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Response of African Catfish, *Clarias gariepinus* (Burchell 1822), Fingerlings Fed Diets Containing Differently Timed Wet-Heat-Treated Sesame (*Sesamum indicum*) Seedmeal

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Abstract

The response of catfish fed differently timed wet-heat-treated sesame seedmeal was evaluated in the diet of *Clarias gariepinus* using growth performance, nutrient utilisation and apparent digestibility coefficient as indices. Three batches of sesame seed, which were cooked for 10, 20 and 30 minutes, dried, milled, and mechanically defatted using locally made screw press. Each of these differently processed seedmeals was included in the diet of African catfish at varying replacement levels, 15, 30 and 45% with soybean meal. There was good growth performance and nutrient utilization by *Clarias gariepinus* fed with differently timed wet-heat-treated sesame seed that was not significantly different ($p > 0.05$) from fish fed control diet. More so, the apparent digestibility coefficient for organic matter, protein, energy, lipid, fibre, carbohydrate in *Clarias gariepinus* fed with differently timed wet-heat-treated sesame seedmeal based diets in this study were comparable with the results obtained for fish fed control diets.

Keywords

Cooked Sesame, *Clarias gariepinus*, Growth Performance, Nutrient Utilization, Digestibility

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1. Introduction

Nutrition plays a critical role in intensive aquaculture as it influences not only the production cost but also fish growth, health and waste production [1]. Cost effective diets are essential for successful fish farming. The profitability and success of compound feed production depends on the cost, availability and digestibility of the feed ingredients to be used. The conventional feed ingredients for fish are mainly from plant and animal products especially by-products of processing plants. These products are also used as human food [2]. Therefore there is a need to search for lesser known materials suitable for fish feed. Legumes are less expensive sources of protein that have been identified to be capable of reducing the cost of fish feed when combined as complementary ingredients to meet the nutritional requirement of fish. Soybean meal has high protein content and the best protein quality among plant protein feedstuffs used in fish feeds [3]. It has been reported to partially or totally replace fish meal in diets of many aquaculture species [4] [5]. However, wider utilization and availability of this conventional source for fish feed is limited by increasing demand for human consumption and by other animal feed industries [6]. This phenomenon according to [7] has hindered the expansion and profitability of aquaculture enterprise in many developing countries and has to encourage the need to look for cheaper alternative protein source for the development of low-cost feed that can replace this conventional feedstuff without reducing the nutritional quality of the diets. It then becomes a priority to look for cheaper, alternative protein source. In the recent past, researches were mostly focused on the under-utilized plant proteins in fish diets. Prominent among which are soybean meal [8] [9], groundnut cake [10], Lima bean [11], Jackbean [12] [13], African Yam bean [14], Pigeon Pea [15]. Relatively, work on the use of other oilseeds residue such as sesame meal in warm water fish nutrition is limited [16]. Sesame seed (*Sesamum indicum*) is one of the important annual crops of the world grown for oil. They have nutrient density comparable to other oilseed proteins including soybean meal and other conventional legumes [17]-[19] and their potentials as dietary protein sources are well recognized [20] [21]. In fish feeding, sesame seed cake had been tested with species such as *Clarias gariepinus* [21]-[23], common carp [17] [18] [24]. The meal leftover after oil production containing 34% - 50% protein can be used as a feed for livestock and poultry [25]. Furthermore, Sesame seed cake is known to be rich in methionine [26]-[28] and also tryptophan [29] [30], amino acids lacking in most plant protein feedstuffs and its incorporation in fish diets has been little investigated [22]. This study therefore investigates the replacement value of differently timed wet-heat-treated sesame seedmeal with soybean meal in the diet of *Clarias gariepinus* using growth performance, digestibility and nutrient utilisation as indices.

2. Material and Methods

Fish meal, soybean meal and other feedstuffs obtained from commercial sources in Nigeria were separately milled, screened to fine particle size (<250 µm) and triplicate samples were analysed for proximate composition. Sesame seeds were obtained from a farm in Kebbi State. Three batches of sesame were cooked for 10, 20 and 30 minutes dried, milled in a hammer mill and mechanically defatted using the pressure generated from locally made screw press. The cake thereafter was analysed for its proximate composition [31]. Amino acid analysis of differently-processed sesame seedmeals were determined by using the ion exchange chromatography (IEC). The samples were defatted, hydrolyzed and evaporated in a rotator evaporator and then injected into the Automatic Technicon Sequential Multi-sample Amino Acid Analyser (Model No 0209, Technicon, Ireland). The gross energy content of samples was calculated based on the physiological value of 5.61Kcal/g protein, 9.50 Kcal/g lipid and 4.11 Kcal/g carbohydrate [33].

Based on the nutrient composition of the protein feedstuff (**Table 1**), a control diet and nine test diets (40% crude protein, 12% crude lipid and 18.45 Mj/kg gross energy) were formulated. The control diet (CTR) contained soybean meal, providing 50% of total protein. Nine tests diets contained each of these differently processed seedmeals at three replacement levels, 15, 30 and 45%, for soybean meal (**Table 2**). The feedstuffs were ground and hot water was added to aid binding after which it was then introduced in a Hobart-200T pelleting and mixing machine to obtain a homogeneous mass and then passed through a mincer to produce 0.8 mm (long) 0.2 mm (diameter) pellet which was immediately be sun-dried (30˚C - 32˚C). After drying for some days, the diets were kept frozen in a refrigerator.

Clarias gariepinus fingerlings were acclimated to experimental condition for 7 days prior to the feeding trial. Groups of 15 catfish fingerlings (3.38 ± 0.015 g) were stocked into aquaria comprising 60 litre-capacity rectangular plastic tanks. Each diet was fed to the catfish in triplicate tanks twice daily (09.00 h, 16.00 h) at 5% body

Table 1. Proximate composition (g/100g dry matter) and essential amino acid profile of feedstuff (g/100g protein).

