SDRP JOURNAL OF AQUACULTURE, FISHERIES & FISH SCIENCE

2016

OPEN ACCESS

RESEARCH

Comparison of Economic Conversion Ratios of fishmeal and peanut-based meals fed to pond-cultured Nile tilapia, *Oreochromis niloticus L.*; a case for Busoga sub-region, Eastern Uganda.

DOI: 10.15436/JAFFS.1.1.3

***Musita A. A.[1], Owiti D. O[1], Balirwa J. S.[2], & Otieno A. C.[3]**

[1.]Maseno University, School of Agriculture and Food Security, Department of Fisheries and Natural resources, P.O.Box,333-40105, Maseno, Kenya.

[2.] National Fisheries Resources Research Institute, P.O.Box 138, Jinja, Uganda.

[3] School of Humanities & Social Sciences, Jaramogi Oginga Odinga University of Science & Technology, P.O.Box 210-40610, Bondo, Kenya.

RECEIVED DATE: 24-08-2016; ACCEPTED DATE: 05-09-2016; PUBLISHED DATE: 12-10-2016

CORRESPONDENCE AUTHOR: Musita A. A

E-MAIL: cotieno70@yahoo.com;

ADDRESS: Maseno University, School of Agriculture and Food Security, Department of Fisheries and Natural resources, P. O. Box 333-40105, Maseno, Kenya.

CONFLICTS OF INTEREST

THERE ARE NO CONFLICTS OF INTEREST FOR ANY OF THE AUTHORS.

ABSTRACT:

Scarcity and rising cost of fishmeal-based aqua feeds has led to the need for low cost and locally available alternatives that are capable of sustaining rapid fish growth. A field experiment was conducted in order to compare Economic Conversion Ratios (ECR's) of fishmeal and peanut-based diets as sources of dietary protein for pond-cultured Nile tilapia *Oreochromis niloticus L*. Earthen ponds were used as the rearing units at Busoga University farm and were stocked with six-week old mono-sex fingerlings. A sample survey targeted local fish markets located in Busoga sub-region of Eastern Uganda in order to determine the local Retail Prices(RP's) for Nile tilapia fish. Dietary treatments included the fishmeal (FM)-based diet and two peanut (PN)-based diets; the peanut meal (PNM)-based diet and the mixed plant meal (MPM)-based diet. The locally available Nile tilapia commercial feed (CF) acted as the control diet. Results indicated no significant difference ($p>0.05$) in mean values for Economic Conversion Ratios (ECR's) of the FM and MPM-based diets. However, a significant difference in ECR's existed ($p< 0.05$) between the FM and PNM-based diets and MPM and PNM-based diets. Since FM and MPM-based diets exhibited similarity in ECR's, MPM-based diet should be used for complete substitution of the FM-based diet in aqua feeds for pond-cultured Nile tilapia.

KEYWORDS: Fish meal, peanut-based diets, Nile tilapia

INTRODUCTION

Fish meal as a conventional dietary protein ingredient constitutes between 40%-70% of the aqua feed cost (Borski, et al 2012). It is an essential ingredient in formulated aqua feeds (Hassan, 2001). There is a stiff competition for inclusion of fishmeal in human and animal diets. That is partly why it has become scarce and expensive in recent times. Many authors agree that less expensive plant-based ingredients have been processed into dietary protein meals (Higgs et al, 2003; El-saidy & Gaber, 1997; FAO, 2009) but most have led to poor fish growth.

Peanut products that are commonly cultivated in many parts of Uganda are potential alternatives to fish meal in aqua feeds. They can provide a balanced fish diet because they are rich in lipids, protein (Bainempaka *et al*, 1989; Jauncey, 1998) and minerals especially phosphorus (Peanut Institute, 2003). They offer a good taste and are acceptable feed ingredients for cultured fish (National Peanut Board, 2005). Peanut meal has already been included in the diets of pigs, poultry cattle, sheep and horses. Since peanut products have been successfully utilized in some cultured tilapiine fish species, they are potential alternatives to fish meal in Nile tilapia diets. According to Fagbenro & Davies, 1997) peanut meal has been utilized to replace 25% of fishmeal in the diet of *Oreochromis mossambicus* without any significant effect on growth rate.

