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Dietary effect of sodium chloride (NaCL) on growth and nutrient utilization of *Clarias gariepinus* fingerlings

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Abstract
This study was conducted to determine the dietary effects of sodium chloride (NaCl) on the growth and nutrient utilization of the African *Clarias gariepinus*. Four practical diets containing different levels of NaCl (T1, 0%; T2, 1%; T3, 2% and T4, 4%) were fed to *C. gariepinus* fingerlings (n= 100; mean weight, 36.7-41.5 g), at 5% body weight for 70 days. The weight gain of catfish was highest in T2 diet (89.35±14.78) and lowest in T4 diet (98.95±0.35). Catfish survival and specific growth rate, as well as feed efficiency and protein intake showed no significant differences ($p>0.05$) among the dietary treatments. Therefore, in order to make this experimental trial complete and useful to the aquaculture industry (for profit maximization and production of high quality fish), an inclusion level of 4% NaCl is recommended to improve growth and nutrient utilization in *C. gariepinus.*

1. Introduction

All forms of aquatic animals require inorganic elements, or minerals, for their normal life processes. Fishes are able to absorb some inorganic element from their diets and external environment in both fresh and sea water. Many essential elements are required in such small quantities which are difficult to formulate in the diet. The most commonly used measure of nutritional status is the level of trace elements, which is a range of tissue levels compatible with optimum growth and function. The level of mineral intake influences tissues concentration which causes a gradual decline in the function of an organ until clinical and deficiency occur.

Although most of the naturally occurring mineral elements are found in animal tissues, many of these are present because they are constituents of animal food and may not have essential function in the animal metabolism. The term essential mineral element is restricted to a mineral element which has a metabolic role in the body. Before an element can be classified as essential, it is generally considered necessary to prove that purified diets lacking the element cause deficiency symptoms in animals and that those symptoms can be eradicated or prevented by adding the element to the diets. Most research on mineral nutrition has been carried out in this way, but some of the mineral elements required by animals for normal health and growth are needed in such minute amounts that the construction of deficient diets is often difficult to achieve in such studies, but also to ensure that animals do not obtain the element under investigation from cages, troughs, attendants, or dust in the atmosphere.

The minerals, such as Na, K, and Cl have primarily electro-chemical functions, which are concerned with the maintenance of acid-base balance and osmotic control of water distribution within the body. The quantitative dietary requirements for Na, K, and Cl depend on the amounts required for growth and reproduction and that which is unavoidably lost by the animal through gut, kidney and by passive diffusion across the gills and general body surface. Freshwater fishes remain dependent on an adequate supply of minerals as there is a continuous efflux of ions from the body (Cowey and Sargent, 1979).

Diets supplemented with various levels of NaCl have been widely used in the fish farming industry, mainly for seawater adaptation. Nutritional effects of such diets are not fully understood, with different assessments resulting from the differences in diets preparation methods, salt content, nutrient balance and feeding levels. Thus the objective of this study was to determine the effects of dietary inclusion of NaCl on survival, growth performance, nutrient utilization and carcass composition of *Clarias gariepinus* fingerlings.

2. Materials and Methods

There were four duplicated treatments, each representing different inclusion level of NaCl: 0% (control), 1% (treatment 2), 2% (treatment 3), 4% (treatment 4) in diets 1, 2, 3 and 4, respectively. Four experimental diets were formulated to provide 40% crude protein. All dietary ingredients were weighed using a top balance (Meter Toledo, PB8001 London). The ingredient was then grounded to small particle size. Ingredient including vitamin/premix and sodium chloride were thoroughly mixed in a Hobart A-200T pelleting and mixing machine (Hobart LTD London, England) to obtain a homogenous mass, cassava starch was added as binder. The resulted mash was then pressed without steam through a mixer with 4.0mm die attracted to the Hobart pelleting machine. Diets were immediately sun-dried for two days to prevent molten and mucus growth. After drying, the diets were stored in the laboratory at room temperature prior to feeding.

