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Effect of Dietary Salt (Sodium Chloride) Supplementation on Growth, Survival and Feed Utilization of *Oreochromis shiranus* (Trewavas, 1941)

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Abstract

A study was conducted to determine growth response, survival and feed utilization efficiency of *Oreochromis shiranus.* Fingerings of 12.32 ± 0.34 g were fed diets containing different levels of sodium chloride. (Diet 1= 0%, diet 2=1%, diet 3=1.5% and diet 4=2%). Treatments were replicated three times and 25 fish were stocked in each of the 100 L grass tanks. Fish were fed 5% body weight twice a day. Weight measurements were recorded fortnightly. Fish fed diet 3 and diet 1 had final a weight gain (6.45 g) and (5.25 g) respectively, higher than other diets. In diet 3 fish grew from 12.24 g to 18.69 g and in diet 2 fish grew from 12.34 g to 17.19 g on average. Feed Conversion ratio (FCR) was best in diet 2 (1.51) and diet 3 (1.44), highest was in diet 4 with FCR of 1.87. Diet 1 had an average weight gain of 3.86 g which was statistically not (P>0.05) different from that of diet 4. % Survival was higher in diet 1=0% NaCl level *(97.7%) and lowest in diet 2 (94.8%).* The study indicates that salt can be incorporated in fish diets enhance growth, but can be used up to a limit beyond which growth is compromised.

Keywords: *Oreachromis shiranus*; Dietary salt; Feed utilization; Growth; Survival

Introduction

Malawi's fish production is dwindling and the development is not in tandem with the human population increase. In view of this, it is imperative to increase fish production to tally with the high market demand. To achieve this, there is a need to increase aquaculture production in Malawi through, among other important ways, fish feed supplementation. Thus, nutrition is critical in an effort to produce more fish. FAO [1] indicated that supplementation of fish diet increase yield over and above what would have been achieved without it.

A supplement is defined as a thing added to supply deficiencies. In aquaculture nutritional context, it will be tantamount to the supply of feed to meet one or more nutrient deficiencies of the system for the well-being of the stock (FAO) [1]. Supplementing the naturally available food in a culture system is the most simplistic functional interpretation of supplementary feeds. Supplementary feeding can affect feeding habits and food selection; the fish tend to select narrower range of food on supplementary feed regimes (FAO) [1]. According to Zaugg et al. [2] adding salt to the diet of fish has several advantages some of which are it increases appetite and also acts as humectants by reducing water activity.

Additives like sodium chloride are essentially ideal to enhance growth if incorporated in artificial feed as supplements. The use of salt (sodium chloride) is not a new advent. Salt is one of the essential mineral elements required by the animal and plant bodies for their normal functioning namely; making food taste better, regulating osmotic pressure of the body, form acid in mucous membrane of the stomach (activation of pepsin and enzymes of the salivary glands of the throat and keeping digestive processes normal). Elsewhere, research on salt supplementation has been conducted and yielded significant results. According to Nandeesha et al. [3] addition of salt to the diet of freshwater carp at 1.5% inclusion level resulted in better growth and is widely used in India. Therefore, knowing the optimal levels of different level of salt to be incorporated as a supplement in fish diet would play a vital role in enhancing feed intake and ultimately promote growth.

In freshwater-adapted fish, the passive outward flux of ions such as Na and CI from the fish to the external medium, via the gills, feaces and renal system must be overcome by active uptake of ion (e.g. Na^+, CL- K^+ and Ca^{2+}) from the water and/or from the diet. Therefore, the diet constitutes an important source of salts that can satisfy the osmoregulatory requirements of fish kept in freshwater and thus spare energy used for osmoregulation leaving more energy available for somatic growth.

Addition of 2% NaCl and 2% potassium chloride to practical diets has shown to have a positive effect on growth of red drum in freshwater and brackish (6 ppt) water but no positive effect were in full strength artificial seawater. The beneficial effect of dietary salt supplementation for red drum in dilute water appears to be due to provision of ions, which were relatively scarce in this hypotonic environment [4].

The beneficial effects of dietary salt supplementation on growth of freshwater and euryhaline fish have not been consistently observed; however, significant improvements in seawater have been noted [4]. A high-salt diet prior to transfer to sea water has also been found to reduce osmoregulatory stress and increase the survival rates in sea water of some African Tilapia (*Oreochromis* species).

