Journal of Environmental Issues and Agriculture in Developing Countries
Volume 12, Number 1, April 2020
ISSN: 2141-2731
Published By
International Centre for Integrated Development Research, Nigeria
In collaboration with
Copperstone University, Zambia.

Growth Performance, Fillet Yield and Composition of *Clarias gariepinus* Fed Diets Containing Microalgae Protein Sources Replacing Fishmeal

Raji A. A.
Jimoh W. A.
Mohd. Taufek N. H.
Alias Z.
Milow P.
Abdul Razak S.

ABSTRACT

Growth performance, fillet yield and composition by Clarias gariepinus fed diets containing microalgae protein sources were investigated in an 84-day feeding trial. Spirulina and Chlorella, was used to replace fishmeal at 50 and 75% respectively producing four test diets. Control diet was without microalgae protein sources. Each dietary treatment was allotted to triplicates groups of fish in a completely randomized design. The results revealed that superior growth was recorded among the microalga fed groups when compared with control diets. Although fish fed CL75% had the highest value of weight gain which was significantly different (p<0.05) from the weight gain by other fish groups, the SP fed groups had higher values of protein retention and protein productive value than the CL fed groups. Significantly higher level of fillet proteins and reduced level of fillet lipid were observed among the fish fed microalgae protein sources than the fish fed control. Comparatively, SP fed groups had higher fillet protein and lipid than CL fed groups, while CL75% group had significantly (p<0.05) highest fillet yield than other fish groups.

***Keywords**: Spirulina, Chlorella, fillet yield, Clarias gariepinus, waste yield*

INTRODUCTION

Fish is made up of high-quality protein, essential minerals and vitamins. It is very rich in Omega-3 series of poly unsaturated fatty acid (Maqsood &Benjakul, 2010). Catfish is well relished by Africans especially Nigerians (Taufek et al., 2016). Its production is more than half of the total fish produced in Nigeria (FAO,

****Raji A.A.** is affiliated with the Department of Science Laboratory, School of Applied Sciences, Federal Polytechnic, Ede, Osun State, Nigeria and the Institute of Biological Sciences, Faculty of Sciences, University of Malaya, Kuala Lumpur Malaysia. **Mohd.Taufek N. H., Alias Z., Milow P. and Abdul Razak S.** are affiliated with the Institute of Biological Sciences, Faculty of Sciences, University of Malaya, 50603, Kuala Lumpur Malaysia, while **Jimoh W. A** is affilaited with the Department of Aquaculture and Fisheries, Faculty of Agriculture University of Ilorin, PMB 1515, Ilorin, Kwara State, Nigeria. *E-mail: ameenatabiodunraji@gmail.com.*

2017) and various forms of it including its waste are now being retailed along the supply value chains in form of whole fish; filleted fish; minced fish, visceral mass and so on, either fresh or smoked (Ayeloja et al., 2017). Preparation of fish products or cut is dependent on carcass quality (Souza et al., 2015). Hence information on chemical quality of fish is very important in determining its nutritional profile which is relevant to consumer's acceptance and demand. Fillet yield and chemical composition is directly related to the type of food consumed by fish (Boran &t Karaçam, 2011). Due to ever increasing growth in aquaculture in the recent time, there is dire need to find alternative to fishmeal which aquaculture relies on for sustainable growth and development in aquaculture industry because fishmeal supply is dwindling by days. A viable option is to look for alternative feed ingredients that will be of minimal competitive use and have good nutritional profiles comparable to fishmeal. Plant protein could have been a veritable alternative but for their lack of comparable nutrient density as fishmeal majorly lacking in some essential amino and fatty acids (Enyidi, 2017). Microalgae has been identified to be very rich in essential minerals, amino acids, fatty acids, carotenoid pigments and some vitamins like vitamin A, vitamin E and ascorbic (Ahlgren et al., 1992; Walker &Berlinsky, 2011). They have been successfully included as dietary components at different life stages of aquatic organisms with emphasis on replacement studies (Olvera Novoa et al., 1998; Badwy et al., 2008).

