African Journal of Biotechnology Vol. 10(46), pp. 9473-9478, 22 August, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.333
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

Evaluation of yeast single cell protein (SCP) diets on growth performance, feed conversion and carcass composition of Tilapia *Oreochromis niloticus* (L.) fingerlings

F. G. Bob-Manuel[1]* and J. F. Alfred-Ockiya[2]

[1]Department of Biology, Rivers State University of Education, Port-Harcourt, Nigeria.
[2] Niger Delta University, Amasoma, Bayelsa State, Nigeria.

Accepted 29 June, 2010

An investigation was carried out on the possibility of replacing fishmeal with graded levels of yeast single cell protein (SCP; 10, 20, 30, 40 and 50%) in isonitrogenous feed formulations (30% protein) in the diet of *Oreochromis niloticus* fingerlings for a period of 12 weeks. The control diet had fishmeal as the primary protein source. There were six treatments and four replicates. The result indicates that the 50% yeast SCP diet gave the best in growth response with percentage weight gain (PWG) of 6.04, specific growth rate (SGR) of 0041, daily growth rate (DRG) of (0.0088) and feed conversion ratio (FCR) of 1.94. There was however no significant difference in growth parameters and feed conversion ratio between treatment ($p > 0.05$). The proximate examination of the carcass composition of the whole fish body showed that the 50% yeast SCP fed fish had the highest percentage of body protein (55.35%), but with a lower amount of fat at the end of the feeding trial compared to the control. There was however no significant difference in carcass protein and fat content between treatments ($p > 0.05$). It could therefore be concluded that yeast SCP can successfully replace fishmeal up to 50% level with 0.25% dietary methionine supplementation in a 30% protein diet for O. *niloticus* fingerlings with no significant difference in fish performance ($p > 0.05$).

Key words: Tilapia, yeast single cell protein, growth, carcass composition, feeding trials.

INTRODUCTION

The increasing world population has resulted in a rising demand for protein for human consumption and animal production. The demand for protein is certain to become more serious with over exploitation of the sea and the depletion of most of the available arable land with the ever rapid population growth. There is, therefore, the need to find; new protein sources whose production would require less of the agricultural land, with lower production cost (Israelidis and Conduonis, 1982). Aquaculture has been suggested as a veritable means of bridging the protein demand supply gap. However, this production system can only be effective if operated as an enterprise. In developing countries like Nigeria, the development of aquaculture has been hindered by the prohibitive cost of commercial aquafeeds. Aquafeeds have high protein content and this tends to increase the cost of production, especially with the high inclusion level of fish meal. It has thus become imperative to search out for cheaper alternative protein sources to fish meal.

Fish nutritionists have conducted several studies to evaluate the suitability of various conventional and unconventional protein sources in replacing fish meal in fish diets. Some of such studies evaluated are the substitution of fishmeal by single cell protein (SCP) in fish

*Corresponding author. E-mail: fayeoforib@yahoo.com.

Abbreviations: SCP, Single cell protein; **CRD,** complete randomization design; **RGR,** relative growth rate; **RWG,** relative weight gain; **PWG,** percentage weight gain; **SGR,** specific growth rate; **DGR,** daily growth rate; **DRF,** daily rate of feed intake; **FCR,** feed conversion ratio; **NFE,** nitrogen free extract.

Table 1. Composition of the experimental diets (g/l00 g dry wt.).

Ingredients	Do	D_{IO}	D_{20}	D_{30}	D_{40}	D_{50}
Wheat bran	17.08	17.08	17.08	17.08	17.08	17.08
Fish meal	49.82	44.83	39.00	34.87	29.89	24.92
SCP	0.00	10.94	21.88	32.77	43.67	49.90
Palm oil/Cod liver oil	2.40	2.40	2.40	2.40	2.40	2.40
Bone meal/Oyster shell	2.00	2.00	2.00	2.00	2.00	2.00
Salt	0.20	0.20	0.20	0.20	0.20	2.00
Methionine	0.00	0.05	-0.10	0.15	0.20	0.25
Vitamin/mineral premix*	0.80	0.50	0.50	0.50	0.50	0.50
Binder (Cassava meal))	3.00	3.00	3.00	3.00	3.00	3.00
Corn starch	25.00	19.05	13.03	7.18	1.25	0.00
Total	100	100	100	100	100	100

