The effect of different diets and temperatures on growth rate, nutrient utilization and body composition of *Clarias gariepinus (Burchell 1822)*

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Abstract: Growth and nutrient utilization of *Clarias gariepinus* of initial mean weight (101.87 ± 0.9) were investigated using four diets (D1, D2, D3 and D4) of a constant protein level (36%). The diets were maintained at three different temperatures (24, 28 and 32 ℃). The four diets showed significantly higher ($p < 0.05$) growth rate at temperature 28 °C (192.42 g, 154.22g, 157.46g and 164.21g for D1, D2, D3 and D4 respectively) and temperature 32 ℃ showed the least growth performance in all experimental diets (134.62g, 111.71g, 116.93g, 126.63g for D1, D2, D3 and D4 respectively). D1-28 showed the highest ($p < 0.05$) growth (192.42g) in all diets. The daily feed intake, Daily protein intake, specific growth rate and mortality rate were not significantly ($p > 0.05$) different between all treatments. The fish composition was also not significantly ($p < 0.05$) different before and after the experiment for all diets and temperatures. Protein efficiency ratio(142.24), feed Conversion efficiency (54.96), protein retention efficiency (87.05) and the condition factor (0.7) were significantly ($p < 0.05$) higher in D1-28, followed by D4-28 (126.03, 45.48, 78.53, 0.66 respectively). Lipid retention efficiency was significantly ($p < 0.05$) greater in D4-32 (41.34) followed by D1-24 (42.95). Gonadosomatic index was significantly ($p < 0.05$) higher in D1-32 (24.56) followed by D2-32 (23.98).

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Key words: African catfish, partial replacement, optimum temperature.

1. Introduction

Fish feed is one of the most expensive items in aquaculture. Feed cost represents more than 50% of the total cost of production in intensive fish culture (Adewolu and Adoti, 2010). The shortage of fishmeal and its comparatively high cost has led to the consideration of alternative dilatory sources of protein (Bureau and Viana, 2003). There is a growing interest in using cheap and locally available stuffs in feed formulation for aquaculture (Anyanwu, 2008; Eyo, 2001;). The effect on growth rate, feed utilization and energy metabolism by dietary protein level has been studied by (Degani, et al., 1989; Michiels & Henken, 1985, 1987). Some studies concentrated on the trial of non-conventional sources of animal protein to substitute fishmeal in fish diets such as hydrolyzed feather, meat bone meal, blood meal and fish and chicken viscera (Bureau, et al., 2000; Giri, et al., 2000). Successful replacement of dietary fishmeal with sunflower, soybeans, cottonseed, groundnut and bean meals has been tried by many authors without negative effect on survival and growth of *Clarias gariepinus* (Adewumi, 2006; Fagbenro, 1998, 1999; Nyina-wamwiza, et al., 2010, 2012). Relatively few works have been done on the combined effect of temperature with partial replacement of fishmeal on growth and nutrient utilization by plant proteins. Nutrient utilization for growth and survival are usually affected by temperature, but growth and survival rates perform better at their temperature optima (McCauley and Huggins, 1979; Pedersen and Jobling, 1989).

Fishmeal is scarce in many countries like Saudi Arabia, The present study was undertaken to evaluate the partial replacement of fishmeal in the diet of *Clarias gariepinus* by locally available plant ingredients at different temperatures on growth performance production cost and nutrient utilization. So, we examined the effect of plant protein in partial replacement of fishmeal on growth parameters, mortality rate and feed cost per fish production compared to a fishmeal diet at different temperatures.

2.Materials and methods

2.1.Experimental setup

The experiment was conducted in the department of Zoology, College of Science King Saud University. A total of 36 Glass aquaria of the size (100X30X40cm) supplied with aquarium filters to clean the tanks and heaters to adjust temperature and covered with mosquito screen to prevent fish from jumping out. A total of 540 of *Clarias gariepinus* were obtained from KACST research station were used for the study. The average weight of the fish was (101.87± 0.9).The fish were acclimatized for 15 days using commercial diet of 36% protein at (22-24 °C). prior the commencement of the experiment, fish were starved for 24 hours to enable them to empties their guts.

