E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2020; 8(5): 197-202

www.fisheriesjournal.com
Received: 13-07-2020
Accepted: 15-08-2020

Razia Liaqat
Department of Zoology, Lahore College for Women University, Lahore, Pakistan

Shafaq Fatima
Department of Zoology, Lahore College for Women University, Lahore, Pakistan

Qandeel Minahal
Department of Zoology, Lahore College for Women University, Lahore, Pakistan

Wajeeha Komal
Department of Zoology, Lahore College for Women University, Lahore, Pakistan

Shumaila Munir
Department of Zoology, Lahore College for Women University, Lahore, Pakistan

Corresponding Author:
Razia Liaqat
Department of Zoology, Lahore College for Women University, Lahore, Pakistan

Study of fatty acid profile, serum biochemical parameters and digestive enzymes activity of different fish species cultured in marine and fresh water under higher biomass: A review

Razia Liaqat, Shafaq Fatima, Qandeel Minahal, Wajeeha Komal and Shumaila Munir

Abstract
Stocking density is one of the most significant factors in deciding the efficiency and productivity of the fish. The stocking fish at low density results in high production costs, low economic gain and inadequate utilization of space. Increasing stocking density may activate stress response which negatively affects growth parameters, survival, behavior, health, feeding of fish. Serum cortisol, triglyceride, alanine aminotransferase, aspartate transaminase, alkaline phosphatase and DHA, PUFAs increased significantly as the stocking density increased. So, for good yield fish should be stocked at optimum level. Optimum stocking density is the level where the maximum yields are reached. As stocking density vary from species to species, before stocking any species one must figure out the optimum stocking density to obtain beneficial results.

Keywords: Fatty acid, cortisol, antioxidant resistance, stocking density, stress

Introduction
Stocking density is basically the number of animals kept in given unit of area. It is one of the vital factors in defining the yield and profitability of the fish farm. Be that as it may, high biomass can adversely affect development, behavior of fish, size heterogeneity, physiological reactions, immunity, intestinal micro biota and resistance against disease (North *et al*., 2005) [1] Fish production could increase by increasing biomass but it has adverse relation with fatty acid, amino acid growth parameters and serum level. High biomass may cause poor growth rate, less production and survival chances as well high immune and stress responses (Ellis *et al*., 2002) [2]. High biomass affects the metabolism of fish lipids, especially triglycerides mobilization to energy demand (Alvarellos *et al*., 2005; Martin *et al*., 2017) [21, 22]. The cholesterol levels were significantly increased as the number of fish increased (Ruane, 2001) [23]. An increase in serum aspartate aminotransferase and alanine aminotransferase levels indicates that failure in heart function due to higher biomass. The function of Alanine aminotransferase (ALP) is in nutrient absorption and utilization. Higher level of this enzyme indicates that higher rate of metabolism tend to damage liver (Alvarellos *et al*., 2005) [24] and damage to the liver (Ringo *et al*., 2018) [25]. Free radicals can be removed from body by antioxidant system but external parameters because oxidative stress leads to suppress immune function (Xing *et al*., 2002) [26, 27]. The secretion of goblet cells can keep the integrity of the intestinal mucus barrier [28] and relieve signs of persistent intestinal inflammation (Jaqueline *et al*., 2011) [29]. The intestinal flora of fish is not simplest associated with outside elements however additionally has a mutual interaction with fish itself (Sun *et al*., 2014) [30].

Fatty Acid Profile of Fish
Fish and shellfish are generally accepted as highly nutritious and healthy foods. Fatty acids are heterogeneous group of compound that is composed of long chain hydrocarbons (Figure 1). The contribution of fish for human consumptions and nourishment relies on accessibility, cultural and personal preferences (Beveridge *et al*., 2013) [3]. Quality of fats in fish meat can be determined by *n*-6/*n*-3 ratio.

