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The effect of different sources of plant protein on the growth of tilapia fry (*Oreochromis niloticus*)

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Abstract: Decreased feed cost is exceptionally much craved in aquaculture and as a rule this can be done by lessening the level or substituting costly feed ingredients with cheaper ones without negative impacts on the growth. Four feeding experiments were conducted to investigate the effect and possibility of utilizing more than one protein source on the performance growth of Nile tilapia fry (*Oreochromis niloticus*) average weight of 2.82±1.02g for six weeks. Fifteen fry fish were stocked in glass aquaria (75X35X30 cm). Diets were formulated from diverse sources of plant proteins peanut meal (PM), sesame meal (SM), cottonseed meal (CSM) together with wheat bran (WB) and sorghum (S) as energy source feeds. . Diet 1 contained (PM) as the only protein concentrate source. Diet 2 contained equal amounts of (PM) and (SM), diet 3 contained equal amounts of (PM) and (CSM), whereas diet 4 contained equal amounts of all the three protein source concentrates in a proportion of 1:1:1. Fish in one aquarium were cleared out without food as a control treatment though each of the other four bunches of fish gotten one of the four experimental diets, formulated with distinctive combinations of plant protein concentrates but having the same protein level of 35%. Fish were fed at 5% of their weight per day (3 doses). Fish weight increased in all the treatments means the experimental diets were well accepted by the fish. At the end of the experiment results showed no significant differences ($p \geq 0.05$) were observed between the diets. But, diet 3 resulted in the highest weight gain (108.2±0.96%) and Food Conversion Ratio (2.27±0.39). Considering both diet cost and FCR, diet (3) was the best diet having the lowest feed cost per kilogram fish produced (2.84 SP/kg fish).

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1. Introduction

Rising global demand for fish for human consumption has required rapid growth in fish farming, which greatly enhances aquaculture feed production. Fish is the cheapest source of animal protein for some communities, including those who do not consume red meat. Fish farming is the controlled cultivation and harvesting of fish for sale in the market. The expansion of the fish industry is due to progress and innovations in modern technology and farming methods in terms of fingerling production, culture systems, culture methods and the production of high quality fish feed [25].

Many species of fish have been part of the diet of some ethnic groups in all continents for a long time [14]. Tilapia is among the most farmed fish in the world. Farmed tilapia currently accounts for more than 75% of the world's tilapia production [15], and this contribution has increased significantly in recent years. Several factors contributed to the rapid global growth of tilapia. Among these are: genetic improvement, ease of culture, highly adaptable to a wide range of environmental conditions [21].

Fish uses dietary protein for growth, energy, and maintenance of the body. Therefore, understanding protein requirement for maximum growth of any species of fish is a step forward in developing cost-effective feed for fish farming [10]. The level of dietary protein plays an important role in the feed formulas. Therefore, the feed protein was the most important component that affected the fish growth performance, and feed costs [17].

Protein is the single most important component of aquatic feed, especially for carnivorous and marine fish that require a high protein content as it constitutes 50-60% of feed costs for aquaculture production [26]. For good growth in fish farming, it is essential to feed the fish on proper and balanced diets. Feed quality can be measured from the protein levels in the feed, where the protein concentration has a direct impact on growth, physiological and biochemical aspects of the fish. Feeds with a higher protein content resulted in increased fish growth, weight gain, and specific growth rate (SGR) with lower feed conversion value.

A high level of protein in feed may have a negative effect on fish growth, due to its conversion into energy, which also leads to an increase in nitrogen excretion in the water [22]. Therefore, there is a priority for the optimal use of feed protein in industrial feed formulations, in order to achieve the best performance for fish growth at the lowest cost [23].

In recent research, it has been shown that many plant protein sources has potential protein source in fish feed and was utilized successfully in many experimental aquaculture diets [6]. Plant proteins are almost similar to Fish Meal in terms of the protein content and amino acid digestibility [1], plant-based protein source exploitation as an alternative ingredient of fish diet frequently obstructed by the antinutritional compound. An excessive level of the antinutritional compound will directly affect nutrient intake and digestibility [5,16]. Plant protein concentrates have an advantage over whole meals as their non-digestible fiber contents are eliminated which allows the use of high levels in aqua feeds [13]. Therefore, is need to exploit cheaper plant protein sources for the growth and performance of Nile tilapia fry, thus stimulating the use more than one plant protein feedstuff sources that are locally and commonly available.