Proximate Composition						
	CMS10	**CMS20**	**CMS30**	**Fishmeal**	**Soybean Meal**	**Corn Meal**
Moisture	9.1	8.97	9.28	7.59	8.92	9.21
Crude protein	40.39	38.36	35.83	69.76	42.81	8.89
Crude lipid	11.90	12.83	12.58	8.82	18.56	1.49
Crude fibre	5.38	6.22	5.41	-	5.63	29.78
Ash	11.28	10.38	12.28	13.83	6.01	3.81
NFE	22.02	22.02	24.62	-	18.07	46.82
Amino Acid Profile				*	*	*
Lysine	3.66	3.22	3.04	4.96	3.10	0.28
Histidine	2.72	2.88	3.06	1.47	1.26	0.29
Arginine	11.68	11.72	12.01	4.41	3.41	0.48
Threonine	2.98	3.21	3.10	2.82	1.92	0.4
Cystine	1.95	2.02	1.82	0.82	0.63	0.25
Valine	4.80	4.92	5.08	3.31	2.53	0.5
Methionine	3.42	3.47	3.71	1.84	0.72	0.19
Isoleucine	2.32	3.76	3.91	2.98	2.92	0.39
Leucine	3.62	8.12	5.22	4.78	4.02	1.37
Tyrosine	2.33	2.96	2.18	2.0	1.72	0.43
Phenyalanine	3.68	3.34	4.81	2.50	2.45	0.54

*Values obtained from [32]; CMS10: Sesame seeds cooked for 10 minutes; CMS20: Sesame seeds cooked for 20 minutes; CMS30: Sesame seeds cooked for 30 minutes.

Table 2. Gross composition (g/100g dry matter) of experimental diets at varying replacement levels of differently cooked sesame seedmeals.

	CTR	**$CSS1_{15}$**	**$CSS1_{30}$**	**$CSS1_{45}$**	**$CSS2_{15}$**	**$CSS2_{30}$**	**$CSS2_{45}$**	**$CSS3_{15}$**	**$CSS3_{30}$**	**$CSS3_{45}$**
Fishmeal	27.24	27.24	27.24	27.24	27.24	27.24	27.24	27.24	27.24	27.24
Soybean Meal	46.71	39.71	32.70	25.70	39.71	32.70	25.70	39.71	32.70	25.70
Cooked Sesame	-	7.42	14.86	22.80	7.86	15.72	23.58	8.37	16.75	25.12
Corn Meal	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25
Fish Oil	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09
*Vit/Min Premix	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Starch	4.71	4.29	3.86	2.92	3.85	3.00	2.14	3.34	1.97	0.60
Total	100	100	100	100	100	100	100	100	100	100

***Specification: each kg contains: Vitamin A, 4,000,000 IU; Vitamin B, 800,000 IU; Vitamin E, 16,000 mg, Vitamin K_3, 800 mg; Vitamin B_1, 600 mg; Vitamin B_2, 2000 mg; Vitamin B_6, 1600 mg, Vitamin B_{12}, 8 mg; Niacin,16,000 mg; Caplan, 4000 mg; Folic Acid, 400 mg; Biotin, 40 mg; Antioxidant 40,000 mg; Chlorine chloride, 120,000 mg; Manganese, 32,000 mg; Iron 16,000 mg; Zinc, 24,000 mg; Copper 32,000 mg; Iodine 320 mg; Cobalt, 120 mg; Selenium, 800 mg manufactured by DSM Nutritional products Europe Limited, Basle, Switzerland.

weight for 56 days. Fish mortality was monitored daily, total fish weight in each tank was determined at two weeks intervals and the amount of diet was adjusted according to the new weight. Growth response and feed utilization indices were estimated. Water temperature and dissolved oxygen were measured using a combined digital YSI dissolved oxygen meter (YSI Model 57, Yellow Spring Ohio); pH was monitored weekly using pH meter (Mettler Toledo-320, Jenway UK). Eight catfish and 6 catfish per treatment were respectively sacrificed at the beginning and end of the feeding trial respectively and analysed for their carcass composition [31]. All data were subjected to one-way analysis of variance (ANOVA) test using SPSS 13.0 version. Where ANOVA revealed significant difference ($P < 0.05$), Duncan multiple range test [34] was applied to characterize and quantity the differences between treatments.

2.1. Acid Insoluble Ash Analysis

AIA in feed and faeces was obtained by adding 25 ml of 10% HCl to their weighed ash content. This will then be covered with a water glass and boiled gently over a low flame for 5minutes after which it was filtered through ashless filter and washed with hot distilled water, the residue from the filter was returned into the crucible and then ignited until it is carbon-free and it was weighed. The AIA was calculated as

$$\%\ \text{AIA} = \frac{\text{Weight of AIA}}{\text{Weight of ash}} \times 100 .$$

2.2. Digestibility Coefficient

The value obtained for AIA in different diets and faecal samples was used as indicator in the calculation of digestibility coefficient as

$$\%\ \text{Digestibility} = 100 - \left(100\left(\frac{\%\ \text{AIA in Feed}}{\%\ \text{AIA in Faeces}} \times \frac{\%\ \text{Nutrients in Faeces}}{\%\ \text{Nutrients in Feed}}\right)\right).$$

Organic Matter Digestibility (AOMD) was calculated as follow

$$\text{AOMD} = 100 - \left(100\left(\frac{\%\ \text{AIA in Feed}}{\%\ \text{AIA in Faeces}}\right)\right).$$

2.3. Diet Performance Evaluation

Growth performance and nutrient utilization of fish was determined following the methods of [21] in term of Final Individual Weight, Survival (%), Specific Growth Rate (SGR %/ day), Feed Conversion Ratio, (FCR) and Protein Efficiency Ratio (PER), Net Protein Utilisation (NPU) responses was calculated as

$$\text{Weight Gain}\ (\%) = \frac{\text{Final weight} - \text{Initial Weight}}{\text{Initial Weight}} \times 100$$

$$\text{SGR}\ (\%/\text{day}) = \frac{\ln(\text{final body weight}) - \ln(\text{initial body weight})}{\text{Time}(\text{in days})}$$

$$\text{FCR} = \frac{\text{Dry weight of feed fed}}{\text{Fish weight Gain}}$$

$$\text{PER} = \frac{\text{Fish weight gain}}{\text{Protein Fed}}$$

$$\text{NPU} = \frac{\text{Net protein in Carcass}}{\text{Protein Fed}} .$$

2.4. Statistical Analysis

All data were subjected to one-way analysis of variance (ANOVA) test using SPSS 13.0 version. Where ANOVA revealed significant difference ($P < 0.05$), Duncan's multiple-range test [34] was applied to characterize and quantity the differences between treatments.