Unfortunately, most investigators have recommended the utilization of dietary protein ingredients on the basis of biological performance without regard to the economics (El-sayed, 2006; Ogello et al, 2014). Currently, economics is regarded as the major driver for utilization of alternative ingredients in aqua feeds (Rust et al 2012), The economics of aqua feed utilization is mainly governed by the cost of raw ingredients. The cost of feed ingredients is regarded as the primary challenge to the increased production of aqua feed (Ogunji & Wirth, 2001). Among the feed ingredients dietary protein is more costly than all other ingredients combined. It represents more than 50% of the aqua feed cost (Hashim, 2006). The high cost of fishmeal as dietary protein ingredient has limited the use of aqua feeds on most fish farms in Uganda.

In order to provide economical diets for fish, less expensive dietary protein ingredients capable of promoting fast fish growth should be used. According to Gonzalex (2010) and (Hardy, 2010) alternatives to fishmeal in aqua feeds should be low cost ingredients capable of providing a similar or better growth performance. What is preferred are cost-effective dietary protein ingredient promotion of fast fish growth at least cost. Economic Conversion Ratios (ECR's) can be used for measuring the cost-effectiveness of fish diets. ECR is a product of Cost of diet x Feed Conversion Ratio (Piedecausa et al, 2009). It is the combination of diet cost and Feed Conversion Ratio that can reveal the most economical choice of a feed (Gebhart, 2000).

Therefore, the main objective of this study was to compare the Economic Conversion ratios of fishmeal and peanut-based meals as sources of dietary protein for pond cultured Nile tilapia.

2.0 MATERIALS AND METHODS

2.1 Study area

Busoga sub-region in Eastern Uganda was used as the study area. There were two study sites. The experimental study site shown in Figure 1.0 was composed of two sampling zones for field experiments while then non-experimental study site that was conducted in Iganga central market.

2.1.1 Experimental Study site

This was divided into sampling zones 1 and 2 study sites were used for conducting field experiments. Zone 1 that was stocked with fish during dry weather was referred to as the Dry Season Stock (DSS) while study site 2 or Wet Season Stock (WSS) was stocked during wet weather. The experiment was initially conducted as in zone 1 and later replicated in zone 2.

Figure 1. Sampling zone 1 for the Dry Season Stock (DSS)

They sampling zones were located at Busoga University farm land situated three kilometers south of Iganga municipality, 117 km south east of Kampala City. They were located 12 meters apart.

Figure 2. Sampling zone 2 for the Wet Season Stock (WSS)

Each zone consisted of 20 freshly prepared earthen ponds as fish culturing units (Liti et al, 2006; Rohani et al, 2009). The pond units were of uniform size of 4.0 m long, 3.0 m wide and 1.0-1.2 m. A water reservoir of a size of 15.0 m long, 5.0 m wide and 2.0 m deep was constructed between the zones.

2.1.2 Non-experimental study site

The non-experimental study in form of market survey was conducted in Iganga central market situated in Iganga municipality. The market was divided into six sampling zones. Each zone consisted of five clustered retail units as indicated in Figure 3. Iganga central market was selected for the sample survey because it was involved in retail trade for all the relevant study materials.

Figure 3. One of the retail units for peanut meal in a selected sampling zone in Iganga central market.

