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Effects of replacing fish by-product meal with poultry by-product meal on growth performance of African catfish (*Clarias gariepinus*, Burchell 1822) in Recirculation Aquaculture System (RAS)

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Abstract
The study was conducted in recirculation aquaculture system in 20 July 2017. RAS is the moderate system in aquaculture technology. The experiment designed by five treatments with three replicates, 75 *Clarias gariepinus* (10.05gm) in 150 L/tank. Five experimental diets were formulated (37.36 % C.P.) depended on replacements of fish by-product meal with poultry by-product meal as T_1 (0.0) %, T_2 (25%), T_3 (50%), T_4 (75%) and T_5 (100%). Results showed fish fed diet T_1 attained highest weight (371.18± 7.30), weight gain (361.11± 7.21) and RGR (97.28± 0.03%). Next in performance was diet T_5; T_3 and T_2 respectively. While the lowest growth were attained by fish fed T_4 ($p<0.05$). The best FCR was in T_1 ($p<0.05$), while diets T_4 showed the poorest performance. The survival rate showed no significant different ($p>0.05$). Body composition resulted highly significant differences ($p<0.05$). Water quality resulted no significant ($p>0.05$) between T_1 and T_5. It is concluded that complete replacement of fish by-product meal with poultry by-product meal in diets of *Clarias gariepinus* it's affectless.

Keywords: RAS, growth performance, *Clarias gariepinus*, poultry by-product

1. Introduction
Fish and fish products play a vital role in human nutrition, fighting hunger and malnutrition. Fish is acting as the goodies quality source of animal protein; healthy fats and minerals. In addition to main sources of protein in animal food includes fish. In fish feed formulation, fish meal in most important feed ingredient [1]. The fish feed price depend on the amount of fish meal in the formulae. The commercial fishmeal is high value and rich in protein content, while the local fish by-product meal is low nutritional value. The high price of commercial one and the low nutritional value of the later, encourage the nutritional specialist for further research into alternative cheaper protein sources and cost efficiency and effectively feed formulation for fish culture [2]. As alternative source some efforts have been done on partial or total replacement of commercial fish meal in ration with other cheaper ingredients of animal and plant origins [3, 4, 5, 6, 1]. A huge potential animal protein source is considerable amount of poultry by-products meal, as raw or rendering process is the most available animal protein used with success in fish feeds [7, 8, 9, 10]. The present study was aimed to evaluate the optimum growth performance and response of African catfish *Clarias gariepinus* fed gradually replacement of fish meal with poultry by-product meal in semi closed recirculation aquaculture systems (RAS).

2. Materials and Methods
2.1 Experimental system layout
The present study was conducted in private farm with basic important facilities in Sundus Agricultural Project, Khartoum State. A closed Recirculation Aquaculture System (RAS) were constructed with production unit (15 plastic tanks, 200 L vol); water treatment unites, (Sand and bio-filter) and 2000 L reservoir tank.

2.2 Experimental diets
Five experimental diets were formulated depend on replacement of fish by-product meal

(Crude protein 41.31%, oil 15.4%, fiber 0.9%, moisture 4.4% and Ash 26.4%) as main sources of protein with poultry by-product meal (Crude protein 52 %, oil 25.3%, fiber 1.2%, moisture 3.6% and Ash 8.4%) as alternative protein source. Diet T_1(0%), T_2(25%), T_3(50%), T_4(75) and T_5(100%) contains poultry by-product meal in replacement of fish by-product meal respectively. For preparing the diets, dry ingredients were ground to a small particle size (approximately 250 µm) in fine grinder. Diet were passed through pelletize machine with 1.5 – 2.5 mm diameter pellet, which were dried under shadow area for about 8 – 10 h. The approximate compositions of ingredients chemical compositions of each of the diets are given in (Table 1).

2.3 Experimental fish management

C. gariepinus with average weight of (10.5 g) were collected from private hatchery and randomly distributed in culture tanks at 75 fish per tank, each treatment was in triplicates group of fish, the fish were acclimated to the experiment conditions and their respective diets for one week prior to the start of the feeding trial. The fish were fed with their experimented diets at (7 – 5 – 3 %) body weight twice daily. Fish weights were measured every 10 days and the quantity of feed adjusted based on the changes in body weight of fish. Five growth parameters includes feed conversion ratio, daily growth rate (DGR,) relative growth rate, protein efficiency ratio and survival rate were measured according to Hagar (2017) [1].

2.4 Water quality management

During 140 days from feeding trial, the water-quality parameters were regularly monitored in culture tanks and treatment line (before and after filtering).Temperature, dissolved oxygen, ammonia, nitrite and nitrate were daily measured. Salinity, pH, alkalinity, total hardness and total suspended solid were measured biweekly used digital equipment's.