3. Results

3.1. Proximate Composition and Amino Acid Profile of the Experimental Diets

Table 3 showed the proximate composition of experimental diets and amino acid profile of the experimental diets fed to *Clarias gariepinus*. It revealed the diets to be isonitrogenous, isolipidic as well as isocalorific as there

Table 3. Proximate composition and amino acid profile of experimental diets fed to *Clarias gariepinus* at varying replacement levels of differently cooked sesame seedmeals.

	CTR	CSM_{115}	CSM_{130}	CSM_{145}	CSM_{215}	CSM_{230}	CSM_{245}	CSM_{315}	CSM_{330}	CSM_{345}	
Proximate Composition (g/100g DM) and Gross Energy (Kcal/100g)											
Moisture	9.43 ± 0.35	9.55 ± 0.18	9.72 ± 0.40	9.79 ± 0.06	9.36 ± 0.21	9.65 ± 0.33	9.57 ± 0.16	9.46 ± 0.25	9.57 ± 0.31	9.33 ± 0.15	
Protein	40.53 ± 0.22	40.61 ± 0.29	40.50 ± 0.29	40.41 ± 0.34	40.69 ± 0.27	40.60 ± 0.41	40.48 ± 0.27	40.29 ± 0.34	40.33 ± 0.45	40.05 ± 0.80	
Lipid	12.30 ± 0.25	12.25 ± 0.10	12.21 ± 0.13	12.39 ± 0.22	12.29 ± 0.28	12.39 ± 0.38	12.41 ± 0.18	12.40 ± 0.15	12.52 ± 0.13	12.20 ± 0.11	
Fibre	5.25 ± 0.29	5.48 ± 0.16	5.36 ± 0.17	5.38 ± 0.05	5.36 ± 0.14	5.34 ± 0.35	5.39 ± 0.23	5.30 ± 0.36	5.63 ± 0.11	5.36 ± 0.41	
Ash	6.56 ± 0.38	6.63 ± 0.47	6.50 ± 0.19	6.36 ± 0.20	6.53 ± 0.34	6.38 ± 0.18	6.44 ± 0.23	6.76 ± 0.07	6.46 ± 0.24	6.74 ± 0.14	
NFE	25.93 ± 0.57	25.47 ± 0.92	25.71 ± 0.77	25.67 ± 0.50	25.77 ± 0.33	25.64 ± 1.19	25.71 ± 0.32	25.78 ± 0.29	25.48 ± 0.46	26.31 ± 1.05	
Energy	450.15 ± 5.12	448.30 ± 1.59	448.21 ± 0.55	449.25 ± 1.30	450.27 ± 3.22	450.22 ± 0.45	449.96 ± 1.86	449.15 ± 3.17	449.30 ± 0.34	448.06 ± 2.47	
Amino Acid Profile (g/100g Protein)											**
Lysine	3.15	2.89	2.94	3.01	2.87	2.90	2.94	2.87	2.91	2.91	4.8
Histidine	1.02	1.08	1.14	1.21	1.21	1.40	1.60	1.18	1.33	1.49	1.2
Arginine	2.85	3.28	3.70	4.18	3.31	3.78	4.24	3.37	3.89	4.40	3.6
Threonine	1.71	1.80	1.88	1.99	1.83	1.95	2.06	1.84	1.96	2.09	2.8
Cystine	0.55	0.65	0.75	0.86	0.66	0.78	0.89	0.65	0.76	0.87	
Valine	2.14	2.32	2.50	2.70	2.35	2.56	2.77	2.39	2.64	2.88	2.4
Methionine/ TSA	0.86	1.06	1.27	1.49	1.08	1.30	1.53	1.11	1.38	1.64	2.4
Isoleucine	2.22	2.19	2.16	2.14	2.31	2.40	2.49	2.34	2.47	2.59	2.0
Leucine	3.33	3.32	3.31	3.31	3.69	4.05	4.40	3.49	3.65	3.80	3.5
Tyrosine	1.40	1.45	1.50	1.57	1.51	1.62	1.73	1.50	1.52	1.58	
Phenyalanine/ TAA	1.89	1.99	2.10	2.21	1.98	2.07	2.16	2.12	2.35	2.58	4.0

**Amino Acid requirement of *Clarias gariepinus* Source: Uys (1989); Unprasert, N. G. (1994).

was no significant difference ($p > 0.05$) in the crude protein, crude lipid and energy contents of the experimental diets. The protein, energy and lipid contents of the diet met the dietary requirement of *Clarias gariepinus.* Fish in different dietary groups actively fed on the experimental diets throughout the experiments.

3.2. Whole Body Composition

Table 4 revealed the whole body composition of fish fed differently cooked sesame meal based diets at the beginning and at the end of the experiment. There was significant difference ($P < 0.05$) between the initial and final body composition of fish used during the experiments with respect to moisture crude protein, crude lipid and ash content. Among the fish fed the experimental diets, the highest value of tissue crude protein was recorded in fish fed CSF_{330} but this did not significantly ($P > 0.05$) differ from the values observed for the fish fed CTR, CSM_{115}, CSM_{215}, CSM_{315}, CSM_{230} while the lowest value of tissue crude protein was recorded for fish fed CSM_{145} though this did not significantly differ ($P > 0.05$) from fish fed CSM_{245} and CSM_{345}. The lowest crude lipid was recorded in the initial body composition of fish used for the experiment which was significantly different ($P < 0.05$) from that of the final body composition while the highest lipid content was recorded in fish fed diet CSM_{115}. There was no significant difference ($P > 0.05$) in lipid content of the fish fed diets CTR and other test diets. The highest ash content was recorded in fish fed diet CSM_{345}, however, this was not significantly different ($P > 0.05$) from fish fed other test diets except that of CTR. There was no significant difference ($P > 0.05$) in the ash contents of the fish fed diets CTR and CSM_{130}, CSM_{145}, and CSM_{245}. The HSI of the fish fed diffe-

Table 4. Proximate composition of carcass of *Clarias gariepinus* fed varying levels of cooked samples sesame seedmeal based diets.

