



Effect of Dietary Lipid Sources on Feed Utilization, Growth Efficiency and Carcass Composition of *Clarias gariepinus* Juveniles

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study was designed to investigate plant and animal lipid that can enhance feed utilization, growth, and survival of *Clarias gariepinus* Juveniles. Juveniles with mean weight $32.50 \pm 0.5g$ were stocked randomly to seven tanks replicated thrice, with each tank having seven fish each and were fed with the prepared diets with varied lipid. 40% crude protein and isocaloric diets with digestible energy of 2,933.76Kcal were formulated and labelled Diet 1-7 with different sources of plant and animal lipids. Diet 1, 2 and 3 contained palm oil, Groundnut oil and soybean oil respectively, while diet 4, 5 and 6 contained Pork lard, Cod Liver oil and Beef tallow. Diet 7 (Control diet without any lipid source).

The result showed that there was no significant difference ($P > 0.05$) in Feed conversion ratio (FCR) and survival rates among the diets. The mean weight gain was highest in fish fed with pork lard (22.12g) while the lowest value of 15.36g was recorded in fish fed with soybean oil. Relative weight gains and feed intake showed no significant difference ($P > 0.05$) between fish fed lipids of plant origin. However, there was significant difference ($P < 0.05$) among fish fed lipids from animal origin. The Highest Total Cholesterol (28.18 mg/dl) was recorded in fish fed beef tallow as lipid sources

while the least value of low-density cholesterol (value of 2.26 mg/dl) was recorded in fish fed with soybean oil. In conclusion, *C. gariepinus* was able to utilize animal-based lipid sources more in terms of growth and feed utilization while the lipid profile result of the individual carcass after the culture period showed that *C. gariepinus* fed lipid from plant sources had a slightly better cholesterol level than those fed lipid of animal sources.

Keywords: *Clarias gariepinus*; plant lipids; animal lipids; nutrition.

1. INTRODUCTION

Once fish are removed from their natural environment to an artificial one, enough food must be supplied to enable them grow. This could be in the form of complete rations, where the artificial diet furnishes all the nutrients required by the fish or supplementary diets, where part of the nutritional needs of fish is supplied by the natural food in the aquatic environment [1]. Both intensive and semi-intensive fish culture systems involve input of supplementary and complete feed, which account for up to 40% and 60% of production costs respectively [2] and can sometimes negate the economic viability of a farm if suitable feed are not used. This problem has become a major source of fear and phobia to many prospective fish farmers in Nigeria and urgent solution must be proffered if fish farming is to be attractive, lucrative, and sustainable [3]. The principal cost in manufacture of compound feed is that of raw materials, this could amount to as much as 80% more of the manufacturing costs in large size mills [4]. Due to increasing transportation costs and the need to conserve foreign exchange, the tendency in most developing countries will be to use locally available ingredient. Carefully compounded feed when fed at the recommended level (rate) are usually backed by the manufacturer's guidance to meet the nutrient requirements of physiologically defined farm animals for a sustainable level of production.

Dietary lipids are utilized in fish as a major energy source to spare proteins, provide essential fatty acids needed for proper functioning of many physiological processes and maintenance of membrane fluidity and permeability as well as for growth and survival [5]. Dietary lipids also influence flavour and texture of prepared feeds and flesh quality. Although increasing dietary lipids can help reduce the high costs of diets by partially sparing protein in the feed, problems such as excessive fat deposition in the liver can affect fish health and reduce market quality of fish [6]. It is important to investigate the lipid type that can

generate faster growth/fish yield at a cheaper cost without compromising the quality of the fish produced for consumption. This work therefore assesses the Efficiency of lipids from plant and animal source incorporated in the diet of *C. gariepinus* juveniles.

2. MATERIALS AND METHODS

2.1 Experimental Unit and Setup

The study was carried out in the Department of Aquaculture and Fisheries Management Wet laboratory, Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria. The experiment contained seven treatments and three replicates. Twenty-one rectangular plastic tanks measuring (30cm×36cm×52cm) was used for this study.