*Vitamin-mineral premixeach 2.5 kg contains: Vitamin A, 8,000,000 I.U; vitamin D3, 1,600,000 I.U ; vitamin E, 6,000 I.U; vitamin K, 2,000 mgr; thiamine B1,1,500 mgr; riboflavin B2, 4,500 mgr; pyridoxine B6, 1,500 mgr; niacin, 15,000 mgr; vitamin B12, 10 mgr; pantothenic acid, 5,000 mgr; folic acid, 500 mgr; biotin, 20 mg; choline chloride, 200 g ; antioxidant, 125 g ; manganese, 80 g; zinc, 50 g; iron, 20 g; copper, 5 g; iodine, 1.2 g; selenium, 200 mg; cobalt, 200 mg.

diets. These include the works of Matty and Smith (1978), Attack and Matty (1979), Beck et al. (1979), Mahnken et al. (1980), Davies and Wareham (1988), Avnimelech and Mokady (1988), Kiesling and Askbrandt (1993), Bhosale (1997) and Lara-Flores et al. (2003). The results suggest that the SCPs have significant potentials in their utilization in aquafeeds. It is our view that extending these studies to tropical fish, especially those that feed on plant based matter, would go a long way to provide a solution to the problem of aquafeeds in commercial aquaculture in developing countries like Nigeria.

The term SCP according to Israelidis (2003) refers to dead, dry cells of microorganisms such as yeast, bacteria, algae, which grow on different carbon sources. They are commonly produced from wastes from agro-based industries. These wastes include: cereal husks, crop peel, cocoa processing wastes, sugar cane (bagasses) waste from citrus, mango, coconut, etc. Some of these wastes are lignocelluloses and accumulate in considerable amount thereby posing environmental and public nuisance. Conversion of these wastes to SCP serves the dual purpose of mitigating environmental degradation arising from waste accumulation and providing a good protein source for fish diets. There is a dearth of information on the utilization of SCP in the diets of tropical fish species. This study is therefore, aimed at evaluating the effect of replacement of fish meal by SCP (yeast) in the diet of *Oreochromis nitoticus* fingerlings on their growth and nutrient utilization.

MATERIALS AND METHODS

Twenty-four circular plastic tanks of about 30-litre capacity were used for the study. These were filled with dechlorinated water and covered with a chicken mesh. The tanks were all connected to aerators and the water was regularly aerated. Three hundred (300) *O. niloticus* fingerlings of the same stock and average weight of 8 ± 0.02 g were purchased from African Regional Aquaculture Centre (ARAC) fish farm in Aluu, Rivers state, Nigeria. They were stocked in the tanks at the rate of 10 fingerlings per tank and allowed to acclimate for a period of two weeks. During this period, dead fish were removed and the remaining fish were then redistributed at the rate of 5 fish per tank. During the period of acclimation the fish were trained to accept pelleted feed and fed with the control diet at 3% of their body weight twice daily at 0900 and 1600 h. Six isonitrogenous (30% crude protein) diets were formulated and designated (D_o, D_{IO}, D_{20}, D_{30}, D_{40}, and D_{50}) (Table I). Diet D_o was prepared, using fishmeal as the main protein source. This feed also served as the control diet. Diets D_{IO}, D_{20}, D_{30}, D_{40} and D_{50} have fishmeal substituted by yeast (SCP) at graded levels of 10, 20, 30, 40 and 50%, respectively. The yeast SCP was produced by ino-culating yeast from palm wine dregs into milled sweet orange *(Citrus sinensis)* waste which was incubated for 7 days and then harvested and dried. The feeds so formulated were subjected to proximate analysis.

The experimental design used was the complete randomization design (CRD) as described by Wahua (1999). Each of the six diets represented the various treatment levels. Each treatment level (diet) had four replicates. Water in all the tanks was changed weekly throughout the feeding trials. Temperature was measured by a mercury thermometer; pH was determined by a pH meter while dissolved oxygen was measured by an oxygen meter. Water in all the tanks was aerated. The fish were fed with the six experimental diets at 3% of their body weight twice daily. The daily ration was split into two and dispensed at 0900 and 1600 h. The fish were weighed in grams, (g) weekly using a top loading weighing balance and the new feeding regime was adjusted accordingly. Fish lengths were also measured with a measuring board calibrated in millimeters. The experiment lasted for a period of 12 weeks.