	Experimental Diets										
	Initial	**Control**	**CSM_{115}**	**CSM_{130}**	**CSM_{145}**	**CSM_{215}**	**CSM_{230}**	**CSM_{245}**	**CSM_{315}**	**CSM_{330}**	**CSM_{345}**
Moisture	78.61 ± 0.10^{a}	73.25 ± 0.31^{b}	73.16 ± 0.20^{bc}	73.14 ± 0.25^{bc}	73.16 ± 0.13^{bc}	72.94 ± 0.37^{bcd}	72.75 ± 0.11^{cd}	73.16 ± 0.34^{bc}	72.92 ± 0.14^{bcd}	72.70 ± 0.10^{d}	72.93 ± 0.25^{bcd}
Protein	15.29 ± 0.01^{e}	17.68 ± 0.20^{a}	17.68 ± 0.09^{ab}	17.50 ± 0.04^{cd}	17.42 ± 0.04^{d}	17.69 ± 0.09^{a}	17.62 ± 0.03^{abc}	17.48 ± 0.04^{cd}	17.70 ± 0.02^{a}	17.70 ± 0.02^{a}	17.54 ± 0.05^{bcd}
Lipid	3.32 ± 0.04^{a}	5.83 ± 0.04^{b}	5.73 ± 0.10^{b}	5.84 ± 0.10^{b}	5.87 ± 0.09^{b}	5.74 ± 0.10^{b}	5.85 ± 0.09^{b}	5.81 ± 0.17^{b}	5.75 ± 0.08^{b}	5.84 ± 0.09^{b}	5.75 ± 0.26^{b}
Ash	2.77 ± 0.13^{c}	3.24 ± 0.18^{b}	3.43 ± 0.17^{ab}	3.52 ± 0.31^{ab}	3.55 ± 0.21^{ab}	3.62 ± 0.24^{a}	3.78 ± 0.06^{a}	3.54 ± 0.29^{ab}	3.64 ± 0.08^{a}	3.76 ± 0.06^{a}	3.77 ± 0.06
HSI	1.67 ± 0.03^{f}	1.80 ± 0.02^{ab}	1.79 ± 0.02^{ab}	1.78 ± 0.01^{abc}	1.81 ± 0.01^{a}	1.78 ± 0.02^{bc}	1.75 ± 0.02^{cd}	1.75 ± 0.02^{cd}	1.77 ± 0.03^{bcd}	1.74 ± 0.02^{de}	1.72 ± 0.01^{e}

Row means with different superscripts are significantly different ($p < 0.05$). Row means with no superscripts are not significantly different ($p > 0.05$); HSI: Hepatosomatic Index.

rently cooked sesame seedmeal based diets differ significantly ($P < 0.05$) but there was no significant difference between the control and CSM_{115}, CSM_{130}, CSM_{145}, CSM_{215} and CSM_{315}.

3.3. Growth Performance and Nutrient Utilization

Table 5 presents growth performance and nutrient utilization of *Clarias gariepinus* fed varying levels of cooked sesame meal based experimental diets. There was no significant difference ($P > 0.05$) in the initial mean weight of the fish at the beginning of the experiment. Although the fish fed the control diets had the best growth performance, the Feed Conversion Ratio, Protein Efficiency Ratio and Net Protein Utilization were not statistically different ($P > 0.05$) among the fish fed different dietary treatments. So also the specific growth rate of fish fed these diets were not statistically different ($P > 0.05$) from that of control except those fed CSM_{345}. Percentage survival in all the fish fed dietary treatment was above 80 and there was no significant difference in percentage survival of all the fish fed the dietary treatment. **Figure 1** represents the growth curve of *Clarias gariepinus* fed varying levels of cooked sesame meal based experimental diets.

3.4. Proximate Composition of the Faeces

Table 6 showed the proximate composition of faecal samples of *Clarias gariepinus* fed varying levels of cooked sesame meal based diets. There was reduction in the nutrient contents of the faecal samples tested when compared with the nutrient contents of the feed. There was no significant difference (($P > 0.05$) in the moisture content of the faecal samples of fish fed the different dietary treatment. There was significant difference in the crude protein content ($P < 0.05$) of the faecal samples of fish fed the different dietary treatments. The fish fed diet CTR had the lowest faecal crude protein content while those fed with diets CSM_{245} and CSM_{345} had the highest faecal crude protein. Fish fed diet CTR, CSM_{115}, CSM_{130} and CSM_{230} were not significantly different in their faecal crude protein contents. The fish fed diet CTR had the lowest faecal crude lipid content while those fed with diet CSM_{345} had the highest faecal crude lipid content. There was no significant difference (($P > 0.05$) in the crude lipid content of the faecal output of fish fed diet CTR and fish fed other test diets except diets CSM_{115}, CSM_{215}, CSM_{315}, CSM_{130} CSM_{230}, CSM_{245} and CSM_{330}. The fibre content of the faecal output of the fish fed dietary treatment were not significantly different ($P > 0.05$) from one another. The fish fed diet CTR had the lowest faecal crude fibre. Other fish fed on test diets were not statistically different (($P > 0.05$) in their faecal crude fibre from that of control except that fed with CSM_{145}. The ash contents of the faecal samples of fish fed the differently cooked sesame meal based dietary treatments were not significantly different ($P > 0.05$) from that of control except the fish fed with CSM_{330}. The highest NFE value was recorded in fish fed CTR while the fish fed CSM_{345} recorded the lowest NFE value. There was significant difference ($P < 0.05$) in the NFE value of the faecal output of the fish fed the differently cooked sesame meal based dietary treatments. The AIA in faeces of the fish fed various dietary treatment were not significantly different ($P > 0.05$). Similarly no significantly variation ($P > 0.05$) was recorded in the energy value of the faecal samples of fish fed all the test diets from that of control except those fed with CSM_{245} and CSM_{345}.

Table 5. Growth performance and nutrients utilisation of *Clarias gariepinus* fed cooked sesame meal based diets.