2.2 Experimental Design

The experiment was laid out as a complete Randomized Design (CRD) with seven treatments and three replicates. Each treatment represents different plant and animal sources while the control diet did not have any lipid source.

2.3 Experimental Fish

One hundred and eighty healthy *C. Garienpinus* Juveniles were obtained from the Department of Aquaculture and Fisheries hatchery unit, University of Benin. They were acclimatized for one week in the laboratory during which they were fed with commercial diet of 42% CP (multi-feed). At the end of the acclimatization, the fish were weighed to get the initial weight and were transferred in batches of seven into each of the experimental units that was replicated three times. The fishes were fed twice daily at 5% body weight to ensure maximum growth between 8:00am-9:00am and 3:00pm-4:00pm. Feeding was monitored for each unit to ensure that fishes were not underfed or overfed. The experimental units were cleaned daily by siphoning with a thin

hose to remove unconsumed feed and faecal waste of the fish to reduce pollution of the water. Water in each unit was reduced by half and replaced before fishes are fed to provide more dissolved oxygen. Total replacement of water and washing of culture unit was carried out during the weekly weighing of fish. All fish per treatment was weighed and counted weekly to determine growth and survival.

2.4 Experimental Diet

Seven 40% crude protein and isocaloric diets with digestible energy of 2,933.76Kcal were formulated and labelled Diet 1-7 with different

sources of plant and animal dietary lipids. Diet 1, 2 and 3 contained palm oil, groundnut oil and soybean oil respectively, while diet 4, 5 and 6 contained pork lard, cod liver oil and beef tallow each diet while Diet 7 served as the control without any lipid source. The rendered animal fats (beef tallow and pork lard) were extracted by washing the fat and heating in a pan until fat melts to extract the oil. The composition of the experimental diet is presented in Table. 1. In preparing the diets, ingredients were thoroughly milled, mixed, and prepared as described by Martínez-Palacios et al. [7] and made into pellets (4mm in dimension) with a pelleting machine. All diets were then sun dried and stored for subsequent use.

Table 1. Gross composition of experimental diets (%)

	T ₁ PMO	T ₂ GNO	T ₃ SBO	T ₄ PKL	T ₅ COD	T ₆ BTW	T ₇ CONT
Fishmeal (65.5% CP)	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Soybean (44% CP)	51.00	51.00	51.00	51.00	51.00	51.00	51.00
Maize (9% CP)	7.16	7.16	7.16	7.16	7.16	7.16	7.16
Wheat offal (13% CP)	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Palm oil	8.00	-	-	-	-	-	-
Groundnut oil	-	8.00	-	-	-	-	-
Soybean oil	-	-	8.00	-	-	-	-
Pork Lard	-	-	-	8.00	-	-	-
Cod liver oil	-	-	-	-	8.00	-	-
Beef Tallow	-	-	-	-	-	8.00	-
Bone meal	4	4	4	4	4	4	4
Vitamin E	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Vitamin AA mixture	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Estimated Crude Protein	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Estimated Digestible Energy	2991.6	2991.6	2991.6	2991.6	2991.6	2991.6	2991.6

Key:

PMO- Palm oil

SBO- Soybean oil

GNO- Groundnut oil

BTW- Beef Tallow

PKL- Pork lard

COD- Cod liver oil

CONT- Control (Zero Oil Supplement)

2.5 Parameters to be Monitored

1. Weight gain (WG) = $W_2 - W_{1(g)}$ (Bagenal, 1978)

Where: W_1 = initial weight
 W_2 = final weight

2. Feed intake = initial weight of feed – final weight of feed. (Bagenal, 1978)

3. Specific growth rate (SGR) % = $\frac{\text{Loge } W_2 - \text{loge } W_1}{T_2 - T_1} \times 100$. (Bagenal, 1978)

Where: T_1 and T_2 are time of experiment in days.