People feed having *n*-6/*n*-3 fatty acid ratio helps to prevent coronary heart disease by reducing cholesterol in the blood, whereas increased levels of this ratio may lead to cardiovascular disease (Artemis *et al*., 2016) [4]. (Mishra & Samantaray. 2004) [5] studied that at 32 °C lipid level of fish was high whereas at 21 °C lipid contents was less. Tissue monounsaturated fatty acid (MUFA) contents decreased with increasing lipid level at 32 °C, but the reverse occurred at 21 °C. Pamidighantam *et al*. (2010) [6] indicated that Rohu and Murrel fish egg lipids are good sources for polyunsaturated n-3 fatty acids. Swapna *et al*. (2010) [7] described that major fractions of neutral lipids are hydrocarbons sterolesters and triacylglycerol while Palmitic acid and oleic acids were the major fatty acids in the lipid extracts. In most of the fishes, the content of eicosapentaenoic acid and docosahexaenoic acid were higher in visceral lipids. Fatty acid in Rohu, Grass carp and Tilapia was C16:0, ranging from 32.2% to 38.23%. The other major fatty acids detected were C18:0, C18:1 and C18:3. Abou (2013) [8] suggested that for better growth of fish and consumption of good quality fish meat contained essential fatty acids can be achieved if Nile tilapia culture in pond and feed with Azolla diets. Different fishes have different requirement of fatty acid (Table 1). (Bastien & Benjamin, 2019) [13] Studied the impact of different sources of dietary lipids in Nile tilapia. Fish supplementation with palm oil (PO) and Soya oil, (SO) had a higher concentration of 18: 2n - 6, while fish fed with the liver oil (LO) diet had a higher level of 18: 3n - 3 and those who received the fish oil (FO) diet had more 22: 6n – 3 than to those supplemented with vegetable oils. Zhang *et al*. (2020) [14] decided the profile of unsaturated fat organizations of freshwater fish. Unsaturated fat arrangements comprised of 60.12% to 97.14% soaked unsaturated fats (SFA), 0.90% to 19.28% monounsaturated unsaturated fats (MUFA) and 1.17% to 18.35% polyunsaturated unsaturated fats (PUFA). Zhang *et al*. (2020) [14] determined the protein content of *Tilapia zillii* and *Clarias gariepinus* as 19.0% and 18.8% (% wet weight), respectively. The all out lipid content was high for *C. gariepinus* (9.3%) and low for *T. zillii* (1.1)%. Most elevated extents were palmitic corrosive (C16: 0, 22.0-32.2%), myristic corrosive (C14: 0, 4.2-5.2%), palmitoleic corrosive (C16: 1, 3.6-13.2%), heptadecanoic corrosive (C17: 0, 0.7-3.0%), stearic corrosive (C18: 0, 8.1-9.5%), linoleic corrosive (C18: 2, 1.4-12.3%) and oleic corrosive (C18: 1). Erondu & Akpoilih. (2010) [16] studied that palmitic acid was the most abundant fatty acid in *L. rohita*, from 32% to 46% (Table 2).

Effect of Stocking Density on Serum cortisol and Enzymes

Serum cortisol level is an essential indicator of stress response in fishes (Swapna *et al*., 2010) [17] and it indicates that increasing biomass tend to increase stress (Swapna *et al*., 2010; Wang *et al*., 2018) [17, 18]. Anti-stress response, serum level was increased for energy mobilization and Lactate dehydrogenase was used for energy production to resist external stimulation (Jabeen & Chaudhry, 2011; Zarkasi *et al*., 2016) [19, 20]. At higher biomass the antioxidant and digestive capacities of fish tend to decrease. As a result the intestinal microstructures showed inflammation; the numbers of Clostridium, Bactericides, Lactococcus, Lactobacillus and Bacillus decreased significantly, whereas those of Acinetobacter, Aeromonas, Pseudomonas and Vibrio increased significantly (Wong and Rawals. 2012) [31]. Lipid usually store in subcutaneous tissue, belly flap, muscle tissue, liver, mesenteric tissue, and the head but it may vary according to fish species (Sun *et al*., 206) [32]. Palmitic (C16:0) and myristic (C14:0) acids followed by stearic acid are major saturated fatty acids in fish lipids whereas oleic and palmitoleic acids are major monounsaturated fatty acids (MUFA) (Nair *et al*., 2010) [33]. The digestive enzyme, such as lipase, trypsin, and amylase had been reduced with higher number of fish stocked per unit area and the immune associated enzymes, which include lysozyme, also reduced within side the excessive density institution (Nair *et al*., 2010) [33] (Table 4). *Gilthead seabream*, *Sparus aurata* juveniles stock with high biomass indicates that plasma cortisol level tend to increase. Similar results have been described for *Atlantic salmon*, *Salmo salar* (Nayak. 2010; She *et al*., 2019) [34, 35] *Plecoglossus altivelis* (Kwetegyeka *et al*., 2008; Orsavova *et al*., 2018) [36, 37]. The trypsin, amylase, and lipase activities of shrimp drastically reduced with growth in stocking density. Nonspecific immune signs reduced drastically with growth in density, however there have been no significant variations in phrases of the total haemocyte count (THC), phenoloxidase activity (PO), lysozyme (LZM), catalase (CAT), and superoxide dismutase (SOD) (Donga *et al*., 2018) [38]. High biomass had a negative impact at the fitness and welfare of aquaculture fish as well (Sirakov *et al*., 2011) [39]. In particular, high densities could increase stress which causes susceptibility of disease, elevated prevalence of physical injuries (Costas *et al*., 2007) [40] (Table 3).

