

# Effect of formulated feed (containing common bean and leftover flour) on growth performance of Nile tilapia (*Oreochromis niloticus* L.) in earthen ponds at Nono district, Ethiopia

Mekonnen Melesse Diriba\*, Mathewos Temesgen and L. Prabadevi

College of natural and computational science, Ambo University School of Graduate Studies, Ethiopia.

\*Corresponding author. Email: mekonnen.m9980@gmail.com/mekonnen0924997096@gmail.com

Copyright © 2019 Diriba et al. This article remains permanently open access under the terms of the [Creative Commons Attribution License 4.0](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Received 5th October, 2019; Accepted 30th December, 2019

**ABSTRACT:** Fish feed plays a critical role in aquaculture; it influences production costs, fish growth, health and fish production. One of the approaches to tackle this problem has been to experimentally test the use of agro-industrial byproducts to grow fish in ponds. Thirty (30) fingerlings of Nile tilapia were stocked in each pond and fed with five percent of their body weight twice a day. Fish growth was measured using measuring board and sensitive balance and recorded fortnightly. Feed 1 performed better body weight gain (BWG) and Feed 3 produced the lowest BWG. The formulated Feed 1 which formulated from 50% of leftover flours from local grain mill machine and 50% of common bean indicated also a better profit index than others. In addition, Feed 1 showed the highest mean PR 88.59, which indicates the yield that it can produce in the given area and showed statistically significant (ANOVA ( $F = 2.39$ ),  $P = 0.02$ ). It is ascertained that the formulated Feed 1 can be recommended for farming Nile tilapia in the study area.

**Keywords:** Aquaculture, Ethiopia, formulated feed, Nile tilapia, Nono district.

## INTRODUCTION

As the human population continues to grow, the problem of food security is becoming a greatest challenge around the globe. As a result, healthy diet with high protein content is very important to ensure the food and nutritional security for the highest growing population. Fish protein has a high nutritional value due to a well-balanced amino acid profile, ample amount of poly unsaturated fatty acids (PUFA) as well as a number of vitamins and minerals (Edwards, 1997). Fish is one of the important protein sources contributing to more than 200 million people living in rural and urban areas of the African countries (Béné and Heck, 2005). However, harvesting of the only wild fishes, crustaceans and other aquatic species cannot meet the increasing demand of the growing human population. Unless fish supply is increased through sustainable aquaculture production, fish protein will become scarce

and the price of the fish will highly increase (FAO, 2012). The present water bodies are also unable to meet the growing demand of fish. This calls for an increasing focus on stocking and enhancement of artificial water bodies and the development of aquaculture in Africa (FAO, 2012).

As in more traditional forms of animal production, fish feed plays a crucial role in aquaculture production, because it influences not only the production costs, but also growth, health and production volume (da Silva and Anderson, 1995). For the fast growth and health of fishes, they should feed on nutritionally balanced diet which are cheap and should have efficient ingredients (Tacon, 1990). This needs the investigation of appropriate feeds that enhances the fish growth in economically safe way. To evaluate the effects of feeds on the growth performance, fish should feed with proper amount of feed without

degrading water quality and avoid nutritional deficiency diseases (Davis, 1968).

Today, there is high competition for the same food stuffs between human being and his domestic animals. For both economic and practical reasons, fish feed should be prepared by using locally available ingredients, preferably from those that are unsuitable for human consumption (Hossain and Jauncey, 1989). Therefore, formulating diets well suited to target species will overcome financial challenges, contributing to the long-term sustainability of aquaculture. Moreover, diets can be formulated to reduce effluents and dependence on resources not renewable in the short term (i.e., fishmeal) (Gatlin and Hardy, 2002). The population of Ethiopia was estimated at about 96.5 million in 2015, with an annual growth rate close to 2.6 %. The country often suffers risks of food in security largely due to recurring drought that affects crop production. The agriculture sector, parse, dominated by small scale farmers with low productivity could not lend itself to ensure food security and poverty alleviation to the fast-growing population.

In Ethiopia, the demand for fish has increased significantly over the past two decades according to the Addis Ababa Chamber of Commerce and Sectorial Associations Agri- business Support Facility Project of May (2015). However, fish stocks in the lakes and rivers are being depleted due to uncontrolled fishing activities (Abegaz et al., 2010). Due to the increasing human population, the need of fishes for additional nutritional security and reduction of wild fish catches from Ethiopian water bodies makes it mandatory and timely to look for alternative ways of fish production (Wakjira, 2013). Therefore, there is a need to develop fish feed as an alternative solution to increase fish culture in the context of increasing demand. With this aim, the study were conducted by using the cheap feed ingredients (common bean and leftover flour of local grain mill machine), as alternative source of protein to develop low-cost diets for small and medium scale fish farmers, and to test their efficiency in the growth of Nile tilapia (*Oreochromis niloticus*) with in earthen pond at Nono District, Ethiopia.

## MATERIALS AND METHODS

### Description of the study area

The present study was conducted at Nono District, West Shoa zonal administration, Oromia Regional State, Ethiopia, which is located at a distance of 100 km from Ambo to the south west and 214 km from the capital city of Ethiopia Addis Ababa. It has a good climate condition and high water potential for fish production. Corn or maize (*Zea mays*), sorghum (*Sorghum bicolor*) and teff or taf (*Eragrostistef*) are the major crops being produced in the district, which contribute to the main economy of the region.