2. Material and Methods:

2.1 Fish sample and Experimental Procedures

The present study was conducted in the fisheries laboratory, Department of Fisheries, Faculty of Natural Resources and Environmental Studies, Bahari University. Fry *Oreochromis niloticus* with an initial weight 2.3±1.02g were obtained from Elseleit Hatchery, Khartoum state. Fish were acclimatized to aquarium conditions for one week before being stocked. The fish were stocked in 5 glass aquaria (75X35X30 cm) about 68 liters of water and allotted randomly into five experimental groups with three replicates. Fish in one aquarium were left without food as a control treatment whereas each of the other four groups of fish received one of the four experimental diets. Diets were formulated from different sources of plant proteins peanut meal (PM), sesame meal (SM), cottonseed meal (CSM) together with wheat bran (WB) and sorghum (S) as energy source feeds. Diet 1 contained (PM) as the only protein source, while diet 2 contained equal amounts of (PM) and (SM). Diet 3 contained equal amounts of (PM) and (CSM), whereas diet 4 contained equal amounts of (PM), (SM) and (CSM) in a ratio of 1:1:1. All four diets were formulated to contained the same protein level (35%) based on NRC recommendations for Nile tilapia.

2.2 Diet Formulation

Proximate analysis of the ingredient feeds was conducted in the nutrition laboratory of the Animal Production Research Center, Khartoum. The proximate composition of the diets and diet ingredients were measured by the standard methods [4]. The crude protein content was determined using the Kjeldahl method (N x 6.25). The crude lipid content was determined using Soxhlet extraction method. Moisture Content was done by oven drying to a constant weight; Total ash by muffle furnace combustion; Carbohydrate was calculated as difference obtained after subtracting moisture, total organic nitrogen (protein), ether extract, and ash from 100% Table 1.

All feed ingredients except (wheat bran) were first ground to fine powders in a commercial grain grinding mill. Each diet was prepared by thoroughly mixing the appropriate amounts of the ingredients. Water was then slowly added until a moist mash (dough) was obtained, and then was pelleted using an electric meat grinder (2mm). Diets were then allowed to dry in the sun during daytime and continued drying indoor under ventilating ceiling fans overnight. The dry pellets were broken into smaller crumbles (1.5-mm sieve) to be easily consumed by the fry. Ingredient compositions of the four diets are described in Table 2.

2.3 Feeding and growth performance analysis:

Feeding was done thrice a day at 8:00 am, 12:00 am and 3:00 pm. Daily feed rations were adjusted each week based on growth and observation of the feeding response. Fish were fed at a rate of 5% of their body weight per day for six weeks. At the end of the growth trial, fish were counted and group weighed to determine weight gain, survival rate, feed conversion ratio and the food cost per diet were calculated. Different performance criteria were calculated according to the following equations [18].

$$\text{Mean weight gain (g)} = \text{Mean final weight (g)} - \text{Mean initial weight (g)}$$

$$\text{Mean weight gain(\%)} = \frac{\text{Mean weight gain (g)}}{\text{Mean initial weight (g)}} \times 100$$

$$\text{Daily growth rate (g / day)} = \frac{\text{final weight - initial weight}}{\text{Number of experimental days}}$$

$$\text{Food Conversion Ratio (FCR)} = \frac{\text{Food intake (g)}}{\text{Weight gain (g)}}$$

$$\text{Survival rate (\%)} = \frac{\text{Number of fish at harvest}}{\text{Number of fish stocked}} \times 100$$

$$\text{Feed cost /kg Fish} = \text{Feed price /kg} \times \text{FCR}$$

$$\text{Economic efficiency\%} = \text{(Return)/ (Feed cost)} \times 100$$

2.4 Statistical analysis:

The data obtained were analyzed computerized using Statistical Package for Social Science (SPSS) Software (version 21), the means were tested for significance using (ANOVA, two way) and the post Hock test used the least significant difference (LSD) test for the mean separation, and the significance was defined at $P<0.05$.