Determination of growth and nutrient utilization parameters

The following indices were determined:

Relative growth rate (RGR) = Growth as percentage of initial body

Table 2. Proximate composition of experimental diets (9/100 g dry wt).

Parameters analyzed	Experimental diets					
	Do	D_{10}	D_{20}	D_{30}	D_{40}	D_{50}
Protein	30.24	30.79	30.5	30.85	30.30	30.75
Fat	4.71	6.10	6.12	6.02	6.56	6.13
Fibre	5.33	4.97	5.12	5.21	5.00	4.92
Ash	4.03	4.53	4.83	3.93	4.91	3.68
Moisture	6.80	7.28	7.70	6.79	8.02	7.99
Nitrogen free extract (NFE)	48.89	46.33	45.72	47.20	45.21	46.53

Table 3. Growth and nutrient utilization data of *O. niloticus* fingerlings fed yeast-substituted diets.

Parameters	Diets							
	Do	D_{10}	D_{20}	D_{30}	D_{40}	D_{50}	SE	Level of
Relative growth rate (RGR)%	8.66	6.0[1]	7.44	5.24	.6.3	7.11	0.583	NS
Relative weight gain (RWG)	0.067	0.067	0.074	0.063	0.070	0.030	0.036	"
Percentage weight gain (PWG)%	5.22	5.42	5.94	4.16	5.09	6.04	0.446	"
Specific growth rate (SGR)%/day	0.35	0.34	0.23	0.30	0.33	0.41	0.040	"
Daily growth rate (DGR) g/day	0.0059	0.010	0.0091	0.0084	0.0077	0.0088	0.001	"
Daily rate of feed intake (DRF)	0.058	0.38	0.045	0.038	0.051	0.031	0.004	"
Feed conversion ratio (FCR)	1.23	1.84	1.98	0.72	1.77	1.94	0.229	"

weight (EIFAC, 1980).

$$RGR = \frac{(W_1 - W_0)}{W_0} \text{ x } 100\%$$

Where, Wt = Body weight at time t, Wo = initial body weight. Relative weight gain (RWG) was calculated using the formula shown below (Utne, 1979)

RWG = (Final weight- initial weight) / initial weight

Specific growth rate (SGR) was calculated according to the method of Brown (1957) as:

$$SGR = \frac{Log_e W_1 - Log_e W_2}{T_2 - T_1} x100$$

Where, W_2 = Weight of fish at time T_2 days, W_1 = weight of fish at time T_1 days, Log_e = natural log to base e. According to the method of Utne (1979), daily growth rate (DRG), daily rate of feed intake (DRF) and percentage weight gain (PWG) were calculated as:

DGR = Mean increase in weight per day / Body weight of fish

DRF = Mean ration per day / Body weight of fish

The PWG was calculated from the relationship between weight gain and mean fish weight.

PWG= (Mean weight gain / Mean fish weight) x 100

The feed conversion ratio (FCR) was expressed as the proportion of dry feed fed per unit live weight gain of fish (Reay, 1979).

FCR = Dry feed fed (g) /Live weight gain (g)

Samples of the experimental diets and carcass quality of fish were analyzed for their proximate composition. Before the analysis, the whole fish carcass was dried in hot air oven. This was milled to fine particle size for the proximate analysis. Crude protein was determined using the Micro-kjeldahl procedure (Osborn and Voogt, 1978; Jobling, 1983). This method assumes that the protein content in the sample consist of 16% nitrogen. The crude fat content was determined by the soxhlex extraction method. Ash was evaluated according to the method of De Silva (1989), crude fibre was estimated by ashing the sample at 500°C for 3 h cooled and weighed. The weight of fibre was calculated by the difference method and expressed as percentage. Moisture was determined according to the method of AOAC (1995). Carbohydrate was estimated by the difference method (EIFAC, 1980).

Analysis

The growth data were subjected to analysis of variance test (ANOV A) based on Wahua (1999). Mean differences were determined using Duncan's Multiple Range Tests in cases of significant differences at ($p \leq 0.05$).

RESULTS

The growth parameters determined include RGR, RWG, PWG, SGR, DGR, DRF and FCR. The compositions of the experimental diets as well as the proximate composition are given in Tables 1 and 2. Growth and nutrient utilization data is shown in Table 3. Carcass composition

Table 4. Carcass composition of experimental fish before and after the experiment.