Oreochromis shiranus being a freshwater is fish hyper osmotic to its surrounding medium, and encounter the physiological problem of solute loss and in order to compensate this, they resort to active uptake of salt ions from the medium. It is reasonable to expect that diet is an important source of salts that would satisfy the osmolegulatory requirement of *Oreochromis shiranus* and that supplemental salt

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spares energy used in osmoregulation, thereby leaving more energy available for growth [5]. Study by Nandeesha et al. [3], affirms that the addition of salt to the diet of freshwater carp at 1.5% levels resulted in better growth and is widely used in India. This corresponds with an experiment conducted on juvenile red drum, where it was found out that addition of 2% NaCl to the diet resulted in greater feed efficiency and greater weight gain [5].

Commercial aquaculture in Malawi is stagnating due to costly protein source especially fishmeal. Therefore, it is worthwhile finding ways of reducing protein intake without realizing significant decrease in growth. Salt act as a feed attractant can therefore help to minimize protein intake if incorporated into a diet. Freshwater fish, being hyper osmotic to the surrounding medium, encounter the physiological problem of solute loss and in order to compensate this, they resort to active uptake of salt ions from the medium. It is reasonable to expect that diet is an important source of salt that would satisfy the osmoregulatory requirement of the fish and that supplement salt spare energy used in osmoregulation, thereby leaving more energy available for growth. Until the recent survey, there had been no documentation that common salt was used as an additive to supplementary feed(s) (FAO) [1]. Therefore, results of this study are expected to provide information of salt as a fish diets supplement impact on growth performance; survival and feed convention ration *Oreochromis shiranus*.

Material and Methods

Experimental site and fish

The experiment was conducted inside the wet laboratory at Bunda fish farm using 100 litre tanks each stocked with 25 fish. It used water from the reservoir which is first pumped to the biofitration tank before it goes to the elevated storage tanks from where it is channeled through pipes to the hatchery and the laboratory. Seed (fingerings) were procured from earthen ponds at the farm with an average weight and total length of 12 g and 93 mm respectively. This was done to achieve uniform growth and minimize competition over space and food as recommended by Webster and Lim [6].

Acclimatization

Fingerings destined for the experiment were first acclimatized in concrete tanks for a fortnight.

Diet preparation

Soybean meal, maize bran and cassava flour were bought from areas in the vicinity of Bunda College, Lilongwe, Malawi. Dry fish, rice bran, unionized salt (sodium chloride) mineral and vitamin premixes were bought from Lilongwe market, Malawi. Soy bean was first roasted before grinding in line with Jauncey [7] who reported that raw bean contains a number of anti-nutritional factors, Soybean trypsin inhibitor which is destroyed by heating during processing. Samples of the ingredients were subjected to proximate analysis following the (AOAC) [8]. Mixed ingredients were used to formulate the diets as illustrated in Table 2. Finally, pellets of approximately 2-2.5 mm were produced using a meat mincer.

Proximate analysis of feed ingredients

The ingredients were assayed for in the aquaculture laboratory using proximate analysis using appropriate methods (AOAC) [8] before feed formulation (Tables 1 and 2).

Experimental design

The experiment was layed out in a Completely Randomized Design (CRD) using 100 litre tanks each stocked with 25 fingerings in triplicate totaling to 12 tanks. Fingerings were stocked at mean weight of 12 g to minimize competition over space and food as recommended by Webster and Lim [6]. Each of the diets was fed at 5% body weight twice a day (8:00 – 9.00 am and 2:00 - 3:00 pm) for 90 days and the quantity of feed was adjusted after a fortnight. Mortality was monitored every day to calculate survival rate. Data on water quality parameters was recorded twice daily before feeding, temperature at (6:00 - 7:00 and 1:00 – 1:30) using a water checker.

Sampling techniques and growth monitoring

Sampling was done every fortnight. 15 fish from each tank were weighed (g) using an electronic scale while measuring board was used to record standard length (mm) Mortality was recorded every day. The following growth parameters were calculated using the following formulae:

$$G_R = \frac{WG}{IW};$$

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

$$FCR = \frac{FI}{WG};$$

$$Survival = \frac{N_H - N_S}{N_S}$$

Statistical analyses

Data analysis was done using SPSS-Statistical Package for Social Scientists (16.0 versions). One-way analysis of variance (ANOVA) was

Proximate Component	Maize bran	Fish meal	Rice bran	Soy bean
Dry Matter %	91.3[a]	91.9[a]	91.4[a]	92.09[b]
Crude Protein %	10.2[a]	62.14[b]	9.53[b]	42.1[d]
Ash %	3.41[a]	11.64[b]	5.48[c]	4.13[d]
Fat %	0.17[a]	13.87[b]	1.65[c]	18.90[d]

Means in the row with the same superscript letter are not significantly different (P>0.05).

