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Comparison of net fish yields in pond cultured Nile tilapia (*Oreochromis niloticus* L.) fed on peanut-based meals as alternatives to dietary fishmeal

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Abstract

Although net yield directly relates to actual production at harvest, feeding trials aimed at replacing dietary fishmeal in cultured fish have largely ignored the performance indicator. A 16-week experiment aimed at comparing Net Fish Yields in Nile tilapia fed on peanut-based meals as alternatives to dietary fishmeal took place at Busoga University farmland in Eastern Uganda. Earthen ponds of size 4.0 x 3.0 x 1.0 for length, width and depth respectively were used for culturing the experimental fish. Each of the 16 pond units were stocked at a density of 48 Nile tilapia fingerlings of initial live weight of 21.95 grams. Iso-nitrogenous diets containing 30% and 25% Crude Protein (CP) for the first 12 and last four weeks respectively, were used during the trial. Dietary treatments included the fishmeal (FM)-based diet and two peanut-based diets. The latter consisted of peanut meal (PNM)-based diet and mixed plant meal (MPM)-based diet in a ratio of 50:50. The commercial feed (CF) for grow-out Nile tilapia containing 25% CP acted as a control diet. NFYs of 5668 and 5624 kilograms per pond unit for Nile tilapia fed on the MPM and FM-based diets respectively, showed no significant difference ($p>0.05$). On the contrary, NFY of 4819 kilograms characteristic to the PNM-based diet was the lowest and significantly poorer ($p<0.05$) than the two test diets. Basing on the comparable NFYs, the MPM-based meal should substitute the conventional fishmeal in the diet of pond cultured Nile tilapia.

Keywords: peanut-based meals, net fish yields

1. Introduction

The optimal growth in Nile tilapia fed on fishmeal-based diet [9, 31] often leads to high yield in the cultured fish. According to [32], feed cost has surpassed productivity as determinant for economical production of farmed species. Although hiking prices are increasingly reducing the cost-effectiveness of fishmeal as a dietary ingredient in farmed fish [11, 14], they are often overwhelmed by the high biological production. That accounts for the positive correlation between fish productivity and profitability [15, 8]. Superiority in terms of production performance accounts for the persistence of fishmeal in fish diets.

Plant derived products have dominated the list of tested alternatives to dietary fishmeal in farmed fish particularly Nile tilapia. According to [12, 30], adults in Nile tilapia largely prefer vegetable feed. The herbivorous character exhibited by the species accounts for its increased preference in plant-based feeding trials. Since wild vegetation is under threat by the intensification of human activities [25], aqua feed formulation is increasingly resorting to on-farm resources. Irrespective of the competing alternative uses, feed formulation in farmed Nile tilapia is destined for crop derived ingredients. That accounts for the increasing number of oil seed meals in the species diet: cottonseed meal [19], soybean meal [29, 35], peanut meal [39] and sunflower meal [23].

Among the investigations involving oil-seed meals, only soybean meal (SBM) was regarded as the suitable protein source in the diet of Nile tilapia. SBM that was comparable to dietary fishmeal in terms of biological production in farmed fish; [37] became expensive due low supply in many countries including Uganda [3]. The phenomenon discouraged further inclusions of the dietary ingredient in aqua feed formulations. Subsequently, none of the tested plant-derived alternatives to dietary fishmeal has been sustained in many countries [28, 29, 40]. The persistence of dietary fishmeal in farmed Nile tilapia implies that further research on other

potential oil seed meals is inevitable. Peanut products have rarely been included in fish diets [33, 11, 39] despite the high potential in many countries. In addition to the local supply of in Uganda [3], other relative advantages of peanut products link to their nutrient composition. According to [13], peanut is palatable and contains high levels of Crude Protein and phosphorus. Although aflatoxin contamination of peanut products led to restricted use in fish feeds [27, 21], the limitation is invalid. Aflatoxins can attack any oilseed meal stored under dirty and humid conditions [7] implying that the fungal pathogens are not specific to peanut derived products. Growth trials aimed at complete substitution of dietary fishmeal by peanut meal [4, 2, 39, 21] were not successful probably due to under-evaluation. Unlike growth rate, net yield considers both gain and loss in fish biomass [36]. Fast fish growth may not necessarily result into high fish production at harvest due to mortality losses [5, 20, 38]. Since fish yield equates to the final output at the end of a production cycle [5], it is the most relevant indicator of production performance in culture species. High yield is the major target on fish farms [4] despite its limited application in feeding trials. The objective of the current study is to compare net yields in pond cultured Nile tilapia fed on peanut-based meals as alternatives to dietary fishmeal.