Kousoulaki et al. (2016) reported that dietary supplementation of micro algae increases dress-out percentage as well as improves fillet quality of Atlantic salmon (Salmo salar L.). Similarly, Jafari *et al.* (2014) reported that inclusion of Spirulina platensis in rainbow trout (Oncorhynchus mykiss) diet improved the fillet fatty acid profile. Micro algae such as Spirulina spp have been reported to enhance growth, reduce stress and improve carcass quality in many fish species (Mustafa et al., 1994; Mustafa et al., 1995; Mustafa et al., 1997). Although Raji et al. (2018) reported Chlorella and Spirulina to be a good antioxidant with high protein content capable of replacing fishmeal in catfish diet with growth, immune response (Raji et al., 2019) improvement and reduced stress condition recorded, paucity of information exists as far as our knowledge is concerned on the effect of dietary inclusion of Spirulina and Chlorella on the fillet quality and composition of African catfish, Clarias gariepinus, Thus this study investigates the fillet quality and composition of African catfish, Clarias gariepinus fed microalgae protein replacing fishmeal.

MATERIALS AND METHOD

Five experimental diets were formulated; the control diet consists of fishmeal

Journal of Environmental Issues and Agriculture in Developing Countries
Volume 12, Number 1, April 2020
ISSN: 2141-2731
Published By
International Centre for Integrated Development Research, Nigeria
In collaboration with
Copperstone University, Zambia.

and soybean as the major protein sources, Based on the nutrient profile of the feed ingredients, the fishmeal portion of the control diets was replaced by *Chlorella vulgaris* (CL) (Taiwan Chlorella Manufacturing Co., Taiwan) or *Spirulina platensis* (SP) (Earthrise Nutritional, CA, USA) powder at 50 and 75% respectively to make four test diets (Table 2). 300 Juveniles of *Clarias gariepinus* (42.07g) were procured from Balakong hatcheries Malaysia and conveyed in aerated plastic bags (filled with pond water and oxygen) to the University of Malaya, Fresh water aquatic laboratory located at the Institute of Biological Sciences in the Faculty of Sciences. They were acclimatized for two weeks weighed before they were randomly grouped into 5 different dietary groups in triplicates of 15 *C. gariepinus* (average weight 42.07± 0.3g) The quality of water in all tanks was monitored according to the procedure described by (APHA, 1992).

Table 1: Gross composition (g/100g Dry Matter) of the experimental diets containing graded levels of Spirulina and Chlorella

	Experimental Diet				
Ingredient	**Control**	**SP50%**	**SP75%**	**CL50%**	**CL75%**
Fishmeal @ 66.32	21.11	10.55	5.28	10.55	5.28
Spirulina @ 60.7	0.00	11.53	17.30	0.00	0.00
Chlorella @ 59.32	0.00	0.00	0.00	11.80	17.70
Soybean @ 44.28	45.17	45.17	45.17	45.17	45.17
Corn meal @ 10.5	9.52	9.52	9.52	9.52	9.52
Vitamin Premix	0.75	0.75	0.75	0.75	0.75
Mineral Premix	0.75	0.75	0.75	0.75	0.75
Methionine	0.75	0.75	0.75	0.75	0.75
Lysine	0.75	0.75	0.75	0.75	0.75
Fish oil	3.80	3.80	3.80	3.80	3.80
Binder	17.40	16.42	15.93	16.15	15.53
Total	100.00	100.00	100.00	100.00	100.00
Proximate composition (DM)					
Moisture	8.42	8.31	8.26	8.19	8.08
Crude protein	35.28	35.34	35.36	35.39	35.22
Crude Lipid	3.71	3.50	3.40	3.83	3.90
Crude Fibre	3.15	3.12	3.10	3.16	3.17
Ash	5.61	4.66	4.18	6.12	6.38
NFE	43.84	45.07	45.70	43.30	43.25
Moisture	8.42	8.31	8.26	8.19	8.08
Crude protein	35.28	35.34	35.36	35.39	35.22
Crude Lipid	3.71	3.50	3.40	3.83	3.90
Crude Fibre	3.15	3.12	3.10	3.16	3.17
Ash	5.61	4.66	4.18	6.12	6.38
NFE	43.84	45.07	45.70	43.30	43.25

