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A comparative study of the effect of yeast single cell protein on growth, feed utilization and condition factor of the African catfish *Clarias gariepinus* (Burchell) and tilapia, *Oreochromis niloticus* (Linnaeus) fingerlings

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An investigation was carried out to compare the effect of feeding yeast single cell protein (SCP) on the growth and feed utilization parameters of *Clarias gariepinus* and *Oreochromis niloticus* cultured separately. The parameters investigated include the percentage weight gain (PWG); feed conversion ratio (FCR); specific growth rate (SGR); and condition factor (CF). The findings indicate that for *C. gariepinus* fingerlings optimum growth and nutrient utilization was obtained with 30% SCP substitution of fishmeal while for *O. niloticus* fingerlings 50% substitution level gave optimum growth and feed utilization. Fishmeal could therefore be replaced with yeast SCP at these levels to cut down on cost of aquafeeds for sustainable aquaculture development of these species.

Key words: Yeast single cell protein (SCP), growth, nutrient utilization, catfish, tilapia.

INTRODUCTION

One of the constraints to the successful practice of fish culture in many developing countries like Nigeria is lack of nutritionally adequate and low cost feeds. Hence fish nutritionists are searching for alternative sources of feed that is cheap, reliable and accessible. The search for alternative feed resources in aquafeeds is increasing and has gained increasing significance as traditional ingredients are becoming costly or less available. Fish meals is regarded as the best natural feed ingredient for aquafeeds, due to its high protein content and balanced amino acid profile. However, global fish meal productions from wild sources continue to decline. Therefore, suitable alternative sources of protein have to be sought for sustainable aquaculture development.

In order for aquaculture to register further growth and meet its potential of bridging the gap between fish supply from capture fisheries and the demand for fish, the direction of aquaculture development in Nigeria will have to be focused on increasing production efficiencies and intensities so as to produce more fish using less land, water, financial resources and the development of cheap, high quality source of protein for feeding fish

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(Ibigo and Olowosegun, 2005).

Evaluation of yeast single cell protein (SCP)

The term single cell protein refers to dead dry cells of micro-organisms such as yeast, bacteria, fungi and algae. Single cell proteins have reasonably well balanced amino acid profiles, is an excellent source of some vitamins and minerals and also possess useable lipids and carbohydrates (Israelidis, 2003). In Nigeria, the history of SCP is relatively new, and its inclusion in fish feed is a novel idea.

According to Tacon and Jackson (1985), SCP is being developed as a veritable alternative to fish meal as protein source in fish feed. The cultivation of yeast as single cell protein for utilization in aquaculture is becoming more and more popular in the developing countries. This trend is so because SCP provides suitable alternative to fish meal which is becoming expensive for the fish nutritionist to utilize in feed formulation. The pivotal role of SCP in feeding fish cannot be over-emphasized as demonstrated by several studies (NRC, 1983; Steffens 1989; Jackson et al., 1996; Heindl, 2002; Debaath, 2003). It has been evaluated as viable sources of protein in fish feed; with advanced processing techniques, their nutritive value has been enhanced to such an extent that they are now almost considered as conventional ingredients in aquafeeds (Eyo, 2003). The most commonly used and widely available SCP for fish feeding is torula yeast (*Candida utilis*). This is cultured on substrates comprising a variety of industrial wastes, including molasses, dried citrus pulp, or sulphite liquor from the wood pulp and paper industries (FAO, 1983).

Feed-qrade yeast have been shown to be excellent substitutes for fish meal at low levels in diets for fish (Jauncey and Ross, 1982). The amount of substitution depends upon the type of yeast and the manner in which it is produced. In general yeast are relatively low in methionine. Proper supplementation with synthetic sources of the amino acid could permit yeast to be the only protein source in the diet (Luguet, 1981). Yeast from molasses and other industrial wastes are less costly to produce than other SCP. Yeast as a class of feed stuff are very cheap to use than fish meal and other protein supplements of vegetable origin in fish feed (Marty, 1980).

Culture potentials of *Oreochromis niloticus*

Tilapia (*O. niloticus)* is the most common species of tilapia in Nigeria. The culture of this species have been more widely used in aquaculture because they are hardy, available all year round and are easily cultured in virtually any type of enclosure in monoculture system and in polyculture with other species like catfishes, torpor, snappers etc. (Anyani and Awa, 1988; Oladosu et al., 1990). They are very cheap, tasty, increasing the availability of protein and the quality of nutrition of poor fish farmers and consumers (Changadeya et al., 2003).