2. Materials and Methods

2.1 Study area

The experiment occurred at Busoga University farm land in Iganga district of Busoga sub-region.



Plate 1.0: Earthen pond units that were located at Experimental site 1

The sub-region is located in the Eastern part of Uganda 0°-1°North (N) and 33°-34°N. The study area was approximately 120 kilometers east of the Ugandan city of Kampala. The field sites consisted of earthen ponds for culturing the experimental fish. The feeding trial at experimental site 1 (Plate 1.0) that lasted for 16 weeks from January to May 2015 was replicated at experimental site 2 from March to July 2016.

2.2 Experimental design

Simple Random Sampling characterized the assignment of stock in 16 out of the 20 pond units at each of the experimental sites. Stock equivalent to 48 'all male' Nile tilapia fingerlings of mean weight of 21.7 grams were placed in each of the 16 plastic bags (PBs) corresponding with the number of ponds. Each of the 16 PBs were half filled with water prior to the insertion of fish stock. In order to randomize the assignment of stock into the pond units, figures were applied. Stickers marked with figures ranging from 01-

16 were reshuffled repeatedly for three minutes prior to attachment onto the PBs in a row. The top most followed by the next sticker served the first and second PBs respectively. The pattern was maintained till all the 16 stickers were accomplished. PBs with sticker markings of 01- 04, 05-08, 09-12 and 13-16 stocked pond units of the first, second, third and fourth treatment group respectively.

The earthen ponds that cultured all male Nile tilapia stock were rectangular in shape. They exhibited shallower and deeper ends measuring 1.0 and 1.2 meters deep respectively. Each of the pond units of size 4.0 x 3.0 x 1.0 cubic meters for length, width and depth respectively were stocked at a rate of four fish per cubic meter. A perimeter of dykes measuring 1.5 and 2.0 meters wide separated the pond units and treatment groups respectively. There were four dietary treatment groups including a control. Each treatment group consisted of three pond units. One extra pond per group referred to as fish reserve pond (FRP) was established to mitigate variations in stock densities due to possible fish mortality losses.

Water liming with calcium carbonate at a rate of five grams per cubic meter occurred prior to pond filling. Wire mesh enclosures were inserted onto the in-let and over-flow plastic pipes to eliminate predators and loss of fish in pond units. The following non-experimental variables were controlled; application of equal amounts of feed input, use of water reservoirs to maintain uniformity in pond water levels, periodic scooping of pond contents and bush clearing to prevent infestation by foreign organisms.

2.3 Proximate analysis and rationing

A dried and powdered sample was scooped from each of the sisal bags containing 100-kilograms of a specific feed ingredient. Guided by [1], proximate analysis for the ingredients (Table 1.0) took place at the Faculty of Agriculture of Makerere University.

Table 1: Proximate analyses for selected nutrients in the feed ingredients

Dietary nutrients	Composition in formulated test diets (%)			
	PNM	MPM	FM	MB
Crude Protein	55.16	44.5	38.68	6.8
Crude Fat	35.07	29.81	4.58	
Crude Ash	2.82	3.26	20.15	

*PNM=peanut meal, MPM= mixed plant meal, FM=fish meal, MB=maize bran

During formulation of the FM-based diet and PNM-based diets, sole protein sources were used respectively at 100% inclusion level. The MPM-based diet contained combined protein sources: (PNM and SBM) in a ratio of 50: 50. The commercial feed (CF) for Nile tilapia from Uga-chick Limited acted as control diet (Table 2.0).