W_2 = final weight at T_2

W_1 = initial weight at T_1

Loge = natural logarithm.

$$4. \quad \text{Relative weight gain (RWG) \%} = \frac{\text{Weight Gain}}{\text{Initial Weight}} \times 100. \quad (\text{Bagenal, 1978})$$

$$5. \quad \text{Survival rate \%} = \frac{\text{Initial stocked} - \text{mortality}}{\text{Initial stocked}} \times 100. \quad (\text{Bagenal, 1978})$$

$$6. \quad \text{Absolute growth rate (AGR)} = \frac{\text{increase in weight}}{\text{time}}. \quad (\text{Bagenal, 1978})$$

$$7. \quad \text{Food Conversion Ratio (FCR) \%} = \frac{\text{Feed Intake(g)}}{\text{Wet Weight Gain(g)}}. \quad (\text{Bagenal, 1978})$$

$$8. \quad \text{Protein Efficiency Ratio (PER) \%} = \frac{\text{Weight Gain (g)}}{\text{Protein Intake}}$$

Where protein intake = feed consumed \times % crude protein. (Bagenal, 1978)

$$9. \quad \text{Net Protein Utilization (NPU)} = \frac{\text{protein gain(g)} \times 100}{\text{Protein intake (g)}}. \quad (\text{Bagenal, 1978})$$

2.6 Proximate Analysis of Diets and Fish Carcass

Samples of Experimental fishes before and after the experiment from each treatment was analysed. Samples from the seven diets were also collected. They were analysed using standard methods of the Association of Official Analytical Chemists (AOAC, 1990) for protein, fat, ash and moisture.

2.7 Lipid Profiling of Experimental Fish

Samples of final carcass from each treatment was taken to Quality Analytical Laboratory, Benin City for lipid extraction and subsequently profiling. The concentrations of total cholesterol (TC), Triglyceride (TG), HDL- cholesterol and LDL cholesterol were determined by enzymatic colorimetric test described by Fossati and Prencipe (1982). In this direct colorimetric procedure, serum triglycerides are hydrolysed by lipase, and the released glycerol is assayed in a reaction catalysed by glycerol kinase and L- a-glycerol-phosphate oxidase in a system that generates hydrogen peroxide. The hydrogen peroxide was monitored in the presence of horseradish peroxidase with 3, 5-dichloro-2-hydroxybenzenesulfonic acid/4-aminophenazone as the chromogenic system. The high absorbance of this chromogen system at 510 nm affords useful results with a sample/reagent volume ratio as low as 1:150, and a blank

sample measurement is not needed. A single, stable working reagent was used; the reaction was complete in 15 minutes at room temperature.

2.8 Statistical Analysis

The data obtained from the feeding trials was analysed using the Genstat Version 8.1 (2005) computer software. Data collected was analysed using one-way Analysis of Variance (ANOVA). Means were separated using Duncan's multiple range tests.

3. RESULTS

3.1 Growth Parameters and Nutrient Utilization

The result of the growth Efficiency recorded in the various treatments are presented on Table 2. From the result in Table 2, Feed incorporated with Pork lad recorded the highest weight gain value of 22.12g while the least weight gain value (15.36g) was recorded in feed with soybean oil. There was no significant difference ($P < 0.05$) between feed with palm oil, groundnut oil and cod liver oil with weight gain value of 17.36g, 16.54g and 17.66g respectively.

The feed intake result showed that feed with pork lad recorded the highest value of 12.31g and was significantly different ($P < 0.05$) from feed with

lipids of plant origin. Fish feed with beef tallow recorded the second highest value of feed consumption (11.65g). Fish feed with groundnut oil recorded the least value for feed intake value. Among the three lipid sources of plant origin, palm oil had the highest value while groundnut oil recorded the least value. For lipids of animal origin, feed with cod liver oil recorded the least feed intake value while feed with pork lad had the highest feed intake value.