Table 1. Proximate composition (%) of the ingredient used for diet Formulation

Feedstuff	Dry matter	Crude protein	Crude lipid	Ash	Carbohydrates
Peanut meal	91.8	42.0	8.0	5.4	36.4
Sesame meal	95.2	41.3	11.9	17.6	24.4
Cottonseed meal	95.9	32.1	8.2	5.7	49.9
Wheat bran	92.3	11.8	2.5	3.9	74.1
Sorghum	91.7	10.7	3.4	2.8	74.8

Table 2. Composition of the Experimental Diets (%)

Ingredients	Diet 1 (35%CP)	Diet 2 (35%CP)	Diet 3 (35%CP)	Diet 4 (35%CP)
Peanut meal (42% protein)	77.00	38.95	46.00	29.04
Sesame meal (41.3%protein)	-	38.95	-	29.04
Cottonseed meal (32.1% protein)	-	-	46.00	29.04
Wheat bran (11.8%protein)	17.25	16.58	6.00	9.66
Sorghum (10.7% protein)	5.75	5.52	2.00	3.22
Total	100	100	100	100

3. Results and discussion:

Fish require protein in their diets; protein levels can affect the growth, gut microbial composition, nutrient metabolism, and various physiological reactions in fish [27]. In the present study, ingredients were selected to consider their nutritional quality and also their cost effectiveness. The results obtained showed that the fish accepted the prepared diets, so the fish weight increased in all the treatments Table 3. The control treatment which was left without food lost some of their weight Figure 1. Loss of fish weight was due to mobilization and utilization of their stored fats.

Best growth in this study was obtained with fish that were fed diet (3) 108.2±0.96%, followed by diet (1) 81.1±1.32%. Least growth was obtained with diet (4) 61.7±2.01% and diet (2) 60.9±2.01% (Table 3). Body weight gain of fish fed diet (3) was 34.4% higher than those fed diet (1) though both diets have the same protein level of 35 % Figure 2. This can be explained by the improved quality of the diet due to the addition of cottonseed meal which augmented the essential amino acid contents. The P M & CSM contains good protein contents and amino acid profile depending on processing methods [12]. In addition, cottonseed meal is known to be rich in many vitamins, especially the B vitamins which act as co-enzymes in the metabolism of protein, lipids and carbohydrates. [11] found that CSM (42% CP) used as the only feed input for Nile tilapia reared in earthen ponds. CSM is readily available and cheap plant protein source in most parts of the world.

The addition of sesame meal to peanut meal as another protein concentrate source did not improve fish performance as did cottonseed meal. In fact fish growth in this treatment (diet 2) was less than that of fish fed the diet containing peanut meal only (diet 1). The latter increased by 81.1±1.32 % whereas diet (2) fish (fed peanut meal and sesame meal) increased by only 60.9±2.01% Table 3. This is an unexpected outcome of this study as sesame meal is known for its superiority over other oilseed meals – including peanut meal – in terms of its balance of essential amino acids. Plant protein meals contain antinutritional factors (ANFs) and these cause reduce in growth performance and feed efficiency [20], and affect digestive enzyme activity and digestion/absorption capacity of animal [3]. This observation agrees with the findings of [24] for rainbow trout (*Oncorhynchus mykiss*) feed sesame seed and peanut meals based diet. [7] declared that high participation levels of some oilseed meals resulted in poor growth and feed utilization by Nile tilapia (*Oreochromis niloticus*). Sesame meal in this study also depressed the growth of fish when added to peanut meal and cottonseed meal (diet 4) resulting in a body weight gain 61.7±2.01% as compared to 108.2±0.96 % obtained with diet (2) Table 3. Therefore, it is evident from this study that sesame meal had a negative impact on fish growth. This is probably due to abnormally high contents of tannins in sesame meal aggravated by the poor storage conditions. Sesame meal is known to contain tannins at levels reaching 20 g/kg i.e. 2% [19]. Tannins are considered "nutritional inhibitors" by binding to consumed plant proteins. [2,9] reported poor intake in Nile tilapia (*Oreochromis niloticus*) fed diets containing tannin.