Table 2: Inclusion levels for protein supplements in the test diets during the experiment

Test diet	% of inclusion		
	FM	PNM	SBM
D1	100	00	00
D2	00	100	00
D3	00	50	50

*%=percentage, D1=fish meal-based diet, D2=peanut meal-based diet, D3=mixed meal-based diet, FM=fishmeal, PNM=peanut meal, SBM=soybean meal.

The Pearson Square Method standardized the Crude Protein (CP) contents of test diets. Consequently, iso-nitrogenous test diets resulted when maize bran (MB) (basal ingredient) mixed with the protein ingredients. During the first rationing phase (RP) (12 weeks after stocking), test diets were standardized to 30% CP when 23.2 kg of FM, PNM and MPM were mixed with 8.68, 26.16 and 14.5 kg of maize bran (MB) respectively. Due to declining demand for protein as fish grows [20] the CP content reduced to 25% until end of the feeding trial. This was achieved when 18.2 kg of the protein ingredients (FM, PNM MPM) mixed with 13.68, 30.16 and 19.5 kg of MB respectively. Unlike the test diets, the control diet inevitably maintained a CP of 25% throughout the experiment. Prior to mixing, a top loading electronic balance (version 3.1, 2009) weighed the ingredients. Micronutrients (vitamin and mineral premixes) and cassava flour binder (CB) constituted 2.5% and 7.5% of the test diets respectively. Provision of all the essential ingredients aimed at satisfying nutritional requirements for cultured Nile tilapia. Feed pellets were sun dried at room temperature for eight hours before storage. Pellet shelf life was maintained at 28 days.

Daily Feeding Ration (DFR) of 5% of mean body weight of the experimental fish was used following [29]. The fish fed twice daily at 9.00 am and 5.00 pm. Basing on [32], adjustments in DFR occurred on the 28th, 56th 84th and 112th days of the trial.

2.4 Calculation Net Fish Yields in Nile tilapia in treatment groups

NFY or Net production per unit [4] was calculated following [10]; NP=TBMH-TBMS. Where;
 NP=Net production per pond unit (Kg/pond)
 TBMh=total body mass at harvest
 TBMs=total body mass at stocking

The performance in terms of Net Fish Yields (NFYs) was determined as indicated (Table 3.0). PBg was equivalent to biomass at harvest minus biomass at stocking. TBI was the product of treatment mortality and MWg. PBI was the division of biomass loss in a treatment group by the six constituent pond units. NFY per pond unit was equivalent to PBg minus PBI.

Table 3: Net Fish Yields in Nile tilapia in pond units of treatment groups

DT	Np	Tm	MWg (g)	TBI (g)	PBI (g)	PBg (g)	NFY (g/p)
D1	1	25	129.3±2.5	3,232.5	539	6121	5582
	2	25	129.3±2.5	3,232.5	539	6074	5535
	3	25	129.3±2.5	3,232.5	539	6218	5679
	4	25	129.3±2.5	3,232.5	539	6293	5754
	5	25	129.3±2.5	3,232.5	539	6218	5679
	6	25	129.3±2.5	3,232.5	539	6319	5780
D2	1	22	109.5±4.45	2,422.2	404	5284	4854
	2	22	109.5±4.45	2,422.2	404	5223	4819
	3	22	109.5±4.45	2,422.2	404	5189	4785
	4	22	109.5±4.45	2,422.2	404	5403	4999
	5	22	109.5±4.45	2,422.2	404	5276	4872
	6	22	109.5±4.45	2,422.2	404	5366	4962
D3	1	20	125.8±2.65	2,516	419	6074	5655
	2	20	125.8±2.65	2,516	419	5958	5539
	3	20	125.8±2.65	2,516	419	5891	5472
	4	20	125.8±2.65	2,516	419	6145	5726
	5	20	125.8±2.65	2,516	419	6097	5678
	6	20	125.8±2.65	2,516	419	6097	5678
D4	1	23	104.7±2.9	2408.1	401	4990	4589
	2	23	104.7±2.9	2408.1	401	4897	4496
	3	23	104.7±2.9	2408.1	401	4959	4558
	4	23	104.7±2.9	2408.1	401	5104	4703
	5	23	104.7±2.9	2408.1	401	5172	4771
	6	23	104.7±2.9	2408.1	401	5055	4654