Proximate composition (moisture, crude lipid, crude protein, crude fibre, total ash) of the diets was carried out according to AOAC (1990) methods. A total of 100 *C. gariepinus* fingerlings were stocked in circular transparent plastic containers containing 15 litres of water during a 5-day acclimation period. Ten catfish fingerlings were weighed and stocked in each plastic container. The water in containers was changed and the fish were sampled every other weeks to measure growth parameters. Water quality parameters (temperature, dissolved oxygen level and pH values) were monitored daily using a thermometer, dissolved oxygen meter and a pH meter respectively.

Table 1. *Ingredient composition of experimental diets (g/100g dry matter).*

Ingredients	**Diets**			
	T1	**T2**	**T3**	**T4**
Fish meal (65% CP)	25	25	25	25
Soya bean (42% CP)	35	35	35	35
Maize (9.5% CP)	15	14	13	11
Sodium chloride	0	1	2	4
Blood meal (85% CP)	10	10	10	10
Fish oil	6	6	6	6
Vegetable oil	4	4	4	4
Vit- mineral. Mix	3	3	3	3
Starch (Binder)	2	2	2	2

The fish were hand-fed twice daily (8:00 - 9:00am and, 5:00 - 6:00pm) according to their body weight (5% BW) for 70 days. Fish mortality (%) was monitored daily and recorded. At the end of the feeding trial, proximate composition of five experimental fish in each treatment was carried out according to AOAC (1990) methods. The mean growth rate (MGR), relative growth rate (RGR), specific growth rate (SGR), feed conversion ratio (FCR), and condition factor (K) were estimated from fortnightly measurements made using the following formulas:

Weight Gain: difference between the initial weight and final weight gain.

Mean Weight Gain=Mean Final Weight-Mean Initial Weight

Total Weight Gain= Final Average Weight-Initial Average Weight

Percentage Weight Gain (PWG): This was calculated using the formula

$$\mathrm{PWG} = \frac{\text{Total Weight Gained x 100}}{\text{Initial Weight}}$$

Daily Growth Rate (DGR): This was calculated as

$$\mathrm{DGR} = \frac{\text{Weight Gain (g)}}{\text{T (days)}}$$

Average Daily Growth Rate (ADGR): This was calculated as

$$\mathrm{ADG} = \frac{\text{Final weight} - \text{Initial weight}}{\text{No of days}}$$

Specific Growth Rate (SGR): This was calculated from the relationship of the different in the weight gain fish within the experimental period.

$$\mathrm{SGR}\ (\%) = \frac{\text{Log W2} - \text{Log W1 x 100}}{\mathrm{T}}$$

Where W2= final body weight

W1= initial body weight of fish

T = duration of study in days

Feed Conversion Ratio (FCR): From the weight gained and feed consumed by each group of fish, the feed conversion ratio (FRC) was calculated using the following expression.

$$FCR = \frac{\text{Feed intake}}{\text{Net weight gain}}$$

Protein Intake (PI): This was calculated as
PI = feed intake x % crude protein in the diet.

2.1. Statistical Analysis

All data obtained were presented as means ± SE and analysed by one way analysis of variance (ANOVA) test using the SPSS Software (2004 version, Chicago Illinois, US).

3. Results

Water temperature ranged from 25.1 to 27.0°C, dissolved oxygen ranged from 6.7 to 9.6 mg/L and pH ranged from 7.0 to 9.3 as seen in Fig 1.Fish mortality was low (< 10%) throughout the feeding trial with values of 10%, 10%, 15% and 10% for treatment 1,2,3 and 4 respectively. Table 2 shows the proximate composition of the experimental diets. Moisture composition ranged between 5.07 and 8.53 g/100g, catfish in the control treatment had the lowest value followed by Diets T4 (4% NaCl), T3 (2% NaCl) and T2 (1% NaCl). Diet T2 has the lowest ash content while Diet T4 had the highest value. Diet T1 had the highest lipid content while Diet T4 had the lowest lipid content. Diet T3 had the lowest crude protein content while Diet T4 had the highest value.