Food conversion ratio (FCR) was defined as amount of food consumed (Kg) per kilogram fish produced. Diet (3) had an FCR of 2.27±0.65, as compared to 3.18±0.44, 3.63±0.78, and 3.74±0.78, for diets (1, 4& 2), respectively Table 3. Fish fed diet (3) were better than the other diets, and there were no significant effect (P>0.05) on FCR among the four experimental diets fed by tilapia fish. A number of study argued that low food conversion ratio (FCR) value is an indicator of feed utilization efficiency of formulated feed. Poor performance in terms feed conversion ratio for fish-fed diets that contain vegetable protein, refer to Protease inhibitors such as trypsin and chymotrypsin inhibitors, and the diet contained less lysine than this fish needs.

One of the nutritional aspects that are specifically important to be in the feed ingredient and directly determine the cost is protein [8]. Based on the recent prices of the different ingredient feeds used in this study, it is evident that diet (3) contained PM and CSM is the most expensive diet having a price 1.253 SDG/kg, followed by diet (4) consist of PM, SM and CSM with a price 1.065 SDG/kg. Diet (1) contain PM only having a price 0.936 SDG/kg, while the diet (2) consist of PM and SM being the least expensive diet having a price 0.839 SDG/kg. The high prices of the diets were due to their contents of cottonseed meal which has an abnormally high price in the market Table 4. On the other hand, when taking into consideration both diet cost and Food Conversion Ratio (table 5) it is clear that diet (3) is the best diet with the lowest feed cost per kilogram fish produced (2.84 SDG/kg fish), followed by diet (1) (2.98 SDG/kg fish), then diet (2) (3.14 SDG/kg fish), and finally diet (4) (3.87 SDG/kg fish). According to this study the best diet was the one which contained both peanut meal and cottonseed meal as protein concentrates.

Table 3. Growth Performance of fry Fish in a 6-week

Parameter	Control	Diet 1	Diet 2	Diet 3	Diet 4
Initial weight(g)	2.75±1.45	2.80±1.02	2.81±1.02	2.82±1.02	2.82±1.02
Final weight (g)	1.71±1.89	5.07±1.56	4.52±1.12	5.891.67	4.56±1.12
Weight Gain (g)	- 1.04±4.45	2.27±0.39	1.71±0.45	3.05±0.87	1.74±1.21
Weight gain (%)	-37.8±4.67%	81.1±1.32%	60.9±2.01%	108.2±0.96%	61.7±2.01%
Daily weight gain(g)	- 0.025±0.22	0.054±0.12	0.041±0.09	0.073±0.02	0.041±0.09
FCR	—	3.18±0.44	3.74±0.78	2.27±0.65	3.63±0.78
Survival %	46.7±2.12%	80.0±2.22%	60.0±2.44%	63.3±2.24%	60.0±2.44%

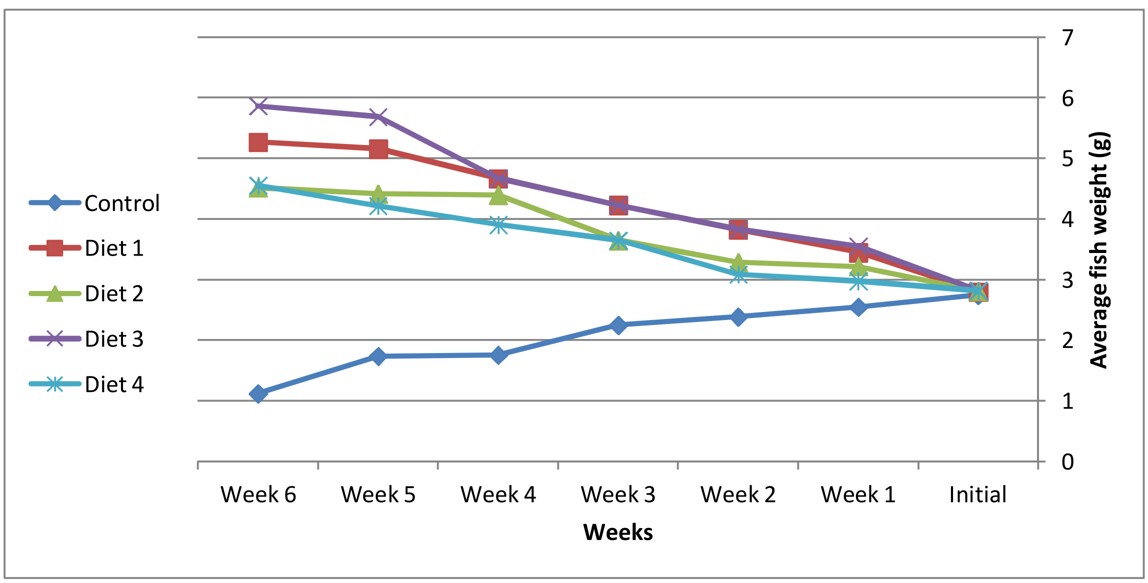

Figure 1: Weekly increase in body weight of fry fish fed different experimental diets.