Journal of Environmental Issues and Agriculture in Developing Countries
Volume 12, Number 1, April 2020
ISSN: 2141-2731
Published By
International Centre for Integrated Development Research, Nigeria
In collaboration with
Copperstone University, Zambia.

Proximate Analysis of fish fillets

The proximate composition of the experimental diets and ingredients were investigated according to the method reported by Association of Official Analytical Chemist (AOAC, 2005) as described in Raji *et al.* (2018) and Raji *et al.* (2019)

Growth Performance indices

These were calculated as earlier reported in Raji *et al.* (2018) and Raji *et al.* (2019) as:

Mean weight gains = $(W_f – W_i)/n$

Where: W_f: final weight; W_i: initial weight; and n: number of fish.

Specific growth rate = $(\log W_f – \log W_i) \times 100/t$

Where: t = time.

Feed conversion ratio (FCR) = F_i/FW_g

Where: F_i = dry feed fed and FW_g = fish wet weight gain.

Protein efficiency ratio (PER) = MWG/MPI

Where: MWG = mean weight gain and MPI = mean protein fed.

Survival rate = Fn/In x 100

Where Fn= final quantity of fish at the end of experiment and In = initial quantity of fish at the beginning of experiment.

Protein Productive Value (PPV) = FPE/FPB x 100

Where FPE = total fish protein at the end and FPB = total fish protein at the beginning of feeding experiment.

Condition (K) factor = $FW \times 100/ L^3$

Where W = the weight of fish (g) and L = standard length (cm) (Htun-Han, 1978).

Hepatosomatic index = (Liver Weight (g))/Body wieght (g)) x 100

%Flesh Yield = Total weight - Waste yield/Total Weight x 100

%Waste Yield = Total weight - Flesh yield /total weight x 100

RESULTS

Growth Performance

The growth performance and nutrient utilization by *Clarias gariepinus* fed graded level of micro-algae protein sources is presented in Table 3. Superior growth was recorded among the microalga fed groups when compared with control diets. Fish fed CL75% had the highest value of weight gain which was significantly different ($p<0.05$) from the weight gain by other fish groups. However, weight gain by fish fed SP50 and CL50% were not significant ($p>0.05$). Fish fed control diet had the least value of weight gain. Significant variations ($p<0.05$) in the protein productive value and protein retention existed between microalgae fed groups and the control diet fed fish groups. The SP fed groups had higher values of protein retention and protein productive value than the CL fed groups

Table 2: Growth performance and nutrient utilization by *Clarias gariepinus* fed graded level of micro-algae protein sources

	Experimental Diet				
Parameter	**Control**	**SP50**	**SP75**	**CL50**	**CL75**
Initial Weight	42.11±0.32[a]	42.06±0.04[a]	42.05±0.28[a]	42.07±0.07[a]	42.03±0.04[a]
Final Weight	381.89±0.10[d]	387.16±0.16[c]	391.01±0.01[b]	387.26±0.04[c]	394.08±0.06[a]
Weight Gain	339.77±0.01[d]	345.09±84[c]	348.96±1.01[b]	345.18±0.98[c]	352.04±0.97[a]
FCR	0.75±0.00[a]	0.72±0.00[b]	0.71±0.01[bc]	0.72±0.00[b]	0.71±0.01[c]
SGR	2.62±0.00[a]	2.64±0.02[a]	2.65±0.03[a]	2.64±0.03[a]	2.66±0.03[a]
PER	3.04±0.01[c]	3.15±0.01[b]	3.18±0.03[ab]	3.15±0.00[b]	3.21±0.05[a]
PPV	23.47±0.23[d]	26.15±0.01[a]	26.00±0.05[b]	25.44±0.05[c]	25.34±0.05[c]
K-Factor	1.46±0.0.02[b]	1.55±0.05[ab]	1.56±0.04[a]	1.55±0.01[ab]	1.61±0.05[a]
HSI	1.43±0.01[c]	1.59±0.02[b]	1.58±0.02[b]	1.59±0.02[b]	1.70±0.09[a]
Protein Retention	45.09±0.34[d]	49.29±0.09[a]	48.50±0.09[b]	47.74±0.08[c]	47.74±0.08[c]