Table 1: Proximate analysis of feed ingredients used in feed formulation.

Ingredient	Diet 1 (0% salt)	Diet 2 (1% salt)	Diet 3 (1.5% salt)	Diet 4 (2% salt)
Fish meal	21.90	21.65	25.52	21.40
Soybean meal	21.90	21.65	25.52	21.40
Maize bran	25.60	25.35	25.23	25.10
Rice bran	25.60	25.35	25.23	25.10
Cassava flour	2.0	2.0	2.0	2.0
Salt	0	1.	1.5	2.0
Vitamins 1*	1.5	1.5	1.5	1.5
Minerals 2*	1.5	1.5	1.5	1.5
Total	100	100	100	100

1*.Vitamin premixes (as active matter g/100): A, 2000, 000 UI; D3 245, 000 UI; E, 1, 000 UI; C, 500g; B12, 3 mg; d-Pantothenic, (B6), 100 mg; pyridoxine, 100 mg

2*. Mineral premixes (as active matter g/100): Calcium hydrogen orthophosphate, 10.29; Magnesium sulphate, 50.00; Sodium chloride, 30.00; Potassium chloride, 5.00; Zinc sulphate, 2.75; Manganese sulphate, 1.27; Copper sulphate, 0.39; Cobalt sulphate, 0.24; Chromic chloride, 0.064. Premixes contained also 1.06 g Potassium and 21.2 g, Sodium salts.

Table 2: Composition of the experimental diets (Kg) fed to *Oreochromis shiranus*

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used to test significant differences among treatment means at 0.05% alpha level. Least Significant difference (LSD) test was employed to separate significantly different means.

Results

Fish growth

There was no significant difference (P>0.05) among treatments in the first 2 weeks in terms of weight gain. From week 2 to week 10, growth was significantly different (P<0.05) among treatments. Treatment 3 (1.5% salt level) and treatment 2 (1% salt level) had higher mean weight gains recording 18.69 g and 17.19 respectively while treatment 4 and treatment1 registered 15.93 g and16.32 mean weights at harvest (Figure 1 and Tables 3-5).

Survival of fish

Survival was not significantly different (P>0.05) among treatments (Table 4). Survival rate was higher in treatments 1 and 4 while treatment 3 had the lowest survival.

Discussion

Results show that higher fish growth was observed at 1% and 1.5% salt inclusion level (Table 4). Thus, consistent to a large dimension with other researchers in that significant growth can be observed when fish are fed on salty diet than salt free diet. The addition of salt to the diet of freshwater carp at a level of 1.5% resulted in significantly better growth and is in widespread use in India [3]. The final weight gain of Rohu, *Labeo rotiha* fed 0.5% and 1% NaCI –incorporated diets were significantly (P<0.005) higher than that of the control (0% NaCI) [9]. Freshwater fish, being osmotic to the surrounding medium, encounter the physiological problem of solute loss and in order to compensate this, they resort to active uptake of salt ions from the medium [5]. Therefore, it is reasonable to speculate that dietary salt satisfied the osmolegulatory requirement of *Oreochromis shiranus* as it is a freshwater fish and that supplemental salt spared energy used in osmoregulation, thereby leaving more energy for somatic growth. Smith et al. [10] reported that the dietary sodium intake of salmonids kept in fresh water increased by eightfold from winter to summer. This corresponds to the increase in feeding and shows that almost all the sodium required can be derived from dietary salt. This can therefore be used as a source of salts for fish kept in freshwater, providing ions which the fish cannot obtain from the hypotonic environment.

In addition, Asian sea bass *Lates calcirifer* reared in freshwater recirculating fed 1% NaCI diet exhibited a better feed conversion ratio and a higher (yet not significant) growth, not only that, but also enhanced the activity of brush body enzymes e.g. leucine amino peptidase and were pronounced in pyloric caeca [11]. The better enzymatic activity can be explained by the absorption mechanism of end products –glucose and amino acids. Since the glucose and most of amino acids is dependent on the Na+/K+ ATPse pump [12], a higher concentration of Na+ in the lumen might lead to a better absorption of carbohydrates and amino acids. Since the activity might be inhibited by its end products (amino acids and carbohydrates) [13], reduction of the end products concentration can lead to better enzyme activity in the lumen of fish fed feed enhanced with NaCl. Therefore, the previous work corroborates with this study in that *Oreochromis shiranus* had a better enzyme activity owing to dietary NaCl, thus registering a better growth 1% and 1.5% inclusion level.