2.2.Water quality

The physicochemical prosperities of the aquarial water were monitored regularly and renewed weekly throughout the experimental. Temperature was determined using digital thermometer (Checktem ℃) immersed in the water surface. The dissolved oxygen and PH were measured using dissolved oxygen meter (HANNA-HI9142) and Ph meter (HANNA-HI98107) respectively.

2.3.The diets

Diet ingredients comprises of fishmeal powder (ARASCO), soybean meal (ARASCO), pea meal, wheat (Local market), vegetable oil (Local market), mineral premix (ARASCO), vitamin premix (ARASCO) and feed binder (ARASCO). All diets were formulated with a fixed protein content (36%) using Pearson Squire Method according to (Jauncey and Ross, 1982). Wheat was used as a source of energy while the fishmeal, soy beans and pea meal were the protein sources. All ingredients with addition of the binder were finely ground mixed in a plastic bowel in a dough form using hot water. The mixture was then pelleted by it through a 2 mm diameter mincer to produce pellets of 2 mm diameter. These were then dried in a furnace at 65℃ to about 10% moisture content. The prepared diets together with the commercial diet were packed in plastic containers and kept safely dry for use.

2.4.Feeding Trial

Clarias gariepinus were fed twice at the rate of 3% per body weight per day with four experimental diets of 36% protein at three different temperatures (24, 28, and 32 ℃) for four months. There were triplicated twelve treatments in this study. Each treatment was fed diet-D1 as (D1-24,D1-28,D1-32 ℃), diet-D2 as(D2-24,D2-28,D2-32℃), diet-D3 as (D3-24, D3-28, D3-32℃) or diet-D4 as (D4-24,D4-28,D4-32℃).The fish were weighted at the commencement of the experiment and mean weight was calculated and recorded for each treatment. Fish were reweighted every month and feed weights were adjusted accordingly.

2.5.Chemical analysis

Fish samples were oven dried at 65 ℃ until constant weight was obtained. The proximate analysis of fish before and after experimentation, feedstuff and diets were carried out to determine the moisture content, ash, lipid, crude protein, crude fiber and nitrogen free extract procedures (A.O.A.C. (1990); Kekeocha 2001).

2.6.Fish growth and nutrient utilization

Body weight measurements were taken monthly and accordingly rations were adjusted to fish weight. Growth and nutrient utilization index were calculated according to the following formulae (AOAC, 1990; Brown,1957; Htun-han, 1978; King, 1995).

Feed intake was calculated as

Feed intake(g) = 3% body weight of fish per day

Protein intake (g) = Feed intake × Percentage protein in the diet.

Percentage gain weight = $\frac{(Y-X)\times 100}{X}$, Where:

Y= Final mean body weight (g), X= Initial mean body weight (g).

Feed conversation ratio (FCR) = $\frac{\text{Dry feed intake (g)}}{\text{Wet weight gain (g)}}$

Lipid efficiency ratio (LER) = $\frac{\text{Total live weight gain}}{\text{Total lipid fed}}$

Protein efficiency ratio (PER) = $\frac{\text{Wet weight gain (g)}}{\text{Crude protein fed}}$

Feed conversion efficiency = $\frac{\text{weight gain (g)}}{\text{Feed supplied (g)}}$

Protein retention efficiency= $\frac{\text{Weight gain}}{\textit{protein}\text{ fed}} \times 100$

Specific growth rate (SGR) = $\frac{W2 - W1}{T2 - T1} \times 100$

Where:

W_2 = final body weight, W_1 = initial body weigh, T_2= Time at the end of the experiment in days, T_1 = Time at the beginning of the experiment in days

Gonadosomatic index (GSI) = $\frac{\text{weight of the gonad}}{\text{weight of the fish}} \times 100$

The condition factor (K) = $\frac{W}{L^3}X100$, Where:

K= condition factor, W= body weight, L^3 = cubic body length

2.7.Statistical analysis

Data were subjected to two way Analysis of variance (ANOVA) as described by Sokal & Rolf (2012), using a significance level of α = 0.05, (Duncan, 1955).

