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Comparison of nutrients and fatty acid of wild and hatchery fingerlings of *Clarias gariepinus* fed five formulated feeds and cultured in recirculating aquaculture system

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Abstract

Wild and hatchery fingerlings of *Clarias gariepinus* were cultured in recirculated aquaculture system. They were fed five diets composed of fish meal: poultry by-product meal at a ratio of 100:0%, 75:25%, 50:50%, 25:75% and 0:100%, respectively. The gross chemical composition showed no significant differences in the flesh of wild and hatchery fingerlings in composition, except that the fat content of 25:75% diet was significantly higher ($p < 0.01$) in the wild fingerlings. The highest calorific values was shown by wild fingerlings given 25:75% diet. The lowest fat to protein ratio was obtained by fingerlings fed 75:25% diet. The 29 fatty acid obtained from the oil of *C. gariepinus* included 15 saturated fatty acids, 7 monounsaturated and 7 Polyunsaturated fatty acids.

Keywords: *Clarias gariepinus*, body composition, fatty acid, RAS

1. Introduction

Fish is an important source of nutritious animal proteins locally, regionally and worldwide. They are rich in minerals, vitamins, amino and fatty acids with high protein digestibility (Mahmoud) ^[1]. Fish oil is valuable oil, due to its high level of polyunsaturated fatty acids required by human body to maintain good health (Kolanowski and Laufenberg, ^[2]; Jabeen and Caudhry) ^[3]. Fish oils mainly fatty acids play an important role in the development and function of brain and reproductive system, immune system, preventing cardiovascular disorder, reduce risk of cancers, and treatment of inflammatory diseases (Mahmoud) ^[1]. The gross chemical composition of fish vary considerably in response to abiotic and biotic factors (Silva and Chamul,) ^[4] and cultural systems (Rahman *et al.*; Ashraf *et al.*; Anyanwu *et al.*) ^[5, 6, 7].

The culture of African catfish *C. gariepinus* is profitable due to its fast growth, high fecundity, fleshy and palatable meat, tolerance and resistance to intensive and super intensive culture and high economic value (Offem *et al.*; Hagar) ^[8, 9].

In Sudan, the chemical composition of captured *C. gariepinus* was assessed from different perspectives. It was tackled in relation to fish grading and quality (Mahmoud,; Babiker,; Karrar,; Obany *et al.*) ^[10, 11, 12, 13]; as an indicator of fish raising in treated sewage effluent (Ahmed, and Ahmed,) ^[14, 15]; in relation to changes associated with post-harvest treatment (Khalifa) ^[16] and biological contamination of the on shelf dry commodity (Ahmed *et al.*) ^[17]. With respect to aquaculture of *C. gariepinus* the growth performance was studied by Hagar, ^[9] in recirculating aquaculture system and by El Hassan, ^[18] in ponds, both ^[9, 18] studied the fatty acids as well.

Comparative studies of the flesh quality of *C. gariepinus* captured and/cultured was given attention in West Africa, reference can be made to the work of Ayinla *et al.* ^[19]; Osibona ^[20]; Olapade *et al.* ^[21]; Onyia *et al.* ^[22]; Solomon and Oluchi ^[23]; Michael and Adedayo ^[24]; Mmandu and Clement ^[25].

The objective of this study was to compare the proximate composition and fatty acid content of wild and hatchery fingerlings of *C. gariepinus* cultured in recirculating aquaculture system

(RAS), fed partial replacement of fish meal with poultry by-product meal.

Materials and Methods

Source of fish

Fingerlings of *C. gariepinus* (average weight 10.6g) from wild and hatchery sources were collected and cultured under intensive condition system. The experimental work was conducted in a private farm (18.06, 28°N and 45.63, 28°E). Fingerlings were reared in 15 plastic tank each of 100L capacity. Five treatments and 3 replicates were set up. The

experiments were conducted in a semi closed recirculated aquaculture system (RAS).

Experimental diets

Five experimental diets were formulated. The main protein source was fish meal with poultry by-product, carbohydrates, plant oil and vitamin preix substituted at a rate of 0% (T₁), 25% (T₂), 50% (T₃), 75% (T₄) and 100% (T₅), respectively. The physical composition and proximate compositions of the diet Table 1. Proximate analysis followed AOAC [26].

Table 1: Feed formulations and their proximate analysis.