Values are means of three replicates per diet ± SE. Mean with different superscript in the same row are significant ($p < 0.05$)

Fillet Composition and Yield

The fillet composition of *Clarias gariepinus* juveniles at the beginning and end of the experiment is as presented in Table 4. There was significant increase ($p<0.05$) in protein at the end of the experiment. Microalgae fed groups had significantly higher ($p<0.05$) fillet protein than the control diet fed groups. SP50% had the highest value of fillet protein. The fillet lipid significantly reduced ($p<0.05$) at the end of the experiment. Among the dietary treatment groups, control diet fed groups had the highest fillet lipid which was significantly different ($p<0.05$) from the fillet lipid of other fish groups. The lowest fillet lipid was recorded in the SP75% fed groups.

Table 3: Fillet composition *Clarias gariepinus* juveniles fed diets containing graded levels of microalgae protein sources

		Experimental Diet				
Nutrient	**Initial**	**Control**	**SP50%**	**SP75%**	**CL50%**	**CL75%**
Moisture	7.96±0.01 [a]	4.31±0.01 [c]	3.50±0.01 [e]	4.88±0.01 [b]	3.76±0.02 [d]	4.85±0.01 [b]
Protein	73.35±0.01[d]	84.76±0.08 [c]	87.07±0.56 [a]	86.59±0.01 [ab]	86.29±0.07 [b]	86.15±0.07[b]
Lipid	8.52±0.01 [a]	6.01±0.01 [b]	4.78±0.01 [d]	4.00±0.01 [e]	5.44±0.01 [c]	4.80±0.01 [d]
Ash	9.98±0.01 [a]	4.75±0.01 [b]	4.60±0.12 [c]	4.44±0.01 [cd]	4.48±0.02 [cd]	4.13±0.01 [e]
Fibre	0.19±0.01 [a]	0.17±0.02 [a]	0.05±0.01 [cd]	0.09±0.01 [b]	0.03±0.01 [d]	0.07±0.01 [bc]

Values are means of three replicates per diet ± SE. Mean with different superscript in the same row are significant ($p < 0.05$)

Table 5 presents the flesh and waste yield of *C. gariepinus* fed diets containing graded levels of microalgae protein sources. Significant variations (*p<0.05*) existed in the flesh yield of fish groups exposed to the different dietary treatments. The flesh yield of the microalgae fed groups were significantly higher (*p<0.05*) than that of the control fed group. Conversely, the waste yield of the control fed group was the highest.

Table 4: Flesh and waste yield of *C. gariepinus* fed diets containing graded levels of microalgae protein sources