3.Results

3.1.Water quality

The values of water quality of the aquaria were presented in table 1. Temperature ranged between (24.1 - 24.4 ❙), (28.1 - 28.3) and (32.0 - 32.3), dissolved oxygen ranged between (5.09 ± 0.69 - 5.76 ± 0.68), pH (6.49 ± 0.95 - 7.03 ± 0.53), ammonia (0.03 ± 0.01 - 0.10 ± 0.03), nitrite (1.63 ± 0.21 - 2.88 ± 0.25) and nitrate (2.38 ± 0.97- 4.58 ± 0.64) for all treatments.

Table 1: Water quality parameters of different feeding treatments used for *C. gariepinus* (n= 16)
D1= Fishmeal, D2= Soybean meal, D3= Pea meal, D4, Commercial diet

Parameters	D1-24 ($\bar{x}$ ±SD)	D1-28 ($\bar{x}$ ±SD)	D1-32 ($\bar{x}$ ±SD)	D2-24 ($\bar{x}$ ±SD)	D2-28 ($\bar{x}$ ±SD)	D2-32 ($\bar{x}$ ±SD)	D3-24 ($\bar{x}$ ±SD)	D3-28 ($\bar{x}$ ±SD)	D3-32 ($\bar{x}$ ±SD)	D4-24 ($\bar{x}$ ±SD)	D4-28 ($\bar{x}$ ±SD)	D4-32 ($\bar{x}$ ±SD)
Temp ℃	24.3± (0.15)	28.1± (0.08)	32.3± (0.12)	24.4± (0.34)	28.5± (0.76)	32.3± (0.83)	24.5± (.0.48)	28.2± (0.64)	32.1± (0.87)	24.4± (0.92)	28.2± (0.17)	32.3± (0.79)
Dissolved oxygen (Mg/L)	5.91 ± (0.49)	5.18 ± (0.69)	5.09 ± (0.69)	5.73 ± (0.47)	5.13 ± (0.59)	5.52± (0.75)	5.76± (0.68)	5.20± (0.77)	5.41± (1.22)	5.70± (0.59)	5.70± (1.04)	5.39± (1.07)
pH	6.49 ± (0.95)	6.80± (0.38)	7.03± (0.53)	6.98 ± (0.70)	6.93 ± (0.54)	6.96± (0.43)	6.88± (0.94)	6.85± (0.61)	6.90± (0.72)	6.98± (0.67)	6.86± (0.48)	6.73± (0.77)
Ammonia (mg/l)	0.05± (0.01)	0.03± (0.01)	0.07± (0.03)	0.04± (0.02)	0.03± (0.03)	0.06± (0.04)	0.04± (0.04)	0.03± (0.0!)	0.10± (0.03)	0.04± (0.04)	0.03± (0.05)	0.05± (0.03)
Nitrite (mg/l)	1.74± (0.12)	1.63± (0.04)	2.50± (0.10)	1.87± (0.21)	2.13± (0.06)	2.38± (0.31)	2.25± (0.14)	1.63± (0.21)	2.25± (0.09)	2.13± (0.18)	2.88± (0.25)	2.50± (0.17)
Nitrate (mg/L)	3.63± (0.12)	3.18± (0.80)	2.38± (0.97)	3.75± (0.75)	3.43± (0.83)	3.28± (0.48)	2.81± (0.36)	3.76± (0.69)	3.09± (0.87)	4.18± (0.27)	4.45± (0.95)	4.58± (0.64)

Table 2: Gross composition of dietary experimental feeds/100g, X = Unknown quantities, D1= Fishmeal, D2= Soybean meal, D3= Pea meal, D4, Commercial diet

ingredients:	Treatments			
	D1 (36%protein)	D2 (36% protein)	D3 (36%protein)	D4 (36%protein)
Fishmeal %	47.42	25.50	40.61	X
Soybean meal %	NIL	25.50	NIL	X
Pea meal %	NIL	NIL	40.61	X
Wheat %	36.71	34.45	2.94	X
Vitamin and Mineral premix %	2.98	2.71	2.97	X
Binders %	2.98	2.71	2.97	X
Fat %	9.91	9.04	9.90	X
Total %	100%	100%	100%	100%