### Experimental pond construction

Seven experimental earthen ponds with similar size (3 m width x 3 m length x 1.5 m height) were constructed. The ponds were covered with plastic sheet to control the seepage. The ponds bottom was fertilized with animal manure to promote algal growth before stocking the fish. The ponds were filled with water two week before stocking the fingerlings (Table 1).

### Feed preparation

The experiment consisted of four experimental diets, each with two replications but not for control diet. The experimental feeds were prepared by using locally available feed stuffs i.e. leftover flours from local grain mill machine (LGMM) and common bean (*Phaseolus vulgaris*) were used for fish feed preparation. Experimental diet I was formulated from 50% of leftover flours from local grain mill machine and 50% of common bean; experimental diet II was formulated from 75% of leftover flours from local grain mill machine and 25% of common bean; experimental diet III was formulated from 25% of leftover flours from local grain mill machine and 75% of common bean and experimental diet IV was kept as control, which fed on 100% of diet collected from Alemakoudjis concentrate feed. In addition, a constant amount of linseed cake (30% of combined ingredient) was used as supplementation for all formulated feed. The feeds were blended by composing these ingredients in different ratios in order to get different concentration quality as shown in Table 1.

### Stocking and feeding rate

#### Stocking of fish

The 210 fingerlings of *O. niloticus* with a body length that range from 5 to 15 cm were obtained from Sebeta National Fisheries and other Living Aquatic Resources Research Center on 24th December, 2017 and held in seven small ponds constructed at the study area. Based on the stock density recommended by El-Sayed (2008) for *O. niloticus* in one pond (2 to 5 fingerlings per m<sup>2</sup>), 30 fingerlings were stocked in each pond. The fingerlings were acclimatized for two weeks by randomly giving the formulated feeds. Then weight and length of the fish were measured at 10 days after stocking. They were regularly fed and regular measurement of the fish length and weight continued for 12 consecutive weeks.

#### Feeding of fish

After 10 days of acclimatization period, Pond 1 A&B were supplied with diet 1; Pond 2 A&B were supplied with

**Table 1.** Experimental pond with stocking size and experimental feed.

Treatment pond	Stocking density	Experimental feed		Remark
		Feed No.	Ratio of ingredient	
T2&T6	30 fingerlings	Feed 2	25% CB & 75% LO	Equal amount of LOC is supplemented (i.e 30% of combined ingredients)
T1&T5	30 fingerlings	Feed 1	50% CB & 50% LO	
T3&T7	30 fingerlings	Feed 3	75% CB & 25% LO	
T4	30 fingerlings	Feed 4	Alemakoudjis concentrate feed	Control feed

T = Treatment Pond; CB = common bean; LO = left over; LOC = linseed oilcake.

experimental diet 2; Pond 3 A&B were supplied with diet 3 and Pond 4 were fed with diet 4 (control feeding only with Alemakoudjis concentrate feed). The feeds were given to the fish as pellets. The feeding rate was two times per day (morning and evening) with an amount of 5% of their body weight. Feeding of the fish was done always at the regular time. A daily record of feeds given and fish mortality was also recorded. This helped to determine the efficiency of a feeding program and interpret if the experiment was successful or not.

### Fish growth parameter

Fish samples were collected by hand net per two weeks from each pond. Length and weight of the fish were measured by using measuring board nearest to 0.1 cm and sensitive balance nearest to 0.1 g, respectively. However, prior to sampling, the fish were not fed for 24 hours, to obtain the real weight gain. For the length and weight measurement, about 2/3 of the fish stocks were covered. Then growth and nutrient utilization were determined in terms of feed intake (FI), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER) and survival rate of the fish. These were calculated based on the Ridha (2006) methods as described below:

$$\text{Feed conversion ratio (FCR)} = \frac{\text{dry weight of feed given}}{\text{weight of gain}}$$

$$\text{Condition factor (k)} = \frac{\text{weight(g)}}{\text{L3(cm)}} \times 100$$

$$\text{Survival} = \frac{\text{Final total fish number}}{\text{Initial total fish number}} \times 100$$

$$\text{Feed efficiency (FE)} = \frac{\text{Wet weight gain}}{\text{Total feed intake}}$$

$$\text{Protein efficiency ratio (PER)} = \frac{\text{Wet weight gain}}{\text{Total protein intake}}$$

$$\text{Production rate} = \frac{\text{Final total fish weight}}{\text{Water volume}}$$

$$\text{FI (g fish/day)} = \frac{\text{Total feed intake per fish}}{\text{Number of days}}$$

$$\text{SGR} = \frac{\text{In final weight} - \text{In Initial weight}}{\text{time 2} - \text{time 1}} \times 100$$

$$\text{BWG (\%)} = \frac{\text{FBW} - \text{IBW}}{\text{IBW}} \times 100$$

Where BWG = body weight gain, FBW = final body weight and IBW = initial body weight

### Proximate composition of experimental feeds

#### Moisture content

Moisture content in the ingredients and the feeds were determined by the oven drying method following the procedure of AOAC (1990) by measuring the weight of a sample before and after the water was removed by evaporation.

$$\text{Moisture content} = (\text{Weight of wet sample} - \text{Weight of dried sample}) \times 100$$

#### Crude protein

Crude protein in the feeds and the ingredients were quantified by Kjeldahl method (AOAC, 1990). The nitrogen content was estimated using the following formula:

$$\% \text{ N} = \text{N HCl} \times (\text{Volume of HCl titrates sample} - \text{Volume of HCl titrates blank}) \times 14 \text{ g} \times 100$$

Then the amount of total protein was calculated as:

$$\text{Crude protein} = 6.25 \times \text{N}$$

Where 6.25 is the conversion factor.

