometric measurements and feed utilization

Table 3 summarizes the growth performance of *O. niloticus* in terms of final body weight (FBW), daily weight gain, feed conversion ratio (FCR) and protein efficiency ratio (PER) and also survival rate (SR) under the four experimental diets. The effects of including graded level SWF in the diets were not significantly different ( $P > 0.05$ ). However, weight gain performance was higher in T1 as compared to the rest and mortality rate is slightly lower in T2. The highest FCR but lowest PER were recorded in T4.

Survival rate (%)	64	72.9	58.3	62.5
Feed conversion ratio	1.04	1.04	1.75	2.46
Fulton's condition factor	1.7	1.69	1.7	1.67
Protein efficiency ratio	4.19	4.14	1.87	1.58

T1=31% bone and meat meal + 44% wheat flour + 20% roasted soybean + 5% noug cake, T2=35% bone and meat meal + 40% wheat flour + 15% roasted soybean + 5% noug cake + 5% silkworm feces, T3=40% bone and meat meal + 35% wheat flour + 5% roasted soybean + 10% noug cake + 10% silkworm feces, T4=43% bone and meat meal + 32% wheat flour + 0% roasted soybean + 10% noug cake + 15% silkworm feces

Studies conducted in many parts of the world have indicated that the type of feed offered affect the growth performance of the fish but not all diets which produce fastest growth are always profitable [11-13]. Diets in the current study had optimum CP level (29.40 to 30.54%) which is close to protein levels of 30 to 36 % which is considered to be adequate for most warm water fishes [14]. Protein is a significant dietary component because of its cost and also gross protein requirements in fish are higher than in warm blooded animals. Even if there is recommended level of CP for fish feed the correct level of protein required for optimum growth of fish is controversial. Many authors obtained conflicting results from their biology and environmental conditions or other unknown factors studied on tilapia nutrition.

The dietary proteins which mask the standardization of requirements of several species of tilapia have been estimated to range from 20% to 56% [15]. The general conclusion that fry of tilapia <1g require diet with 35-50% protein, 1-5g fish require diet with 30-40% and 5-25g fish require diet with 25-35% protein [16], is in line with the current study where Tilapia fingerlings had average weight of 5.2g. It can thus be claimed that experimental diets in this study met requirement of protein and was also economical. Most economical dietary protein requirement for young tilapia (1 to 5g) was 28 %, however; maximum growth was achieved at about 34% [17].

In line with the study fish can grow well on a feed containing 20-30% CP of which 7-10% of the protein is of animal origin [18]. The current study used enough proportion of animal source protein and high densities of fish per aquarium and the amount of protein obtained from the test feeds appear to be sufficient enough for optimal growth of juvenile *O. niloticus* and studies show that excess protein is not economical and at the same time it could be toxic. Excess amino acids may impair proper fish growth [19]. The total organic matter in all test feeds was generally high and exceeded 90% of the total dry matter. The amount of ash was between 8.42 and 13.67% which indicates that there was sufficient mineral. The crude fiber content of the diets is in safe range for growth of Tilapia [20].

All feeds (T1, T2, T3, and T4) showed comparable palatability. Average initial weight used in the current study is 5.2g. T1 showed numerically highest final weight, final body length, weight gain and daily growth rate. And the rest showed lesser values and the least was from T4. This might be due to higher crude fiber content in the SWF containing diets, even if they contain optimum amount of CP.

T2 had the highest and T3 the lowest survival rate. Throughout the study period there is no record of disease and water quality problem which could affect the physiology of the fish and thus major reason for mortality in this study is perhaps mechanical problem. The fish jump out from the experimental aquaria during night time when there was no one to catch and put them back to the water which resulted in death, this is the phenomena that made survival rate lower in this study. So the survival rate doesn't show the effect of feed or the culture environment. Growth rate of fish under culture conditions depends much on management practices applied during the culture period [21,22]. Weight gain was low in this study possibly due to the culture system which is completely artificial and high stocking density. Some of the factors which determine the growth performance of the fish include species cultured, stocking density, fertilization of the culture (if it is pond), control of water quality parameters and type of food supplemented [21-23]. And also it has been reported that stocking density and type of culture affect tilapia production [12,24,25].