3.2.Fish growth and nutrient utilization

Data on gross and chemical composition of the formulated diets are presented in Table 2 and 3 respectively. The growth and nutrient utilization parameters of *C. gariepinus* fed diets (D1, D2, D3 and D4) at three different temperatures (24, 28 and 32 I) are shown in Table: 4, 5 and. The initial body weight, final body weight (Figure 1) and increase in body weight of the experimental fish ranged from 101.19 -103.36g, 214.67 - 295.78g and 111.71-192.42g respectively. The increase in body weight in D2-28 (192.42g) was significantly (p<0.05) higher than other treatments (Table: 4) followed by D1-24(166.35g), D4-28(164.21g) and D2-28(154.22g) respectively. Fish mortality within 120 days of experimentation ranged between 10 -33.3 within. Daily feed intake, daily protein intake, specific growth rate (SGR) and feed conversion ratio (FCR) were not significantly (p>0.05) different. The protein efficiency ratio for D2-28 (142.24) was significantly (p<0.05) higher than the rest of the treatments followed by D1-24 (130.39), D4-28 (126.03) and D2-28 (119.21) respectively. Feed conversion efficiency% of D2-28 (54.96) was significantly (p<0.05) higher than other treatments followed by D1-24 (48.79), D4-24 and D3-28(45.48) (43.63). A significant increase (p<0.05) in protein retention efficiency % was seen in D2-28 (87.05), D1-

24 (78.62), D4-28 (78.53) and D2-28 (73.87) respectively. Lipid retention efficiency (%) was significantly (p<0.05) higher in D4-32(61.14), D1-24 (42.95), D4-28(41.34) and D1-28(42.95) respectively. Condition factor (K) in D1-28 (0.7) was significantly (p<0.05) higher than the rest of treatments followed by similar values of D2.28 (0.68) and D1-24 (0.68).

The cost of feed per kg-fish production in Saudi Riyals (SR) showed significantly (p<0.05) lower values in D2-28 (SR 6.66), D4-28 (SR 6.97), D4-24 (SR 6.97), D3-28(SR 7.77) and D3-24 (SR 8.56) respectively. The gonadosomatic index (GSI) showed higher values (p<0.05) in D 1-32 (24.56), followed by D2-32 (23.98), D1-28 (23.80) and D1-24 (21.51) respectively. The cost of kilogram production of *C. gariepinus* in (SR) was significantly (P<0.05) higher in D1-32(12.45), D3-32(11.44), D1-24 (9.7), D2-32 (9.52), and significantly (p<0.05) lower in D2-28 (6.88), D4-28 (7.33), D4-24(7.33), D2-24 (7.52) respectively.

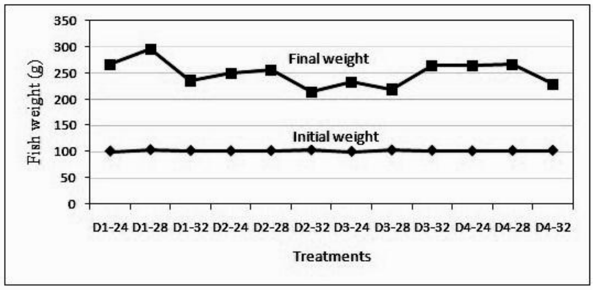

Figure1: Initial and final weight of* Clarias gariepinus *at different treatments and different temperatures
D1= Fishmeal, D2= Soybean meal, D3= Pea meal, D4, Commercial diet, g = grams

The proximate composition of *C. gariepinus* carcass at the start and end of the 120 day experimental period was shown in table 6. The results of fish proximate composition showed no difference (p<0.05) between the initial and final values for all treatments.

Table 3: Chemical composition of the formulated diets used for *C.gariepinus*, D1= Fishmeal, D2= Soybean meal, D3= Pea meal, D4, Commercial diet at different temperatures.

Parameters	Treatments			
	D1-24,28.32	D2-24,28.32	D3-24,28,32	D4-24,28.32
Moisture%	8.98	!0.91	8.31	3.50
Crude protein%	36.05	36.26	35.95	36.16
Crude fiber%	1.56	3.24	4.11	3.57
Ash %	10.59	19.81	9.95	9.69
Ether extract %	13.18	12.10	10.78	10.28
Total carbohydrates%	29.64	22.68	25.90	30.80
Calcium %	2.85	6.00	2.81	1.47
Phosphorus %	1.37	1.15	1.26	0.93
Sodium %	0.58	0.69	0.50	0.15
Manganese ppm	827.0	3925.00	738.00	102.00
Iron ppm	503.0	1187.00	416.00	224.00
vitamin D3 IU/Kg	3333.0	16427.00	2436.00	409.00
Vitamin B1 (μg /100g)	0.944	0.913	0.913	0.488
Vitamin B2 (μg /100g)	2.16	1.66	2.34	2.28
Vitamin B6 (μg /100g)	0.10	0.083	0.071	0.050
Vitamin B12 (μg/100g)	1.88	2.14	1.88	1.76