Culture potentials of *Clarias gariepinus*

This is the most cultured fish in Nigeria at present. Their important role in tropical aquaculture according to De Graaf and Janson (1996) includes hardiness to adverse environmental conditions, capacity to undergo aquatic and aerial respiration, resistance to parasite and disease. In addition, they exhibit reasonable growth rate in captivity and demand a high consumer preference in the market (Haylong, 1996). Additional attributes of *C. gariepinus* of relevance to culture include the high fecundity, potential for all year round induction of final oocyte maturation, favourable nutritional efficiency and tolerance of high density culture (Viveen et al., 1985). Since tilapia (*O. niloticus*) and the catfish (*C. gariepinus*) are the most popular cultivable fish in Nigeria, the use of SCP in their diet will go a long way in enhancing growth and maximization of profit in aquaculture ventures. In time past, the tilapias have been more widely promoted for farming, but now *C. gariepinus* the African catfish have over taken tilapia as major culture species in Nigeria (FAO, 1999, 2003). The present investigation is thus an attempt at substituting fishmeal in the diet of *C. gariepinus* and *O. niloticus* with single cell protein (SCP) at varying levels, to evaluate its effect on growth and nutrient utilization as well as determine optimum levels of substitution.

MATERIALS AND METHODS

Experimental site and materials

The work was carried out in the Biology Department of the Rivers State University of Education, Rumuolumeni, Port Harcourt. The fingerling about 300 in number of equivalent weight was obtained from the African Regional Aquaculture Centre (ARAC) Aluu near Port Harcourt. The experimental tanks consisted of 24 concrete tanks in the Department of Biology of the University. The fish were left to acclimate in these tanks for four days during which they were not fed. This was to enable them empty their gut in preparation for the feeding trials. There were no mortalities during the period. After the period of acclimation the fish were reweighed and redistributed into the tanks. Each of the tanks contained 25 fingerling. The experimental design consisted of six treatments and four replicates. Given a total of 24 experimental units. The tanks have dimensions 1.0 × 0.8 × 0.7 m. Before the fish were stocked the tanks were cleaned, dried and left for two weeks. This is to ensure elimination and eradication of any micro-organism, competitive animals and parasites. The tanks were then filled ¾ with fresh tap water. At the end of the acclimation the fish were fed with the control diet for 2 days before the feeding trial started.

Experimental diets

Experimental diets consisted of six trial diets namely S_{A}, S_{B}, S_{C}, S_{D},

Table 1. Composition of the experimental diets (g/100 g dry wt.).

Ingrédients	S_A	S_B	S_C	S_D	S_E	S_F
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*	0.50	0.50	0.50	0.50	0.50	0.50
Binder (gari)	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 premix (optimix premix animal care product Nigeria) was added to all of the diets.

S_E and S_F. S_A was the control diet which had 30% exclusive fish meal protein diet. S_B had 30% protein in which 10% was substituted with yeast SCP. Diet S_C had 20% of the fish meal substituted with yeast SCP. Diet S_D had 30% SCP substitution of fishmeal. Diet S_E had 40% replacement of the fishmeal and diet S_F had 50% replacement of fishmeal. The diets were all isonitrogenous, and made into very small pellets. The composition of the experimental diets is presented in Table 1.

Feeding of experimental fish

The fish were fed with the prepared diets at the rate of 3% of their body weight twice daily at 0900 and 1500 h. The fish were fed six days in the week on the seventh day; they were left to browse on left-over feed in the tank. The water in the tanks was renewed once in the week during which period the fish were also weighed and new feeding regime determined for the next one week. The feeding trial lasted for 8 weeks.

Determination of growth and feed utilization parameters

Growth rate of the fish fed with the experimental meals were expressed as changes in the average fresh body weight of the fish during the experimental period. The percentage weight gain (PWG), feed conversion ratio (FCR), specific growth rate (SGR) and condition factor (CF) for the fish were computed using the formulae below: The percentage weight gain (PWG) was determined from the relationship between weight gain and mean fish weight (Reay, 1979).

$$\text{PWG} = \frac{\text{Mean weight gain}}{\text{Mean fish weight}} \times \frac{100}{1}$$

Feed conversion ratio

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

$$\text{FCR} = \frac{\text{Dry feed fed (g)}}{\text{Live weight gain (g)}}$$

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

$$\text{SGR} = \frac{\log_e W_1 - \log_e W_2}{T_2 - T_1} \times 100$$

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.
The condition factor was expressed as Fulton's condition factor (Nikolsky, 1963).

$$\text{CF} = \frac{100W}{L^3}$$

Where W is the weight of fish in gram and L its length in cm.

