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SHORT COMMUNICATION KISA BİLGİLENDİRME

GROWTH AND ECONOMIC PERFORMANCE OF *Clarias gariepinus* FED DIFFERENT SOURCES OF CALCIUM AND PHOSPHORUS DIETS

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Abstract: One hundred and fifty juveniles of *Clarias gariepinus* of mean weight 53 g were stocked randomly at seven fish per tank (52.5 X 33.5 X 21 cm^3) in triplicate. Seven experimental diets were formulated with varied inclusion levels of calcium and phosphorus sources; Diet 1 (1 % DCP and 1% Egg shell), Diet 2 (2% DCP), Diet 3 (2% Egg shell), Diet 4 (1% Bone meal and 1% Oyster shell), Diet 5 (1% Egg shell and 1% Bone meal), Diet 6 (0.5% Egg shell, 1% Bone meal and 0.5% Oyster shell) and Diet 7 had no extra calcium or phosphorus source. The mean weight gain, MWG and specific growth rate, SGR of the result showed significant difference ($P < 0.05$) across the test treatments. Diet 2 showed the highest MWG and SGR (63.5 g and 2.13 %/day respectively), it also showed highest value for protein intake (23.09) while Diet 4 had the best values for protein efficiency ratio (3.01) and feed conversion ratio (0.96). Diet 2 (2% DCP) recorded remarkable significant different ($p < 0.05$) values for the net profit value, investment cost analysis and gross profit for the tested economic indices compared to other diets. Therefore, results from the study suggest 2% inclusion level of DCP as optimum requirement for the growth of *C. gariepinus*.

Keywords: Mineral utilization, Dicalcium phosphate, Diet, *C. gariepinus*

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Özet:

Farkli Kaynaklı Kalsiyum ve Fosfor Diyetleriyle Beslenen *Clarias gariepinus'* un Büyüme ve Ekonomik Performansı

Ortalama ağırlığı 53 g olan 150 genç *Clarias gariepinus* rastgele olarak üç tekrarlı ve her tankta (52.5 X 33.5 X 21 cm^3) 7 balık olacak şekilde stoklandı. Yedi deneysel diyet kalsiyum ve fosfor kaynaklarının değişik içerikli seviyeleriyle formüle edildi. Bunlar; Diyet 1 (% 1 dikalsiyumfosfat ve % 1 yumurta kabuğu), Diyet 2 (% 2 dikalsiyumfosfat), Diyet 3 (% 2 yumurta kabuğu), Diyet 4 (% 1 kemik unu ve % 1 istiridye kabuğu), Diyet 5 (% 1 yumurta kabuğu ve % 1 kemik unu), Diyet 6 (% 0.5 yumurta kabuğu, % 1 kemik unu ve % 0.5 istiridye kabuğu) ve Diyet 7 herhangi bir kalsiyum yada fosfor kaynağına sahip olmayan diyetlerden oluşmaktadır. Ortalama ağırlık artışı (OAA) ve spesifik büyüme oranı (SBO) sonuçları test deneyleri karşısında belirli bir farklılık ($p<0.05$) gösterdi. Diyet 2 en yüksek OAA ve SBO gösterdi (63.5 ve %2.13 /gün sırasıyla). Diğer yandan Diyet 4 en iyi protein yeterlilik oranı (3.01) ve yem dönüşüm oranına (0.96) sahipken Diyet 2 ayrıca protein alımı için en yüksek değeri (23.09) gösterdi. Diyet 2 (% 2 dikalsiyumfosfat) diğer diyetlerle karşılaştırılarak test edilen ekonomik endeksler içinde net kar değeri, yatırım maliyet analizi ve brüt kar için dikkat çekici belirli farklılık ($p<0.05$) kaydedilmiştir. Bu nedenle, çalışmadan elde edilen sonuçlar *C. gariepinus*' un büyümesi için optimum ihtiyaç duyulan miktar olarak dikalsiyumfosfat' ın % 2 civarlarındaki seviyesi önerilmektedir.

Anahtar Kelimeler: Mineral kullanımı, Dikalsiyum fosfat, Diyet, *C. gariepinus*

Introduction

Nutrition is the process by which organisms obtain food and use it for metabolic processes, growth and repair of worn out tissues. It is highly important in aquaculture as it carries about 60-70% of the total cost of production (Ayinla and Ajayi, 1996). Fish needs feeds to grow, irrespective of the good health, quality or condition of their environment and if this is not adequately supplied, a malnourish condition may occur (Fagbenro, 1987).