Ingredient%	Physical composition				
	Diet T ₁	Diet T ₂	Diet T ₃	Diet T ₄	Diet T ₅
	0%	25%	50%	75%	100%
Poultry by-product	0.00	12.50	25.00	37.50	50.00
Fish meal	50.00	37.50	25.00	12.50	0.00
Wheat bran	22.50	22.35	22.40	26.00	25.00
Sorghum	12.00	13.00	13.50	12.15	13.75
Ground nut cake	14.45	14.00	13.25	11.00	10.00
Wheat flour	0.70	0.30	0.50	0.50	0.90
Plant oil	0.25	0.25	0.25	0.25	0.25
Vitamin premix ¹	0.10	0.10	0.10	0.10	0.10
Chemical composition					
Crude protein	37.46	37.75	37.94	37.81	37.88
Crude lipid	4.14	4.17	4.17	4.30	4.21
Crude fiber	1.77	1.78	1.95	2.39	1.99
Ash	8.74	7.90	9.95	6.68	8.98
M. energy (Kcal / g)	199.345	201.385	202.330	204.810	202.620

The gross chemical composition and fatty acids of fish:

The gross chemical composition followed AOAC [26]. The fatty acids were identified and quantified by gas chromatography with a flame ionization detector following D:\fatty acid analysis.gcm, method and attached to an integrator (Shimadzu- Japan GC 2010). For calorific value calculation followed Babiker, [11].

Calorific value (CV) Kcal/g:

$$CV = 4.1 \times \text{protein} + 9.3 \times \text{fat} + 4.1 \text{ Carbohydrate}$$

Digestibility: Fat: Protein ratio.

Statistical analysis

Data were analyzed by Microsoft excel program (version 13). Results were compared with Analysis of variance and considered significant at (p<0.05). The t-test was used to identify statistically significant differences among the means of treatment means.

Results

On wet weight basis, the results of proximate composition (Table 2) showed that *C. gariepinus* have an appreciable level of moisture content, crude protein; fats and ash contents in both wild and hatchery fingerlings sources.

Table 2: The proximate composition of wild and hatchery fingerlings of *C. gariepinus* farmed under different protein sources in RAS.

%	Treatment	Wild fingerlings	Hatchery fingerlings	t-value	p-value
Moisture	T ₁	78.38±0.09	77.72±0.55	1.171	0.307
	T ₂	77.27±0.03	78.46±0.76	1.569	0.192
	T ₃	78.13±0.01	78.23±0.35	0.294	0.783
	T ₄	77.90±0.04	79.25±0.14	9.388	0.001
	T ₅	78.44±0.07	79.24±0.95	0.839	0.449
Protein	T ₁	19.21±0.01	19.83±0.40	1.546	0.197
	T ₂	20.31±0.01	20.86±0.34	1.618	0.181
	T ₃	20.18±0.03	19.35±0.74	1.122	0.325
	T ₄	19.92±0.02	20.71±0.64	1.236	0.284
	T ₅	20.08±0.04	19.15±0.43	2.171	0.096
Fat	T ₁	4.92±0.01	4.01±0.49	1.840	0.140
	T ₂	4.91±0.01	3.66±0.42	2.961	0.042
	T ₃	5.08±0.02	5.39±0.29	1.067	0.436
	T ₄	5.44±0.01	4.86±0.10	5.663	0.005
	T ₅	5.78±0.02	5.98±0.01	24.495	1.560
Ash	T ₁	2.68±0.01	2.69±0.26	0.323	0.763
	T ₂	2.13±0.03	2.44±0.49	0.630	0.563
	T ₃	3.37±0.21	3.72±0.18	1.239	0.283
	T ₄	2.78±0.01	2.98±0.11	1.877	0.134
	T ₅	2.92±0.02	2.08±0.44	1.907	0.129

Calorific values

The results of proximate chemical composition (Table 3) showed that *C. gariepinus* have an appreciable level of calorific values. Wild and hatchery fingerlings yield fed diet T₅ recorded high level of calorific values (136.08±0.18) and (134.12±1.74) and fat to protein ratio (0.288:1) and (0.312:1) while the lowest levels were obtained by feed T₁ in both wild and hatchery fingerlings yield (124.52±0.07) and

(118.61±2.95) with significantly differences ($p < 0.05$). The order of calorific value was T₅>T₄>T₃>T₂>T₁ and ranged from 124 to 136 for wild fingerlings yield and T₅>T₄>T₃>T₂>T₁ and ranged from 118 to 134 for hatchery fingerlings yield, While the order of fat to protein ratio was T₅>T₄>T₃>T₁>T₂ and it ranged from 0.242:1 to 0.288:1 for wild fingerlings yield and T₅>T₃>T₂>T₄>T₁ and it ranged from 0.202:1 to 0.312:1.