Feed conversion ratio (FCR) of the fishes, determined as weight of the feed consumed per weight gained differs according to experimental conditions, culture system and species of fishes [26]. For the fish with higher growth rate like *O. niloticus*, FCR can be below 3 as reported by different researchers in different part of the world [21,26-28]. However, under certain conditions it may be higher than 3 [29,30]. In the current study FCR is acceptable and decreased with increasing dietary protein levels from T1 to T4. This might be due to higher feeding rate i.e.10% of ABW of the fish and high stocking density and crude fiber content of feeds. Stocking density of current study is 12 fish per aquaria. In line with the study of [31] increasing stocking density led to diminishing social dominance resulting in higher survival but lowers individual growth rate. On the other hand, low stocking densities lead to low feed utilization efficiency due to lack of competition for food or difficulty of tracing feed particles or flush of uneaten food by drainage water since the study was conducted in recirculation system as it was claimed in earlier studies [29,32].

The PER in current study decreased from 4.19 (T1) to 1.58 (T4), a decrease with increasing levels of inclusion of SWF which is in line with earlier findings [32].

Juvenile *O. niloticus* fed on control diet (T1) had slightly higher BWG, DGR, final body weight and final body length than those on T2, T3 and T4, although differences among diets were

not significant. The growth rate of fish was similar throughout the experimental period, which might be due to controlled environment of the culture system. Since the CP content of experimental diets was adjusted to be optimal the reason for these differences might have been caused by the higher fiber content (15.4%) of the SWF. The other reason might be related to the major source of nitrogen (up to 90%) in an aquaculture system. Nitrogen (N) matters because it is the main component to protein synthesis but the chemistry of N in ponds is very complex because of the many states in which N exist: NH<sub>3</sub>, NH<sub>4</sub><sup>+</sup>, N<sub>2</sub>, N<sub>2</sub>O, NO, N<sub>2</sub>O<sub>3</sub>, N<sub>2</sub>O<sub>5</sub>, NO<sub>2</sub>, and NO<sub>3</sub>. [33]. And so is in the highly controlled system like in the current study (aquarium), N will affect the processes of protein formation in the system. Difference in temperature may affect feeding and growth rates of fishes under controlled system in aquaria [34].

Change in body length of fishes showed no significant differences among treatment diets and as weight of the fish increased length also increased but it was not proportional.

### Water quality parameters (physiochemical parameters)

The water quality parameters (ammonia, nitrate, nitrite, dissolved oxygen, and pH and temperature) in all aquaria were identical (1, 0, 0, 5.2-7.6 mg/l, and 7-7.6 and 26.4-28.9 °C, respectively). Water used for this experiment was re-circulated using electric power. The water temperature has been monitored daily and the other parameters at 3 to 4 days interval. All parameters were kept in ranges safe for Tilapia production over the entire study period.

Water quality parameters were monitored regularly throughout this study. Although the environment in aquaculture is complex, management of the water quality parameters is essential because environmental factors affect the fish body condition, growth performance and yield [35]. Water quality determines the growth performance of Tilapia whereby excellent quality of water may lead to high survival, growth rate and yield [36]. High levels of nitrogen in the form of un-ionized ammonia or nitrite may be toxic to the fish and also fish start to die at nitrite levels of 5 mg/l [37,38]. In the current study nitrite (NO<sub>2</sub>) level was below the maximum accepted tolerance level (0.55 mg/l). Level of ammonia was also found to be at 1mg/l. According to [39], generally only 1%, about 5 to 9%, 30 to 50% and 80 to 90% of the total ammonia is in the toxic un-ionized form at pH 7, 8, 9 and 10, respectively. In the current study pH value observed was in agreement with the recommended levels (6.5 to 9) for aquaculture [36,30]. Fish can survive in a wide range of water pH between 3.5 and 12 [40].