Table 4: Growth performance in* Clarias gariepinus *fed dietary levels of four diets (36% protein) at three different temperatures, D1= Fishmeal, D2= Soybean meal, D3= Pea meal, D4, Commercial diet

Parameters	Treatments											
	D1-24	D1-28	D1-32	D2-24	D2-28	D2-32	D3-24	D3-28	D3-32	D4-24	D4-28	D4-32
Initial weight (g)	100.76	103.36	101.8	101.19	101.73	102.96	100.07	102.83	102.83	101.17	101.86	102.23
First month(g)	134.55	137.17	129.75	128.65	129.41	127.36	125.85	132.16	128.69	127.69	131.39	129.66
Second Month(g)	174.08	177.92	156.26	157.66	162.23	152.51	148.46	171.96	152.49	163.45	166.95	154.91
Third Month(g)	214.92	214.60	200.95	206.29	210.70	185.42	196.64	214.60	190.13	214.90	204.57	184.66
Fourth month(g)	267.11	295.78	236.42	250.41	255.95	214.67	233.61	260.29	219.76	263.95	266.07	228.86

Table 5: Growth rate and nutrient utilization of *Clarias gariepinus* during experimentation, D1= Fishmeal, D2= Soybean meal, D3= Pea meal, D4, Commercial diet. IW=Initial weight, FW= Final weight, IBW (g)= Increase in body weight, M= Mortality %, DFI= Daily feed intake, DPI= Daily protein intake, SGR%= Specific growth rate, PER%= Protein efficiency ratio, FCR= Feed conversion ratio, FCE %= Feed conversion efficiency, PRE% = Protein retention efficiency%, LRE= Lipid retention efficiency%, Feed cost per Kg-fish production., K= Condition factor, GSI = Gonadosomatic index.. SL= Significance Level. NS= Not significant. ****= highly significant.

Treatments													
parameters	D1-24	D1-28	D1-32	D2-24	D2-28	D2-32	D3-24	D3-28	D3-32	D4-24	D4-28	D4-32	SL
IW (g)	100.76	103.36	101.8	101.19	101.73	102.96	100.07	102.83	102.83	101.17	101.86	102.23	NS
FW (g)	267.11	295.78	236.42	250.41	255.95	214.67	233.61	260.29	219.76	263.95	266.07	228.86	***
IBW(g)	166.35	192.42	134.62	149.22	154.22	111.71	133.54	157.46	116.93	162.78	164.21	126.63	***
M (%)	16.6	13.3	23.3	10	13.3	23.3	13.3	21.6	33.3	10	10	16.6	***
DFI (g)	3.10	3.24	2.94	2.96	3.02	2.77	3.11	3.12	2.86	3.03	3.02	2.90	NS
DPI (g)	1.12	1.17	1.06	1.07	1.09	1.00	1.12	1.12	1.03	1.09	1.09	1.04	NS
SGR%	0.78	0.87	0.69	0.73	0.76	0.6	0.70	0.77	0.63	0.75	0.79	0.66	NS
PER%	130.39	142.24	109.70	117.37	119.21	96.17	116.82	118.61	97.20	122.50	126.03	103.69	***
FCR	2.94	1.72	2.49	2.38	2.22	2.88	2.32	2.1	2.86	2.05	2.05	2.60	NS
FCE (%)	48.79	54.96	40.27	42.34	42.58	35.37	40.46	43.63	34.96	44.97	45.48	37.30	***
PRE (%)	78.62	87.05	65.74	70.77	73.87	57.03	66.15	71.23	56.02	77.55	78.53	62.10	***
LRE (%)	42.95	39.68	26.16	36.14	39.44	33.88	27.97	31.97	14.69	25.63	41.34	61.14	***
K	0.68	0.7	0.63	0.68	0.63	0.56	0.63	0.63	0.61	0.65	0.66	0.6	***
GSI	21.51	23.80	24.56	15.24	18.84	23.98	18.23	16.55	21.89	15.84	19.11	19.31	***

Table 6: initial and final Chemical composition of *Clarias gariepinus*, D1= Fishmeal, D2= Soybean meal, D3= Pea meal, D4, Commercial diet.