Parameters analyzed (%)	Before experiment	After experimental					
		Do	D_{IO}	D_{20}	D_{30}	D_{40}	D_{50}
Protein	43.24[a]	54.93[b]	53.29[b]	52.97[b]	53.02[b]	52.86[b]	55.36[b]
Fat	2.17[b]	17.06[c]	19.92[c]	I5.87[c]	I5.58[c]	I5.89[c]	I5.45[c]
Fibre	2.53[b]	3.3 7[b]	3.81[a]	3.04[a]	3.15[b]	2.99[b]	3.21[b]
Ash	4.99[a]	2.15[b]	2.15[b]	2.86[b]	2.00[b]	2.21[b]	2.38[b]
Moisture	8.96[a]	4.91[c]	4.91[c]	6.78[a]	4.33[c]	5.05[c]	5.21[c]
NFE	38.11[a]	17.57[b]	16.33[b]	18.40[b]	21. 92[b]	23.99[b]	18.39[b]

Values on the same horizontal row having similar superscripts are not significantly different at ($p > 0.05$).

of the experimental fish before and after the experiment is shown in Table 4. The results showed that the protein content of the diet ranged between 30.24-30.85%, fat content from 4.71-6.56%, crude fibre content 4.92-5.33%, ash between 3.68-4.53%, moisture approximately between 6.79-8.02 and nitrogen free extract (NFE) ranged between 45.21 - 48.89%, respectively.

The initial carcass protein was 43.24% (before the experiment) but the values after the trial experiment ranged between 52.86% (D_{40}) to 55.36% (D_{50}) indicating an increase with the feeding trials (Table 4). The value of the fat content before the experiment was 2.17%. At the end of the feeding trial, fish carcass fat ranged between 15.45% (D_{50}) to 19.92% (D_{10}) showing an increase in carcass fat. The fibre content before the trial feeding was 2.5% while carcass fibre after the experimental period ranged from 2.99% (D_{40}) to 3.81 % (D_{10}) giving a slight increase. There was a decrease in ash content at the end of the experiment compared to that before the experiment. Ash content decreased from 4.99% before the experiment to between 2.00 and 2.38% at the end of the feeding trials. The moisture content fell from 8.96% to between 4.33% (D_{30}) and 6.78% (D_{20}). The NFE values also decreased in the fish carcass at the end of the feeding trails. The value before the experiment was 38.11% while the range at the end of the feeding trials was between 16.33% (D_{IO}) and 21.92% (D_{30}).

DISCUSSION

Growth performance and feed conversion are important indicators as par whether the feed given is converted to fish flesh. The growth and nutrient utilization parameters were evaluated by such indices as RGR, RWG, PWG, SGR, DGR, DRF and FCR. The result of this work was supported by that of Mahnken et al. (1980) who evaluated an alkane yeast as a substitute for fishmeal in Oregon moist pellet (OMP) for *Oncorhynchus kisutch* and *Salmo gairdneri* and observed that alkane yeast was an acceptable partial substitute for fishmeal in the rainbow trout diets at all level tested providing growth equal to the control. The daily rate of feed intake in this work was highest for the 100% fishmeal diet (D_o) but had relatively low FCR (1.23). The high DRF may be due to the initial palatability of the diet to the fish. There is however no evidence to suggest that the quantity of SCP in the diet negatively affected palatability, since diet D_{IO} was the next highest in DRF. Since there was no clear-cut trend in the DRF values, palatability could not have played a major role in the DRF. The DRF values in this work (0.031 - 0.058) are higher than those of Aboaba (1990) for *Chrysichthys nigrodgitatus* fingerlings with values at 0.030. The FCR values obtained in this work are similar to those obtained by Davis and Wareham (1988), El-Saidy and Gaber (2002) and Belal and Al-Owafeir (2004) in O. *niloticus.* The values of the FCR obtained in this study are higher than those reported by Erondu et al. (2006) for C. *nigrodigitatus* with 30% crude protein having a value of 2.72. Some of these discrepancies may have risen from differences in species as well as culture systems. The results of the present investigation showed that 50% of the fishmeal in a practical diet for *O. niloticus* could be effectively replaced by yeast SCP without a significant reduction in growth performance. This compares well with the work of Viola and Zohar (1984) in which 50% of fishmeal protein in diets for hybrid tilapia *(O. niloticus x Oreochromis aureus)* was successfully replaced by bacterial SCP "Pruteen". It also compares favourably with the work of Davies and Wareham (1988), which showed that up to 40% fishmeal, could be replaced by an industrial single cell protein without a significant reduction in growth.