	Experimental Diets									
	CTR	CSM_{115}	CSM_{130}	CSM_{145}	CSM_{215}	CSM_{230}	CSM_{245}	CSM_{315}	CSM_{330}	CSM_{345}
Initial Weight (g)	4.37 ± 0.38	4.33 ± 0.31	4.57 ± 0.27	4.52 ± 0.35	4.29 ± 0.26	4.39 ± 0.48	4.71 ± 0.14	4.27 ± 0.22	4.40 ± 0.41	4.52 ± 0.20
Final Weight(g)	14.80 ± 0.31^{ab}	14.18 ± 0.52^{abc}	14.55 ± 0.16^{abc}	14.74 ± 0.93^{abc}	13.95 ± 0.74^{abc}	15.06 ± 0.69^{a}	14.61 ± 0.49^{abc}	15.20 ± 0.34^{a}	14.69 ± 0.57^{abc}	13.71 ± 0.27^{c}
[1]MWG (g)	10.43 ± 0.18^{ab}	9.85 ± 0.23^{abc}	9.98 ± 0.22^{abc}	10.22 ± 0.98^{abc}	9.66 ± 0.48^{bc}	10.67 ± 1.06^{ab}	9.90 ± 0.61^{abc}	10.93 ± 0.23^{a}	10.29 ± 0.54^{ab}	9.18 ± 0.12^{c}
[2]%WG (%)	239.99 ± 23.06^{ab}	227.99 ± 11.50^{ab}	219.06 ± 17.09^{ab}	227.51 ± 32.85^{ab}	225.40 ± 3.26^{ab}	246.48 ± 46.62^{ab}	210.46 ± 19.02^{ab}	256.55 ± 13.18^{a}	235.30 ± 28.79^{ab}	203.30 ± 8.50^{b}
[3]SGR	2.67 ± 0.02^{ab}	2.63 ± 0.04^{abc}	2.65 ± 0.01^{abc}	2.66 ± 0.06^{abc}	2.61 ± 0.05^{bc}	2.69 ± 0.05^{a}	2.65 ± 0.03^{abc}	2.70 ± 0.02^{a}	2.66 ± 0.04^{abc}	2.59 ± 0.02^{c}
[4]FCR	1.08 ± 0.09	1.09 ± 0.13	1.10 ± 0.14	1.21 ± 0.14	1.13 ± 0.08	1.14 ± 0.20	1.28 ± 0.12	1.09 ± 0.11	1.17 ± 0.09	1.20 ± 0.09
[5]PER	2.33 ± 0.2184	2.30 ± 0.27	2.29 ± 0.30	2.09 ± 0.23	2.22 ± 0.16	2.23 ± 0.35	1.97 ± 0.17	2.30 ± 0.23	2.15 ± 0.17	2.09 ± 0.15
[6]NPU%	54.78 ± 9.01	52.91 ± 8.15	49.92 ± 5.39	49.70 ± 1.31	51.63 ± 4.73	51.00 ± 5.43	47.35 ± 1.12	51.78 ± 5.10	51.48 ± 1.46	51.58 ± 3.57
[7]Survival%	77.78 ± 10.18	77.78 ± 7.69	82.22 ± 7.70	86.67 ± 6.67	82.22 ± 7.69	84.44 ± 7.69	86.67 ± 6.67	82.22 ± 10.18	86.67 ± 6.67	86.68 ± 6.67

Row means with different superscripts are significantly different ($p < 0.05$); Row means with no superscripts are not significantly different ($p > 0.05$); [1]Mean weight gain = final mean weight − initial mean weight; [2]Percentage weight gain = [final weight − initial weight/initial weight] × 100; [3]Specific growth rate = [In final weight − In initial weight] × 100; [4]Feed conversion ratio = dry weight of feed fed/Weight gain (g); [5]Protein efficiency ratio = fish body weight (g)/Protein fed; [6]Net protein utilization = [protein gain/protein fed] × 100; [7]Percentage survival = {(total number of fish − mortality)/total number of fish] × 100.

Table 6. Proximate composition (g/100g dry matter) of faecal samples of *Clarias gariepinus* fed at varying replacement levels of cooked samples of sesame seedmeal based diets.

	Experimental Diets									
	Control	CSM_{115}	CSM_{130}	CSM_{145}	CSM_{215}	CSM_{230}	CSM_{245}	CSM_{315}	CSM_{330}	CSM_{345}
Moisture	10.02 ± 0.64	9.80 ± 0.69	10.33 ± 0.44	10.49 ± 0.14	10.46 ± 0.38	9.95 ± 0.64	10.36 ± 0.62	10.26 ± 0.80	10.25 ± 0.75	9.81 ± 0.54
Protein	15.64 ± 0.61^{e}	15.71 ± 0.32^{de}	16.42 ± 0.27^{cde}	18.01 ± 0.32^{b}	16.54 ± 0.23^{cd}	16.43 ± 0.05^{cde}	20.00 ± 0.75^{a}	16.68 ± 0.08^{c}	17.23 ± 0.82^{bc}	19.85 ± 0.54^{a}
Lipid	6.22 ± 0.14^{c}	6.47 ± 0.74^{bc}	6.98 ± 0.50^{abc}	7.76 ± 0.97^{ab}	6.37 ± 0.88^{bc}	6.77 ± 0.79^{abc}	7.38 ± 1.11^{abc}	6.54 ± 0.58^{bc}	7.19 ± 0.92^{abc}	8.11 ± 0.32^{a}
Fibre	10.85 ± 0.63^{b}	11.47 ± 0.63^{ab}	11.62 ± 0.63^{ab}	12.43 ± 0.33^{a}	12.05 ± 0.42^{ab}	11.82 ± 0.71^{ab}	11.58 ± 0.62^{ab}	11.37 ± 0.89^{ab}	11.94 ± 0.55^{ab}	11.76 ± 0.92^{ab}
Ash	8.17 ± 0.40^{ab}	8.86 ± 0.52^{a}	7.97 ± 0.42^{ab}	7.91 ± 0.62^{ab}	8.21 ± 0.18^{ab}	7.89 ± 0.47^{ab}	7.60 ± 0.62^{b}	8.84 ± 0.68^{a}	8.95 ± 0.41^{ab}	8.28 ± 1.04^{a}
[1]NFE	49.10 ± 0.27^{a}	47.69 ± 0.96^{ab}	46.68 ± 1.10^{b}	43.40 ± 0.63^{d}	46.37 ± 0.87^{b}	47.13 ± 1.34^{b}	43.08 ± 0.71^{d}	46.29 ± 0.83^{b}	44.43 ± 0.91^{c}	42.18 ± 1.20^{d}
[2]AIA	3.35 ± 0.27	3.41 ± 0.08	3.47 ± 0.24	3.33 ± 0.18	3.44 ± 0.38	3.33 ± 0.34	3.39 ± 0.25	3.60 ± 0.26	3.52 ± 0.18	3.28 ± 0.18
Energy	348 ± 5.50^{bc}	345.01 ± 5.88^{c}	349.63 ± 3.90^{abc}	352.48 ± 8.29^{abc}	343.26 ± 6.10^{c}	349.60 ± 2.40^{abc}	358.72 ± 3.97^{ab}	345.36 ± 7.28^{c}	346.96 ± 9.73^{bc}	361.17 ± 5.28^{a}

Row means with different superscripts are significantly different ($p < 0.05$); Row means with no superscripts are not significantly different ($p > 0.05$); [1]NFE: Nitrogen Free Extract; [2]AIA: Acid Insoluble Ash. Energy (kcal/100g).