Salt appears to affect growth rate inversely when the level of supplementation interferers with the balance of other essential dietary components. Feeding supplementary NaCI in freshwater has strongly stimulated gill Na+ -K+ - ATPse activity, which has been found to be accompanied by an increase in the number of chloride cells. This is ascribed to the need for increased gill NaCI extrusion capacity because the salty diet imposed a salt load that exceeded the normal capacity for diffusion loss across the gills and the excretion through urine [14]. The decrease in weight gain and SGR of *Oreochromis shiranus* in the present study could be at 2% could be because of excess salt level that hindered other metabolic processes responsible for growth.

However, there was slow fish growth in the first two weeks among all treatments but increased later. This might be because the fish were still in the process of being accustomed to the new feed and the environment of the experimental unit. According to Likongwe [15], and Lovell [16], there is a specific period of rapid growth in the growth curve of fish.

The experiment also indicates that fish fed on 1% NaCI and 1.5% NaCI levels had a better utilization of feed as evidenced in the lower Feed Conversion Ratio of 1.51 and 1.47 respectively (Table 4). This is an indication that feed was appropriately utilized and hence a superior growth rate. The results agrees favorably with Gangadhara et al. [9] reported that 0.5% NaCI and 1% NaCI produced better FCRs at 1.56 and 1.44 respectively and subsequently higher growth rate. Fish feeds constitute one of the most expensive components in rearing of fish, and high protein levels required for these fish are also a major source of nitrogenous products harmful to fish in closed systems. Therefore, the fact that the addition salt to the feed resulted in a better FCR is of great importance as this is an indication of good feed conversion into fresh. 2% NaCI had the highest FCR clearly showing that feed utilization was poor. Low digestibility and faster evaluation of food have been associated with high levels of NaCI in diets [17]. This in turn could affect assimilation and conversion efficiency. It is, therefore, reasonable to suggest that 2% salt level led to excessive salt loading and adversely affected feed intake, digestion and/or absorption, because of

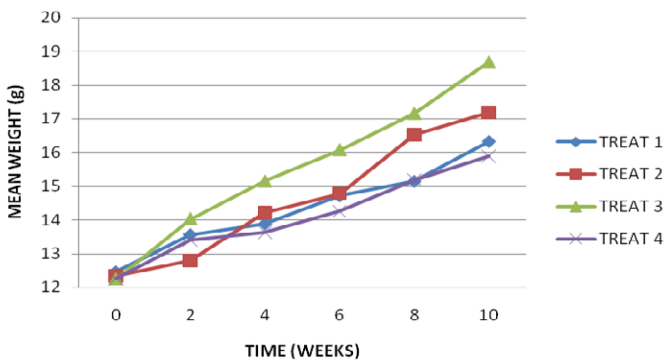

Figure 1: Growth trend in weight (g) of *Oreochromis shiranus* fed on different salt (sodium chloride) levels in the diets.

Proximate Component	Diet 1 (0% salt)	Diet 2 (1.0% salt)	Diet 3 (1.5% salt)	Diet 4 (2.0% salt)
Dry mater	92.28 ± 0.27[a]	92.22 ± 0.12[a]	92.44 ± 0.27[a]	90.48 ± 0.6[b]
Fat (%)	14.21 ± 0.05[a]	16.01 ± 0.0[b]	19.87 ± 0.06[c]	15.14 ± 0.04[a]
C P (%)	30.70 ± 0.02[a]	30.63 ± 0.12[a]	30.48 ± 0.05[a]	30.41 ± 0.02[a]
Ash	14 ± 0.04[a]	12.42 ± 0.2[b]	10 .65 ± 0.03[c]	13.70 ± 0.23[a]
Energy(kJ/g)	21.04 ± 0.2[a]	21.35 ± 0.10[a]	21.56 ± 0.23[a]	20.21 ± 0.15[b]

Means in the row with the same superscript letter are not significantly different (P>0.05).

Table 3: Proximate composition of experimental diets (Mean ± SE).

the changed gastric/intestinal environment and may even have had pathological effects on *Oreochromis shiranus* in this experiment. That is probably the reason for a depressed weight gain and SGR.