2.2 Research designs

2.2.1 Experimental design

A Completely Randomized Design (CRD) was used for setting up of the field experiments at the experimental study site. This experimental design was regarded as the most appropriate for the three treatment groups per experiment as guided by Schefler (1999) and in an environment such as earthen ponds with a lot of non-experimental variables (Bailey,1994). The Non-experimental variables were controlled as guided by Musita et al, (2015a;) and Musita et al, (2015b). Each treatment group consisted of three replicated pond units. Out of the 20 pond units at each sampling zone, only 12 were utilized as experimental ponds. Four pond units were utilized as Fish Reserve Ponds (FRP's). The remaining four ponds were used as water reserve ponds were used for regulation o pond water levels in FRP's

2.2.2 Non-experimental design

2.2.2.1 Two-stage Sampling Design

This was conducted in Iganga central market following Ross (2005). It was aimed at establishing the retail prices (RP's) per kilogram (kg) of all ingredients that were used for formulation of test diets. The study materials included; dietary protein sources (FM, MPM and PNM), maize bran, feed binder (cassava flour) and micronutrients (Minerals and vitamins) as shown in table 3.0. The initial clustering involved the non-random selection of six sampling zones. The second clustering involved the random selection of five retail units out of a sampling frame of 15. Data was collected from all the retail units of every zone. A total of 30 retail attendants were interviewed during each sampling. The first sample was collected on the first day of the study. Sampling was repeated after every 28 days. Five samples were collected during the study.

2.3 Sampling methods

2.3.1 Simple Random Sampling

Simple Random Sampling (SRS) was applied for the field experiments following Bailey (1994) at the study sites 1 and 2. Out of a population of 6000 fish fry at Sun fish farm hatchery of Njeru near Jinja town in Uganda, 2000 fish fry were transferred to the nursing ponds of respective study sites. At the study sites, 16 plastic bowels (PB's) were each packaged with 48 fish scooped from the 2000 fish stock in the nursing ponds. 16 paper cards (PC's) were marked with figures ranging from 1-16. The PC's were reshuffled several times before assigning them to a row of 16 PB's. The first PB of the row was served with the top most PC and so on. PB's with PC's marked with numbers 1-4 were selected to provide fish stock for the first column of four pond units. PC's with numbers 5-8stocked the second column of pond units. Those marked with the 9-12, stocked the third column while 13-16stocked the forth column. Each column included the three experimental ponds and one Fish Reserve Pond (FRP).

2.3.2 Two-stage Cluster Sampling

Following Ross (2005), Two-stage cluster sampling was the most appropriate for Iganga central market for the selection of the six sampling zones consisting of five retail units. Initially, cluster sampling led to the selection of six sampling zones that were clustered. This was followed Simple Random Sampling (SRS) that was applied for selection of the five out of a sampling frame of 15 retail units in each zone. SRS involved numbering 15 thick, rigid and rectangular-shaped paper cards (PC's) systematically from 1-15. Only one Unit Identification Number (UIN) of a retail unit was written on the underside of a PC. In order to select the five retail units for each zone, the 15 PC's were reshuffled. Only five PC's starting from the top, were selected from the rest of the PC's. The Unit Identification Numbers (UIN's) of the selected PC's were used to identify the retail units for each zone.

2.4 Formulation of test diets and fish feeding

Ingredients were grounded into meals. These were combined with other supplements to produce formulated diets. The meals were moistened to form thick pastes using with hot water at varying temperatures to facilitate proper binding of feed ingredients.

Water temperatures were as follow; 55° for the PNM-based diet, 60° for the MPM-based diet and 75° centigrade for the FM-based diet. The above temperatures were required as minimum for effective binding or paste formation for different textures associated with the meals. The pastes were later channeled through a hand-operated pellet. The pellets were sun dried for a minimum of 8 hours and finally stored at room temperature to serve for a particular feeding phase that lasting for 28 days. Complete diets with a minimum content of all essential nutrients for Nile tilapia fish were provided as recommended by Jauncey & Ross (1982). All feed ingredients were kept constant for all test diets apart from the dietary protein source as shown below;

Table 1 Percentage contribution of ingredients as sources of dietary Protein in test diets