*DT=dietary treatment, D1=Fishmeal-based diet, D2=Peanut meal-based diet, D3=mixed plant meal-based diet, D4=commercial feed for Nile tilapia. TD=test diet, Np=pond number, MWg=mean of fish weight gain, Tm= mortality in treatment group, TBI= Biomass loss in a treatment group, PBI= biomass loss in pond units, PBg=biomass gain in pond units, NFY=Net Fish Yield, g=grams, p=pond unit.

2.5 Data analysis

One-way Analysis of Variance (ANOVA) Variation was applied to test possibility significant difference among group means at p<0.05 following [32]. Guided by [6], the Turkey's Honestly Significant Difference (HSD) was used for post-hoc testing of significance (p<0.05) among specific mean NFY values.

3. Results

3.1 Net Fish Yields in cultured Nile tilapia fed on test diets

During the experiment, NFYs in Nile tilapia were determined by considering pond biomass gain and loss. Values for six pond units in each treatment group from the two experimental sites are indicated (Table 4.0).

Table 4: Net Fish Yields of Nile tilapia in pond units of different dietary treatment groups

Np	NFYs (g/p)			
	D1	D2	D3	D4
p1	5582	4854	5655	4589
p2	5535	4819	5539	4496
p3	5679	4785	5472	4558
p4	5754	4999	5726	4703
p5	5679	4872	5678	4771
p6	5780	4962	5678	4654
_X	5,668	4,819	5,624	4,628

*Np=pond unit serial number, p=pond unit, D1=Fishmeal-based diet, D2= Peanut meal-based diet, D3=mixed plant meal-based diet, D4=commercial feed for Nile tilapia, NFYs=Net Fish Yields, X =mean value of Net Fish Yields, g=grams.

Table 5: One-way Analysis of Variance that tested the possibility of a significant difference ($p < 0.05$) among Net Fish Yields

SOV	DF	SS	M	F-value
Group	3	4,964,169	1,649,723	183.5
Error	20	179,735	8,986	
Total	23	5,143,904		

*SOV=source of variation, DF=degrees of freedom, SS=sum of squares, MS=mean square.

A one-way Analysis of Variance (ANOVA) F-test determined the possibility a significant difference ($p < 0.05$) among NFYs in Nile tilapia of different treatment groups. The F-value indicated as 183.3 (Table 5.0) was equivalent to a critical value of 3.1 in the F-distribution table @ 0.05 (3, 20). Since the latter was less than the former, the results provided evidence of a significant difference ($p < 0.05$) among the mean NFYs. Consequently, the null hypothesis was rejected. In order to identify the significantly different ($p < 0.05$) group means, a post-hoc test was applied.

Table 6: Comparison of differences in group means for Net Fish Yields in Nile tilapia based on the Honestly Significant Difference

Comp.	Paired values					
	D1 & D2	D1 & D3	D1 & D4	D2 & D3	D2 & D4	D3 & D4
TGs						
GMs	5.668 & 4.819	5.668 & 5.624	5.668 & 4.628	4.819 & 5.624	4.819 & 4.628	5.624 & 4.628
Diff. in GMs	849	44	1040	805	191	996
Diff. in GMs & HSD	849a & 138.5b	44a & 138.5a	1040a & 138.5b	805a & 138.5b	191a & 138.5b	996 a & 138.b

*Pairs of group means in the same row having a different subscript denote that the values are significantly different ($p < 0.05$).

*D1=fishmeal-based diet, D2 =peanut-based diet, D3 =mixed plant meal-based diet, D4 =Commercial feed for Nile tilapia.

*Comp. =comparisons, TGs =treatment groups, Diff. =Differences, HSD =Honestly Significant Difference.