	Experimental Diet				
Variable	Control	SP50%	SP75%	CL50%	CL75%
Flesh yield	281.20 ± 2.51^{d}	290.59 ± 1.71^{c}	293.84 ± 2.73^{b}	290.63 ± 0.61^{c}	296.39 ± 0.31^{a}
Waste yield	100.69 ± 0.58^{a}	96.57 ± 0.73^{d}	97.17 ± 0.20^{c}	96.62 ± 0.20^{d}	97.69 ± 0.04^{b}
% Head	22.94 ± 0.02^{a}	21.73 ± 0.06^{b}	21.51 ± 0.06^{c}	21.73 ± 0.03^{b}	21.34 ± 0.02^{d}
% Visceral	4.01 ± 0.19^{a}	3.86 ± 0.02^{a}	3.98 ± 0.08^{a}	3.88 ± 0.07^{a}	4.07 ± 0.01^{a}
%Flesh yield	73.05 ± 0.03^{c}	74.41 ± 0.06^{b}	74.51 ± 0.05^{ab}	74.40 ± 0.06^{b}	74.58 ± 0.02^{a}
%Waste yield	26.95 ± 0.06^{a}	25.59 ± 0.05^{b}	25.49 ± 0.06^{bc}	25.60 ± 0.02^{b}	25.42 ± 0.02^{c}

Results are mean values of 15 fish/treatments ± SE with three fish per tank. Mean values with different superscript are significantly different ($p < 0.05$)

DISCUSSION

The present study assessed the effect partial inclusion of *S. platensis* and *C.vulgaris* on growth performance, fillet yield and composition of *Clarias gariepinus* juveniles. Superior growth was recorded among the microalga fed groups when compared with control diets with fish fed CL75% having the highest value of weight gain which was significantly different (*p<0.05*) from that of other fish groups. This may be due to the type of Chlorella (thin and broken cell wall) which makes it highly digestible and the processing method (spray- drying by pressure release) that conserved most of the nutrients within the algae may be responsible for the improved growth of the *Chlorella* Fed fish. Dietary *Chlorella* has also been reported to promote the activity of the digestive enzyme in the hepatopancreas leading to increasing diet utilisation and growth of gibel carp (Xu *et al.*, 2014) *Spirulina* is also linked with increased ability to absorb nutrients (Promya & Chitmanat, 2011) and high digestibility of *S. platensis* and *C. vulgaris* as observed by Raji (2018). Both algae have been found to stimulate the intestinal flora of fish thereby increasing the activity of digestive enzymes resulting in efficient diet utilization (James *et al.*, 2006; Dawood *et al.*, 2016; Khani *et al.*, 2017). Besides, the increase in the value of HSI in the algae fed-fishes could be because of high lipid and buildup of glycogen in the liver (Cazenave *et al.*, 2006).

This shows the availability of a large amount of food at a favourable aquatic environment for growth for the fish fed supplemented diet. Fishes with higher HSI values are more energetic because HSI value is related to the performance and size of the liver. The increase in the value of the K factor, which increases significantly upon diet supplementation, also confirms the favourability of the environmental condition.

The SP fed groups had higher values of protein retention and protein productive value than the CL fed groups with ssignificantly ($p<0.05$) higher level of fillet proteins and reduced level of fillet lipid detected among the fish fed microalgae protein sources than the fish fed control. This corroborate the work of Kim *et al.* (2013). (James *et al.*, 2006) reported that Spirulina increases the breakdown of ingested feed constituents to extract more nutrients and stimulates the production of enzymes that transport fat for metabolism instead of storing them in the fish body through the stimulation of the intestinal flora of fish. Kim *et al.* (2002) also found that *Chlorella* powder at 2% and 4% had positive effect on lipid metabolism of juveniles of Olive flounder by reducing the whole-body fat. The flesh yield of the microalgae fed groups were significantly higher ($p<0.05$) than that of the control fed group. Conversely, the waste yield of the control fed group was the highest. This may be because of the superior weight gain observed in the algae treated group thereby increasing the relative amount of fillets. This is in agreement with Fagbenro (2017) who reported a positive correlation between size of fish, flesh and waste yield of *C .kingsleyae*, Kousoulaki *et al.* (2016) also observed an increase dressed-out percentage and fillet in Atlantic salmon with increasing Schizochytrium algae sp.

CONCLUSION

Spirulina and Chlorella inclusion at 50-75% can successfully replace fishmeal in the diets of *C.gariepinus* juveniles without compromising growth rate fillet composition and yield. Both microalgae improved fillet proteins and quality, and reduced level of fillet lipid of the treated fishes.