#### Fat content

Total lipid was determined following the modified Bligh and Dyer method (1959). The method was used to collect the fat from the feeds using the methanol and chloroform solvent, which was calculated as:

% Fat content = Weight of fat x 100

### **Total carbohydrates**

Total carbohydrate was determined by subtracting the sum of % fat (F), % CP and % ash contents (A) from 100 (Onyeike et al., 2000) by using the following equation:

Percentage of total carbohydrates = 100 – (% moisture + % ash + % crude protein + crude fat)

### **Gross energy**

Gross energy value (kcal/g) was calculated by overall addition of the protein content multiplied by 4 and the total lipids content multiplied by 9 and using Atwater's conversion factors. The result was expressed as kcal per 100 grams

Gross energy value = ((4 x protein content) + 9) x fat content

### **Physico-chemical parameters of the water**

The water quality parameters were monitored daily. The water samples were collected per two weeks from each pond for the measurement of physico-chemical parameters based on APHA (1998) method. The parameters (water temperature, pH and conductivity) were measured *in situ* at the time of sampling using digital probes. Monitoring the level of dissolved oxygen in each pond was also done regularly. In ponds with low dissolve oxygen (DO) concentrations, fish eat less and do not convert food to flesh efficiently. Therefore, routine pond cleaning and stock inventory works were done regularly. This is because aquatic macrophytes remove inorganic nutrients and limit phytoplankton growth. In addition, the combination of food and wastes makes the water turbid and increases the stress that is already placed on fish by the breeding and harvesting process.

### **Length-weight relationship and condition factor**

The relationship between total length and the total weight of the fish were computed using power function of Bagenal and Tesch (1978) as given below:

$$TW = a \times L^b$$

In addition, the well-being or plumpness of fish was calculated by using Fulton condition factor (Bagenal and Tesch, 1978) as given below:

$$FCF = TW/TL^3 \times 100$$

Where, TW = total weight (g), TL = Total length (cm), a =

intercept of the regression line and b = slope of the regression.

### **Economic analysis**

A simple economic analysis using incidence cost and profit index calculations was conducted at the end of the study to assess the cost-effectiveness of diets used in the feed trial. In addition, the value of fish produced during the trial was calculated. The incidence cost and profit index were calculated as:

$$\text{Incidence cost} = \frac{\text{Cost of feeding fish}}{\text{Weight of fish produced}}$$

$$\text{Profit index} = \frac{\text{Value of fish}}{\text{Cost of feeding}}$$

### **Data analysis**

Descriptive statistics, ANOVA and Regression analysis were carried out using Microsoft Office Excel 2010.

## **RESULTS**

### **Proximate analysis of formulated feeds**

The proximate compositions of the formulated feeds are presented in Table 2. The mean protein content recorded in feed formulated was 14.57±3%. The result indicated that Feed 3 had the highest protein content (17.07%) and Feed 1 showed the lowest protein content (10.42%). Similarly, the mean gross energy content measured in this study was 131.02±11 kcal/g, where the highest energy content (144.10%) was measured in Feed 1 and the least energy content (124.3%) was measured in the Feed 2. Feed 1 showed a better fat content followed by Feed 2. The result also indicated that the moisture content in Feed 3 was the highest (9.28%) and the content recorded in Feed 1 was the lowest (7.45%). Generally, the result did not show a significant variation in its proximate contents among the formulated feeds (Table 1) (ANOVA, p>0.05).

### **Physico-chemical parameters of the treatment ponds**

The results of physico-chemical parameters of the treatment ponds are presented in Table 3. The DO±SD content ranges from 9.82 to 13.49 mg/L with the mean DO content of 11.53±0.63. The highest DO content was found in the first pond (pond 1) (13.49 mg/L), and the least DO content was recorded in pond 2 and pond 6, which is replication of each other (9.82 mg/L). The highest water pH was recorded in pond 3, 5 and 7 (8.6) and the least pH

**Table 3.** Physico-chemical parameters of water in the treatment ponds.

Water parameter	Treatment pond						
	T1 mean±SD	T2 mean±SD	T3 mean±SD	T4 mean±SD	T5 mean±SD	T6 mean±SD	T7 mean±SD
DO mg/l	13.49±0.14	9.82±0.2	12.15±0.09	9.84±0.2	13.49±0.12	9.82±0.03	12.15±0.03
PH	8.4±0.04	8.5±0.03	8.6±0.20	8.5±0.10	8.6±0.12	8.5±0.21	8.6±0.13
Temp in °C	24.1±0.1	23.3±0.2	23.9±0.1	23.7±0.1	23.8±0.1	23.9±0.0	23.7±0.0

T = treatment pond DO = dissolve oxygen; SD = standard deviation.