Apart from the FM and MPM-based diets, differences among mean NFYs were significantly different ($p < 0.05$).

4. Discussion

Although feeding trials aimed evaluating fish yield were affected by both survival rates and weight of fish at harvest [32, 18] the current study partially contradicts the investigations. Determination of yield performance was restricted to biomass at harvest due to the fish reserve ponds (FRPs) that controlled mortality during the current experiment. The FM-based diet that exhibited the highest mean NFY equivalent to 5,668 grams per pond unit (g/p) was the best performer among test diets. Several feeding trials on yield performance published similar results. For example, NFY was significantly lower ($p < 0.05$) for Silver carp (*Hypophthalmichthys molitrix*) fed on the FM-based diet than a combination of water fern (*Azolla*) and oil-seed cakes [36]. Generally, the use of plant-based ingredients as substitutes to dietary fishmeal have always resulted into reduced growth [2] and ultimately poor yield in cultured fish. According to [24], both optimal growth and yield occurred in cultured Nile tilapia fed on the FM-based diet. The higher nutritional quality of fishmeal [39] accounted for the excellent performance of the fishmeal-based diet in terms of biomass production and NFY. The investigation conducted by [26] and [18] where final weight gain and yield of the experimental fish followed a similar trend concurs with the current findings.

Performances in Nile tilapia fed on the MPM-based diet (5,624 g/p) and FM-based diet did not differ significantly ($p < 0.05$). Similar results were obtained by [28] where NFYs of hybrid tilapia fed on mixed plant and FM-based feeds were comparable. Just like [18], there was a correlation between pond fish biomass and survival rates in Nile tilapia. Unlike the FM-based diet, lower mortality in Nile tilapia fed on the MPM-based diet (Table 3.0) preserved the pond biomass consequently resulting into the competitive performance (Table 6.0). The above statement is consistent with the

The Turkey's Honestly Significant Difference (HSD) acted as the standard for determining significant differences basing on the formula; $HSD = q\sqrt{MSE/n}$.

Where;

q=studentized range test

MSE=Mean Square of Error

n=number of observations in a treatment group.

Following the above formula, $HSD = q\sqrt{8986/6} = q\sqrt{1,497.7} = 38.7$. According to the table of distribution of q, the value at @ 0.05: 3, 20 was 3.58. When 3.58 multiplied by 38.7, the HSD equated to 138.5.

The difference between mean NFYs in Nile tilapia fed on the FM and PNM-based diets was the only value less than the HSD. Differences among all other paired group means were higher than the standard value (Table 6.0).

following: the feeding trial by Mensah [22] and [5] where levels of fish yield were due to interactions between mortality and productivity in earthen ponds. On the contrary, the study of [18] stated that similarity in yields between dietary treatment groups in Nile tilapia was due to comparable growth and survival rates.

The NFY in Nile tilapia fed on the PNM-based diet was significantly lower ($p < 0.05$) (5,624 g/p) than those of the FM and MPM-based diets. Similar results were obtained from the investigations of [39] and [17] where dietary PNM induced low biomass production. Others included [34] who recorded lower fish biomass when 100% of PNM replaced SBM in the diet of *Heteropneustes fossilis*. Although low fish yield was attributed to high mortality [22, 38], the lower NFY in Nile tilapia fed on the PNM-based diet during the current study was due to retarded growth as indicated by the harvest weight (Table 3.0). According to [2], the decrease in feed utilization with increasing inclusion levels of groundnut (peanut) products was linked to deficiency in essential amino acids particularly lysine. The current findings are supported by the trial of [16] where dietary FM replacement levels above 50% by PNM significantly decreased yield in Nile tilapia due to retardation in fish growth.

5. Conclusion and Recommendation

Among the peanut-based diets, the MPM-based diet exhibited a significantly higher ($p < 0.05$) Net Fish Yield in the Nile tilapia. Since its performance was comparable, the MPM should be used for complete substitution of dietary fishmeal in pond cultured Nile tilapia.