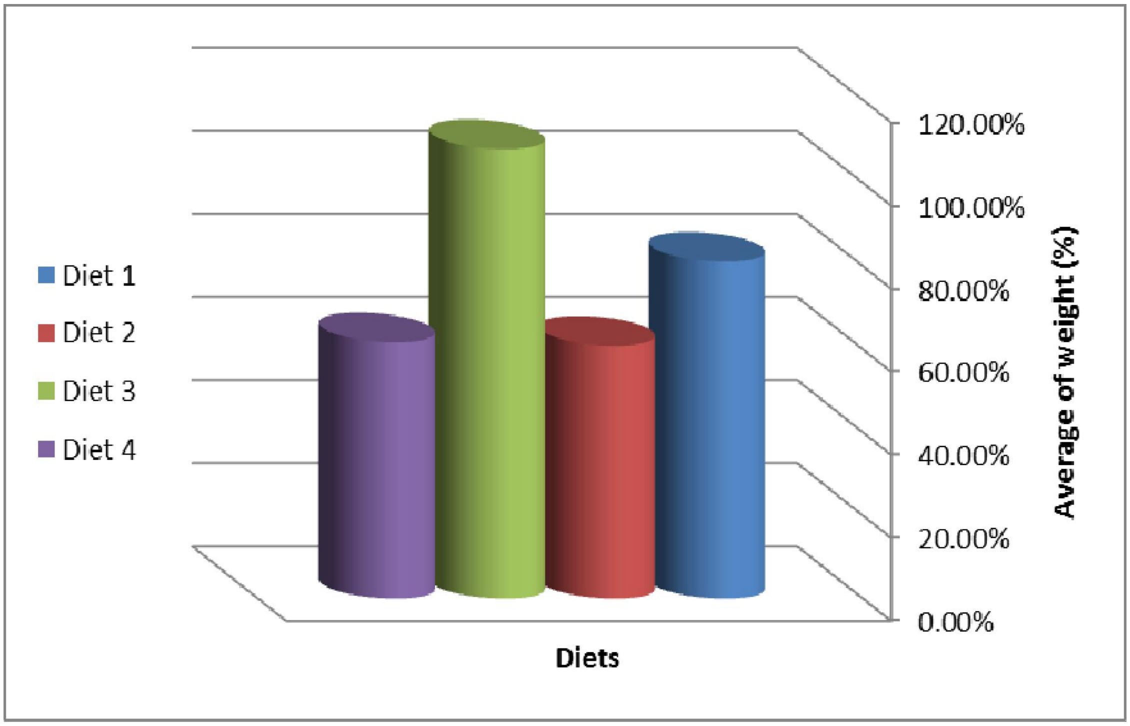

Figure 2: Final weight (%) of fry fish fed different experimental diets.

Table (4): Cost of the Experimental Diets(SDG/ kg)

Ingredient	Cost/kg ingredient	Diet 1		Diet 2		Diet 3		Diet 4	
		% in diet	Cost/ kg diet	% in diet	Cost/kg diet	% in diet	Cost/kg diet	% in diet	Cost/kg diet
Peanut meal	1.00	77.00	0.77	38.95	0.389	46.00	0.460	29.04	0.29
Sesame meal	0.75	-		38.95	0.292			29.04	0.218
Cottonseed meal	1.603	-				46.00	0.736	29.04	0.465
Wheat bran	0.6	17.25	0.104	16.58	0.099	6.00	0.036	9.66	0.058
Sorghum	1.07	5.75	0.062	5.52	0.059	2.00	0.021	3.22	0.034
Cost/kg diet			0.936		0.839		1.253		1.065