2.5 Statistical Analysis

All collected data were subjected to Analysis of variance (ANOVA). Duncan's multiple range tests were used to test for differences among treatment [11] at ($p > 0.05$). The statistical test were carried out on OPSTAT (Statistical Package for Agricultural Research Workers)

3. Results and Discussion

Results obtained in this study were shown in tables below. Table (1) gives the ingredient and approximate chemical composition (%) of experimental tested diets.

Table 1: Ingredients and chemical composition of experimental tested diets.

Ingredients	**Experimental diets**				
	T_1 (0%)	**T_2 (25%)**	**T_3 (50%)**	**T_4 (75%)**	**T_5 (100%)**
Poultry by-product meal	0.00	12.37	24.73	36.86	49.03
Fish by-product meal	48.99	36.62	24.72	12.29	0.00
Wheat bran	22.88	23.00	22.82	23.00	23.30
Sorghum	13.09	13.10	13.00	13.00	12.82
Ground nut cake	14.17	14.06	13.88	14.00	14.00
Wheat flour	0.52	0.50	0.50	0.50	0.50
Plant oil	0.25	0.25	0.25	0.25	0.25
Vitamin-mineral premix	0.10	0.10	0.10	0.10	0.10
Proximate composition of tested diet					
Dry matter	92.11	93.75	93.58	92.79	93.97
Crude protein	37.07	37.75	37.88	37.11	37.00
Crude lipid	9.80	12.91	13.00	13.71	16.98
Crude fiber	2.81	5.02	4.97	3.77	7.39
Ash	9.89	12.12	11.90	10.87	13.02
NFE(Nitrogen free extract)	40.43	32.20	32.25	34.54	25.61
Metabolic Energy (Kcal)	3,136	3,355	3,571	3,729	3,966

Table (2) shows the means of growth performance evaluation indices of *C. gariepinus* fed on the test diets containing different protein source, all the parameters except initial weight showed significant differences between the treatments ($p<0.05$). The performance of fish in treatment (T_1) and (T_5) as the major and alternative sources of protein clearly shows highest level as regards DWG (2.58 ± 0.05 and 2.47 ± 0.02 g/d), PER (9.74 ± 0.19 and 9.36 ± 0.09) as compeer with fish in treatments (T_2 and T_3) with DWG (2.23 ± 0.06 and 2.35 ± 0.06 g/d), PER (8.27 ± 0.23 and 8.69 ± 0.21), while fish in treatment (T_4) resulted lower level specifically in DWG (2.01 ± 0.04/d). From previous result fish fed with diets containing fish meal performed best considering the final weight, daily weight gain and feed conversion ratio, this was closely followed by *C. gariepinus* fed with poultry by-product meal, in the same result the chemical analysis of body composition or fish carcass analysis of fish feed containing fish meal and that of poultry meal based diets had a very comparative performance. Similar results obtained by Otubusin *et al*. (2007) [12] when the feed containing (25%) poultry by-product meal replacing of fish meal fed to catfish obtaining significant result in growth performance with additional of some requirement of amino acid adding to the replacement feed while the feed contains fish meal is uniquely rich in most essential amino acid, so there no significant differences ($p>0.05$) between feed intake and feed conversion ratio of the two experimental diets (T_1 and T_5). From the cost effectiveness view considering the cost of protein in ingredient is the most determine factors for diets cost, so the total replacement of fish meal protein with poultry by-product meal protein resulting low cost feed price [7].

Table 2: Growth performance of *C. gariepinus* fed formulated diets T_1, T_2, T_3, T_4 and T_5 (means ± SD)

Variable	T_1	T_2	T_3	T_4	T_5
Initial wt0 (g)	$10.07^a \pm 0.09$	$10.03^a \pm 0.11$	$10.05^a \pm 0.17$	$10.11^a \pm 0.06$	$10.05^a \pm 0.03$
Final wt1 (g)	$371.18^d \pm 7.30$	$322.23^b \pm 8.67$	$339.22^{bc} \pm 7.71$	$291.27^a \pm 5.00$	$356.58^{cd} \pm 3.52$
Weight gain	$361.11^d \pm 7.21$	$312.19^b \pm 8.57$	$329.17^{bc} \pm 7.78$	$281.15^a \pm 5.05$	$346.53^{cd} \pm 3.45$
Feed intake	$866.12^a \pm 21.16$	$871.01^a \pm 41.99$	$1006.35^b \pm 25.81$	$1030.02^b \pm 43.45$	$1473.95^c \pm 21.92$
DGR (g/day)	$2.58^d \pm 0.05$	$2.23^b \pm 0.06$	$2.35^{bc} \pm 0.06$	$2.01^a \pm 0.04$	$2.47^{cd} \pm 0.02$
RGR (%)	$97.28^d \pm 0.03$	$96.88^b \pm 0.05$	$97.03^{bc} \pm 0.10$	$96.52^a \pm 0.08$	$97.18^{cd} \pm 0.01$
FCR	$2.40^a \pm 0.04$	$2.79^b \pm 0.06$	$3.06^c \pm 0.04$	$3.66^d \pm 0.09$	$4.25^e \pm 0.03$
PER	$9.74^c \pm 0.19$	$8.27^b \pm 0.23$	$8.69^b \pm 0.21$	$7.58^a \pm 0.14$	$9.36^c \pm 0.09$
Survival rate	$76.89^a \pm 4.64$	$80.44^a \pm 1.94$	$82.22^a \pm 4.38$	$78.22^a \pm 6.99$	$87.11^a \pm 3.11$