**Table 4.** Growth parameters of Nile tilapia fed on different formulated feeds.

Growth parameters	Experimental feed			
	Feed 1	Feed 2	Feed 3	Feed4 (control)
Mean initial length (cm)	9.06	8.04	8.41	8.31
Mean final length (g)	14.62	11.36	9.27	11.72
Mean initial weight (g)	14.58	9.76	12.72	12.15
Mean final weight (g)	39.86	30.52	22.1	32.63
Mean weight gain in g	39.86	30.52	22.1	31.54
Body weight gain (%)	173.43	139.12	73.67	168.37
Specific growth rate (%)	1.11	1.26	0.06	1.09
Feed conversion ratio (%)	3.62	3.56	6.61	4.9
Protein efficiency ratio	114.77	74.31	38.84	51.15
Survival rate (%)	100	100	100	100
Production rate (g/m <sup>3</sup> )	88.59	67.82	49.12	70
Feed in take (g fish/day)	1.753	1.2	1.62	1.71
Feed efficiency	0.92	0.85	0.7	0.83
Condition factor	1.25	1.95	2.07	1.99
Incidence cost (birr/g)	0.02birr	0.021	0.39	0.05
Profit index	7.02	7.02	3.78	2.54

value was measured in the pond 1 (8.4) with the mean pH of 8.52±0.02. Similarly, the water temperature recorded ranged from 23.3 to 24.10°C with the mean temperature of 23.77±0°C. The highest temperature (24.10°C) was recorded in the pond 1 and the lowest water temperature was recorded in the pond 2 (23.3°C). However, the result did not show any significant variation in physico-chemical parameters between experimental ponds (ANOVA (F = 0.03), P = 0.99).

#### Growth performance parameters of Nile tilapia

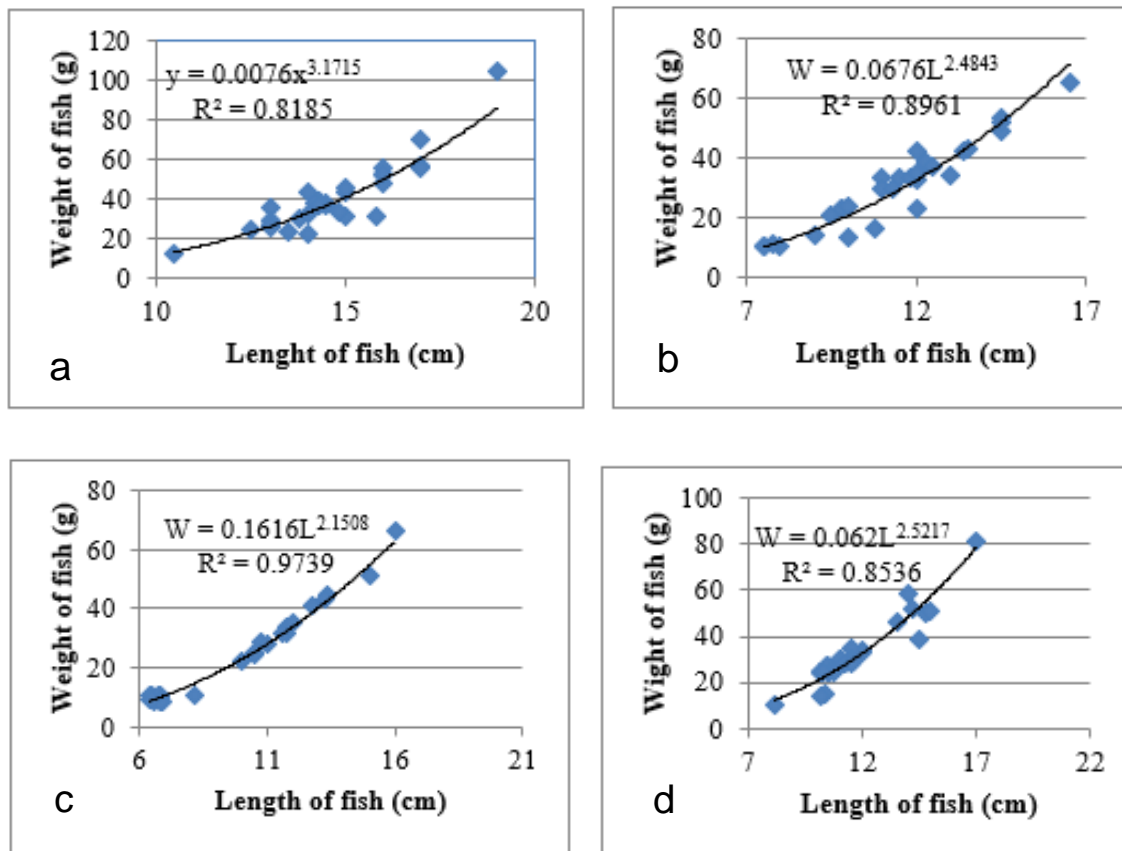
The growth responses and food utilization of Nile tilapia fingerlings under different feeding condition are presented in Table 4. The body weight gain observed in all of the feed types ranged from 22.10 to 39.86 g with the mean body weight gain of 31.00±3.63g. The highest mean body weight gain (39.86 g) was observed in fish fed on Feed 1, which indicated about 173.43% increments, whereas the fish fed on Feed 3 showed the least weight gain (22.10 g) with the only 73.67% increment. The result showed a significant difference in weight gain among the Nile tilapia

fed on different formulated feeds (ANOVA (F = 2.39), P = 0.02).

The specific growth rate of Nile tilapia fed on different feeds in the present study also ranged from 1.26 to 0.06% with the mean growth rate of 0.88±0.27% (mean±SD). The highest specific growth rate was observed in fish fed on Feed 2, which showed 1.26% of specific growth rate, and the least growth was recorded in fish fed on Feed 3, which showed only 0.06% of specific growth rate. The variation in growth rate of Nile tilapia fed on the formulated feeds was statistically highly significant (ANOVA (F = 0.05), P = 0.98).