Test diets	Percentage composition in the formulated diet		
	FM	PNM	SBM
FM-based diet	100	00	00
PNM-based diet	00	100	00
MPM-based diet	00	50	50

Test diets were mixed basing on percentages of dry weight ingredients following Musita et al, (2015a). Pearson's square method was used for standardization of dietary protein ingredients following Bainemaka et al, 2006. Test diets were iso nitrogenous with a crude protein content of 20%. Test diets possessed the following proportions ingredients during the first 84 days (12 weeks) after stocking; dietary protein source (30%), maize bran (60%), Cassava floor binder (7.5%) and micronutrients (2.5%). The dietary protein source was adjusted after the 84 days to match with the increasing size of fish as guided by Fitzsimmons, (2009) as follows; dietary protein source (25%), maize bran (65%), Cassava flower binder (7.5%) and micronutrients (2.5%).

Fish were fed twice daily as guided by at 5% of their BW as Daily Feeding Ration (DFR) at 9.00 am in the morning and at 5.00 pm following Belal (1999). The DFR was regularly adjusted following Charo-Karisa (2013) after every 28 days basing on the grand mean BW of fish sampled in all treatment groups. The 28 days constituted a feeding phase which was characterized by different quantities of feed per pond unit. The Total Feed Consumed (TFC) per pond unit for a particular study site was calculated following Sweilum et al, (2005) by adding together all feed quantities from the various feeding phases.

Dietary treatments included the fish meal (FM)-based diet, peanut-based diets;
peanut meal (PNM)-based diet and mixed plant meal (MPM)-based diet. The locally available commercial feed (CF) for Nile tilapia was utilized as the control diet.

2.5 Body weight measurements of experimental fish

Measurements of Body Weight (BW) the experimental fish were carried out using a weighing balance of a readability of 0.1 grams. Data was collected as follows; fish specimens were placed in a trough half-filled with water. The weight of fish was calculated after the weight of trough had been subtracted from the combined weight of the trough and the fish specimen.

The Initial Body Weight (IBW) was determined by weighing all fish stock prior to stocking at every study site. The final body weight (FBW) was determined at the end of a particular experiment. The Body Weight Gain (BWG) of fish was a result of subtracting the IBW from the FBW. Mean BWG's from the different dietary treatment groups utilized to determine the RGR's and FCR's of test diets.

2.6 Data collection

2.6.1 Determination of FCR's of test diets

The FCR's of test diets were calculated following USAID-Harvest (2011) as follows;

$$FCR = \frac{\text{Total amount of feed given (kg)}}{\text{Weight gain of fish (kg)}}$$

Table 2. Determination of Feed Conversion Ratios of test diets

TFC per pond unit (gm)	BWG of pond units (gm)			FCR		
15670	FM-based diet	PNM- based diet	MPM-based diet	FM- based diet	PNM- based diet	MPM- based diet
	6121	5258	6074	2.56	2.98	2.58
	6074	5223	5958	2.58	3.00	2.63
	6218	5189	5891	2.52	3.02	2.66
	6293	5403	6145	2.49	2.90	2.55
	6218	5276	6097	2.52	2.97	2.57
	6319	5366	6097	2.48	2.92	2.57

The TFC of 15670 was uniform for every pond unit in all treatment groups The FM-based diet had the highest BWG followed by MPM and PNM-based diets. The FCR's for the various test diets was calculated by dividing the TFC by the BWG of fish from the experimental pond units.

2.6.2 Determination of diet costs

Retail prices of ingredients used for formulation of test diets were determined during the study. Five samples were collected during the 16 week period (112 days) from Iganga central market as shown in table 3.0. The cost of one kilogram of a particular test diet is shown in table 4.0.