In all experimental aquaria temperature was kept between 26.4 and 28.9 °C. The temperatures preferred by *O. niloticus* range from 25 to 30 °C but, they may also do well in waters of 20 to 35 °C and moreover, Tilapia may tolerate temperatures as low as 16 -17 °C for short periods [41]. The lower and upper lethal temperatures for most Tilapia species are 11 °C and 42

°C, respectively [2141,42]. In line with this study *O. niloticus* fingerlings performed well when temperature was held between 23.8 °C and 28 °C [21].

Low water temperature and oxygen level below the tolerance limit influence feed intake. This study testified this fact because temperature in the system was kept optimum by adjusting the level using electrical heater connected to the water circulation system so that it doesn't fluctuate as that of the natural day and night. Feed intake decreases when water temperature is low under controlled system in aquarium [34].

Dissolved oxygen (DO) concentration in this study was within the safe limits (5 to 8mg/l) recommended for aquaculture [11,38,42]. However, *O. niloticus* have been reported to be able to survive in DO as low as 0.1mg/l [43]. Prolonged depletion of oxygen is often a major cause of mortality in culture systems. However, Tilapias are able to survive long periods of up to 6 - 8 hours of low oxygen concentration by gulping at the air-water interface [36].

### Chemical composition of carcass of experimental fish

The proximate composition of the carcass (fillet) of fish after feeding the experiential diets for 90 days is shown in Table 4. Differences in CP and CF contents of the fillet were not statistically significant although these values increased from T1 to T4.

**Table 4:** Nutrient composition of the carcass (% DM basis) of *O. niloticus* fed on experimental diets.

Treatments	Dry matter	Crude protein	Ether extract	Crude fiber	Ash
T1	16.9	54.78	7.23	0.02	5.6
T2	17.51	55.64	6.01	0.03	5.04
T3	17.75	55.75	5.66	0.15	4.89
T4	18.7	56.28	5.67	0.33	5.44

T1=31% bone and meat meal + 44% wheat flour + 20% roasted soybean + 5% noug cake, T2=35% bone and meat meal + 40% wheat flour + 15% roasted soybean + 5% noug cake + 5% silkworm feces, T3=40% bone and meat meal + 35% wheat flour + 5% roasted soybean + 10% noug cake +10% silkworm feces, T4=43% bone and meat meal + 32% wheat flour + 0% roasted soybean + 10% noug cake + 15% silkworm feces

Tissue protein content increased as feed protein increased. The current study agreed with earlier study which concluded that like other fish species Tilapia has high CP, EE and ash contents and is mainly affected by diet [40]. Fish body composition is affected by both exogenous and endogenous factors such as the composition of diet and frequency of feeding and the salinity and temperature of water [44]. Various studies have examined the effects of temperature, light, salinity, pH and oxygen concentration on the proximate composition of fish but these factors would seem to have very limited effects. On the other hand, endogenous factors are genetic and linked to the age, size and sex of the fish [45]. Usually around 20 to 30% of

the N contained in feed is recovered in fish flesh at harvest, with the remainder potentially entering the culture system as NH<sub>3</sub> nitrogen [46].

The fillet in this study is lower than earlier reports of 69.18 to 73.4% CP in Malaysia for *O. niloticus* fed diets containing different levels of super worm meal [47]. However, low CP ranging from 50.95 to 52.75% for *O. niloticus* fed on plant based diets (a mixture of 24.5% soybean meal, 11.5% wheat gluten, 22.5% corn and 32.5% wheat) and supplemented with graded levels of different sources of microbial phytase were reported [48].

As opposed to low fat content (5.66 to 7.23% DM) in this study, high EE (11.7 to 26.4) have been reported for *O. niloticus* supplemented with the diet containing fish meal, soybean meal, wheat meal, vitamin and mineral premix [47,49,50]. Fiber and ash content of the fillet increased with the level SWF in the diet.

### Fulton's condition factor index

Fulton's condition factor of fish fed the four experimental diets did not vary significantly (Figure 1). Fish given test diets were found not greater than that of basal diet without SWF. There was no significant variation seen in Fulton's condition factor index.