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7. References

- Abdulrazak S, Otie D, Oniwapele YA. Proximate analysis and anti-nutritional factors of groundnuts and melon husks. *Journal of Animal and Feed research*, 2014; 4(2):25-28.
- Agbo NW, Adjei-boateng D, Jauncey D. The potential of groundnut (*Arachis hypogea* L.) by-products as alternative protein sources in the diet for Nile tilapia. Dept. of Fisheries & Water shed management, Univ. of Kumasi, Ghana 2011, 23-31.
- Agricultural Planning Department. Statistical Abstract. MAAIF, Entebbe, Uganda 2010;23:41.
- Akinawole AO, Faturori EO. Biological performance of African catfish (*Clarias griepinus*) cultured in recirculating systems in Ibadan. *Aquaculture Engineering* 2007;37:18-23.
- Altoire-acome O, Trejo FG, Sato-Zarazua GM, Rico G. Techniques to assess fish productivity in aquaculture farms and small fisheries: an overview of algebraic methods. *Journal of applied sciences* 2012;12:888-892.
- Amisa S, Oteng A, Ofori JK. Growth performance of African catfish (*Clarias gariepinus*) fed on varying levels of *Leucena leucephalata* leaf meal. *Journal of applied Sciences & Environment management* 2009;13:21-26.
- Bainempaka AB, Kato H, Mulera DB, Abwol-Ametto T. Principles and practices of Agriculture. Macmillan publishers, Kampala, Uganda 2006;1:70-89.
- Cai J, Leung P. Bioeconomic modelling for improving aquaculture performance, innovation and investment. *Global Aquaculture alliance* 2018, 5-16.
- Coyle DG, Menger GJ, Tidwell JH, Webster CD. Evaluation of growth, feed utilization and economics of hybrid *Tilapia* fed on diets containing different protein sources. *Aquaculture research* 2004;35:365.
- El-Haroun ER. Improved growth rate and feed utilization in farmed catfish (*Clarias gariepinus*) through a growth promoter biogenic supplementation. *Journal of Aquatic Science* 2007;2(5):319-327.
- El-Sayed DMSD, Gaber MMA. Replacement of fishmeal with a mixture of different plant protein sources in juvenile tilapia (*Oreochromis niloticus* L.) diets. *Aquaculture research* 2003;34(13):1119-1127.
- El-Sayed DMSD. *Tilapia culture*. CABI Publishing Co. Massachusetts USA 2006, 8-65.
- Health & Nutrition research, Peanut products; diets and eating patterns. Albany, Georgia, USA. 2010, 51-58.
- Hyuha TS, Ekere N, Egna H, Molnar JJ. Social and economic performance of Tilapia farming in Uganda. *FAO Fisheries & Aquaculture Circular*, No. 1130, Rome, Italy 2017;1:2.
- Jimoh WA, Ayelaja AA, Rifat AO, Adeleke AB, Shodamala MO. Incidence cost analysis of producing African catfish (*Clarias griepinus*) using diets containing watermelon (*Citrullus lanatus*) seed 2013, 3-7.
- Koumi AR, Alse BC, Kouame LP. Utilization of soy protein as an alternative protein source in Nile tilapia (*Oreochromis niloticus* L.) diet; growth performance, feed utilization, proximate composition and organoleptic characteristics. *African Journal of Biotechnology* 2009;8(1):91-97.
- Lawal MO, Aderolu AZ, Aarode OO, Seriki BM, Alonge TO. Evaluation of SBM replacement with Sesame seed meal using activated charcoal as an additive in the diet of African catfish (*Clarias gariepinus*) juveniles. *Intern. Journal of Aquatic Biology* 2016;4(1):43-50.
- Limbu U, Shoka AP, Lamtane HA, Mbonde A, Mgaya YD. Supplemental effects of mixed ingredients and rice bran on growth performance, survival and yield of Nile tilapia (*Oreochromis niloticus* L.) reared in earthen ponds. *Springer Plus* 2016;5:5.