Table (5): Feed Cost for Producing 1 Kg of fish

Diet	Cost/ kg	FCR	Diet cost/kg fish
Diet 1	0.936	3.18	2.98
Diet 2	0.839	3.74	3.14
Diet 3	1.253	2.27	2.84
Diet 4	1.065	3.63	3.87

5. Conclusions

It is concluded from this study that best growth and food conversion are obtained when both peanut meal and cottonseed meal (diet 3) were used as protein concentrates in diets for the fry of Nile tilapia due to improved dietary protein quality. Diet (3) also had the least feed cost per kilogram fish produced. Sesame meal used in this study had a negative impact on fish growth performance.

Referances

[1] Alhassan, E.H., Kombat, E.O., Karim, D. (2018). Growth Performance of the Nile tilapia, *Oreochromis niloticus* cultured in cages in two dams in the Bongo District of Ghana. West African Journal of Applied Ecology 26(1):11-21.

[2] Afuang, W., Siddhuraju, P., Becker, K. (2003) Comparative nutritional evaluation of raw, methanol extracted residues and methanol

extracts of moringa (Moringa oleifera Lam.) leaves on growth performance and feed utilization in Nile tilapia (*Oreochromis niloticus*). Aquaculture Research 34: 1147-1159.

[3] Alarcon, F.J., Moyano, F.J, Diaz, M. (1999). Effect of inhibitors present in protein sources on digestive proteases of juvenile sea bream (Sparus aurata). Aquatic Living Reseach 12: 233-238.

[4] A.O.A.C., Official Methods of Analysis (1995). 15th Edition, Association of Official Analytical Chemist, Washington DC. USA. Methods; 930,15, 984.13, 942.05, 920.39.

[5] Bandara, T. (2018). Alternative feed ingredients in aquaculture: Opportunities and challenges. Journal of Entomology and Zoology Studies 6: 3087–3094.

[6] Booth, M.A., Allan, G.L., Frances, J., Parkinson, S. (2001). Replacement of fish meal in diets for Australian silver perch, *Bidyanus bidyanus IV*. Effects of dehulling and protein concentration on digestibility of grain legumes. Aquaculture 196: 67-85.

[7] Davies, S., Fagbenro, O.A., Abdel-Waritho, A., Diler, I. (2000). Use of oil seeds residues as fish meal replacer in diets fed to Nile tilapia, *Oreochromis niloticus*. Applied Tropical Agriculture 5:1-10.

[8] Dodi, H., Muhammad, A., Dedi, J., Alimuddin, and Julie, E. (2021). Evaluation of corn steep powder as a protein source of Nile tilapia *Oreochromis niloticus* diet. Jurnal Akuakultur Indonesia 20 (2), 115–129 (2021). DOI:10.19027/jai.20.2.115-129

[9] Dongmeza, E., Siddhuraju, P., Francis, G., Becker, K. (2006). Effects of dehydrated Methanol extracts of moringa (*Moringa oleifera* Lam.) leaves and three of its fractions on growth performance and feed nutrient assimilation in Nile tilapia (*Oreochromis niloticus* (L.)). Aquaculture 261: 407-422

hhj[10] Effiong, M. U. (2015). Optimum Dietary Protein Requirement Of Genetically Male Tilapia (*Oreochromis niloticus*) Cultured In Floating Hapa System .Animal Research International 12(3): 2292 – 2297.

[11] El-Sayed, A. F. M., Kawanna, M. (2008): Effects of dietary protein and energy levels on spawning performance of Nile tilapia (*Oreochromis niloticus*) broodstock in a recycling system. Aquaculture, 280: 179 -184.

[12] El-Sayed, A. F. M. (1999): Alternative dietary protein sources for farmed tilapia, Oreochromis spp. Aquaculture, 179: 149-168.

[13] Fagbenro, O., Oresegun, A., Nwanna, L., Ilona, P., Olurotimi, O.and Adebayo, A. (2017) Performance of Diets for Oreochromis niloticus and Tilapia zillii by Inclusion of Cassava Leaf Protein Concentrate as Partial Replacement for Solvent Extracted Soybean Meal. Applied Tropical Agriculture, 22: 2, 16-23.