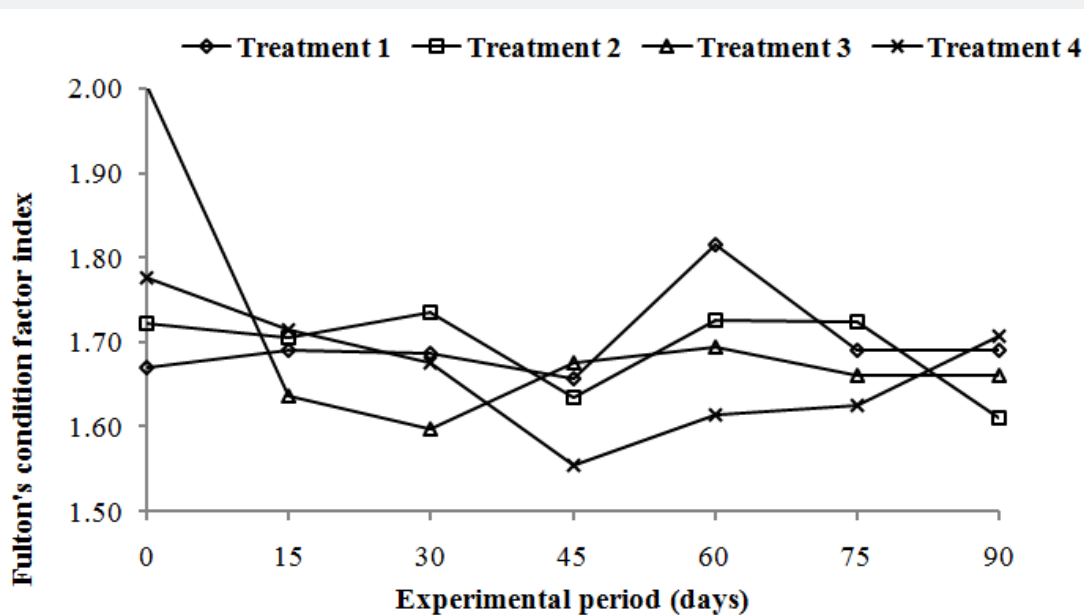


Figure 1: Fulton's condition factor index of *O. niloticus* reared in aquaria under the four experimental feeds.

T1=31% bone and meat meal + 44% wheat flour + 20% roasted soybean + 5% noug cake, T2=35% bone and meat meal + 40% wheat flour + 15% roasted soybean + 5% noug cake + 5% silkworm feces, T3=40% bone and meat meal + 35% wheat flour + 5% roasted soybean + 10% noug cake + 10% silkworm feces, T4=43% bone and meat meal + 32% wheat flour + 0% roasted soybean + 10% noug cake + 15% silkworm feces

Fulton's condition factor of fish fed the four experimental diets did not vary significantly. The condition factor or Ponderal index, or correlation coefficient expresses the condition of a fish, such as the degree of wellbeing, relative robustness, plumpness or fatness in numerical terms. From a nutritional point of view, there is the accumulation of fat and sustainable gonad development [51]. A number of factors (e.g. sex, seasons, environmental conditions, stress and availability of food) are also affecting the condition of fish. It was observed stress as a result of the reduction in the breeding and nursery ground of *O. niloticus* contributed dramatically to higher condition factor [52].

### Conclusion

In a feeding trial conducted, inclusion of silk worm feces (SWF) in diets of Nile Tilapia (*O. niloticus*) visa-vis control diet, fed in aquarium recirculation system in a completely artificial

media in which all the needs were controlled and adjusted resulted in comparable growth. Growth rate of fishes was similar throughout the experimental period; possibly due to the controlled environment of the culture system. Daily growth rate, average weight gain and survival of fishes fed T4 (highest level of SWF) was comparable with the control diet (T1), the slightly lower values of T4 is because of higher crude fiber content. This study revealed that feeding SWF to fishes is an effective way of disposing it as it is good nutrient source and can meet nutrient requirements recommended for juvenile *O. niloticus*. Feeding SWF in open air culture is recommended because it might produce better results if it is applied in pond culture, because growth might be promoted.

### Conflict of interest

There is no conflict of interest of authors.

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