Table 3: The Calorific value and fat to protein ratio of wild and hatchery fingerlings of *C. gariepinus* farmed under different protein sources in RAS.

Parameter	Treatment	Wild fingerlings	Hatchery fingerlings	t-value	p-value
Calorific value	T ₁	124.52±0.07	118.61±2.95	1.998	0.116
	T ₂	128.91±0.08	119.55±4.99	1.876	0.134
	T ₃	129.99±0.03	129.53±0.38	1.247	0.281
	T ₄	132.25±0.12	130.09±3.48	0.619	0.570
	T ₅	136.08±0.18	134.12±1.74	1.121	0.325
Fat : Protein	T ₁	0.256: 1.0	0.202: 1.0	-	-
	T ₂	0.242: 1.0	0.175: 1.0	-	-
	T ₃	0.252: 1.0	0.279: 1.0	-	-
	T ₄	0.273: 1.0	0.235: 1.0	-	-
	T ₅	0.288: 1.0	0.312: 1.0	-	-

Fatty acids composition

The fatty acid compositions of *C. gariepinus* wild and

hatchery fingerlings cultured under different diets showed the presence of 29 fatty acid.

Table 4: Fatty acid profile of wild and hatchery catfish fingerlings fed with five formulated diets in RAS.

Fatty acid	Wild fingerlings					Hatchery fingerlings				
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₁	T ₂	T ₃	T ₄	T ₅
Saturated fatty acids (SFA)										
Myristic acid (C14:0)	+	+			+	+			+	+
Tricosenoic acid (C23:0)	+				+	+	+	+	+	+
Heneicosenoic acid (C21:0)	+				+	+		+		+
Stearic acid (C18:0)	+				+	+			+	
Palmitic acid (C16:0)		+	+	+	+	+	+			+
Lauric acid (C12:0)	+	+	+	+	+	+	+	+	+	+
Pentadecenoic acid (C15:0)	+	+	+	+	+	+	+	+	+	+
Lignoceric acid (C24:0)	+			+				+	+	
Behenic acid (C22:0)			+				+			
Tricosanoic acid (C23:0)		+	+	+		+	+	+	+	+
Arachidic acid (C20:0)		+	+	+			+	+		
caprylic acid (C8:0)		+	+		+	+	+	+	+	+
Capric acid (C10:0)	+	+	+	+	+	+	+	+	+	+
Undecanoic (C11:0)	+	+	+	+	+	+	+	+	+	+
Dodecanoic acid (C12:0)	+	+	+	+	+	+	+	+	+	+
Monounsaturated fatty acids (MUFA)										
Palmitoleic acid (C16:1)	+	+	+	+	+	+	+	+	+	+
Eicosenoic acid (C20:1)	+	+	+	+	+	+	+	+	+	+
Nervonic acid (C24:1n9)		+	+	+	+	+	+		+	+
heptadecenoic acid (C17:1)	+	+			+	+				+
Erucic acid (C22:1)		+	+	+			+	+		
Elaidic acid (C18:1n9t)	+	+	+	+	+	+	+	+	+	+
Myristoleic acid (C14:1)			+				+		+	
Polyunsaturated fatty acids (PUFA)										
Linolelaidic (C18:2n6t)	+				+	+			+	
L-γ-Linolenic acid (GLA, C18:3n6)	+		+		+	+	+	+		
Eicosapentaenoic acid (EPA, C20:5n3)	+				+	+			+	
Docosahexaenoic acid (DHA; C22:6n3)			+	+			+	+		+
Docosadienoic acid (DDA, C22:2n6)	+	+	+	+	+	+	+	+		+
Eicosadienoic acid (C20:2)		+	+	+	+	+	+		+	+
Arachidonic acid (AA, C20:4n6)		+	+	+			+			+
Total	18	19	21	19	21	22	22	19	19	20