The results of this work also surpassed those obtained by some other workers. For instance, Beck et al. (1979), Olvera-Nova et al. (2002) and Ozorio et al. (2005) fed yeast-based diets to trout, tilapia and Pacu *(Piaractus mesopotamicus)* and obtained optimum values at about 30% yeast inclusion level. Beck et al. (1979) reported that methionine supplemented alkane yeast was well utilized by rainbow trout when used in combination with fishmeal. Kiessling and Askbrandt (1993) observed significant growth reduction in rainbow trout fed diet with increasing levels of single cell protein, such as *Brevibacterium lactofermentum* and *Bacterium glutamaticum* when the bacterium, exceeded four percent of the diet. In another

investigation, Davies and Wareham (1988) observed growth depression when more than 10% of fish meal protein was replaced with the bacterium *Micrococcus glutamicus* in tilapia diets. Furthermore, Matty and Smith (1978) showed that a yeast (*Candida lypolytica*), a bacterium *(Pseudomonas spp)* and an alga *(Spirulina maxima)* protein were accepted by rainbow trout, S. *gairdneri* at 20% inclusion. However, there was a noticeable fall in growth rate of fish fed bacterial protein at 40% level. Yeast proteins were observed as the best utilized for growth and gave generally higher FCE values and optimum growth in diets at 40 - 50%. The observation by Matty and Smith (1978) supported the result of the present investigation while from the earlier results, it could be inferred that yeast single cell protein sources provide superior and better nutritional value in fish diets than other SCP sources. This may be due to its acceptability, palatability and digestibility compared to other SCP sources.

The protein sources were well utilized by the fish, with best result in 50% replacement of fishmeal by SCP, (with a FCR of 1.94) which are higher than those reported by Attack and Matty (1979) with petro-yeast in rainbow trout, Tacon et al. (1983) for O. *niloticus;* Davies and Wareham (1988) using industrial SCP in *Oreochromis mossambicus*, Sogbesan et al. (2004) with maggot meal in feeding hybrid catfish. However, these are lower than those of El-Saidy and Gaber (2002) with soybean meal fed to O. *niloticus* fingerling, Ozorio et al. (2005) who fed dried yeast to Pacu *(P. mesopotamicus.* but similar to the findings of Belal and Owafeir (2004) using date pits diets for *O. niloticus.* There was no clear-cut trend-showing decrease in fat level with increase in SCP. The reason for the observed high body lipid might be an attempt by the fish to deaminate protein in which the ammonia was eliminated as by-product and the non-nitrogenous or carbonaceous portion of the diet deposited as fat. This may have occurred in the preparation for breeding as the fish will stop feeding and rely solely on the deposited fat especially in the maternal mouth-brooders like *O. niloticus.* It has been reported (Aboaba, 1990) that accumulated lipid stores, serves as index of spawning preparation, as may be the case with the fish in this study. This view is further supported by the fact that eggs were observed during the processing of the fish for proximate analysis. Some authors (Santiago et al., 1985; Chang et al., 1988) reported that brood fish may require elevated protein and fat levels to increase reproductive efficiency. The lipid values in this work are higher than those reported by Attack and Matty (1979), Davies and Wareham (1988), EI-Saidy and Gaber (2002), Sogbesan et al. (2004) and Ozorio et al. (2005). The values are however lower than those obtained by Belal and Owafeir (2004). It has been observed (Tacon, 1979; Ohmae, 1979) that carp fed on SCP diets had low lipids in their gross carcass composition, which is contrary to the findings of the present investigation.