REFERENCES

Ahlgren, G., Gustafsson, I.B. , &Boberg, M. (1992). Fatty acid content and chemical composition of freshwater microalgae 1. *Journal of phycology, 28*(1), 37-50.

Ayeloja A. A., George F. O. A., Jimoh W. A. & Abdulsalami S. A. (2017).

Effect of processing methods on consumer's acceptability and proximate composition of yellow croaker (*Larimichthys polyactis*). *Journal of Agriculture and Social Research, 17* (1), 24 – 29.

Badwy, T.M., Ibrahim, E. , &Zeinhom, M. (2008). *Partial replacement of fishmeal with dried microalga (Chlorella spp. and Scenedesmus spp.) in Nile tilapia (Oreochromis niloticus) diets*. Paper presented at the 8th international symposium on tilapia in aquaculture.

Boran, G. , & Karaçam, H. (2011). Seasonal changes in proximate composition of some fish species from the Black Sea. *Turkish Journal of Fisheries and Aquatic Sciences, 11*(1), 01-05.

Dawood, M.A.O., Koshio, S., Ishikawa, M., Yokoyama, S., El Basuini, M.F., Hossain, M.S., . . . Moss, A.S. (2016). Effects of dietary supplementation of Lactobacillus rhamnosus or/and Lactococcus lactis on the growth, gut microbiota and immune responses of red sea bream, Pagrus major. *Fish & Shellfish Immunology, 49*, 275-285. doi:http://dx.doi.org/10.1016/j.fsi.2015.12.047

Enyidi, U. (2017). Chlorella vulgaris as Protein Source in the Diets of African Catfish Clarias gariepinus. *Fishes, 2*(4), 17.

FAO. (2017). Fishery and Aquaculture Country Profiles. Nigeria. Retrieved 26 September 2019, from FAO Fisheries and Aquaculture Department [online]. http://www.fao.org/fishery/

Jafari, S.M.A., Rabbani, M., Emtyazjoo, M. , &Piryaei, F. (2014). Effect of dietary Spirulinaplatensis on fatty acid composition of rainbow trout (Oncorhynchus mykiss) fillet. *Aquaculture International, 22*(4), 1307-1315.

James, R., Sampath, K., Thangarathinam, R. , &Vasudevan, I. (2006). Effect of dietary spirulina level on growth, fertility, coloration and leucocyte count in red swordtail, Xiphophorus helleri. *Israeli Journal of Aquaculture-Bamidgeh, 58*(2), 97-104.

Khani, M., Soltani, M., Shamsaie Mehrjan, M., Foroudi, F. , &Ghaeni, M. (2017). The effects of Chlorella vulgaris supplementation on growth performance, blood characteristics, and digestive enzymes in Koi (Cyprinus carpio). *Iranian Journal of Fisheries Sciences, 16*(2), 832-843.

Kim, K.W., Bai, S.C.C., Koo, J.W., Wang, X.J. , &Kim, S.K. (2002). Effects of dietary *Chlorella ellipsoidea* supplementation on growth, blood characteristics, and whole-body composition in juvenile Japanese flounder *Paralichthys olivaceus*. *Journal of the World Aquaculture Society, 33*(4), 425-431. doi:DOI 10.1111/j.1749-7345.2002.tb00021.x

Kim, S.S., Rahimnejad, S., Kim, K.W. , &Lee, K.J. (2013). Partial replacement of fish meal with *Spirulina pacifica* in diets for parrot fish (*Oplegnathus fasciatus*). *Turkish Journal of Fisheries and Aquatic Sciences, 13*(2), 197-204. doi:10.4194/1303-2712-v13_2_01

Kousoulaki, K., Mørkøre, T., Nengas, I., Berge, R. , &Sweetman, J. (2016). Microalgae and organic minerals enhance lipid retention efficiency and fillet quality in Atlantic salmon (Salmo salar L.). *Aquaculture, 451*, 47-57.