The food conversion ratio (FCR) of formulated feeds ranged from 3.56 to 6.61 with the mean conversion ratio of 5.085±1.525. Feed 3 showed the highest value of FCR (6.61) and Feed 2 showed the least conversion ratio (3.56). The result of conversion ratio also indicated significant variation among the feeding differences (ANOVA (F = 0.20), P = 0.88).

Protein efficiency ratio (PER) of fish fed on different feeds ranged between 38.84 and 114.77 with a mean efficient ratio of 69.76±16.70. Fish fed on Feed 1 showed the highest PER (114.77), whereas fish fed on Feed 3



**Figure 1.** (a) The length-weight relationship of Nile tilapia fed on feed formulated from F1, (b) The length-weight relationship of Nile tilapia fed on feed formulated from F2, (c) The length-weight relationship of Nile tilapia fed on feed formulated from F3, (d) The length-weight relationship of Nile tilapia fed on feed formulated from F4.

showed the least PER (38.84). The feed efficiency rate of Nile tilapia ranged from 0.83 to 0.92 with the mean efficiency rate of  $0.87 \pm 0.05$ . The highest efficiency rate was found in fish fed on Feed 1 and the least efficient rate was recorded in fish fed on Feed 3. The result of fish body condition factor was found to be highest in fish fed on Feed 3 (2.07) and the lowest value was measured in fish fed on Feed 1 (1.25). Generally, the Feed 1 showed the highest profit index (7.02), and the Feed 3 showed the lowest profit index (3.78). The growth parameters also showed a significant variation among the fish fed on the feeds (ANOVA,  $P=0.91$ ).

#### Length-weight relationship of fish fed on the formulated feeds

The length-weight relationship of Nile tilapia fed on different feeds was curvilinear and statistically significant ( $\chi^2$ ,  $P = 0.24$ ). Furthermore, the fish fed on Feed 1 showed the isometric growth types ( $b = 3.17$ ) and the length-weight relationship for fish fed from other feeds indicated the negative allometric growth types (Figure 1a to d).

## DISCUSSION

### Proximate analysis of formulated feeds

The mean protein content observed in this study ( $14.57 \pm 1.91\%$ ) is less than the limit of the protein content requirement for growing Nile tilapia (28 to 30%) (Stickney, 1979). Less protein content in the present study could be due to low quality of the ingredients used in formulation of the feeds. The highest protein content recorded in feed formulated from 75% of common bean (CB), 25% of leftover flour of local grain mill machine (LLGMM) and 30% of linseed oil cake (LOC) could be attributed to the large amount of common bean ratio used in the formulated feed. Common beans are very rich in protein (20 to 25%) content (Gepts and Bliss, 1984). However, the protein quality is affected by essential amino acid composition, amino acid imbalance, digestibility and biological availability of the amino acids, and by the anti-nutritional activity of some components of the feeds (Kakade and Evans, 1965). The level of protein in the present experiment was less than the feed formulated using poultry diet, wheat bran and brewery waste (13.7-31.2) used as supplementary diet by Eniyew

et al. (2016) in earthen ponds. The mean gross energy content observed in this study ( $131.02 \pm 5.72$  kcal/kg) is also below the recommended energy requirement (2500 to 2800 kcal/kg) of Nile tilapia growth (FAO, 2018). The low energy content in the feeds may be due to the presence of fiber content in the common bean which is more than 22% (Gepts and Bliss, 1984). The highest energy content obtained for Feed 1, composed from 50% CB, 50 LLGMM and 30 %LOC might be associated with balancing of the ingredient. The mean fat content of all the feeds used was ( $8.08 \pm 2.06\%$ ). The Feed 1 had 11% of total lipid content which is within the recommended range (5 to 15%) of lipid for growth of Nile tilapia (Hasan and New, 2013). The finding is also similar to the report of Eniyew et al. (2016) with feeding of Nile tilapia with supplementary feed (poultry diet, wheat bran, brewery waste) in earthen pond (6.01 to 10.6%). The mean moisture content observed in this study is also within the limit of moisture content requirement for Nile tilapia growth (8 to 12%) (Azim and Little, 2008).

### Water quality parameters

The mean DO content observed in this study ( $11.53 \pm 0.63$  mg/L) was within the requirement of DO content to maintain the body functions for Nile tilapia (above 2 or 3 mg/L) (Popma and Lovshin, 1995). The finding was not in agreement with finding of Eniyew et al. (2016) who recorded 6.5 to 9.0 mg/L in earthen pond. According to the report of Phylly and Kutty (2005), the variation may be due to photosynthesis. The mean pH value observed in this study ( $8.52 \pm 0.02$ ) was also found in between the range of pH limit for aquatic life (6 to 9), where the pH range between 6 to 9 is the best one (Pompa and Michael, 1999). The finding in this research was in agreement with finding of Eniyew et al. (2016) (6.5 to 9.0) with feeding of Nile tilapia with supplementary feed (poultry diet, wheat bran, brewery waste) in earthen pond. The mean water temperature measured ( $23.77 \pm 0.09^\circ\text{C}$ ) was also found between the tolerance range for survival of Nile tilapia (11 and  $42^\circ\text{C}$ ) (FAO, 2012). It was also very similar with the report of Noor et al. (2010) ( $20 \pm 35^\circ\text{C}$ ) and Tadesse et al. (2012) ( $19 \pm 26^\circ\text{C}$ ) using supplementary feeding of agro-industrial by-products such as cake, wheat bran, brewery waste in concrete ponds.