Means with similar superscripts in a row are statistically insignificantly different ($p > 0.05$); those with different superscripts are statistically significantly different ($p < 0.05$).

The result of the whole carcass or body composition (% wet body weight) of *C. gariepinus* at the end of the experimental period is presented in Table (3) according to NRC (1993) [13] and AOAC. (1995) [14]. The analysis of variance showed highly significant differences ($p < 0.05$) between the five feeds in moisture, crude protein, crude fats and ash content. The low fat to protein ratio and the level of colorific value indicated high digestibility of *C. gariepinus* meat.

Table 3: The gross chemical compositions of C. gariepinus wild seeds fed different diets. (Mean ± SE)

Variables	T_1	T_2	T_3	T_4	T_5
Moisture	$78.37^d \pm 0.88$	$77.27^a \pm 0.33$	$78.13^c \pm 0.12$	$77.90^b \pm 0.04$	$78.44^d \pm 0.07$
Crude protein	$19.21^a \pm 0.01$	$20.31^e \pm 0.01$	$20.18^d \pm 0.00$	$19.92^b \pm 0.01$	$20.08^c \pm 0.04$
Crude fats	$4.92^a \pm 0.00$	$4.91^a \pm 0.02$	$5.08^b \pm 0.01$	$5.44^c \pm 0.01$	$5.78^d \pm 0.01$
Ash	$2.68^b \pm 0.01$	$2.13^a \pm 0.001$	$3.37^c \pm 0.21$	$2.78^b \pm 0.01$	$2.92^b \pm 0.02$
Fat : Protein	0.260 : 1	0.242 : 1	0.252 : 1	0.273 : 1	0.290 : 1
Colorific value	125.501	129.916	130.998	133.352	137.238

Means with similar superscripts in a row are statistically insignificantly different ($p > 0.05$); those with different superscripts are statistically significantly different ($p < 0.05$).

It's apparent from table (4) the water quality parameters measured during experiment shows many statistical variations before and after treatment, Dissolved oxygen, Total Hardness and Total Suspended Solid were significant lower in production tanks than in bio-filter unite ($p < 0.05$), while there temperature, pH and salinity were no significant differences among three level during time interval. Concentrations of Ammonia, Nitrate, Nitrite and Total Alkalinity in the bio-filter were significantly higher than that in both production and water treatment tanks ($p < 0.05$).

Table 4: Values of water quality parameters calculated before, during and after treatment in the RAS. (Mean ± SE)

Variables	Production Tanks	Bio-filter	Water treatment tank
Temperature (C0)	$30.74^a \pm 0.63$	$28.25^b \pm 0.56$	$29.87^a \pm 0.51$
Oxygen (mg/l)	$4.78^a \pm 0.31$	$2.56^b \pm 0.25$	$4.26^a \pm 0.31$
PH	$7.26^a \pm 0.18$	$7.43^a \pm 0.20$	$7.20^a \pm 0.18$
Salinity (ppt)	$4.22^a \pm 0.15$	$4.26^a \pm 0.17$	$4.57^a \pm 0.15$
Ammonia (ppm)	$0.09^a \pm 0.02$	$0.52^b \pm 0.09$	$0.08^a \pm 0.01$
Nitrate (ppm)	$0.07^a \pm 0.02$	$0.47^b \pm 0.08$	$0.08^a \pm 0.01$
Nitrite (ppm)	$0.06^a \pm 0.01$	$0.48^b \pm 0.07$	$0.06^a \pm 0.01$
Total Alkalinity (ppm)	$189.90^a \pm 7.82$	$215.00^a \pm 10.29$	$204.30^a \pm 8.24$
Total Hardness (ppm)	$186.10^a \pm 7.62$	$197.45^a \pm 8.26$	$191.65^a \pm 8.17$
Total Suspended Solid (m/l)	$55.75^a \pm 3.95$	$65.35^a \pm 3.27$	$56.85^a \pm 3.87$

4. Conclusion
This study has shown that poultry by-product meal functionally resulted as an equally efficient and effective substitute for fish meal in feed for catfish *C. gariepinus* even in total replacement percentage (100%). The present experiment also demonstrated that filter systems in the RAS has fully maintain the same water quality throughout with no significant differences ($p > 0.05$) between before and after treatments in the RAS.

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