Maqsood, S. , &Benjakul, S. (2010). Preventive effect of tannic acid in combination with modified atmospheric packaging on the quality losses of the refrigerated ground beef. *Food Control, 21*(9), 1282-1290.

Mustafa, G., Wakamatsu, S., Takeda, T.-a., Umino, T. , &Nakagawa, H. (1995). Effects of Algae Meal as Feed Additive on Growth, Feed Efficiency, and Body Composition in Red Sea Bream. *Fisheries Science, 61*(1), 25-28.

Mustafa, M.G., Umino, T. , &Nakagawa, H. (1994). The effect of Spirulina feeding on muscle protein deposition in red sea bream, Pagrus major. *Journal of Applied Ichthyology, 10*(2 3), 141-145.

Mustafa, M.G., Umino, T. , &Nakagawa, H. (1997). Limited synergistic effect of dietary Spirulina on vitamin C nutrition of red sea bream *Pagrus major*. *Journal of Marine Biotechnology, 5*, 129-132.

Olvera Novoa, M., Dominguez Cen, L., Olivera Castillo, L. , &Martínez Palacios, C.A. (1998). Effect of the use of the microalga *Spirulina maxima* as fish meal replacement in diets for tilapia, *Oreochromis mossambicus* (Peters), fry. *Aquaculture Research, 29*(10), 709-715.

Promya, J. , & Chitmanat, C. (2011). The effects of *Spirulina platensis* and Cladophora Algae on the Growth Performance, Meat Quality and Immunity Stimulating Capacity of the African Sharptooth Catfish (*Clarias gariepinus*). *International Journal of Agriculture and Biology, 13*(1), 77-82.

Raji, A., Milow, P., Quazim, J., Alias, Z., Mohd Taufek, N., Simarani, K., . . . Bakar, N. (2019). Dietary Spirulina platensis and Chlorella vulgaris effects on survival and haemato-immunological responses of Clarias gariepinus juveniles to Aeromonas hydrophila infection. *AACL Bioflux, 15*, 1559-1577.

Raji, A.A., Alaba, P.A., Yusuf, H., Abu Bakar, N.H., Mohd Taufek, N., Muin, H., . . . Abdul Razak, S. (2018). Fishmeal replacement with Spirulina Platensis and Chlorella vulgaris in African catfish (Clarias gariepinus) diet: Effect on antioxidant enzyme activities and haematological parameters. *Research in Veterinary Science, 119*, 67-75. doi:https://doi.org/10.1016/j.rvsc.2018.05.013

Souza, M.L.R.d., Macedo-Viegas, E.M., Zuanon, J.A.S., Carvalho, M.R.B.d. & Goes, E.S.d.R. (2015). Processing yield and chemical composition of rainbow trout (Oncorhynchus mykiss) with regard to body weight. *Acta Scientiarum. Animal Sciences, 37*(2), 103-108.

Taufek, N.M., Aspani, F., Muin, H., Raji, A.A., Razak, S.A. , &Alias, Z. (2016). The effect of dietary cricket meal (Gryllus bimaculatus) on growth performance, antioxidant enzyme activities, and haematological response of African catfish (Clarias gariepinus). *Fish Physiology and Biochemistry, 42*(4), 1143-1155.

Walker, A.B. , &Berlinsky, D.L. (2011). Effects of partial replacement of fish meal protein by microalgae on growth, feed intake, and body composition of Atlantic cod. *North American journal of aquaculture, 73*(1), 76-83.

Xu, W., Gao, Z., Qi, Z., Qiu, M., Peng, J.-q. , &Shao, R. (2014). Effect of dietary chlorella on the growth performance and physiological parameters of gibel carp, *Carassius auratus gibelio*. *Turkish Journal of Fisheries and Aquatic Sciences, 14*(1), 53-57.