Poor body condition, and lessen in growth rate as well feed consumption due to high biomass of fish. High stocking density produced a decrease in hepatosomatic index (from 2.26 down to 2.04) and altered liver fatty acid composition. Oleic acid (18: 1n-9) decreased in liver total lipids of fish held at high stocking density and arachidonic acid (20: 4-n6) and n-3 high unsaturated fatty acids (n-3 HUFA) were reduced in liver polar lipids of those fish. These alterations reflect the effect of high biomass on lipid metabolism to help meet the increased energy demand (Montero *et al*., 2009) [41]. Oxidative strain is an unavoidable thing of aquatic life, especially in aquaculture, and the oxidative harm of tissues is without delay related to growth, welfare, fitness and production (Sevcikova *et al*., 2011) [42]. ROS can purpose oxidation of proteins and lipids, changes in gene expression (Grodji *et al*., 2002; Ahmedabad *et al*., 2001) [45] [46]. (Łuczyńska *et al*., 2014) [47] observed that fish held at excessive stocking densities led to remarkably depressed hepatic CAT, SOD and GSH-Px. Fish oils is considered as important sources of omega-3 fatty acids (Mohanty *et al*., 2016) [48] especially docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) which lessen the risk of coronary heart diseases (Łukasik and Pecka. 2017) [49].

Table 1: Fatty acids requirements of different fish species

Fish Species	Requirements of fatty acids (%)	References
Rainbow trout (*Oncorhynchus mykiss*	Linolenic 1%	[54]
Sea bass (*Dicentrarchus labrax*)	Linolenic 0.8%	[54]
Sea bream (*Sparus aurata*)	EPA + DHA 0.4–0.5%	[54]
Common carp (*Cyprinus carpio*)	Linoleic 1%; linolenic 0.5–1%	[54]
Lates calcarifer	n-3/n-6 1.5–1.8	[49]
Grass carp (*Ctenopharyngodon idella*)	Linoleic 1%; linolenic 0.5%	[54]
Tilapia (*Tilapia zilli*)	Linoleic 1%; arachidonic 1%	[54]
Tilapia (*Oreochromis niloticus*)	Linoleic 0.5%	[54]
Red sea bream (*Pagrus major*)	n-3 HUFA at a ratio of 0.5	[15]
African catfish	n-3 PUFA (11.05%)	[16]

Table 2: Fatty acid content (mg/100 g) in the muscle tissue of different fish species cultures in marine and fresh water

#	Fatty Acid (%)	*Labeo rohita* [19]	*C. carpio* [19]	Tilapia [50]	*Pangasius* [50]	*O. mykiss*[51]	*T. putitora* [51]	Grass carp [52]	Bighead carp [52]
1	Caproic	0.03	0.79	0.03	-	0.56	0.12	0.30	0.25
2	Caprylic	0.20	0.27	-	-	-	-	-	-
3	Capric	-	0.02	-	-	-	-	-	0.02
4	Undecanoate	0.007	0.05	-	-	-	-	0.04	0.10
5	Lauric	0.13	0.51	0.11	0.44	0.6	0.5	0.02	0.07
6	Tridecanoate	0.52	0.60	-	-	0.1	0.0	1.76	2.50
7	Myristic	3.17	3.28	2.99	3.70	3.5	5.0	0.28	0.64
8	Pentadecanoic	1.42	1.65	0.46	0.24	0.3	0.6	24.66	21.15
9	Palmitic	32.41	32.96	27.96	29.19	21.8	31.6	0.42	0.63
10	Heptadecanoic	2.30	3.34	0.50	0.26	0.5	0.5	5.48	4.69
11	Stearic	8.19	11.24	6.65	8.14	7.6	9.6	0.15	0.20
12	Arachidic	0.40	0.17	0.26	0.22	-	4.5	0.13	0.05
13	Heneicosanoic	0.17	0.13	0.14	-	-	-	-	-
14	Behenic	0.67	0.31	-	-	-	0.4	0.02	0.01
15	Tricosanoic	0.80	0.11	-	-	-	-		
16	Lignoceric	0.12	0.23	0.32	-	0.21	-	1.80	