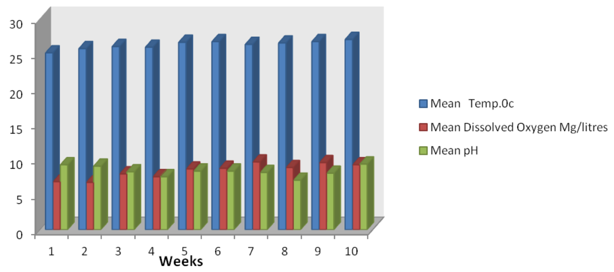

Fig 1. *Water quality parameters*

Table 2. *Proximate composition of the experimental diets (mg/100g DM)*

	T1	T2	T3	T4
Moisture	3.91	4.63	4.94	5.37
Ash	12.96	12.13	14.02	14.23
Lipid	21.43	24.69	24.59	26.27
Protein	39.95	42.04	41.24	38.9
Crude fibre	4.45	3.52	4.13	3.46

Growth performance and nutrient utilization indices of *Clarias gariepinus* fed varying inclusion levels of NaCl are shown in Table 3. There were significant differences (p<0.05) in weight over the 70 day feeding trial. Catfish fed with the control diet had a lower weight gain than catfish fed with the test diets containing NaCl. Fish fed 1% (NaCl) supplemented diet (T2) had the highest percentage weight gain while fish fed with Diet T4 had the highest specific growth rate (SGR). Feed conversion ratio (FCR) gave the highest value in catfish fed with diet T3 and the lowest value when fed with diet T4.

Table 3. *Growth performance and nutrient utilization of Clarias gariepinus fed varying dietary inclusion levels of NaCl.*

	T1	T2	T3	T4
Weight Gain (g)	79.45± 28.92^{c}	89.35±14.78^{b}	89.75±40.52^{a}	98.95±0.35^{d}
Average Daily Growth (g)	1.14 ±0.42^{a}	1.28±0.21^{a}	3.37±0.58^{a}	1.42 ±0.01^{a}
Feed Conversion Ratio	3.32 ± 0.78^{b}	3.13± 0.43^{c}	3.37±1.20^{b}	2.89± 0.13^{a}
Percentage weight gain (%)	213.21±27.05^{d}	260.13±96.39^{e}	221.00±107.48^{a}	205.58±41.71^{b}
Specific Growth Rate (%/fish)	0.71±0.06^{a}	0.72± 0.85^{a}	0.71± 0.21^{a}	0.80± 0.06^{a}
Protein Intake (g)	100.66±13.46^{b}	115.81±3.81^{b}	114.77±11.09^{b}	111.08± 5.64^{b}
Survival (%)	85.00±7.07^{a}	85.00± 7.07^{a}	100.00± 0.00^{a}	95.00± 7.07^{a}

Mean valves in each row with similar superscripts are not significantly different (p>0.05).

Table 4. *Carcass compositions (%) of Experimental Fish*

Treaments	Moisture	Crude Protein	Crude Protein	Total Ash	NFE
T1	5.07	12.96	14.95	65.05	1.99
T2	8.53	12.40	13.29	62.39	3.38
T3	5.58	13.26	12.98	61.62	6.58
T4	5.09	15.05	12.74	65.82	1.30

NFE=Nitrogen –Free Extract =100-(Crude Protein+ Crude Lipid +Total Ash)

4. Discussion

The varying inclusions levels of sodium chloride and the effects on the growth performance and nutrient utilization of *Clarias gariepinus* fingerlings were studied for 70days. The experimental diets were isonitrogenous hence they contained approximately the same crude protein level.

Lovell (1989) noted that the optimum level of protein in feed for growth of intensively cultured American channel catfish, ranged from 25% to 45%, while Balogun (1990), recommended 37.50% crude protein for *Clarias gariepinus* fingerlings. The result of the protein level used for this experiment is within the range of 38% to 42%. The protein intake of all the fish in the dietary treatments were approximately the same and shows no significant differences. This showed that sodium chloride did not have any effects on protein intake of the experimental fish.