The specific growth rate result indicates that fish fed with beef tallow as lipid source had the highest value of 2.29 and was significantly different ($P<0.05$) from other treatments. There was no significant difference ($P>0.05$) between feed with palm oil, soybean oil and cod liver oil with specific growth rate value of 1.95, 1.93 and 1.98 respectively. Fish feed with soybean oil recorded the least SGR value (1.93). Among the three lipid sources of plant origin, groundnut oil had the highest value (2.04) while soybean oil recorded the least value (1.93). However, for lipids of animal origin, feed with cod liver oil had the least SGR value (1.98) while feed with Beef tallow had the highest SGR value (2.29).

The result of the Relative weight gain showed that fish that was fed Beef tallow as lipid source recorded the highest RWG value of 17.58 which was significantly different ($P<0.05$) from fish fed lipid of plant origin. It was however not significantly different ($P>0.05$) from Fish feed with pork lad (16.25), cod liver oil (16.59) and the control diet (15.83). There was no significant difference ($P<0.05$) between the relative weight gain value of fish fed with palm oil (14.64), Groundnut oil (14.43) and Soybean oil (14.40) lipid sources. The least value for relative weight gain across all treatment was record in T₃ which had soybean oil as the lipid source.

The feed conversion ratio for the various treatments were not significantly different ($P>0.05$) from each other. The FCR values recorded were 1.49 (palm oil), 1.55 (groundnut oil), 1.64 (Soybean oil), 1.46 (pork lad), 1.62 (cod liver oil), 1.43 (beef tallow) and 1.42 for the control diet. Since the least feed conversion ratio indicates better conversion of feed to flesh hence control diet had the best FCR value of 1.42 while the worst feed to flesh conversion was found in fish fed with feed of soybean lipid source. From the result of this study there was no mortality recorded across all treatments. Thus, the survival rate of *C. Gariepinus* fed various dietary lipid sources were similar.

3.2 Lipid Profile

The quantitative estimates of the total cholesterol content, triglyceride, high- and low-density lipid cholesterol of *Clarias gariepinus* fingerlings fed different lipid sources of plant and animal origins is shown in Table 3.

3.3 Total Cholesterol

The serum Total cholesterol content of *C. Gariepinus* fed with various lipid sources of plant and animal origin shows that fish fed with feed containing Cod liver oil recorded the least Total Cholesterol value of 14.76mg/dl, this was significantly different ($P<0.05$) from other treatments. Total cholesterol level of Fish fed with Pork lad lipid source (20.13mg/dl) was not significantly different ($p>0.05$) from the control diet but they were however significantly different ($P<0.05$) from the rest treatment. The highest value for total cholesterol (28.18mg/dl) was reported in fish that was fed with Beef tallow as lipid source.

Table 2. Growth Efficiency and nutrient utilization of *C. Gariepinus* fed dietary plant and animal lipids

	T ₁ PMO	T ₂ GNO	T ₃ SBO	T ₄ PKL	T ₅ COD	T ₆ BTW	T ₇ Control	SEM
Weight gain	17.36 ^{bc}	16.54 ^{bc}	15.36 ^c	22.12 ^a	17.66 ^{bc}	21.68 ^a	19.13 ^{ab}	1.54
Feed intake	10.87 ^b	10.49 ^b	10.73 ^b	12.31 ^a	10.91 ^b	11.65 ^{ab}	11.14 ^{ab}	0.60
FCR	1.49 ^a	1.55 ^a	1.64 ^a	1.46 ^a	1.62 ^a	1.43 ^a	1.42 ^a	0.17
SGR	1.95 ^b	2.04 ^{ab}	1.93 ^b	2.17 ^{ab}	1.98 ^b	2.29 ^a	2.09 ^{ab}	0.12
RWG	14.64 ^b	14.43 ^b	14.40 ^b	16.25 ^{ab}	16.59 ^{ab}	17.58 ^a	15.83 ^{ab}	1.20
Survival	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100	-

NB: PMO=Palm oil; GNO= Groundnut oil; SBO= Soybean oil; PKL= Pork lad; COD = Cod liver oil; BTW= Beef Tallow; SEM= Standard error of Mean

FCR= Feed Conversion Ratio; SGR= Specific Growth Rate; RWG= Relative weight gain.