Water quality parameters were within limit throughout the experiment (Table 5). Temperature ranged from 20°C to 24°C which is within the recommended levels. Claude reported that the optimal temperature range for warm water fish is 20°C to 28°C but these are typically encountered in the natural regimes [18]. Dissolved oxygen ranged from 7.02 to 8.71 mg/L and this was within tolerable limit. Claude reported that dissolved oxygen of above 5 mg/L augurs well for the survival of fish [18]. In the present study, pH levels ranged from 7.78 to 8.21 and are considered desirable and could in no way negatively affect growth, survival and feed utilization of *Oreochromis shiranus.* According to FAO [19], the optimal PH levels are 4 to 10 of which below or above become detrimental to fish survival. NH_3 and salinity were also not significantly different (P>0.05) among treatments. However, NH_3 were sometimes slightly higher with a maximum of 0.38 mg/L (Table 4) but this did not have adverse effects on the survival of *Oreochromis shiranus*. According to Lovell, Tilapia can tolerate NH_3 levels up to 2.4 mg/L [16]. Survival was higher in diet1, 0% NaCI level (97.7%) and lowest in diet 2, 1%NaCI (94.8%). This meant that survival did not depend on sodium chloride level.

Conclusion

Different salt (NaCI) levels in a diet of *Oreochromis shiranus* exhibit different growth responses. Salt level of 1.5% (treatment 3) is optimum for incorporation in diets of *Oreochromis shiranus*. 1% inclusion level plays second fiddle. Feed utilization was better in both 1% and 1.5% salt inclusion levels with 1.54 and 1.44 FCRs respectively. At 2% SGR, FCR and weight gain diminished, thus an increase in salt level beyond a certain (optimum) level make the feed less appropriate for consumption and affect growth negatively.

Recommendation

The intensive rearing of fish in closed systems is costly due to high cost of feed like fish meal and calls for methods that will enhance food utilization and growth while generating economic returns. Utilizing a diet enhanced with 1% to 1.5% salt has an advantage on Tilapia species (*Oreochromis shiranus*), as observed from the results of the present study. It can lead to better feed utilization under intensive production conditions and can reduce the cost of feed since there is dilution of expensive component with a cheap mineral. This simple method can be used by small-scale fish farmers and does not require special means. Optimum salt content must be taken into account to prevent growth reduction owing to excess salt incorporation.

PARAMETER	Treatment 1 (0% salt)	Treatment 2 (1.0% salt)	Treatment 3 (1.5% salt)	Treatment 4 (2.0% salt)
Initial Weight(g)	12.46 ± 0.19[a]	12.34 ± 0.09[a]	12.24 ± 0.24[a]	12.26 ± 0.11[a]
Final Weight(g)	16.32 ± 0.99[a]	17.19 ± 0.19[b]	18.69 ± 0.22[c]	15.93 ± 0.19[a]
Weight gain (g)	3.86 ± 0.86[a]	4.84 ± 0.41[b]	6.45 ± 0.38[c]	3.67 ± 0.15[a]
Weight gain/day(g)	0.05 ± 0.01[a]	0.06 ± 0.01[b]	0.07 ± 0.003[c]	0.05 ± 0.003[a]
SGR (%)	0.33 ± 0.06[a]	0.41 ± 0.04[b]	0.52 ± 0.03[c]	0.32 ± 0.01[a]
FCR	1.77 ± 0.06[a]	1.51 ± 0.06[b]	1.44 ± 0.08[c]	1.87 ± 0.09[a]
Survival (%)	97.7 ± 0.5	94.8 ± 0.8	96.2 ± 0.9	95.5 ± 0.7

Means in the row sharing the same superscript letter are not significantly different (P>0.05).

Table 4: Mean initial weights, daily weight gain, Feed conversion ratio (FCR), Specific growth rate (SGR %/day) of *Oreochromis shiranus* raised on different salt (NaCI) diets in 100 L tanks: (Mean ± SE).

Parameter	Treatment 1 (0% salt)	Treatment 2 (1.0% salt)	Treatment 3 (1.5% salt)	Treatment 4 (2.0% salt)
Temperature morning afternoon	20.53 ± 0.13[a] 22.57 ± 0.11a	20.57 ± 0.12[a] 23.27 ± 0.10[a]	21.53 ± 0.13[a] 23.31 ± 0.10[a]	20.08 ± 0.13[a] 23.24 ± 0.10[a]
PH morning afternoon	8.10 ± 0.03[a] 7.96 ± 0.05[a]	7.9 ± 0.04[a] 8.09 ± 0.06[a]	8.13 ± 0.04[a] 8.09 ± 0.06[a]	8.27 ± 0.03[a] 8.17 ± 0.06[a]
Ammonia (NH_3)	0.389 ± 0.02[a]	0.227 ± 0.03[b]	0.327 ± 0.04[a]	0.343 ± 0.04[a]
Dissolved oxygen (DO)	7.87 ± 0.07[a]	8.06 ± 0.08[b]	8.23 ± 0.08[b]	7.02 ± 0.07[a]

Means in the row sharing the same superscript letter are not significantly different (P>0.05).

Table 5: Water quality parameters observed throughout the experimental period.

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