- Mbahinzireki GB. Tilapia (*Oreochromis* sp.) Sex reversal and performance on alternative sources of protein. PhD thesis, Ohio State University, USA 1999, 8-25.
- Meilude EE. Comparative evaluation of growth performance and yield in tilapia under culture conditions. Sokoine University, Tanzania 2013, 46-47.
- Mengle HC, Penelope ML. Evaluation of peanut meal as an alternative dietary protein source for channel catfish. *North American Journal of Aquaculture* 2017;79(2)
- Mensah E, TD. Growth parameters of tilapia cage culture using two commercial diets. *Intern. Journal of Development and sustainability* 2013;2(2):825-837.
- Meric I, Yildirim O, Derm R. Bio-economic analysis of diets comprised of sunflower meal as a substitution of fishmeal in carp diets. *Faculty of Agric., Dept. Fisheries & Aquaculture, Ankra, Turkey* 2015, 12-15.
- Miles RD, Chapman FA. Benefits of fishmeal in aquaculture diets. *IFAS extension, University of Florida, USA* 2006, 3-16.
- Moehl J, Halwart D. A synthesis of the formulated animal and aqua feed industry in sub-Saharan Africa. No. 26, *FAO, UN, Rome* 2005, 12-19.
- Mugo-bundi J, Oyoo-Okoth, Ngugi CC, Manguya D, Lusega D, Rasawo J *et al.* Utilization of *Caridina nilotica* meal as protein ingredient in feeds for Nile tilapia (*Oreochromis nilotica* L.). *Aquaculture Research* 2013;1:12.
- Murjan G. *Chronic alfatoxicosis* in fish and its relevance to human health. *Central Institute of fresh water aquaculture, India*, 2003, 17.
- Nathan G. Fish meal-free feeds for hybrid tilapia. *Global aquaculture advocate. Zemach feed mills, Jordan valley*, 2004, 11-13.
- Nordahl S, Pickering T. *Tilapia fish farming in Pacific island countries*. Noumea, New Caledonia 2004, 12-14.
- Obaroh IO, Achonya-Nzeh. Effects of crude extract of *Azadirachta indica* on breeding control in Nile tilapia (*Oreochromis niloticus* L.). *Asian Journal of Agric* 2011;5:277-282.
- Olafsen T. *Exploitation of Marine Living Resources; Global opportunities*. Royal Norwegian society of sciences, Norway 2006, 7.
- Opiyo MA, Githukia CM, Manguti JM, Ogello EO, Charo-Karisa H. Growth response, survival and profitability of Nile tilapia fed at different feeding frequencies in fertilized earthen ponds. *International Journal of Science & Research* 2014;2319-7064, 893-898.
- Popmat T, Masser M. *Tilapia; life history and biology*. SRAC, No. 283, Aurban University, Texas USA 1999, 21-29.
- Shukula A, Kaur VI, Kumar P. Utilization of dietary soybean meal and groundnut meal as fishmeal

- replacements in blotch (*Heteropneustes fossilis*) Intern. Journal of curr. Microbiol. And appl. Sci 2018;7(6)34:734-74
35. Soliman AK. Partial and complete replacement of soybean meal by roquette seed (*Eurica sativa*) in the diet of Nile tilapia. Faculty of Agriculture, Alexandria University, Alexandria, Egypt. 2006, 3-7.
 36. Tuldhar B. Comparative study of fish yields with plant protein sources and fishmeal. Our nature 2003;1:26-29.
 37. Uga-chick. Challenges of production of quality fish feeds. Animal feed processors, Kampala, Uganda 2014, 4-7.
 38. Wailey R, Beveridge M, Brumme HR. Improving productivity and environmental performance of aquaculture. World Resources Institute, Working 2014;5:13-17.
 39. Yildirim O, Acar U, Turker A, Sunar MN, Kesbic OS. Effects of replacing fishmeal with peanut meal on growth, feed utilization and body composition of Mozambique tilapia (*Oreochromis mossambicus*) fry. Pakistan Journal of Zoology 2014;46(2):497-502.
 40. Yung C. Nutrition and fish health. Department of Nutrition, University of Guelph. Ontario 2002, 63-72.