Mineral elements are inorganic substances, present in animal body including fish and are necessary for the maintenance of certain physico-chemical processes in the tissues and fluids. They may be broadly classified as macro elements which include calcium, phosphorus, sodium and chloride while the micro elements include iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, fluoride, chromium, selenium and sulfur (Soetan et al., 2010).

According to Nwanna et al. (2009) Calcium and Phosphorus make up 70% of the total mineral elements in the body and are essential for the formation of bone, energy transfer through adenosine triphosphate (ATP) and an essential component of buffer systems in the blood. McDowell (1992) noted that Phosphorus is involved in the control of appetite, weight and feed efficiency while Waldroup, (1999) asserted that inadequate supply of Phosphorus may lead to severe consequences in terms of reduced performance, excessive mortality, and reduction in carcass quality. Dietary calcium plays a pivotal role in the regulation of energy metabolism and fish rely entirely on calcium present in water during dietary calcium deprivation (Ichii and Mugiya, 1983).

There are various sources of calcium and phosphorus among which are bone meal, egg shell, dicalcium phosphate (DCP) and oyster shell. These sources have different proportion of calcium and phosphorus; some are rich in calcium while others are rich in phosphorus. The objectives of this study are to investigate the response of *C. gariepinus* to different sources of calcium and phosphorus in terms of growth, nutrient utilization and cost implication of utilizing any of these sources.

Materials and Methods

Experimental design

The experiment was a complete randomized design with seven experimental diets in triplicates for a period of nine weeks, at the Fish Nutrition Unit of the Department of Marine Sciences, Faculty of Science, and University of Lagos, Nigeria.

Experimental feed preparation

Egg shell was collected from the food sellers and other ingredients which include indomie waste, fish meal, soy beans meal, dicalciumphosphate, salt, red oil, vitamin premix, groundnut cake, oyster shell, bone meal were bought from Shoreman Agro Product, Ikotun Lagos, Nigeria.

Egg shell was sun-dried for 4 days, crushed and milled into very fine powder. Other ingredients; oyster shell, bone meal, groundnut cake and soy bean meal were ground separately to 1mm size with hammer mill and stored till when needed. The proximate compositions of feed ingredients were determined at the Department of Animal Science, Faculty of Agriculture, University of Ibadan, Nigeria according to the Association of Analytical Chemists Method (AOAC, 2004) (Table 1).

Feed formulation

Seven isonitrogenous and isocalorific experimental diets were formulated using different sources of calcium and phosphorous sources. Diet 1 (1 % DCP and 1 % Egg shell), Diet 2 (2 % DCP), Diet 3 (2 % Egg shell), Diet 4 (1 % Bone meal and 1 % Oyster shell), Diet 5 (1 % Egg shell and 1 % Bone meal), Diet 6 (0.5 % Egg shell, 1 % Bone meal and 0.5 % Oyster shell) and Diet 7 (control diet) had no extra calcium or phosphorus source (Table 2).

Experimental fish

One hundred and fifty (150) juveniles of African catfish, *Clarias gariepinus* were bought from Fuard Farms at Cele, Ikotun-Egbe, Lagos and transported in aerated aquaria. The fish were acclimatized for a period of 2 weeks, during which they were fed with 2mm coppens feed from Holland. Twenty-one plastic tanks, of dimension 52.5 x 33.5 x 21cm^3, with seven (7) fish (average weight 53g) stocked per tank and each treatment run in triplicate. Tanks were covered with nylon net of mesh size 3mm to prevent fish from jumping out of the tanks.

Feeding trials

Fish were fed to satiation by hand thrice daily; the feeding time was divided into three 08:00, 12:00 and 16:00 hours every day. Fish were weighed on weekly basis, water in the tanks were changed every two (2) days and replaced with dechlorinated water from a borehole to maintain good water quality. Fish were monitored daily for mortality, physical and behavioral changes throughout the experimental period.

Growth performance and Nutrient Utilization

Growth and nutrient utilization were estimated in terms of Mean weight gain, Specific growth rate, Feed conversion ratio and Protein efficiency ratio following Kaur and Saxena (2004).