The difference in percentage weight gain could be attributed to the different sodium chloride levels used in the experimental diets. The weight gain in Treatment 4 (with 4% of sodium chloride) was the highest among the other sodium chloride levels used within the experimental period. This was in conformity with Machiels and Henken (1987) who showed that the highest weight gains will be found when the sodium chloride content in feed is more than 4%.

According to the results presented in Table 3, the highest weight gain 98.95± 0.35(g) was recorded in Treatment 4(with 4% of Nacl) followed by treatment 3 (with 3% of Nacl). There was no significant differences ($p<0.05$) within the treatment used. This may be attributed to the high sodium chloride contents in the Treatment 4.The decrease in weight gain of treatment 1 and treatment 2 (0% and 2% of sodium chloride, respectively), could be as a result of non- acceptability of the particular diet within the period. In treatment 1 (0% NaCl), slow growth rate was recorded. This might be due to low acceptability of the treatment by the fish during the period of experiment.

Haylor (1992) deduced that specific growth rate can vary significantly when measured over successive short interval from first feeding. He also showed that specific growth rate (SGR) at lower stocking density was significantly greater than specific growth rate at high stocking density. The specific growth rate was highest in fish fed with treatment 1 and 3 i.e. (0% and with 2% Nacl).

Hogendoorn (1979) reported an increase in SGR as feeding intake increased. The qualities of the various treatments used were further substantiated by the variation in their final mean weight among various fish.

The lower feed conversion ratio in treatment 4 has significant difference in the weight gain. This may be due to increase in food consumption bringing a proportional increase in growth, however there was significant difference among the treatments ($p<0.05$).

Mean weight gains per fish was also affected by the protein levels of the diets supplied to the test fish. This is justified by the levels of significant difference that occurred within the four sodium chloride level diets. Treatment 1 and 2 have significant difference, from treatment 3 and 4 ($p<0.05$)

This experiment showed that mortality was not high throughout the experimental period, (survival was about 9%) .This result may be attributed to little or no competition for food among the fingerlings as there was enough space to move about for food. The result recorded for the nutrients utilized as shown by the feed conversion ratio(FCR) and feed efficiency (FE) indicated that treatment 2 had the highest protein intake while treatment 1(0% Nacl) had the least protein intake.

The inverse relationship occurring between the feed conversion ratio and protein levels is similar to the one reported by Jauncey (1982) for *Sarotherodon mossambicus*. Dupree and Huner (1984 the pH of the water in various experimental containers rages from 7.5-9.3, the lower limit being below the pH range of 7.8 which Huet (1972) recommended as the best for fish cultivation. Chakroff (1976) gave a range of 6.5- 900 as the best pH for fish growth.

4.1. Carcass Composition of the Experimental Fish

The moisture composition ranged between 5.07 and 8.53, the control has the lowest value of (5.07) followed by T4 (4% of salt), 5.09, T3 (2% salt), 5.58, and T2 (1% of NaCl) has the highest value of 8.53%. Salt as a hygroscopic substance might have caused the increase in the moisture content of the samples. Sample T2 has the lowest ash content of 12.40% and T4 has the highest value of (15.05). The increase in the ash content value might be due to the addition of salt in the diets which was assimilated and deposited in fish tissue. The control has the highest lipid content which may suggest the fact that the addition of salt might have reduced the lipid content of the rest samples other than the control. i.e the more the addition of salt the lower the lipid content of the fish sample. Treatment T3 had the lowest protein content of 61.62% and treatment T4 had the highest of 65.82%. Sodium chloride must have reduced the values but the value increased with additional salt in the diet.

5. Conclusion

This study shows that *C. gariepinus* increased in weight gain and feed efficiency as the dietary level of NaCl increased. Therefore, good management and 4% inclusion level of NaCl is beneficial in order to achieve good growth in the culture of *C. gariepinus*.

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