### Growth performance parameters of Nile tilapia

The mean  $\pm$ SD body weight gain (BWG) of Nile tilapia fed on the formulated feeds was  $31.00 \pm 3.63$  g. This is less than the finding of Eniyew et al. (2016) who fed the fish with wheat bran and reported intermediate growth rate ( $88.01 \pm 0.01$  g). The highest BWG that was obtained in fish fed on Feed 1 could be due to the balanced ratio of CB and LLGMM, in addition it had comparatively high lipid content

than the others. The lowest BWG observed with fish fed on Feed 3 could be associated with the highest proportion of CB (75%) with the presence of high level of fiber and anti-nutritional factors that can reduce their feeding value and low digestibility and absorption of nutrients (El-Sayed, 2008). The fiber content is a portion of cellulose, hemicellulose and lignin. Its high content makes it potential raw material in feed formulation since it causes good bowel movement and aid absorption. The quality of the feed may also have an impact on the growth of this fish (Jatta and Sigurgeirsson, 2013). Fish growth is normally high when good quality feed ingredients such as fish meal is used (Furuya et al., 2004).

The mean SGR observed in this study was  $0.88 \pm 0.27\%$ . The highest SGR recorded in Nile tilapia fed on Feed 2 (the composite of 25% of CB, 75% of LLGMM and 30% of LOC) was due to the highest proportion of LLGMM and lowest proportion of CB in the formulated feed (Table 1). According to Hopkins (1992), the SGR of fish is dependent on body size of fish. The specific growth rate (SGR) obtained in this study ranged from 0.06 to 1.26 which in agreement with the results of Ridha (2006) (0.77 to 1.43%) feed on agro-industrial by-products in earthen pond culture system.

The result of mean food conversion ratio (FCR) recorded in this study was ( $4.67 \pm 0.71$ ) (Table 2). The higher FCR was found with Feed 3 (the formulation of 75% of CB, 25% of LLGMM and 30% of LOC) and the lowest in Feed 2 (the formulation of 25% of CB, 75% of LLGMM and 30% of LOC). The better result recorded in Feed 2 (the lowest value of FCR (3.56)) indicates the possible better ability of fishes to convert the formulated into their body than the other formulated feeds (Fry et al., 2018). The present result is better than the result obtained by Essa (1997) (5.56 to 7.77), who fed the Nile tilapia by utilizing standard diet and higher than the report of El-Sayed et al. (1996) (2.2 to 3.15), who fed the Nile tilapia on artificial feeds formulated from supplemented pelleted diets (25% crude protein).

The mean PER ( $69.77 \pm 16.70$ ) was not in accordance with the results of Al-Thobaiti et al. (2016) who observed (2.43 to 2.70) for feed replaced with 20% fish meal by plant proteins. Various studies suggest that herbivores require comparatively less amounts of proteins compared to carnivores (Vechklang et al., 2011), based on this fact, Nile tilapia shows good performance by low quality feed. The highest PER recorded in feed formulated from 50% of CB, 50% of LLGMM and 30% of LOC (Feed 1) could be due to lowest protein content in the formulated Feed 1 than other formulated feeds, because the protein efficiency shows the protein content in the feed is sufficient to meet the requirements for somatic growth (Muin et al., 2017) and the high level of lipid would have satisfied the energy requirement for the fishes.

During the experimental period, there was no fish mortality observed, which indicated the favourable environmental conditions throughout the experimental periods. According to El Sherif and El-Feky (2009), the

higher survival rate of fish is highly associated with the favourable ecological conditions in the pond.

Generally, Nile tilapia fed well on Feed 1, which resulted in the high percentage of weight gain (173%) and good profit index (increment by 46.6%) than the other formulated feeds. The high weight gain and profit obtained in this feed is attributed to the formulation of feed with balancing ratio of CB and LLGMM. This indicates the highest economic feasibility of Nile tilapia farming with formulated Feed 1; which is in agreement with the finding of Al-Thobait et al. (2016) who recorded similar trend on the feeds formulated from replacing of fish meal by plant material. Generally, the results obtained in replacing fish meal by a mixture of different plant protein sources for Nile tilapia resulted in a good growth, lowest cost feed and better profit index. Therefore, using these locally available agriculture-based by-products can be used profitably for fish production.

### Length-weight relationship

The coefficient values (b) of length-weight relationship provide information on fish growth (LeCren, 1951). When b value is 3 or nearly 3 (2.7 to 3.2), the fish growth is said to be growing isometrically. When the value of 'b' is deviant from 3, the growth is called allometric (i.e. positive allometric growth if  $b > 3$ , and negative allometric growth if  $b < 3$ ). In the present study, the coefficient of length-weight relationship values (b) indicated an isometric growth for Nile tilapia fed on Feed 1, which indicates an increasing trend of fish in weight and length simultaneously. Weight and length of the fish are used for comparing the condition, fatness, or well-being of the fish in a given area (Tesch, 1968). Based on this fact, isometric growth type recorded in Feed 1 might be attributed to the acceptance and effectiveness of that formulated feed. In another way, the negative allometric growth observed in the Nile tilapia fed on Feed 2, 3 and control feed showed an increasing trend of fish growth in length than in its weight. The result is very similar with the findings of Lalèyè (2006), who formulated the Nile tilapia feed from rice bran, soybean, fish meal, groundnut and mustard cake.