Discussion

In the present study, five formulated feeds were fed to wild and hatchery *C. gariepinus* fingerlings. The gross chemical body composition of fish were significantly affected ($p < 0.05$)

by the different diets. Ahmed ^[15] studied the gross chemical composition of *Clarias (lazera) gariepinus* from sewage ponds and White Nile (at Jebel Aulia). He found no significant difference in moisture content but significantly

high ($p < 0.01$) protein in fish from the White Nile. The fat, ash, calorific value and fat: protein ratio were significantly high ($p < 0.01$) in fish from the sewage ponds Ahmed ^[15]. The highest fat 5.98% was observed in the hatchery fingerlings fish fed T₅ and the lowest was 3.66% was in hatchery fingerlings fed T₂. This confirmed the findings of Solomon and Oluchi ^[23] in *C. gariepinus*. Olapade *et al.* ^[20] and Onyia *et al.* ^[21] worked on wild and farm raised *C. gariepinus* and reported that the proximate composition values were higher in wild fingerlings reared in earthen pond. In the present study wild and hatchery fingerlings had ash of $3.37 \pm 0.21\%$ and $3.72 \pm 0.18\%$ in T₃, with a minimum of $2.13 \pm 0.03\%$ and 2.08 ± 0.44 in T₂ and T₅, respectively. Giri *et al.* ^[27] found *Clarias batrachus* fingerlings from the wild sources had high ash content, and linked this to the minerals content of the water body and/or the feed.

The study showed comparable protein content in wild and hatchery fingerlings and related variation in lipid content to variation of its level in the diets. This is in line with Goda *et al.* ^[28] in *C. gariepinus*; Giri *et al.* ^[27] and Sugumaran and Radhakrishnan ^[29] in *C. batrachus*, who reported that replacement of fish meal by poultry meal in diets did not affect the body protein content, but increased fish body lipid content. In *C. gariepinus* fat content increased due to water removal, but its polyunsaturated fatty acids are reduced by salting (Chukwu and Shaba) ^[30]. Ahmed *et al.* ^[17] reported 50.96% moisture, 42.88% protein, 12.75% fat, 6.00% ash, 396.91 calorific value and 0.297:1.0 fat to protein ratio from shade dried *Clarias* spp.

The present study showed an appreciable level of calorific values and fat to protein ratio. The highest calorific values was shown by wild fingerlings given diet T₅. The lowest fat to protein ratio was obtained when by fingerlings fed T₂. Similar findings were obtained by Nwali *et al.* ^[31] in *C. gariepinus*. Ahmed ^[15] in *C. gariepinus* recorded on weight basis fat:protein of 0.337:1.0 and 0.319:1.0 from sewage ponds and White Nile, respectively. Nwali *et al.* ^[31] reported that *C. gariepinus* wild and hatchery fingerlings cultured at earthen ponds yielded 89.38 and 102.18 calorific value, respectively. Ahmed ^[15] recorded on weight basis calorific value of 456.48 ± 5.54 and 451.51 ± 5.41 from sewage ponds and White Nile, respectively. According to Babiker ^[11] low calorific value is advantageous to those who want to keep low calories in their diet, and the low fat to protein ratio is indicative of high digestibility.

Twenty nine fatty acids were obtained from the oil of *C. gariepinus* in the present study. Thirteen fatty acids were identified from the skin of *C. gariepinus* oil by Sayem *et al.* ^[32] and 20 fatty acids from its viscera by Effiong and Fakunle ^[33] obtained twenty. The fatty acids reported in the three studies were Lauric acid (C12:0), Pentadecenoic acid (C15:0), Capric acid (C10:0), Undecanoic (C11:0), Dodecanoic acid (C12:0), Palmitoleic acid.

It was found that Linoleic acid (Effiong and Fakunle) ^[33] and Oleic acid (Goyens *et al.*) ^[34], are highly required by human body to maintain good health status Both acids are not produced by the human body and can be assimilated from fish as food (Kolanowski and Laufenberg ^[2]; Sayem *et al.* ^[32] found that the total proportions of polyunsaturated fatty acids were higher in pure cultured catfish than wild ones.

Conclusions

The chemical composition of *C. gariepinus* indicated that it has low calorific value and high digestibility. Wild and

hatchery fingerlings grown in and fed five different diets showed no significant differences in [protein content. The study showed that *C. gariepinus* exhibited 15 SFA, 7 MUF and 7 PUFA.

Ethics. Ethics approval and consent to participate, human and animal rights, consent for publication, availability of data and materials are not applicable.

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Conflict of Interest. The authors declare no conflict of interest, financial or otherwise.

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