3.5. Apparent Digestibility Coefficients of the Nutrients in Each Diet

Table 7 presents apparent digestibility coefficient of nutrients in cooked sesame meal based diets fed to *Clarias gariepinus* fingerlings. The fish fed various dietary treatment showed significant difference ($P < 0.05$) in their nutrient digestibility's values. There was significant variation ($P < 0.05$) in the AOMD of the fish fed the differently cooked sesame meal based diets. The fish fed diet CSM_{315} had the highest AOMD value while those fed with CSM_{345} had the lowest AOMD. There was no significant difference ($P > 0.05$) in AOMD of the fish fed control diets and the fish fed test diets except CSM_{345} and CSM_{115}. Similarly, there was no significant difference ($P > 0.05$) in the APD of the fish fed control diet and the fish fed test diets CSM_{115}, CSF_{215} and CSF_{315}. The ALD

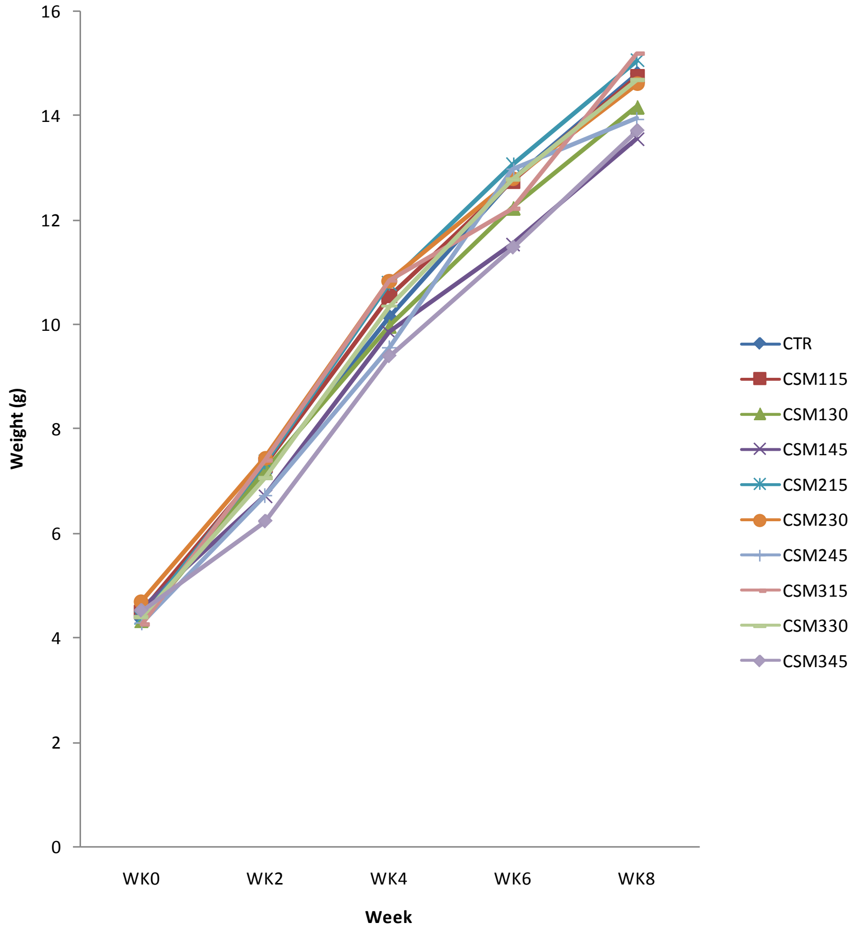

Figure 1. Growth curve of *Clarias gariepinus* fingerlings fed differently cooked sesame meal based diet.

Table 7. Apparent digestibility coefficient of nutrients of cooked sesame meal based diets fed to *Clarias gariepinus*.

	Experimental Diets									
	CTR	**CSM_{115}**	**CSM_{130}**	**CSM_{145}**	**CSM_{215}**	**CSM_{230}**	**CSM_{245}**	**CSM_{315}**	**CSM_{330}**	**CSM_{345}**
AOMD	76.94 ± 0.06^{bc}	76.42 ± 0.54^{cd}	77.25 ± 0.21^{ab}	76.90 ± 0.08^{bc}	77.53 ± 0.30^{ab}	76.87 ± 0.53^{bc}	77.16 ± 0.56^{abc}	77.86 ± 0.03^{a}	77.36 ± 0.55^{ab}	75.92 ± 0.51^{d}
APD	91.10 ± 0.29^{a}	90.88 ± 0.03^{ab}	90.78 ± 0.14^{b}	89.71 ± 0.06^{d}	90.87 ± 0.02^{ab}	90.64 ± 0.10^{b}	88.72 ± 0.15^{e}	90.84 ± 0.03^{ab}	90.33 ± 0.26^{c}	88.06 ± 0.15^{f}
ALD	88.34 ± 0.07^{a}	87.53 ± 1.49^{ab}	87.00 ± 0.78^{ab}	85.56 ± 1.55^{bc}	88.38 ± 1.21^{a}	87.37 ± 1.26^{ab}	86.36 ± 2.51^{abc}	88.34 ± 0.90^{a}	87.02 ± 1.56^{ab}	83.99 ± 0.68^{c}
AED	82.17 ± 0.12^{bc}	81.85 ± 0.61^{c}	82.25 ± 0.33^{abc}	81.88 ± 0.34^{c}	82.88 ± 0.05^{ab}	82.04 ± 0.51^{c}	81.79 ± 0.67^{c}	82.99 ± 0.26^{a}	82.52 ± 0.37^{abc}	80.59 ± 0.46
AAD	71.17 ± 2.84^{ab}	68.31 ± 3.77^{b}	72.09 ± 0.56^{ab}	71.26 ± 2.33^{ab}	71.69 ± 1.36^{ab}	71.40 ± 0.66^{ab}	72.96 ± 3.25^{a}	71.05 ± 2.44^{ab}	68.62 ± 0.19^{ab}	70.50 ± 2.53^{ab}
AFD	52.35 ± 0.73	50.71 ± 0.60	50.72 ± 1.55	46.59 ± 1.24	49.52 ± 0.77	48.73 ± 1.40	50.92 ± 3.40	52.48 ± 3.65	52.00 ± 3.50	46.74 ± 8.48
ACD	56.31 ± 0.88^{de}	55.79 ± 2.96^{e}	58.68 ± 0.83^{bcd}	60.95 ± 0.21^{ab}	59.57 ± 1.67^{abc}	57.44 ± 1.78^{cde}	61.75 ± 0.18^{a}	60.26 ± 0.87^{ab}	60.52 ± 0.10^{ab}	61.39 ± 0.43^{a}