Table 1. Calcium and phosphorus levels in feed ingredients

Feed ingredients	Calcium (%)	Phosphorus (%)
Bone meal	24	1
Dicalcium phosphate	24	18
Oyster shell	51	0.09
Egg shell	35	0.12

Table 2. Feed composition of experimental diets (% dm)

Ingredient	Diet1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7
Fish meal	25	25	25	25	25	25	25
GNC	15	15	15	15	15	15	15
SBM	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Indomie waste	42	42	42	42	42	42	44
Premix	1	1	1	1	1	1	1
Oil	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Salt	0.3	0.3	0.3	0.3	0.3	0.3	0.3
DCP	1	2	-	-	-	-	-
Egg shell	1	-	2	-	1	0.5	-
Bone meal	-	-	-	1	1	1	--
Oyster shell	-	-	-	1	-	0.5	-

KEY: GNC: Groundnut Cake, SBM: Soy beans Meal, DCP: Dicalcium Phosphate

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Growth performance and Nutrient Utilization

Growth and nutrient utilization were estimated in terms of Mean weight gain, Specific growth rate, Feed conversion ratio and Protein efficiency ratio following Kaur and Saxena (2004).

(1) Mean Weight Gain (MWG)

$$\text{MWG (g)} = \frac{\text{Average weight gain}}{\text{Number of days}}$$

(2) Specific Growth Rate (SGR)

$$\text{SGR} = \frac{(\text{Log}_e W_1 - \text{Log}_e W_2)}{T_2 - T_1} \times 100$$

Where e = natural logarithm

$T_2 - T_1$ = Experimental Period

W_1 = Initial Weight

W_2 = Final Weight

(3) Feed Conversion Ratio (FCR)

$$\text{FCR} = \frac{\text{Feed intake (g)}}{\text{Weight gain (g)}}$$

(4) Protein Efficiency Ratio (PER)

$$\text{PER} = \frac{\text{Mean weight (g)}}{\text{Protein intake (g)}}$$

$$\text{Protein Intake (g)} = \frac{\text{Total feed intake}}{\text{Protein content of feed}}$$

Economy of feed production and rearing of fish

The cost was based on current prices of feed ingredients in the experimental locality (Nigeria) at the time of the experiment. The economic evaluations of the diets were calculated from the following methods (New, 1989; Aderolu and Oyedokun, 2008).

(1) Profit Index (PI)

$$\text{PI} = \frac{\text{Value of fish}}{\text{Cost of feeding}}$$

(2) NPV = Mean Weight Gain x Total number of fish (n) x cost per kg of fish

(3) Investment Cost Analysis = Cost of feeding ($) + Cost of Juveniles stocked ($)

(4) Gross Profit (GP)

GP = Net Profit Value (NPV) – Investment Cost Analysis

Statistical analysis

All data collected were subjected to analysis of variance (ANOVA). Comparisons among means were carried out using Duncan Multiple Range test (Duncan, 1955) at significance level of 0.05.

Results and Discussion

The final weights of fish were not significantly different ($p > 0.05$) among fish fed treated Diets and the control group except, fish fed with Diet 2 which recorded the highest weight gain while fish fed Diet 3 recorded the least weight gain (Table 3).

Similarly, significant difference ($p < 0.05$) was recorded with Diet 2 in the values of Mean feed intake (MFI), Mean weight gain (MWG) and Specific growth rate (SGR) compared to other experimental diets. However, the best performance in Feed conversion ratio (FCR) and Protein efficiency ratio (RER) was recorded in fish fed Diet 4 followed by Diet 2 while the least performance was recorded with fish fed Diet 3. Though there was significant difference ($p < 0.05$) in the value of Protein intake (PI) across treatments, Diet 2 had the highest value while the least value was recorded in fish fed Diet 3 (Table 3).

Fish fed Diet 2 (2% DCP) recorded remarkable significant different ($p < 0.05$) values for the Net profit value, Investment cost analysis and Gross profit for the tested economic indices compared to other experimental Diets. Conversely, no significant difference ($p > 0.05$) was recorded in the value of Profit index (Pin) across treatments with the exception of Diets 1, 4 and 5 (Table 4).

Table 3. Growth performance and nutrient utilization of *Clarias gariepinus* fed different sources of calcium and phosphorus