Table 3: Pathological effects of oxidized fish oil of different fish species

Fish Species	Pathological Effects	References
Tilapia (*O. niloticus*)	Marked congestion, with some haemorrhage, in dermal vessels around snout and at bases of pectoral/ dorsal fins, lordosis, exopthalmia, abdominal swelling (oedema), cataract, orbital collapse, increased mortality	[53]
Chinook salmon (*O. tshawytscha)*	Dark body colouring, anaemia, lethargy, abnormal kidney and evidence of gill clubbing	[55]
Channel catfish (*I. punctatus)*	Poor growth, poor food conversion efficiency, increased mortality, exudative diathesis, muscular dystrophy, depigmentation, fatty livers	[56]
Yellow tail (*S. quinqueradiata*)	Reduced growth, swollen liver, decreased lipid deposition ; anorexia, leaning of dorsal muscle, muscular dystrophy	[57]
Tilapia (*O. niloticus*)	Swollen pale liver, fatty liver	[58]
Rainbow trout (*S. gairdneri)*	Reduce growth ; poor food conversion efficiency; microcytic anaemia; reduced haematocrit and haemoglobin content, liver lipoid degeneration	[59]

Table 4: Hepatic alanine aminotransferase (ALT), aspartate transaminase (AST), alkaline phosphatase (AKP), cortisol (COR), 5-hydroxytryptamine (5-HT), and glucose (GLU) values of different fish species under high and low biomass

Fish Species	*O. niloticus*		*Blunt snout bream juveniles*		*Largemouth Bass*		*Palaemonetes sinensis*	
Enzymes	Low Density [38]	High Density [38].	Low Density [60]	High Density [60]	Low Density [42]	High Density [42]	Low Density [45, 46]	High Density [45, 46]
ALT (U g–1prot)	93.04	168.58	10.86	13.62	13.02	38.45	8.57	63.10
AST (U g–1prot)	59.52	70.76	83.5	95.04	130.77	140.10	24.19	54.61
GLU (mmol g–1prot)	7.64	3.62	9.77	6.98	8.03	6.08	---	---
COR (ng mg–1prot)	5.99	2.72	26.07	32.06	8.5	8.95	----	---