The condition factor (K) of a fish reflects the physical and biological circumstances and fluctuations by interaction among feeding conditions, parasitic infections and physiological factors (Bagenal and Tesch, 1978). In the present study, a better body condition seen in feed could be due to the highest protein content (17.5%) in feed, because CB ingredient used in this study with high ratio is expected to have high protein content. However, the result of body weight gains measured in this study (Table 4) indicated that, the fish fed on Feed 1 showed a better body condition than the others. This might be associated with the anti-nutritional factor of ingredient in Feed 3. The result of the body condition factor recorded in this finding is higher than that of Lalèyè (2000) (0.74 to 1.69 with the mean  $\pm$  SD of  $1.09 \pm 0.38$ ) for combined sexes. Thus, the

finding in this research indicated relatively better fish body condition with the formulated feeds.

### Conclusion

Based on the present finding, the highest mean weight gain and highest profit index were observed in Feed 1, which was formulated from 50% CB, 50% LLGMM and 30% LOC. But the highest feed efficiency was observed in Feed 3, which was formulated from 75% CB, 25% LLGMM and 30% LOC. It can be concluded that the formulation of fish feed from locally available agricultural by-product can perform good growth of Nile tilapia without any negative impact on fish growth performance. Using formulation feed from local resources will not only be beneficial to achieve better growth performance in *Oreochromis niloticus* but will also cut down production costs, thereby increasing net profit.

### ABBREVIATIONS

CB = Common bean; LO = Leftover; P = Crude protein; DFR = daily feed ration; DO = dissolved oxygen; FAOSFE = FAO Sub-Regional Office for Eastern Africa; FCF = Fulton's condition factor; FCR = Feed conversion Ratio; FI = Feed intake; GIS = Geographic Information System; LLGMM = Leftover flour of local grain mill machine; LOC = Linseed oilcake; NADS = National Aquaculture Development Strategy; NDF = Number of dead fish; NSF = Number of stocked fish; PER = Protein efficiency ratio; PR = Production rate; SGR = Specific growth rate; SR = Survival rate; TL = Total length; TW = Total weight.

### CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

### ACKNOWLEDGMENTS

We express our profound gratitude to Mr. Tadesse Demisse who provided us with the facilities.

### REFERENCES

- Abegaz, H., Yalew, A. & Mengistu, E. (2010). Fishery Resource Development Program: Survey on fish resource potential and socio-economics of Tendaho Reservoir, Afar National Regional State. *Addis Ababa, Ethiopia: Agricultural Extension Directorate, Ministry of Agriculture.*
- Addis Ababa Chamber of Commerce and Sectoral Associations Agri-business Support Facility Project (2015). Tilapia aquaculture business model for Ethiopia: Feasibility Study. Addis Ababa, Ethiopia.
- Al-Thobaiti, A., Al-Ghanim, K., Ahmed, Z., Suliman, E. M., &