Table 3. Lipid Profile of *Clarias gariepinus* carcass fed with experimental diets

	T ₁ PMO	T ₂ GNO	T ₃ SBO	T ₄ PKL	T ₅ COD	T ₆ BTW	T ₇ Control
TC (mg/dl)	24.60 ^c	24.16 ^c	26.39 ^d	20.13 ^b	14.76 ^a	28.18 ^e	20.13 ^b
HDL (mg/dl)	0.76 ^c	0.95 ^d	19.58 ^e	0.76 ^c	0.95 ^d	0.38 ^b	0.19 ^a
TG (mg/dl)	12.19 ^b	20.73 ^d	22.76 ^e	10.56 ^a	11.78 ^b	15.85 ^c	12.19 ^b
LDL (mg/dl)	21.40 ^d	19.06 ^c	2.26 ^a	17.26 ^c	11.45 ^b	24.63 ^e	17.50 ^c

NB: PMO=Palm oil; GNO= Groundnut oil; SBO= Soybean oil; PKL= Porklard; COD = Cod liver oil; BTW= Beef Tallow; SEM= Standard error of Mean

TC=Total Cholesterol; HDL= High Density Lipid Cholesterol; TG= Triglyceride; LDL = Low Density Lipid Cholesterol.

3.4 High Density Lipid Cholesterol

The result from this study indicates that the level of high-density lipid cholesterol increased from the control diet across the various treatments. The highest value of HDL cholesterol was recorded in the carcass of fish fed with soybean oil with a mean value of 19.58mg/g, this was significantly different ($P<0.05$) from other treatments. The least level of HDL cholesterol was reported in the control diet (0.19mg/ml). There was no significant difference ($P>0.05$) in the HDL cholesterol level between fish fed with groundnut oil as lipid source (0.95 mg/dl) and fish fed cod liver oil as lipid source (0.95 mg/dl).

3.5 Triglyceride

The serum Triglyceride content of *C. Gariepinus* fed with various lipid sources of plant and animal origin showed that fish fed with feed containing Pork lard recorded the least Triglyceride value of 10.56mg/dl, this was significantly different ($P<0.05$) from other treatments. Triglyceride level of Fish fed with cod liver oil lipid source (11.78mg/dl) and palm oil lipid source (12.19mg/dl) were not significantly different ($p>0.05$) from the control diet (12.19mg/dl) but they were however significantly different ($P<0.05$) from the rest treatment. The highest value for Triglyceride (22.76mg/dl) was reported in fish that was fed with Soybean oil as lipid source and it was significantly different ($P<0.05$) from the other treatments. For fish feed incorporated with lipid of animal origin, Beef tallow had the highest value (15.85mg/dl) of Triglyceride.

3.6 Low Density Lipid Cholesterol

The result from this study indicates that the level of low-density lipid cholesterol varied from the control diet across the various treatments. The least value of LDL cholesterol was recorded in

the carcass of fish fed with soybean oil with a mean value of 2.26mg/g, this was significantly different ($P<0.05$) from other treatments. The highest level of LDL cholesterol was reported in carcass of fish fed with feed of Beef tallow lipid source (24.63mg/ml) which was followed by feed of palm oil lipid source (21.40 mg/dl).

4. DISCUSSION

4.1 Feed Utilization and Growth Response

This study suggests that inclusion of the palm oil (PMO), soybean oil (SBO), groundnut oil (GNO), cod liver oil (COD), pork lard (PKL) and beef tallow (BTW) does not impair growth performance of *Clarias gariepinus* juveniles. Similar results were reported for non-salmonids and salmonids in which poultry fat, soybean/corn lecithin, soybean oil, pork lard, beef tallow, goose fat alone or blended with other plant oils and/or animal fats, did not affect the growth parameters in these species [8,9], Liu et al., 2004; Noffs et al., 2009; [10]. In another study growth was similar in all oil and yellow grease treated groups but was retarded in comparison to earlier studies (Genc et al., 2005) and that canola oil can successfully substitute fish oil in rainbow trout feeds [11].