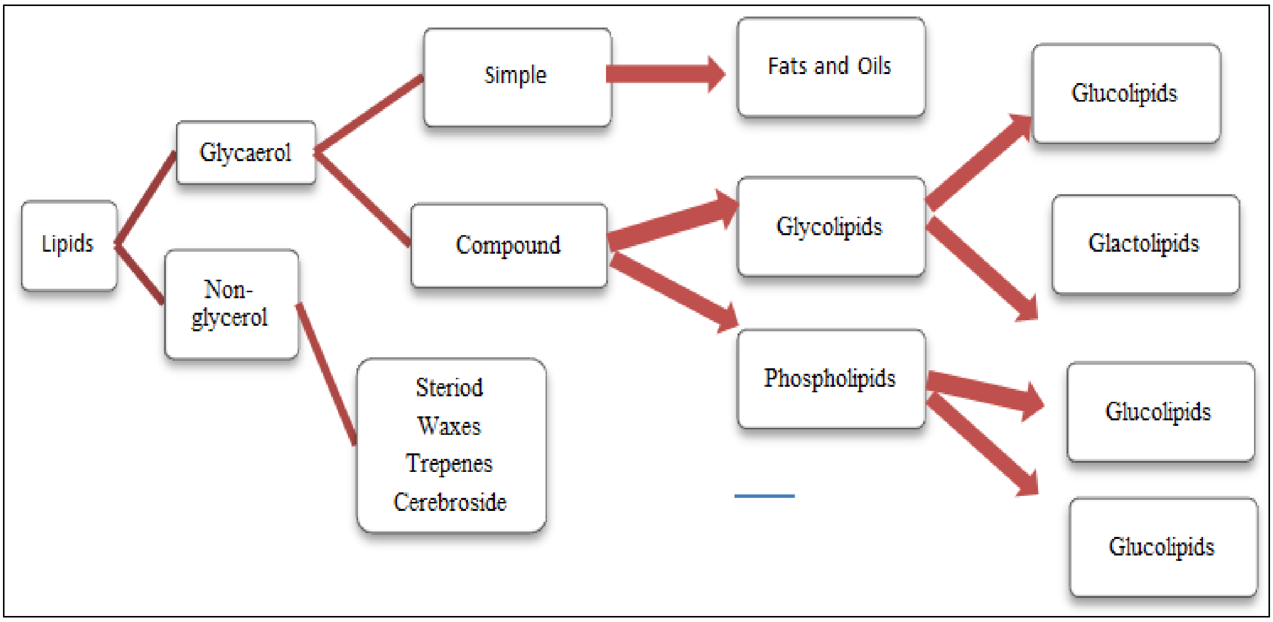

Fig 1: Classification of lipids which are essential for fish growth and metabolism

Conclusion

These results showed that the rearing density has a significant influence on fish growth and results in social hierarchy (bottom settled over swimming) at high density that further causes higher cortisol levels and lower growth rates in low rank individuals.

References

1. North BP, Turnbull JF, Ellis TB, Porter MJ, Migaud HC, Bron J *et al*. The impact of stocking density on the welfare of rainbow trout (*Oncorhynchus mykiss*). Aquaculture. 2005; 255:466-479.
2. Ellis T, North B, Scott AP, Bromage NR, Porter M, Gadd D. The relationships between stocking density and welfare in farmed rainbow trout. Journal of Fish Biology. 2002; 61:493-531.
3. Beveridge M, Thilsted SH, Phillips M, Metian M. Meeting the food and nutrition needs of the poor: The role of fish and the opportunities and challenges emerging from the rise of aquaculture. Journal of Fish Biology. 2013; 83(4):1067-1084.
4. Artemis P, Simopoulos. An Increase in the Omega-6/Omega-3 Fatty Acid Ratio Increases the Risk for Obesity. Nutrients. 2016; 8(3):128.
5. Mishra K, Samantaray K. Interacting effects of dietary lipid level and temperature on growth, body composition and fatty acid profile of rohu, *Labeo rohita* (Hamilton). Aquaculture Nutrition. 2004; 10:359-369.
6. Pamidighantam PR, Tummala J, Karuna MSL, Prasad RBN. Studies on Lipid Profiles and Fatty Acid Composition of Roe from Rohu (*Labeo rohita*) and Murrel (*Channa striatus*). Journal of oleo science. 2010; 59(10):515-9
7. Swapna HC, Rai AK, Bhaskar N, Sachindra NM. Lipid classes and fatty acid profile of selected Indian fresh water fishes. Journal of Food Science Technology. 2010; 47(4):394-400.
8. Abou Y. Growth and fatty acid composition of Nile tilapia *Oreochromis niloticus* L. fed Azolla-diets, in tanks and in earthen ponds: A comparative study. Natural Sciences. 2013; 5(01):77-83.