Final fish composition													
Parameters	Initial fish composition	D1-241	D1-28	D1-32	D2-24	D2-28	D2-32	D3-24	D3-28	D332	D4-24	D428	D4-32
Dry matter %	93.64	97.65	93.56	94.60	91.28	97.55	97.06	89.87	95.97	93.54	83.61	94.30	96.62
Moisture%	6.36	2.35	6.44	5.40	8.72	2.45	2.94	10.13	4.03	6.46	16.39	5.7	3.38
Crude protein%	62.36	63.34	63.4	62.1	60.32	62.48	61.15	60.24	60.72	59.4	62.47	62.46	61.6
Ether extract %	2.75	13.63	11.39	9.73	10.44	11.21	12.21	11.16	11.96	6.83	4.18	6.65	12.27
Carbohydrates (%)	3.93	6.1	5.44	6.21	4.99	9.02	7.11	5.01	6.48	6.96	3.83	6.02	4.62
Total ash %	24.6	14.58	13.35	16.57	14.53	14.85	16.09	13.47	16.83	20.36	13.14	19.18	18.15

4. Discussion

A high pressure is exerted on fishmeal as a source of protein for aquaculture. Fishmeal and fish oil are important feed ingredients in fish cultivation industry. There is an increased demand for aquafeeds while the global supply of fishmeal and fish oil is almost fixed (SEAFEEDS, 2003). Fishmeal constitute the main source of commercial diet protein for aquaculture and its high cost and availability restrictions were the main concern to fish culturists for a long time (Alegbeleye, et al., 2012). The high demand of the fishmeal increases the cost of fishmeal as well as the cost of fish production. An alternative acceptable protein resources to replace fishmeal is urgently needed for the sustainability of aquaculture feed supply. The results of the present study demonstrated that feeding the African catfish *C. gariepinus* with much cheaper and available plant protein sources such as soybean to partially replace fishmeal at 36% protein level and 28 temperature can be acceptable to the fish and significantly reduce the cost of fish production (table 4).

Growth rate, feed efficiency ratio, feed conversion efficiency, protein retention efficiency, lipid retention efficiency, condition factor and gaonadosomatic index shown in (Table 4) were significantly influenced by temperature and type of diet. Overall growth rate was always high at temperature 28 °C within any diets followed by temperature 24 °C and 32 °C respectively. The highest growth rate was shown in D1-28 (192.42g) followed by D1-24 (166.35), D4.28 (164.21), D4-24(162.78), D3-28 (157.46) and D2-28 (154.22). Within each of the four experimental diets, temperature 28°C showed the highest ($p<0.05$) growth rate followed by temperature 24 °C and 32 °C respectively. This showed that the temperature 28 °C was the optimum temperature for growth and nutrient utilization of *C. gariepinus*. Although D1 (fishmeal diet) gave the highest growth rate followed by D4 (the commercial), D3 (Pea meal diet) and D2 (soybean meal diet), but in terms of production cost per kg of *C. gariepinus*, D2-28 (Soy bean meal diet) of 36% protein level gave the lowest cost of production at temperature 28°C which may be used as a substitute of the fishmeal for *C. gariepinus* diet production. Koumi et al. (2008) gave similar results for tilapia *Sarotherodon melanotheron* when fish meal have been partially replaced by soybean meal. Fapohunda, (2012) found comparable growth with the control in using processed soybean in partial replacement of fishmeal for feeding *C. garipinus* fingerlings.

It could be concluded that the source of protein together with water temperature have a great effect on growth performance and nutrient utilization of *C. gariepinus*. The temperature of 28 °C is found to be the optimum temperature for *C. gariepinus* growth and nutrient utilization. It is proposed that further studies should be carried out to investigate the effect of partial replacement of fishmeal by plant protein source on parameters other than growth and nutrient utilization in *C. gariepinus*, when used in partial replacement of the fishmeal.

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