Table 3. Mean retail prices of one kilogram of feed ingredients in Iganga central market

Feed ingredient	Day of the experiment					Average ingredient composition in the test diet
	1st	28th	56th	84th	112th	
FM	2500	2450	2450	2400	2450	27.5%
PNM	3200	3400	3450	3500	3500	27.5%
MPM	2250	2300	2300	2300	2350	27.5%
-MB	400	400	350	300	350	62.5%
Feed binder	1200	1200	1200	1200	1200	7.5%
Micro-nutrients	1000	1000	1000	1000	1000	2.5%

2.7 Data analysis

Since it was a single factor study, data was analyzed using a One-way ANOVA following Bailey (1994). In order to determine the specific group means that were significantly different from each other, post-hoc testing was necessary. The Turkey's HSD was utilized for the post-hoc test using the formula; HSD=q√ MSE/n following Schefler (1999).

3. RESULTS

The costs of all ingredients of each formulated test diet were calculated in order to determine the diet costs. These were tabulated together with the respective FCR's as shown in Table 5.0

Table 4. Mean values of Feed Conversion Ratio's and diet costs during the study

Test diets	Mean FCR's of test diets	Cost of one kg of test diets				
		1st	28thday	56thday	84thday	112th day
FM-based diet PNM-based diet MPM-based diet	2.525 2.965 2.593	1052.5 1235.0 983.8	1038.8 1300.0 997.5	1007.5 1282.6 965.5	962.5 1265.0 935.0	1025.0 1327.5 1011.0

In order to determine the ECR's, diet costs were multiplied by the respective FCR's following Piedecausa et al, (2009).

Table 5. Economic Conversion Ratios for test diets during the study

Test diets	Economic Conversion Ratios				
FM-based diet	2657.6	2623	2543.9	2430.3	2588.1
PNM-based diet	3661.8	3854.5	3802.9	3194.1	3750.7
MPM-based diet	2551	2518.7	2586.5	2424.5	2621.5

The ECR's from the different samples were arranged according to their dietary treatments. The group mean of ECR's for the MPM-based diet was the lowest followed by the FM-based diets. This indicates that it performed better than all other test diets.

Table 6. Mean values for Economic Conversion Ratios of test diets at during the study

Day of sampling	ECR's of test diets		
	FM	PNM	MPM
1st	2657.6	3661	2551
28th	2623	3854.5	2518.7
56th	2543.9	3802.9	2586.5
84th	2430.3	3194.1	2424.5
112th	2588.1	3750.7	2621.5
ΣX	12,842.9	18,263.2	12,702.2
ΣX^2	33,019,013.7	66,992,165	32,291,895.6
$\bar{X}$	2,568.6	3,652.6	2,540.4

N=15, n=5, k = 3, DFG = 2, DFE =12

Mean ECR values were subjected to the ANOVA test. The ANOVA test statistic was calculated as 71.6. However, the Critical Value of F in the distribution table @ 0 .05; (2, 15) was 3.68. This value was less than the calculated value. Thus, HO was rejected because of the evidence of a significant difference between group means corresponding to the different ECR's of test diets.

Table 7. One-way analysis of variance for determination of significant differences among Economic Conversion Ratios of test diets

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value
Group	2	4,021,611.3	2,010,805.7	71.6
Error	12	336,986.4	28,082.2	
Total	14	4,358,597.7		

In order to determine the specific groups of mean ECR's that were significantly different each other, post-hoc testing was necessary. The Turkey's HSD was utilized for the post-hoc test using the formula; HSD=q√ MSE/n as follows;

HSD = q√28,082.2/5= √5616.4=74.9

According to the table of distribution of q (studentized range statistic), the value of q at @ 0.05; 2, 15 was 3.68. When 3.68 were multiplied x 74.9 a value of 275.6 was obtained.

Table 8. Comparison of differences between the mean values of Economic Conversion Ratios with the Honestly Significant Difference

Treatments	Group means	Mean differences	Comparisons with the HSD value (275.6)	Levels of significance
FM & PNM	2,568.6 & 3,652.6	1084	Greater than the HSD	Significantly different ($p < 0.05$)
FM & MPM	2,568.6 & 2,540.4	27.6	Less than the HSD	Not significantly different ($p > 0.05$)
PNM & MPM	3,652.6 & 2,540.4	1112.2	Greater than the HSD	Significantly different ($p < 0.05$)

According to the table above, there was no significant difference ($p > 0.05$) in mean ECR's of FM and MPM-based diets. However, PNM based diets were significantly different ($p < 0.05$) from both the FM and MPM-based diets.