9. Ayisi CL, Zhao J, Rupia EJ. Growth performance, feed utilization, body and fatty acid composition of Nile tilapia (*Oreochromis niloticus*) fed diets containing elevated levels of palm oil. Aquaculture and Fisheries. 2017; 2(2).
10. Justi KC, Hayashi C, Visentainer JV, Souza N. The influence of feed supply time on the fatty acid profile of Nile tilapia (*Oreochromis niloticus*) fed on a diet enriched with n-3 fatty acids Food Chemistry. 2003; 80(4):489-493
11. Robert A, Mfilinge P, Samwel M Limbu, Chacha J. Fatty Acid Composition and Levels of Selected Polyunsaturated Fatty Acids in Four Commercial Important Freshwater Fish Species from Lake Victoria, Tanzania. Journal of Lipids. 2010, 1-7.
12. Ugoala C, Ndukwe IG, Audu T. Fatty acids composition of some freshwater fish. 2009, 3239.
13. Bastien, Benjamin G. Measuring cortisol, the major stress hormone in fishes Sadoul Journal of Fish Biology. 2019; 94(4):540-555
14. Zhang X, Ning X, He X, Sun X, Yu X, Cheng Y *et al*. Fatty acid composition analyses of commercially important fish species from the Pearl River Estuary, China. 2020; 30:1-7.
15. Osibona AO, Kusemiju K, Akande GR. Fatty Acid Composition and Amino Acid Profile of Two Freshwater Species, African Catfish (*Clarias gariepinus*) And Tilapia (*Tilapia zillii*). African Journal of Food Agriculture Nutrition and Development. 2009; 9(1):1684-5374.
16. Erondu ES, Akpoilih BU. Effect of different dietary lipid sources on growth performance and nutrient utilization of + Nile tilapia (*Oreochromis niloticus*) fingerlings. 2010; 47(4):394-400.
17. Swapna HC, Rai AK, Bhaskar N, Sachindra NM. Lipid classes and fatty acid profile of selected Indian fresh water fishes. Food Science Technology. 2010; 47(4):394-400.
18. Wang WY, Zhu J, Ge XP, Sun SM, Su YL, Li B *et al*. Effects of stocking density on the growth performance, digestive enzyme activities, antioxidant resistance, and intestinal microflora of blunt snout bream (*Megalobrama amblycephala*) juveniles. Aquaculture research. 2018, 1-