Row means with different superscripts are significantly different ($p < 0.05$); Row means with no superscripts are not significantly different ($p > 0.05$); AOMD: Apparent Organic Matter Digestibility; APD: Apparent Protein Digestibility; ALD: Apparent Lipid Digestibility; AED: Apparent Energy Digestibility; AAD: Apparent Ash Digestibility; AFD: Apparent Fibre Digestibility; ACD: Apparent Carbohydrate Digestibility.

of the fish fed CTR was not significantly different ($P > 0.05$) from the fish fed other dietary treatments except the fish fed CSM_{145} and the fish fed CSM_{345}. Similarly no significant variation ($P > 0.05$) was recorded in the

AED coefficient between the fish fed CTR and the fish fed other test diets except in the fish fed CSM_{315} which has the highest values of AED and the fish fed CSM_{345}. Apparent ash digestibility in all fish fed the test diets did not differ ($P > 0.05$) from control except in the fish fed CSM_{245}. There was no significant difference ($P > 0.05$) in the AFD of the fish fed control diet and other test diets. The fish fed CSM_{245} had the highest value of ACD while the lowest value of ACD was recorded in the fish fed CSM_{115}. No significant difference ($P > 0.05$) existed in the ACD coefficients between the fish fed CSM_{245} and those of the fish fed CSM_{345}, CSM_{145}, CSM_{330}, CSM_{315}, CSM_{330} and CSM_{215}.

4. Discussion

Comparable performance in growth, nutrient utilization and carcass crude protein deposition in *Clarias gariepinus* fed diets with processed sesame seedmeal based diets showed that the nutritive value of raw sesame seedmeal could be improved by cooking. This is evidenced in more superior growth performance and nutrient utilization of *Clarias gariepinus* fed differently cooked sesame seedmeal even at higher replacement level than those fed raw [23] at level to level comparison. [35] reported good growth performance that was not significantly different from control was recorded when *Clarias gariepinus* was fed diets containing autoclaved nor roasted winged bean (*Psophocarpus tetragonolobus*) replacing up to 80% of fishmeal. Similarly [13] reported that 60% of soybean meal protein could be replaced be replaced with Rosselle (*Hibiscus sabdariffa*) seed meal without affecting growth performance and nutrient utilization in *Clarias gariepinus*. [21] reported that it is possible to replace soybean meal in *Clarias gariepinus* diet with cooked and mechanically defatted sesame seed meal with optimum growth response at a 25% replacement level though at 50% replacement with sesame seedmeal the growth response was different from that of control however it was similar to that of fish fed diets containing cooked and mechanically defatted sesame seed meal at a 25% replacement level with soybean meal. Similarly [36] reported that growth was positively affected by the replacement of up to 52% fish meal by sesame oil cake without amino acid supplementation in a practical pelleted feed for rainbow trout without reducing growth performance when compared to a fishmeal control diets. [37] reported that 62.5% of fishmeal protein replacement by plant proteins showed similar growth performance and feed utilization. [38] submitted that thermal processing of raw pea seed meal improved the quality of the ingredients and that dry heat treatment in particular (180˚C:30 min) led to a greatly improved feed utilization and consequent better growth performances. The response of *C. gariepinus* with respect to SGR was in accordance with those typically obtained for this species by other workers. [9] reported similar values for growth and feed utilization data for soybean meal as a fish meal substitute in practical diets for *C. gariepinus*. Similarly, [38] reported mean SGR of 2.2 - 2.4%/day. Furthermore [39] reported mean SGR values of 2.7%/day for juveniles *C. gariepinus*. [40] also reported a superior growth performance and feed utilization for juvenile rainbow trout fed diets in which pea seed meal was subjected to cooking.

The apparent digestibility coefficient for organic matter, protein, energy, lipid, fibre, carbohydrate in *Clarias gariepinus* fed processed seedmeal based diets in this study were more superior than those fed raw sesame seedmeal by [41] and comparable with the results obtained for fish fed control diets. The values of apparent digestibility coefficient of nutrients recorded in this study were in agreement with the values reported for carp [17] [42]-[44].

The organic matter digestibility coefficient reported in this study was slightly higher than the value reported by [45] the variation may be attributed to processing methods, and or the variation may be attributed to processing methods, and or experimental methodology; different seed meal and fish species was used as it is known that digestibility of nutrients are species specific however the result closely related to that reported in [46] and [47] for juvenile hybrid tilapia fed cottonseed meal. [20] reported AOMD of the sunflower diets fed to *Tilapia rendalli* was over 90%.