- Mahboob, S. (2018). Impact of replacing fish meal by a mixture of different plant protein sources on the growth performance in Nile Tilapia (*Oreochromis niloticus* L.) diets. *Brazilian Journal of Biology*, 78(3), 525-534.
- APHA (1998). Standard methods for examination of water and waste water. 20th edition. Washington, DC Aquaculture Technical Paper. No. 512. p.58. Rome, Italy.
- Association of Official Analytical Chemists (AOAC) (1990). *Official Methods of Analysis*. 15th ed. AOAC, Arlington, V.A. USA.
- Azim, M. E., & Little, D. C. (2008). The biofloc technology (BFT) in indoor tanks: water quality, biofloc composition, and growth and welfare of Nile tilapia (*Oreochromis niloticus*). *Aquaculture*, 283 (1-4), 29-35.
- Bagenal, T. B., & Tesch, F. W. (1978). Age and growth. In 'Methods for Assessment of Fish Production in Freshwater'. 3rd edn. (ed Bagenal, T. B.) pp. 101-136.
- Béné, C., & Heck, S. (2005). Fisheries and the millennium development goals. Solutions for Africa. *Naga, Worldfish Center Quarterly*, 28(3-4), 14-18.
- Bligh, E. G., & Dyer, W. J. (1959). A rapid method of total lipid extraction and purification. *Canadian Journal of Biochemistry and Physiology*, 37(8), 911-917.
- da Silva, S., Anderson, T. A., & Sargent, J. R. (1995). Fish nutrition in aquaculture. *Reviews in Fish Biology and Fisheries*, 5(4), 472-473.
- Davis, R. K. (1968). The Range of Choice in Water Management: A study of dissolved oxygen in the Potomac Estuary, Baltimore, Maryland. Pp.48-56.
- Edwards, P. (1997). Sustainable food production through aquaculture. *Aquaculture Asia*, 2(1), 4-7.
- El-Sayed, A. F., El-Ghobashy, A., & Al-Amoudi, M. (1996). Effects of pond depth and water temperature on the growth, mortality and body composition of Nile tilapia, *Oreochromis niloticus* (L.). *Aquaculture Research*, 27(9), 681-687.
- El-Sayed, A. M. (2008, October). Tilapia feed and feeding in semi-intensive culture systems. In *8th International Symposium on Tilapia in Aquaculture (ISTA8) Cairo, Egypt* (pp. 717-723).
- El-Sherif, M. S., & El-Feky, A. M. I. (2009). Performance of Nile tilapia (*Oreochromis niloticus*) fingerlings. I. Effect of pH. *International Journal of Agriculture and Biology*, 11(3), 297-300.
- Eniyew, M., Tadesse Z., & Prabhadevi L. (2016). Evaluation of supplementary feeds on growth and production of Nile tilapia, *Oreochromis Niloticus* L. in earthen ponds. *Advanced Journal of Agricultural Research*, 4(01), 001-007.
- Essa, M. (1997). Utilization of some aquatic plants in diet of Nile tilapia, *Oreochromis niloticus*, fingerlings. *Egyptian Journal of Aquatic Biology and Fisheries*, 1(2), 19-34.
- FAO (2012). The State of the World Fisheries and Aquaculture Part I: World Review of Fisheries and Aquaculture. Rome, Italy.
- FAO (2018). The FAO blue growth initiative: strategy for the development of fisheries and aquaculture in Eastern Africa. (Fishery and Aquaculture) sub regional Office for Eastern Africa, SFE Addis Ababa, Ethiopia.
- Fry, J. P., Mailloux, N. A., Love, D. C., Milli, M. C., & Cao, L. (2018). Feed conversion efficiency in aquaculture: do we measure it correctly? *Environmental Research Letters*, 13(2), 024017.
- Furuya, W. M., Botaro, D., Neves, P. R., Silva, L. C. R., & Hayashi, C. (2004). Lysine requirement of Nile Tilapia (*Oreochromis niloticus*), for grow-out phase. *Ciência Rural*, 34(5), 1571-1577.
- Gatlin, D., & Hardy, R. (2002). Manipulations of diets and feeding to reduce losses of nutrients in intensive aquaculture. *Aquaculture and the Environment in the United States*. Pp. 155-165.
- Gepts, P., & Bliss, F. A. (1984). Enhanced available methionine concentration associated with higher phaseolin levels in common bean seeds. *Theoretical and Applied Genetics*, 69(1), 47-53.
- Hasan, M., & New, M. B. (2013). On-farm feeding and feed management in aquaculture workshop. Manila, Philippines, 13-15 September, 2010. *FAO Fisheries and Aquaculture Technical Paper*, (583).
- Hopkins, K. D., (1992). Reporting fish growth: A review of the basics. *Journal of the world Aquaculture Society*, 23(3), 173-179.
- Hossain, M. A., & Jauncey, K. (1989). Nutritional evaluation of some Bangladeshi oilseed meals as partial substitutes for fish meal in the diet of common carp, *Cyprinus carpio* L. *Aquaculture Research*, 20(3), 255-268.
- Jatta, S., & Sigurgeirsson, O. (2013). The effects of substituting fishmeal with rapeseed meal at three protein levels on growth and body composition of Nile tilapia fingerlings (*Oreochromis niloticus*). *Tokyo: Fisheries Training Program, United Nations University*.
- Kakade, M. L., & Evans, R. J. (1965). Nutritive value of navy beans (*Phaseolus vulgaris*). *British Journal of Nutrition*, 19(1), 269-276.
- Lalèyè, P. (2000). Acadja fisheries enhancement systems in Benin: their productivity and environmental impacts. *EK Abban. CMV Casal, TM Falks, and RSV Pullin (eds.) Biodiversity and sustainable use of fish in the coastal zone. ICLARM*, Pp. 51-52.
- Lalèyè, P. A. (2006). Length-weight and length-length relationships of fishes from the Oueme River in Benin (West Africa). *Journal of Applied Ichthyology*, 22(4), 330-333.
- Muin, H., Taufek, N. M., Kamarudin, M. S., & Razak, S. A. (2017). Growth performance, feed utilization and body composition of Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) fed with different levels of black soldier fly, *Hermetia illucens* (Linnaeus, 1758) maggot meal diet. *Iranian Journal of Fisheries Sciences*, 16(2), 567-577.
- Pompa, T., & Michael, M. (1999). Tilapia life history and biology. SRAC Publication. No. 23.
- Pillay, T. V. R., & Kutty, M. N. (2005). *Aquaculture: principles and practices* (No. Ed. 2). Blackwell publishing.
- Ridha, M. T. (2006). Comparative study of growth performance of three strains of Nile tilapia, *Oreochromis niloticus*, L. at two stocking densities. *Aquaculture Research*, 37(2), 172-179.
- Stickney, R. R. (1979). *Principles of warm water aquaculture*. Wiley-Interscience Press, 361p.
- Tacon, A. G. J. (1990). Essential nutrients proteins and amino acids. Standard Methods for the Nutrition of Farmed Fish and Shrimp. Redmond.
- Tadesse, Z., Gebriel, A. W., Jovani, M., Tefera, F., & Degefu, F. (2012). Effect of supplementary feeding of agro-industrial byproducts on the growth performance of Nile tilapia (*Oreochromis niloticus* L.) in concrete ponds. *Ethiopian Journal of Biological Sciences*, 11(1), 29-41.
- Tesch, F. W. (1968). Age and growth. In: Methods for assessment of fish production in freshwaters. W. E. Ricker (Ed.). Blackwell Scientific Publications, Oxford, Pp. 93-123.
- Vechklang, K., Boonanutanasarn, S., Ponchunchoovong, S., Pirarat, N., & Wanapu, C. (2011). The potential for rice wine residual as an alternative protein source in a practical diet for

- Nile tilapia (*Oreochromis niloticus*) at the juvenile stage. *Aquaculture Nutrition*, 17(6), 685-694.
- Wakjira, M. (2013). Feeding habits and some biological aspects of fish species in Gilgel Gibe Reservoir, Omo-Turkana Basin, Ethiopia. *International Journal of Current Research*, 5(12), 4124-4132.