The NFE content in test fish may indicate that they do not store carbohydrate in their tissue as a major part was utilized as energy sources. The fraction (carbohydrate) that was observed was probably derived from structural sources such as glycoproteins and glycolipids. It was also possible that part of the glucose (carbohydrate) may have been converted to fat. The ash content in the test fish body decreased compared to the value in the initial fish carcass before the treatments. The values of the ash content were also lower than those from the experimental diet. The fibre content also decreased compared with the proximate composition of the diets but increased slightly when compared with the initial fish carcass. Fibre content of feed has been documented to enhance growth performance in fish (Steffens 1989; Sogbesan et al., 2004). The moisture content also decreased with the treatments compared to the diets as well as the initial fish carcass. These low moisture and ash content values obtained in the fish carcass are indices of good growth as noted by Stuart and Hung (1989). It was also observed in this study that the percentage moisture content in the fish carcass declined as the body lipid increased. This inverse body moisture and lipid relationship as observed here was also seen in other fish species (Jauncey, 1980; Siddiqui et al., 1988; Aboaba, 1990). SCP can replace as much as 50% of fishmeal in isonitrogenous diets (30% crude protein) for *O. niloticus* fingerlings. In fact, the diet with 50% fishmeal substituted with yeast SCP (diet D_{50}) gave the best results in terms of growth response as well as feed conversion. This higher growth performance observed in feeding fish with more than one protein source may be due to the synergistic effect of combining two biological compounds to have a single and superior effect than when individually applied for fish diets as noted by Hossain and Jauncey (1989) and Sogbesan et al. (2004). The diet with 50% yeast SCP supplemented with 0.25% methionine can replace half of the fishmeal in diet for Nile tilapia fingerlings without adverse effect on fish performance. The result of the carcass analysis of the fish showed that diet D_{50} gave the highest body protein value in *O. niloticus* followed by the control diet D_o. This is an indication that the 50% SCP substituted diet was better utilized by the fish than the 100% fishmeal diet, (D_o) at the end of the feeding trial. In practical diets for *O. niloticus* fingerlings, fishmeal could be replaced successfully with 50% yeast SCP without adversely affecting growth, feed conversion and carcass composition. It could therefore be recommended that fish farmers and fish feed technologists make use of this under-utilized protein source. Further studies are required to ascertain yeast SCP substitution at higher levels than those used in this study.

REFERENCES

Aboaba MA (1990). Effects of varying dietary Protein levels on the growth and nutrient ulization of *Chrysichthys nigrodigitatus*