The values of apparent digestibility of protein and lipid for the control diet and diets containing processed sesame seedmeal obtained during the experiment were almost similar to those obtained by [17] [44] [48]. The apparent protein digestibility coefficients of sunflower and sesame meal based diets were similar to the values reported by [49]. [50] reported that sunflower protein concentrate fed to rainbow trout had protein digestibility coefficients ranging from 79.5 to 90.6%. The results of this study also indicated that irrespective of the replacement levels (15, 30 and 45%), the protein in them were well digested by *Clarias gariepinus*. The ranges of APD values in various ingredients of plant origin as reported earlier are 76.2% - 94.0% in rohu [51], 78.9% - 85.8% in common carp [17], 52.5% - 94.1% in catla [52] [53] and 81.2% - 92.8% in mrigal and grass carp [53] [54]. It could therefore be established that sesame oil cakes, may be used for partial replacement of soybean meal in formulating the diets for *Clarias gariepinus*, as they are high in protein content with a fairly good digestible protein. [49] concluded that many of the ingredients tested, particularly the oil cakes, may be used for partial or total replacement of scarce and costly fishmeal in formulating the diets for silver barb, as they are high in protein content with a fairly good digestible protein.

The earlier reported ranges of apparent lipid digestibility (ALD) coefficient for plant-derived feedstuffs are 73.4% - 100% in red tilapia [55] 79.6% - 90.2% in Nile tilapia [56], 69.6% - 86.4% in catla [52], 90.4% - 94.1% and in rohu [51]. A range of 76% to 97% fat digestibility of various sources of fat has been reported for channel catfish. [57] reported that the ability to digest fat appears to be influenced by temperature and the level of fat in the diet. Sesame oil has excellent nutritional properties. They are practically free of toxic composition. In this study, the ALD did not vary widely among the differently processed diets containing sesame seed meal. This indicates that the *C. gariepinus* has the capacity to digest oil that are available in the plant feedstuffs as effectively as the animal oil from fishmeal and therefore, may use both the plant and the animal oil efficiently as source of energy. The high lipid digestibility by this species was found to be in line with what was reported in [58] for rainbow trout [51]. Then [49] did not observe much difference in lipid digestibility between plant- and animal-derived feedstuffs for rohu, which agrees with the present finding for *C. gariepinus* [51]. And [49] observed an ALD value of over 90% in soybean meal for rohu, the results of which were consistent with the ALD of diet containing sesame seed meal for the *C. gariepinus* in this study [11]. Then [59] reported that nutrient digestibility of *Oreochromis niloticus* fed lima bean (*Phaseolus lunatus*) and jackbean meal (*Cannavalia ensiformis*) diets respectively was improved with toasting and autoclaving.

The low carbohydrate digestibility recorded in this study was similar to that reported by [11] for *Oreochromis niloticus* fed lima bean. The digestibility of carbohydrate has been known to vary with their complexity of carbohydrate, source treatment and level of inclusion in the diet [60]-[63] compared the digestibility and growth performance of rainbow trout fed diets containing peas processed by different methods and reported that autoclaving increased starch and energy digestibility.

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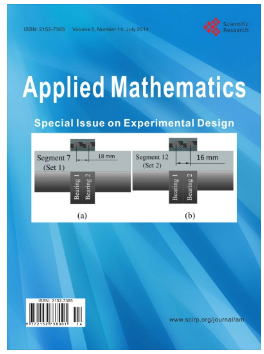
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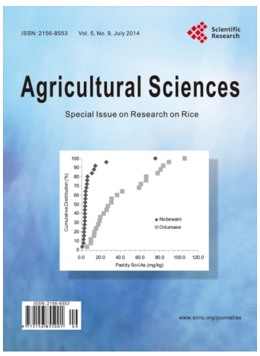
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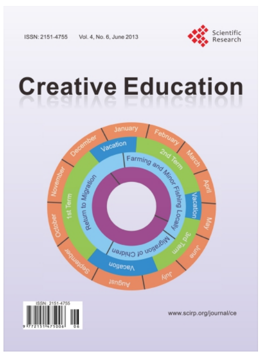
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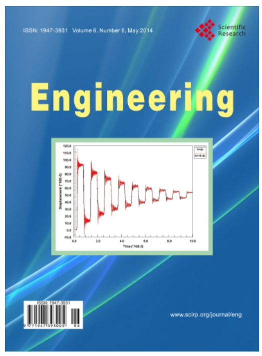
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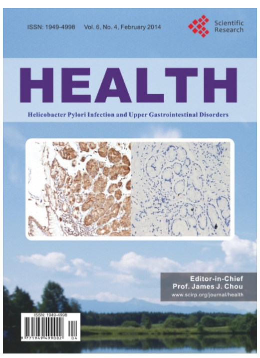
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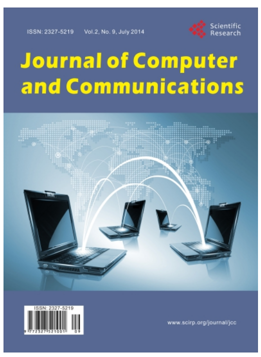
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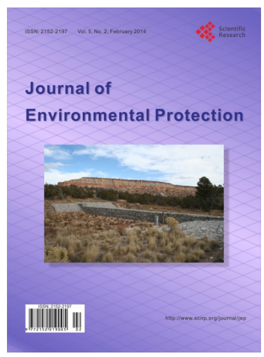
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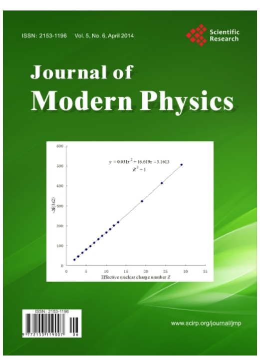
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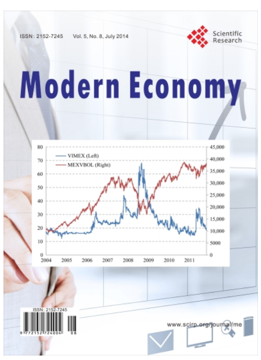
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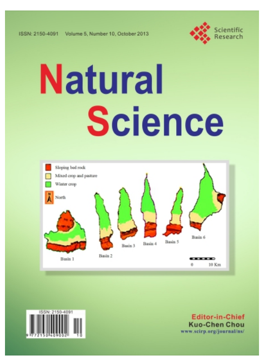
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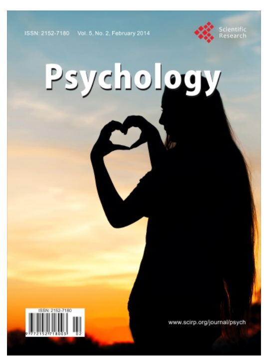
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