4. DISCUSSION

According to Schmittou, (2004) fish feeds should provide optimum growth and yield at a reasonable cost. Evaluation of aqua feed performance using Economic Conversion Ratio's (ECR's) was aimed at determining cost-effectiveness. ECR's reflect both the biological and economic efficiency of a diet. According to the results shown of the study the MPM-based diet exhibited the lowest mean ECR. Although its performance was not significantly different ($p > 0.05$) from that of the FM-based diet, the MPM-based diet was the best and is a more economical alternative in the aqua feeds for Nile tilapia.

Similar findings have been reported by some researchers on sources of dietary protein extracted from mixed plant-based ingredients. A classic example is the study carried out by Liti et al, (2006) where a mixture of plant protein sources used as substitutes for shrimp meal in the diet of Nile tilapia reared in earthen ponds reduced the diet cost by 36%. Hardy (2010) recognized that feed ingredients that promote fast fish growth at a lower cost should be the choice for aqua feed formulations. Soybean which is one of the low cost agricultural products in Uganda (Agricultural planning Department, 2010), constituted 50% as a dietary protein source for the MPM-based test as shown in table 1.0 diet. This greatly contributed to the low cost of the MPM-based diet. The comparatively low Feed Conversion Ratio (FCR) (Musita et, al, 2015a) together with the low cost of the MPM-based diet were responsible for its lowest and best ECR. The above statement is consistent with Gebhart (2000) who revealed that a combination of FCR and cost determines the ECR of a diet.

The ECR of FM-based diet was not as good as that of the MPM-based diet. FAO, (2008) stated that the cost of FM has been rising because of the high competition from other farm animal enterprises and the reduction in catches from the wild resources. As shown from the results in table 5.0, it was the higher cost of the FM-based diet led to the relatively high. Compared to the MPM-based diet, the FM-based diet is less economical for pond cultured Nile tilapia. The above statements are consistent with; Hardy, (2010) who stated that FM-based diets in aqua feeds are no longer cost-effective and Gillespie (2004) who concluded that FM-based diets have become less suitable for aqua feed formulation.

The PNM-based diet exhibited the poorest performance in terms of ECR's. The ECR corresponding to the PNM-based diet indicates that the ingredient is uneconomical as a dietary protein in the aqua feeds for Nile tilapia. The high FCR of PNM-based diet as compared to FM and PNM-based diets (Musita, et al, 2015b) and its relatively high cost (FAO, 2008) were responsible for its high and poor ECR. The above statement is consistent with Gebhart (2000) who stated that a high FCR and diet cost results in a poor ECR.

5. CONCLUSION AND RECOMMENDATIONS

Despite the promotion of fast growth in cultured fish, fishmeal is less economical as a source of dietary protein in aqua feeds for farmers in Uganda. The MPM-based diet processed as a mixed product from peanuts and soybean, is a more cost-effective alternative to fishmeal in the aqua feed for pond cultured Nile tilapia.

6. ACKNOWLEDGEMENTS

The authors would wish to thank the Belgian Technical Cooperation (BTC) based in Kampala for financing the research study. They are also grateful for the farmland that was offered by Busoga University for the field experiment.