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7
Initial Weight (g fish^{-1})	19.67^{a}	20.67^{a}	19.40^{a}	19.33^{a}	19.57^{a}	19.23^{a}	20.00^{a}
Final weight (g fish^{-1})	62.03^{b}	85.17^{a}	49.67^{b}	65.00^{b}	59.50^{b}	65.47^{b}	65.33^{b}
Mean feed intake (g)	51.74^{b}	65.96^{a}	39.41^{c}	44.55^{bc}	51.37^{b}	50.703^{b}	47.63^{bc}
Mean weight gain (g fish^{-1})	42.37^{bc}	63.50^{a}	30.67^{c}	46.67^{b}	40.83^{bc}	46.80^{b}	45.33^{b}
Specific growth rate (%day^{-1})	1.75^{bc}	2.13^{a}	1.46^{c}	1.96^{ab}	1.80^{abc}	1.95^{ab}	1.83^{ab}
Feed conversion ratio	1.26^{ab}	1.04^{ab}	1.38^{a}	0.96^{b}	1.27^{ab}	1.09^{ab}	1.06^{ab}
Protein intake	18.11^{b}	23.09^{a}	13.79^{c}	15.59^{bc}	17.98^{b}	17.75^{b}	16.67^{bc}
Protein efficiency ratio	2.30^{b}	2.76^{ab}	2.18^{b}	3.01^{a}	2.27^{b}	2.65^{ab}	2.72^{ab}

Figures in each row with different superscript are significantly different ($P < 0.05$) from each other.

Table 4. Economic parameters of *C. gariepinus* fed different sources of calcium and phosphorus

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7
Profit index	0.05^{b}	0.06^{ab}	0.06^{ab}	0.063^{a}	0.05^{b}	0.06^{ab}	0.06^{ab}
Net profit value	12353^{b}	20947^{a}	7417^{c}	10766^{bc}	11378^{bc}	12333^{b}	11576^{bc}
Investment cost analysis	506.00^{b}	647.49^{a}	386.38^{c}	440.35^{bc}	501.54^{b}	497.73^{b}	469.09^{bc}
Gross profit	11847^{b}	20300^{a}	7030^{c}	10326^{bc}	10877^{bc}	11836^{b}	11107^{bc}

Figures in each row with different superscript are significantly different ($P < 0.05$) from each other.

The utilization of DCP (2%) corresponded to the highest weight gain and protein feed intake, while the sole use of eggshell at 2% resulted in significant reduction in weight gain and nutrient utilization. Increased phosphorus inclusion in fish diet by 1% have been found to have positive correlation with increased feed intake and invariably growth when the phosphorus in the diet is below the nutritional demand of the fish (Roy and Lall, 2003). Phosphorus is a growth promoter when supplied at optimal concentration in animal feeds and this could probably account for the better result obtained with Diet 2. This result was corroborated by Coloso et al. (2003) who stated that increase in the concentration of available dietary phosphorus from 0.24 to 0.88 % modestly enhanced the growth of rainbow trout. Dietary requirement of phosphorus in channel catfish is less than 10 g/kg (Eya and lovell, 1997), while Mgbenka and Ugwu (2005) reported that the requirement of hybrid African catfish (*Clarias gariepinus* x *Heterobranchus bidorsalis*) is about 10 g P kg-1 diet but the problem of actual amount of phosphorus availability for the fish physiological demand can be a factor in the utilization index of this mineral.

According to Nakamura (1982), mineral deficiency signs often arise from a dietary imbalance of calcium and phosphorus due to the antagonistic effect of excess dietary calcium on the absorption of phosphorus. This may be responsible for the least weight gain observed in Diet 3 (2% Egg shell) which has a very low amount of phosphorus (0.12%) compared to calcium (35%). Equally, Andrew *et al*. (1973) and Cowey and Sargent (1979), also reported that when there is an excess of calcium in comparison with phosphorus, the latter is not absorbed by the intestine because it is combined with the calcium to form calcium phosphate that is biologically unavailable. Calcium-phosphate-phytate complexes also bind directly to starches (Thomson, 1988), inhibit alpha-amylase action (Deshpande and Cheryan, 1984) thereby lowering starch solubility and digestibility (Knuckles and Betschart, 1987).

Furthermore, the insignificant mean weight gain, specific growth rate and elevated feed conversion ratio of the fish fed with the diet low in phosphorus but high in calcium is in consonance with the report of Gatlin and Phillips (1989) who reported that dietary deficiency of phosphorus caused reduced growth and body content of calcium and phosphorus of Channel catfish. The result also agreed with Chavez- Sanchez et al. (2000) who reported that American cichlid (*Cichlasoma urophthalmus*) exhibited reduced growth and high conversion ratio when fed with diet deficient in phosphorus. Though there was marginal similarity in the profit index across treatments however, Diet 2 recorded the highest values for the net profit value, investment cost analysis and gross profit.

Conclusions

Consequently, Dicalcium phosphate which recorded optimal performance in growth rate, nutrient utilization and economic parameters is hereby recommended at 2 % inclusion level in the diet of *C. gariepinus*.

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