The result of this study also agree with Rosenlund et al. [12] and Bell et al. (2002) who reported that growth and feed utilization efficiency of Atlantic salmon fed crude palm oil were comparable to fish fed equivalent levels of dietary marine fish oils. Legendre et al. [13] also reported that *Heterobranchus longifis* grew better when fed experimental diets containing palm oil compared to fish fed peanut, cotton seed or cod liver oil as lipid source. Similarly, climbing perch (*Anabas tertundineus*), fed 20% dietary palm oil was observed to grow just as well as fish fed a similar level of coconut oil or cod liver oil [14].

This is also in accordance with the reported work of Ng et al. [15], who observed that African catfish, *C. Gariepinus*, showed a better growth when fed with semi purified diets containing 10% palm oil as the sole dietary lipid compared with fish fed cod liver based diets. This was also similar to the observation of Piedecausa et al. [16] who reported that *C. Gariepinus* being a fresh water species is adapted to utilize more of plant lipids.

All the experimental diets in this study were adequately consumed by fish and fish showed no sign of stress. This may imply that there were no palatability problem and feed were adequately utilized. This report is similar to the observation of Aderolu and Akinyemi [17] in the utilization of coconut and peanut oil diets and Sotolu [18] in the utilization of sesame seed and palm oil diets by *Clarias gariepinus*.

From the result obtained in this present study, there was an over 50% increase on fish body weight, each of the tested oils exhibited potential and could be used as a dietary lipid source in feeds for *C. Gariepinus* juveniles. The weight gain was slightly better in diets containing oils of animal origin (Pork lard and beef tallow) than those of animal origin. Palm oil had earlier been used to completely replace fish oil with minimal adverse effect on the growth of *H. Longifilis* fingerlings by Francis et al. (2006). Best results has also been reported in survival and growth with palm oil but slower growth in *H.longifilis* fry fed cod liver oil diet [13]. Interestingly, channel catfish fed beef tallow (high in omega-3 FA's) performed as well at 20°C as did those fed menhaden fish oil (high in omega-3 FA's) in a similar study (Stickney, 1977). Beef tallow also out performed fish fed diets supplemented with safflower oil (high in omega-6 FA's). Palm oil contains both omega-3 and 6 essential fatty acids (EFA's) and is also the richest natural source of α -carotene, tocopherols and tocotrienols which function as antioxidants. These offer beneficial effect to growth and flesh quality when fish are fed high levels of palm oil in their diets (Lim et al., 2001).

The performance of palm oil diets in this study was not the best but it was similar to those of soybean oil and groundnut oil. Fish that had soybean oil included in the diet were observed to be similar in growth (weight gain and SGR) and feed utilization as shown in FCR and PER values to those that had palm oil and groundnut oil. This was similar to the observation of Reginald and Tarila, (2014) on *H. Longifilis* fingerlings

The levels of omega-3 (linolenic) and omega-6 (linoleic) FA's are higher in soybean oil than pork lard (Maynard et al., 1979) and probably palm oil in this experiment. Pork lard predominantly contains saturated and monosaturated FA's. The omega-6 FA's are also more abundant in pork lard than palm oil (Oshoke et al., 2012). Although cod liver oil contains a high level of 20 and 22 carbon omega-3 FA's and omega-6 series [13], biological performance of fish fed cod liver oil diet was below pork lard and beef tallow fed fish in this study. Fish cannot synthesize linolenic and linoleic polyunsaturated FA's but have a requirement of them which should be provided from exogenous dietary sources (Francis et al., 2006). These FA's along with stearic (18:0), palmitic (16:0) and oleic (18: 1n-9) series are probably important for better growth of fish (Sarkar, 2002). Higher weight gains and tissue protein deposition have been associated with increased dietary fats and oil in fresh water fish, therefore quality lipid should be provided in the diet of fish. The experimental oils are of different fatty acid composition. An excess of either omega-3 or 6 FA in the dry diet composition could lead to reduced growth in fish [13]. This reasoning probably explains the cause for the reduced performances particularly in fish fed other lipid sources in this study. Also, Oshoke et al., (2012) reported that the n-3: n-6 polyunsaturated fatty acid balance seems critical in the diet of the African catfish