(Lacepede) Unpublished Ph.D Thesis University of Ibadan. Ibadan, Nigeria. p. 145.
AOAC (1995). Official Methods of Analysis of the Association of Official Analytical chemists, Washington, USA. 2: p. 1234.
Attack A, Matty AJ (1979). The evaluation of some single-cell protein in the diet of Rainbow trout, II the determination of net protein utilization, biological values and true digestibility. In. Halver JE and Tiews K (eds). Finfish Nutr. Fish Feed Technol. 1: 450.
Avnimelech Y, Mokady S (1988). Protein Biosynthesis in Circulated Fish pounds In: Pullin RSV, Blukaswan TK, Sympopium on Tilapia in Aquaculture. ICLARM Conference Proceeding, pp. 301-309, 15,623.
Beck H, Gropp J, Koops H, Tiews K (1979). Single Cell Protein in trout diets. In finfish Nutrition and fish feed Technology, Halver JE and Tiews (eds). 2: p. 450.
Belal IEH, Al-Owafeir MA (2004). Incorporating Date pits Pheonix dactylifera and their sprouts in semi-purified diets for Nile tilapia *Oreochromis niloticus* (L.) J. World Aquacult. Soc. 35(4): 452-459.
Bhosale PB (1997). Micro-organisms as fish feed in fish industries. Curr. Sci. 73(7): 562-563.
Brown ME (1957). Experimental Studies on growth. In: Brown ME, Academic Press London, Physiol. Fish. 1: 361-400.
Chang SL, Huang CM, Liao IC (1988). Effects of various feed on se.ed production by Taiwanese red tilapia. In Proceedings of the 2nd International Symposium on Tilapia in Aquaculture. Pullin RSV, Rhukaswan T, Tonguthai K and MacLean JL (Eds) ICLARM, Bangkok, p. 420.
Davies SI, Wareham H (1988). A preliminary Evaluation of an Industrial Single Cell Protein in Practical Diets for Tilapia *Oreochromis mossambicus* (Peters) Aquaculture, 73: 189-199.
De Silva SS (1989). Digestibility evaluation of Natural and Artificial Diets In: DeSilva SS (ed) Fish Nutrition Research in Asia. Proceedings of the Third Asian Fish Nutrition Network Meeting. Asian Fish Soc. Spec. Publ., 4:166, pp. 36-45. EIFAC (1980). Report of the EIF AC/IUNS and ICE working group on standardization of methodol.ogy in fish nutrition research, EIFAC Technical Paper, p. 36.
EI-Saidy DMSD, Gaber MMA (2002). Complete Replacement of Fish meal by soybean meal with Dietary L-Lysine supplementation for Nile Tilapia *Oreochromis niloticus* (L.) fingerlings. J. World Aquacult. Soc. 33(3): 297-306.
Erondu ES, Bekibele D, Gbuludo AT (2006). Optimal crude Protein Requirement of the catfish, *Chrystchhthys nigrodigitatus.* J. Fish. Int. 1(1-2): 40-43.
Hossain MA, Jauncey K (1989). Nutritional evaluation of some Bangladeshi Oilseed Meals as partial substitutes for fishmeal in the diet of common carps C. *Carpio*. Aquacult. Fish Manage. 22: 255:-268.
Israelidis CJ, Conduonis MI (1982). Utilization of agricultural wastes for animal feed and energy. Agric. Res. 6: 243-253.
Jauncey K (1980). The effects of varying dietary composition on minor carp *(Cyprinus carpio)* maintained in thermal effluents in laboratory recycling systems. Proc. World Symp. On Aquaculture in Heated Effluents and recirculation systems. Stavenger 2830 May, 11: 249-261.
Jobling M (1983). A short review and critique of methodology used in fish growth and nutrition studies. J. Fish Biol. 23: 685-703.
Kiessling A, Askbrandt (1993). Nutritive value of two bacterial strains of Singlecell protein for rainbow trout *(Onchorhynchus mykiss).* Aquaculture, 109: 119-130.
Lara-Flores M, Olvera-Novoa MA, Guzman-Menedez RE, Lopez-Madrid W (2003). Use of the bacteria *Streptococcus faecium* and Lactobacillus acidophilus, and the yeast *Saccharomyces cerevisiae* as growth promoters in Nile tilapia *(Oreochromis niloticus)* Aquaculture, 216: 193-201.
Mahnken CVW, Spinelli J, Waknitz FW (1980). Evaluation of an alkane yeast *(Candida sp)* as a substitute for fishmeal as Oregon moist pellet: feeding trials with Rainbow trout *(Oncorhynchus kisutch)* Aquaculture, 20: 41-56.
Matty AJ, Smith P (1978). Evaluation of a Yeast: Bacterium and Alga as a Protein source for Rainbow trout: I Effect of Protein Level on Growth, Gross Conversion Efficiency. EIFACI78/Symp.EI7 FAO Rome, p. 78.
Osborn DR, Voogt P (1978). The Analysis of Nutrients in Foods. Food Science and Technology. A Series of monographs. Academic press, London, New York. San Francisco. p. 250.
Reay PJ (1979). Aquaculture Studies of Biology, No. 16 Edward Arnold p. 60.
Sogbesan AO, Ajuonu ND, Madu CT, Omojowo FS, Ugwumba AAA (2004). Growth Response, Fed Conversion rate and cost- benefits of hybrid catfish fed Maggot meal based diets in outdoor tanks Proceedings of the Fisheries Society of Nigeria (FISON) Annual Conference, pp. 231-237.
Steffens W (1989). *Principles of fish nutrition.* Elhis Horwood Limited U.K. p. 384.
Stuart JS, Hung SSO (1989). Growth of juvenile white sturgeon *(Acipenser transmontatus)* fed different protein. Aquaculture, 76: 303-316.
Tacon AGJ (1979). The Use of Activated Sludge-Single Cell Protein (ASCP), derived from the treatment of domestic sewage in trout diets. In: On Finfish Nut and Fishfeed Tech. Halver JE and Tiews K, Proc. World Symp. 2: p. 450.
Tacon AGJ, Jauncey K, Falaye A, MacGowan I, Stafford EA (1983). The use of meat and bone meal, hydrolysed feather meal and soybean meal in practical fry and fingerling diets for Oreochromis niloticus. Proceedings international symposium on Tilapia in Aquaculture, Fishelson L, Yaron Z (compilers).
Utne F (1979). Standard Methods and Terminology in Finfish Nutrition. In proceedings of World Symposium on Finfish Nutrition and Fishfeed Technology, Hamburg 20-23 June 1978, Berlin, 2: 438-443.
Viola S, Zohar G (1984). Nutrition Studies with market size hybrids of tilapia *(Oreochromis)* in intensive culture. Bamidgeh, 36: 3-15.
Wahua TAT (1999). Applied statistics for scientific studies. African Link books, Ltd. Ibadan. p. 356.