Statistical analysis

The growth, feed utilization and condition factor were subjected to analysis of variance test (ANOVA) based on Wahua (1999). Duncan's multiple range test was used to determine mean differences at ($p>0.05$) (Table 1).

RESULTS AND DISCUSSION

The results of the PWG, FCR, SGR, and CF for *O. niloticus* and *C. gariepinus* are presented in form of bar graphs (Figures 1 to 4). The result of the investigation revealed that diet S_F (50% SCP substitution of fishmeal) gave the highest PWG for *O. niloticus* while for *C. gariepinus* diet S_D (30% SCP substitution) gave the highest values (Figure 1). The values of the control diet (S_A) are quite close to the above values. For the feed conversion ratio diet S_F also gave the best result for *O. niloticus* while diet S_B gave the lowest values. In *C. gariepinus,* diet S_D (30% substitution of fishmeal with SCP) gave the best result which is comparable to the control diet S_A (Figure 2) while the lowest values were obtained for diet S_B (10% substitution) both for *O.*

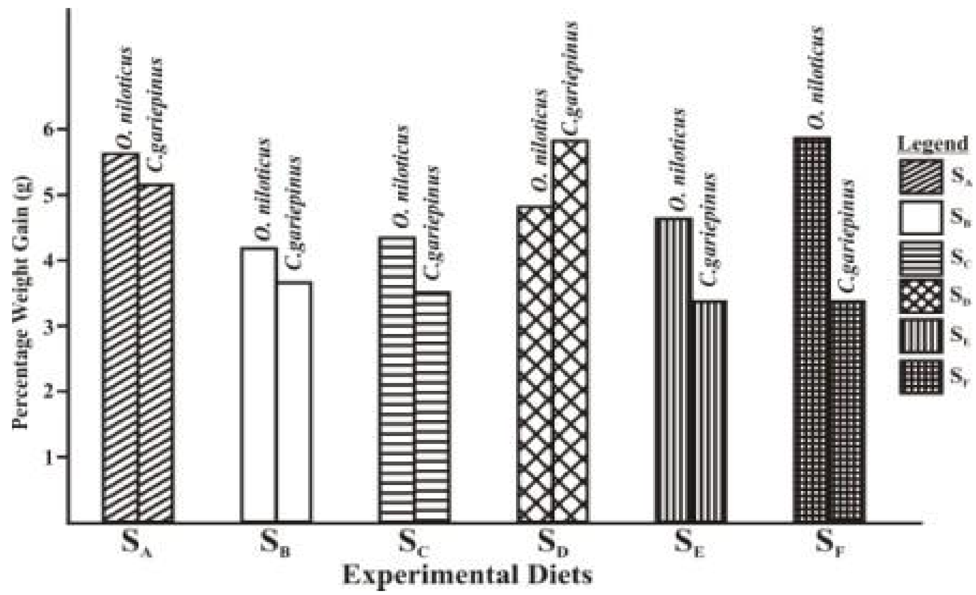

Figure 1. Bar graph showing percentage weight gain in *O*. *niloticus* and *C*. *gariepinus* fed the experimental diets.