The conducive culture condition provided by the measured water quality parameters of temperature, ph and dissolved oxygen according to (Sarkar, 2002) aided the good survival rate observed for the test fish. The result shows that there was no mortality recorded across all treatments. This is in line with Konyeme et al. (2005), Ajana et al., (2006), Madu and Aluko [3], who noted that African catfish maintained its aquaculture qualities such as inability to reproduce in captivity, high growth rate, large size, good flesh quality, tolerance to poor water quality, feed responsiveness under natural conditions. Beef tallow and Pork lard diets seems to be better adapted to the environment than the other diets. This is evident on the distribution of size categories with all the size ranges represented. Observations during the experiments showed that the diets containing beef tallow often have the pond water covered with oil film, which is similar to findings of Reginald and Tarila, (2014) and (Okonji and Okafor, 2013) on *Clarias gariepinus*.

4.2 Lipid Profile

The highest value for total cholesterol (26.39mg/dl) was reported in fish that was fed with Soyabean oil as lipid source while the least value of LDL cholesterol was also recorded in the carcass of fish fed with soyabean oil with a mean value of 2.26mg/gl. Richard et al. (2006) and Peng et al. [19] reported that European seabass and black seabeam fed diets containing vegetable oils showed a lower cholesterol content compared to fish fed a fish oil diet. Whereas, other studies (Dannevig and Norum, 1982; Este´vez et al., 1996; Gilman et al., 2003) have shown that the presence of phytosterol in vegetable oils can affect absorption and metabolism of cholesterol in fish.

The transport of lipids and other lipid-soluble components from the intestine to peripheral tissues is predominantly mediated by lipoproteins (Babin and Vernier, 1989). Lipoproteins are classified according to their density into: chylomicrons, very low density lipoprotein (VLDL), low density lipoprotein (LDL), high density lipoprotein (HDL). In fish, it is not yet clearly understood, which route the chylomicrons and VLDL take from the enterocytes (Turchini et al., 2009). LDL-cholesterol transport cholesterol to the arteries where they can be retained in arterial proteoglycans leading to formation of plaques. Thus, increases in LDL-cholesterol level has been associated with atherosclerosis, heart-attack, stroke, peripheral vascular disease [20]. In this study, significant reduction in the level of LDL-cholesterol in the group fed Soyabean oil diet signified a decreased risk of cardiovascular disease since the high androgenic index of TG/HDL-cholesterol had been positively correlated with cardiovascular disease [21]. Crowwell and Otvos [20] reported that the values of LDL-cholesterol/HDL-cholesterol ratio was less than 2.3 and HDL-cholesterol/Total cholesterol was greater than 0.2 in all treated groups and were desirable and non atherogenic.

This lipid class recorded in this study may probably have resulted from the depot subcutaneous fats in fishes that are mostly composed of tags, (neutral lipids) consisting mainly of saturated and monounsaturated fatty acids (MUFA). When fishes are exposed to migration, they actively use the saturated fatty acids as energy source and hardly use the polar lipids which mostly comprise the phospholipids (PL), as a result they are conservatively stored in the tissues and cell membranes (Saito et al.,

1999). Whilst undergoing normal swimming, rapid outbursts when escaping a predator or when chasing preys, during spawning and the development of gonads, these fishes over a short period of time feed little, conditions that are similar to that of the long migration distances.

5. CONCLUSION

Result from this study showed that *C. gariepinus* was able to utilize animal based lipids sources better than plant based lipid sources in term of growth and feed utilization, while the Lipid profile result of the individual carcass after the culture period showed that *C. Gariepinus* fed with plant lipid sources had a slightly better cholesterol level than feed from animal lipid sources.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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