[14] Fanuel J., Penina G., and Colin M., (2017). Analysis of Nutritional Value of *Oreochromis niloticus* (Linnaeus), Nile Tilapia, Meat from Three Different Ecosystems. Journal of Food Quality, Volume 2017 |Article ID 6714347 | https://doi.org/10.1155/2017/6714347

[15] FAO. (2013). On-farm feeding and feed management in aquaculture. FAO Fisheries and Aquaculture Technical Paper, 583: 1 – 68.

[16] Gaoyang, L., Xiaoqin L, Hang Y., Dianyu, H., Zhen X, Xiangjun, L., Qiping, G., (2019). Dietary oxidized oils decreased growth, antioxidative capacity, and negatively affected skin color of channel catfish, *Ictalurus punctatus*. Journal of the World Aquaculture Society. 2019; 50:692–706.

[17] Lee, S. M., Kim K. D., (2005) Effect of various levels of lipid exchanged with dextrin at different protein level in diet on growth and body composition of juvenile flounder *Paralichthys olivaceus*. Aquaculture Nutrition 11:435-442.

[18] Martins, J.M.S., Carvalho, C.M.C., Litz, F.H, Silveira, M.M, Moraes, C.A, Silva, M.C.A, Fagundes, N.S, Fernandes, E.A. (2016). Productive and Economic Performance of Broiler Chickens Subjected to Different Nutritional Plans. Bras. Cienc. Avic. 18 (02), Apr-Jun 2016. https://doi.org/10.1590/1806-9061-2015-0037.

[19] Mukhopadhyay, N., and Ray, A.K. (1999). Effect of fermentation on the nutritive value of sesame seed meal in the diets for roha, Labeo rohita (Hamilton), fingerlings. Aquacult. Nutr., Vol. 5, pp. 229-236.

[20] Olvera-Novoa, M.A., Olvera-Castillo, L., Martinéz-Palacios, C.A. (2002). Sunflower seed meal as a protein source in diets for *Tilapia rendalli* (Bounlanger, 1896) fingerlings. Aquaculture Research 33(3): 223-229.

[21] Ponzoni, R. W., Nguyen, N. H., Khaw, H. L., Kamaruzzaman, N., Hamzah, A., Bakar, K. R. B. and Yee, H. Y. (2008). Genetic improvement of Nile tilapia (*Oreochromis niloticus*) – present and future. Pages 1 – 33. In: 8thInternational Symposium on Tilapia in Aquaculture, World Fish Center, Malaysia

[22] Sa R., Pousao-Ferreira P., Oliva-Teles A. (2006). Effect of dietary protein and lipid levels on growth and feed utilization of White sea bream (*Diplodus sargus*) juveniles. Aquaculture Nutrition 12:310–321.

[23] Subandiyah S., Sukarman, M. N., H., Tu Y. Q., Xie S. Q., Han D., Yang Y. X., Jin J. Y., Liu H. Q., Zhu X. M., (2015). Growth

performance, digestive enzyme, transaminase and GH-IGF-I axis gene responsiveness to different dietary protein levels in brood stock allogenogynetic gibel carp (*Carassius auratus gibelio*) CAS III. Aquaculture 446:290-297.

[24] Seval D., and Ismihan K. (2017). Partial Replacement of Soybean Meal by Peanut and Sesame Seed Meals in Practical Diets for Rainbow Trout, (*Oncorhynchus mykiss*). J Aquac Mar Biol 6(1):00146. DOI: 10.15406/jamb.2017.06.00146

[25] Tran, N., Chu, L., Chan, C. Y., Genschick, S., Phillips, M. J., & Kefi, A. S. (2019). Fish supply and demand for food security in Sub-Saharan Africa: An analysis of the Zambian fish sector. Marine Policy, 99, 343–350.

[26] Wilson, R.P., 2002. Protein and amino acids. In J. E. Halver and R. W. Hardy (Eds.), Fish Nutrition. Academic Press, San Diego, California, pp. 150.

[27] Yang, C.; Jiang, M.; Lu, X.;Wen, H. (2021). Effects of Dietary Protein Level on the Gut Microbiome and Nutrient Metabolism in Tilapia(*Oreochromis niloticus*). Animals 2021, 11, 1024. https://doi.org/10.3390/ani11041024.

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