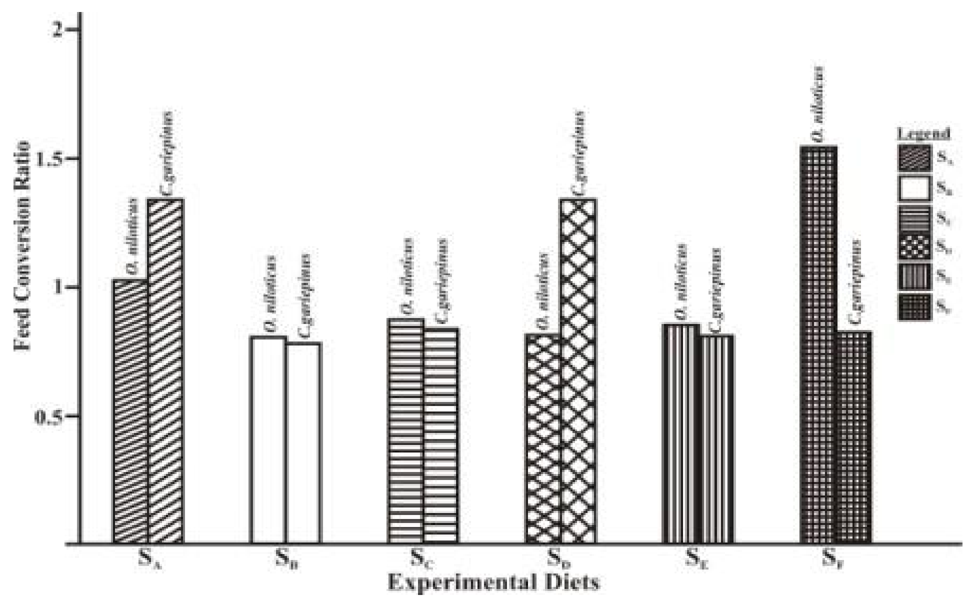

Figure 2. Bar graph showing feed conversion ratio in *O*. *niloticus* and *C*. *gariepinus* fed the experimental diets.

niloticus and *C. gariepinus.* The values of the SGR for *O. niloticus* was also highest for diet S_F while the lowest values were obtained for diet S_D (Figure 3). These values are slightly higher than the control. For *C. gariepinus* diet S_D also gave the highest values for SGR while diet S_F had the lowest values. The values are also slightly higher than that of the control diet.

The results of the CF indicate that diet S_F had the best values for *O. niloticus* while the lowest values were obtained for diet S_B and S_D (Figure 4). The CF values for *C. gariepinus* showed that diet S_D gave the best result while the lowest values were obtained for diet S_E and S_F. The best values obtained for *C. gariepinus* with diet S_D are comparable to those of the control diet (S_A). From the foregoing, it is evident that diet S_F gave the best results for *O. niloticus* as it concerns, PWG, FCR, SGR and CF while for *C. gariepinus* diet S_D gave the best result for these parameters. This is an indication that *O. niloticus*

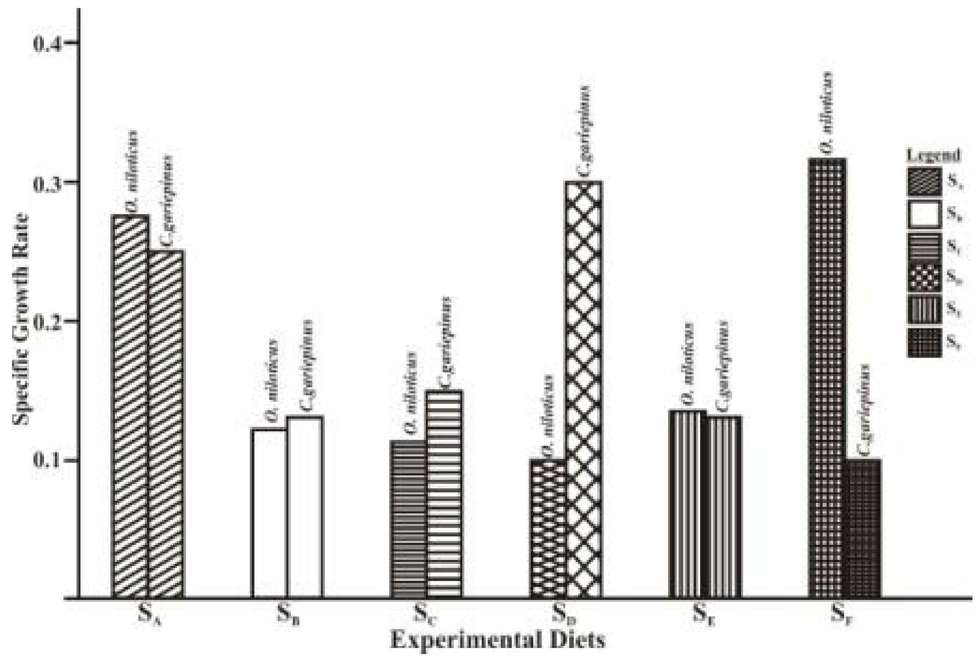

Figure 3. Bar graph showing specific growth rate in *O*. *niloticus* and *C*. *gariepinus* fed the experimental diets.