REFERENCES

1. Agricultural Planning Dept. (2010).*Statistical Abstract*. MAAIF, Entebbe, Uganda. 6-23, 41 pp. http://www.agriculture.go.ug/userfiles/Statistical%20Abstract%202010.pdf
2. Bailey N. T. J. (1994). *Statistical methods in biology***.** 3rd edition, Cambridge Univ. press, Univ. of Liverpool, Britain. 116-120 pp. http://www.cambridge.org/us/academic/subjects/life-sciences/quantitative-biology-biostatistics-and-mathematical-modellin/statistical-methods-biology-3rd-edition
3. Bainempaka A. B., Kato H., Mulera D. B., Abwol-Ametto T. (2006). *Principles and practices of agriculture*. Macmillan publishers, Kampala, Uganda. Vol.1, 70, 89 pp.
4. Belal I. E.H. (1999). Replacing dietary corn with barley seeds in Nile Tilapia, (*Oreochromis niloticus* L.) feed. Aquaculture research, 30: 2698 pp.
5. Bob-Manuel F. G &Erondu E. S. (2010). Yeast single protein in the diet of Nile tilapia *(Oreochromis niloticus L.)* fingerlings; an economic evaluation. African Journal of bio-technology, Vol. 10 (80) 18581-84 pp. http://www.academicjournals.org/journal/AJB/article-full-text-pdf/AA8613E35386
6. Borski R., Boliver R. B., Jimenez E. B. J., Minuel R., Ferket R. P., & Stalk R. C. (2012). *Fish meal-free diets and the cost- effectiveness of culturing Nile tilapia in ponds.* Dept. of biology, North Carolina State Univ., Raleigh, USA. 5-12pp.
7. Charo-Karisa H. (2006). *Selection for growth of Nile tilapia in low input environments.* PhD Thesis, Wageningen Univ., 56-75 pp.
8. El-saidy D. M. S .D. &Gaber M. M. A. (1997).Total replacement of fish meal by soybean meal with various percentages of of supplemental methionine in the diets of Nile tilapia *(Oreochromis niloticus L.)* Journal of Agric. Science, 35; 1223-1238 pp.
9. El-sayed D.M.S.D. (2006). Tilapia culture. CABI Publishing Co., Massacusetts USA, 8-65 pp. https://static- content.springer.com /esm/art%3A10.1007%2Fs13197-014-1581-6/MediaObjects/13197_2014_1581_MOESM3_ESM.pdf
10. FAO, (2008). *Aquaculture Development*, No. 5, Fisheries supplement, Rome, 47 pp.
11. FAO, (2009). *Impact of rising feed ingredients prices on aqua feeds and aquaculture production.* Fisheries and Aquaculture Tech. Paper No. 541, 63 pp. http://www.fao.org/3/a-i1143e.pdf
12. FAO, (2012). *The state of world fisheriesand aquaculture*. Fisheries and aquaculture department, UN, Rome. 14-43 pp. http://www.fao.org/3/a-i3720e.pdf
13. Gatlin D. M. (2010).Principles of fish nutrition. Southern Regional Aquaculture Center, Dept. of Agriculture, New yolk, USA.
14. Gebhart G. E. (2000). Economics of Feed Conversion Ratio. Aquaculture program. Langston University, Langston, 2 pp.