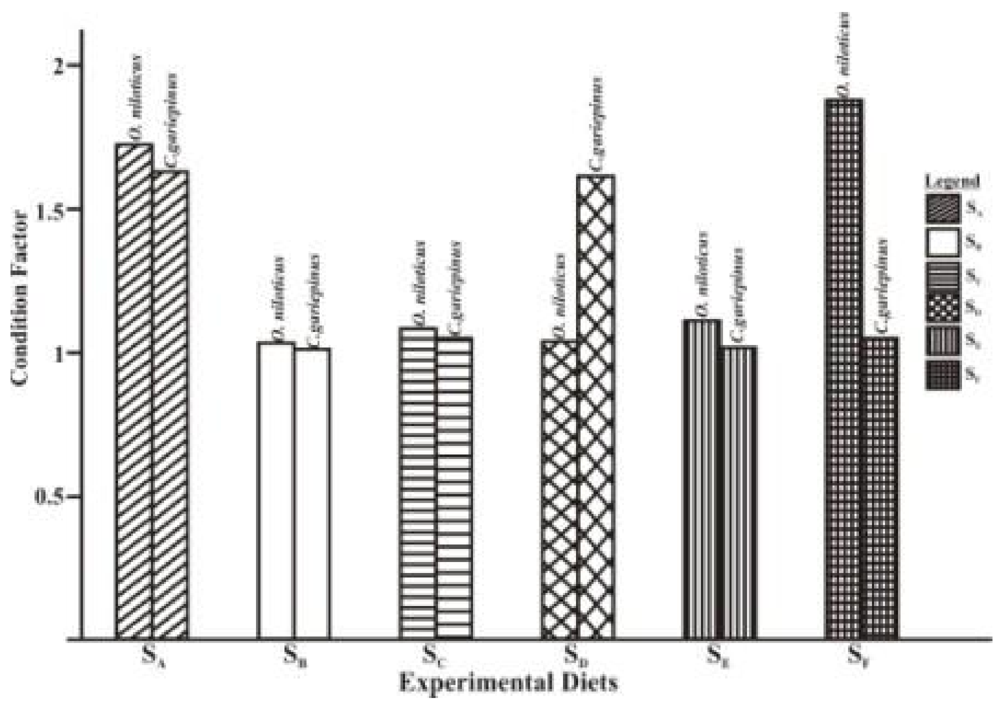

Figure 4. Bar graph showing confition factor in *O*. *niloticus* and *C*. *gariepinus* fed the experimental diets.

could thrive better with higher levels of SCP inclusion in the diet (50% substitution of fishmeal with SCP) while *O. gariepinus* can tolerate lower levels of inclusion of SCP in their diet in replacement of fishmeal (about 30% substitution).

De MuyIder et al. *(*1989) evaluated brewery activated sludge single cell proteins (BSCP) in high quality feeds for *C. gariepinus* fingerlings, at levels of 4 to 22%. BSCP incorporation was found to have a positive effect on the growth performance up to levels of 22%, while this study indicates that the 30% SCP substitution of fishmeal (diet S_D) gave the best value of percentage weight gain in *C. gariepinus*.

The result of this work compares favourably with the work of Viola and Zohar (1984) in which 50% of fishmeal protein in diets for hybrid tilapia (*O. niloticus* x *O. aureus*) was successfully replaced by bacterial SCP, 'pruteen'. It is also in consonance with the work of Davies and Wareham (1988). Lara-Flores et al. (2003) evaluated two bacteria and one yeast as growth promoters in diets fed to *O. niloticus.* Best growth was obtained from a 40% protein diet supplemented with the yeast, *Saccharomyces cerevisiae*. The findings in this work is also comparable to the work cited above since diet S_F (50% SCP substitution) gave the best PWG, FCR, SGR and CF for *O. niloticus*. The findings in this work also agree with those of Beck et al. (1979); Olvera-Novoa et al. (2002) and Ozorio et al. (2005) who fed yeast-based diets to trout, tilapia and pacu (*P. mesopotamicus*) respectively and obtained optimum values at about 30 percent yeast inclusion level.

The use of yeast SCP may revolutionize the future of aquaculture industry world-wide as reported by Vielma et al. (1998), that it increases bio-availability of phosphorus and other minerals to fish. Also Debaath (2003) confirmed that apparent net protein utilization and digestibility in Atlantic Salmon was significantly improved by yeast SCP supplementation. Jackson and Robinson (1996) also observed a higher increase in weight of *Ictalurus punctatus* fed yeast SCP compared to the control group. Furthermore, Steffens (1989) reported on the inclusion of yeast SCP in the diet of Rainbow trout that it had a positive effect on its specific growth rate, percentage weight gain and feed conversion ratio. These findings are in agreement with the present study.

It could be deduced from the findings in this work that in an attempts to reduce feeding cost in aquaculture by the use of yeast SCP in replacing fishmeal in pelleted fish diet, positive growth was recorded up to an inclusion level of 30% for *C. gariepinus* fingerlings while for *O. niloticus* fingerlings yeast SCP gave optimum growth and feed utilization at 50% inclusion level.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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