15. Gillespie J. R. (2004**)**.*Livestock and paultry production*. 7th edition, New York, USA. 23-35 pp.
16. Gonzalex-Felix M. C., Perez-velazquez M. Villalba A. & Civera-cerecedo R. (2010). Tailoring a diet for Nile tilapia (*Oreochromis. niloticus*) culture. Journal of marine sciences and technology, Vol.18, No.5, 674-681 pp.
17. Hassan A. (2012). Fish feed analysis laboratory. Food & Marine sciences Kuwait Institute of Scientific Research, Kuwait 3-5 pp.
18. Hardy R.W. (2010). Utilization of plant proteins in fish diets; effects of global demand and supplies on fish meal. Aquaculture research, 41; 770-776 pp.
19. Higgs D. A., Dosanjh B. S., Prender A. F., Beam R. M. & Hardy R. W. (1995). *Use of rape seed protein products in fish feeds.* Nutrition and utilization of tech. in Aquac., AOCS Press, Chapaign, USA.15-22 pp.
20. Jauncey K. & Ross B. (1982).*A guide to Tilapia feeds and feeding*. Institute of aquaculture, Univ.of Stirling, Stirling. 49-56 pp.,
21. Jauncey K. (1998). Tilapia feeds and feeding. Institute of Aquaculture, Univ. of Sterling, Scotland. 23-31 pp.
22. Liti D.M., Waidbacher H., Straif M., Mbaluka K. K., Manguti J. M. &Kyenza M. K. (2006). Effect of partial and complete replacement of fresh water shrimp meal with a mixture of plant protein sources on growth performance of Nile tilapia in fertilized ponds. Aquaculture research, 37; 477-483 pp.
23. Musita A. A., Owiti O. Badaza R. & Balirwa J.S. (2015a). Feed conversion as ameasure of quality of peanut –based diets for pond cultured Nile-tilapia,*Oreochromis niloticus L.* Intern. Journ. of Fish. &Aquac. Vol. 5 49-58 pp.
24. Musita A. A, Owiti D. O., Balirwa J S, Otieno A. C. (2015b). Peanut-based diets and growth performance of pond-cultured Nile tilapia fish(*Oreochromis niloticus* L.) at Busoga University farm, Eastern Uganda. International Journal of Fisheries and Aquatic Studies. Volume 2, Issue 6, 306-312 pp.
25. National Peanut Board (2005). *Peanut nutrition*. Paces Ferry Road, Atlanta, USA. 11-25 pp.
26. Ogello E. E, Manguti J. M, Sakakura Y. & Hagiwara A. (2014). Complete replacement of fish meal in the diet of Nile tilapia *(Oreochromis niloticus L.)* grow-out with alternative protein sources. Internatioanl Journal of advanced research, Vol. 2, Issue 8, 962-978 pp.
27. Okumus I., Mazlum M. D. (2002). Evaluation of commercial Trout feeds; feed consumption, growth, feed conversion carcass composition and bio-economic analysis. Turkish Journal of Fisheries and Aquaculture, 2:100-107 pp.
28. Peanut institute, (2003).*Eat well, eat pea nuts*. Albany, Georgia, USA. 1-8 pp.
29. Piedecausa M. A, Mazon M. J., Harnandez M. (2009). Effect of tatal replacement of fish oil by vegetable oil in the diets of sharp snout sea bream *(Diplodusplatazzo)* Aquaculture (-4), 211-219 pp.
30. Rohani A. C, Normaho Z. J. Ufama C. M. &Saaiah I. (2009). Quality of fish fillet from pond raised red tilapia and its utilization in the development of Value Added Products. Journ. of Trop. Agric. and Food Sc., 37(2) 153-161 pp.
31. Ross L. G., (2005). *Environmental physiology and energetics*. Fish and Fisheries series 25, Dordretch, Netherlands. 89-128 pp.
32. Rust M. B., Barrows T. F., Hardy W. R., Lazur A., Waughten K. &Siverstein J. (2012). *Current situation and prospects on aqua feeds*. Dept. of Agric., USDA, USA.13-14 pp.
33. Schefler W. C. (1999). *Statistics for biological sciences.* 2nd edition, Addison-wesley publishing co., Ontario, Canada. 121-122 pp.
34. Schmittou H. R, Zang J. & Cremer M. C. (2004). *Principle and practices of pond fish farming.*Arburn University, Albama, USA. 12-24pp.
35. Sweilum A. M., Abdalla M. M., Eldin A. S. (2005). Effect of dietary protein levels and fish initial sizes on growth rate, development and production of Nile tilapia, *Oreochromis niloticus* L. Aquaculture research 36; 1414-1421 pp.
36. USAID-Harvest (2011). Feed Conversion Ratio; Calculation and use. Reccy, Losangels, USA. 2-3 pp.
37. Yueming D. (1988*). The use of soy protein in aqua feeds.*Netherlands. 542-545 pp.