11.
19. Jabeen F, Chaudhry AS. Chemical Compositions and fatty acid profiles of three freshwater fish species. Food Chemistry. 2011; 125(3):991-996.
20. Zarkasi KZB, Taylor RS, Guy CJ, Abell, Mark L. Atlantic Salmon (*Salmo salar*) Gastrointestinal Microbial Community Dynamics in Relation to Digesta Properties and Diet. Microbial Ecology. 2016; 71(3).
21. Alvarellos SS, Jose M, Guzman, Carrión RL, Míguez JM. Interactive effects of high stocking density and food deprivation on carbohydrate metabolism in several tissues of gilthead sea bream Sparus auratus. Journal of Experimental Zoology Part A Comparative Experimental Biology. 2005; 303(9):761-75.
22. Martin, Savon L, Gutierrez O, Febles G. Mulberry, moringa and tithonia in animal feed, and other uses. FAO and Instituto de Ciencia Animal. 2017, 29-42.
23. Ruane N. Plasma cortisol and metabolite level profiles in two isogenic strains of common carp during confinement. Journal of Fish Biology. 2001; 59(1):1-12.
24. Alvarellos SS, Míguez JM, Soengas JL. Actions of growth hormone on carbohydrate metabolism and osmoregulation of rainbow trout (*Oncorhynchus mykiss*). General and Comparative Endocrinology. 2005; 141(3):214-25.
25. Ringo E, Hoseinifar SH, Ghosh K, Doan HV, Beck BR, Song SK. Lactic Acid Bacteria in Finfish an Update. Front microbiology, 2018.
26. Xing J, Zhan WB, Zhou L. Endoenzymes associated with haemocyte types in the scallop (*Chlamys farreri*). Fish and Shellfish Immunology. 2002; 13(4):271-8.
27. Jaqueline D Biller, leonardo S, Takahash. Oxidative stress and fish immune system: phagocytosis and leukocyte respiratory burst activity. Anais da Academia Brasileira de Ciências. 2018; 90(4).
28. Sun J, Shen X, Li Y, Guo Z, Zhu W, Zuo L *et al*. Therapeutic Potential to Modify the Mucus Barrier in Inflammatory Bowel Disease. Nutrients. 2014; 8(1):44.
29. Wong S, Ecol JM. RAWLS Intestinal microbiota composition in fishes is influenced by host ecology and environment sandi wong and jo. Molecular Ecology. 2012; 21(13):3100-3102.
30. Sun J, Shen X, Li Y, Guo Z, Zhu W, Zhao L *et al*. Therapeutic Potential to Modify the Mucus Barrier in Inflammatory Bowel Disease. Nutrients. 2016; 8(1).
31. Nair HB, Vivek BSR, Madan RKM, Chaturvedi M, Bharat, Aggarwal B. Delivery of antiinflammatory nutraceuticals by nanoparticles for the prevention and treatment of cancer. Biochemical Pharmacology. 2010; 80(12):1833-1843.
32. Nayak SK. Role of gastrointestinal microbiota in fish. 2010.
33. She P, Wang Y, Liu Y, Tan F, Chen L, Luo Z *et al*. Effects of exogenous glucose on *Pseudomonas aeruginosa* biofilm formation and antibiotic resistance. Microbiologyopen. 2019; 8(12):933.
34. Kwetegyeka J, Mpango G, Nielsen OG. Variation in Fatty Acid Composition in Muscle and Heart Tissues among Species and Populations of Tropical Fish in Lakes Victoria and Kyoga. Lipids. 2008; 43(11):1017-29.
35. Orsavova J, Misurcova L, Ambrozova JV, Vicha R, Mlce J. Fatty Acids Composition of Vegetable Oils and Its Contribution to Dietary Energy Intake and Dependence of Cardiovascular Mortality on Dietary Intake of Fatty Acids. International Journal of Molecular Science. 2015; 16(6):12871-12890.
36. Donga J, Zhaoa YY, YuaYH, Sunb N, LiaYD, Weia H, *et al*. Effect of stocking density on growth performance, digestive enzyme activities, and nonspecific immune parameters of *Palaemonetes sinensis*. Fish and shellfish. 2018; 73:37-41.
37. Sirakov I, Marinova M, Staykov Y, Ivancheva E. Body and carcass parameters of sea bream (*Sparus aurata L*.) and sea bass (*Dicentrarchus labrax* L.). Agriculture Science and Technology. 2011; 3(4).
38. Costas B, Aragão C, Mancera JM, Dinis TM. High stocking density induces crowding stress and affects amino acid metabolism in Senegalese sole *Solea senegalensis* (Kaup 1858) juveniles. Aquaculture Research. 2007; 39(1):1-9.
39. Montero D, Marisol S, Izquierdo, Tort L. High stocking density produces crowding stress altering some physiological and biochemical parameters in gilthead seabream, *Sparus aurata*, juveniles. Fish Physiology and Biochemistry. 1999; 0(1):53-60.
40. Sevcikova M, Modrá H, Slaninova A, Svobodova Z. Metals as a cause of oxidative stress in fish: A review. Veterinární medicína. 2011; 56(11):537-546.
41. Bano Z, Abdullah S, Ahmad W, Zia MA. Assessment of Heavy Metals and Antioxidant Enzyme in Different Organs of Fish from Farm, Hatchery and Indus River of Pakistan. Journal of zoology. 2017; 49(6).
42. Das K, Roychoudhury A. Reactive oxygen species (ROS) and response of antioxidants as ROS-scavengers during environmental stress in plants. Frontiers in Environmental Science, 2014, 2.
43. Grodji A Gbogouri, Linder M, Fanni J, Parmentier M. Analysis of lipids extracted from salmon (*Salmo salar*) heads by commercial proteolytic enzymes. Eurpean journal of lipid science. 2002; 108(9).
44. Ahmedabad B, Bhaskar V, Vikram M. Atmospheric Particulate Pollutants and their Relationship with Meteorology in Ahmedabad, 2001.
45. Łuczyńska J, Paszczyk B, Marek J, Luczynski. Fatty acid profiles in marine and freshwater fish from fish markets in northeastern Poland. Archives of Polish Fisheries. 2014; 22(3):181-188.
46. Mohanty BP, Ganguly S, Mahanty A. DHA and EPA Content and Fatty Acid Profile of 39 Food Fishes from India. Journal of Biomedicine and Biotechnology. 2016; 14.
47. Łukasik RP, Pecka DK. Fatty Acid Profile of Fat of Grass Carp, Bighead Carp, Siberian Sturgeon, and Wels Catfish. Journal of Food Quality. 2017; 1:1-6
48. Lev M, Polat U. Space and time in masking and crowding. Journal of Vision. 2015; 15:10.
49. Adron JW, Knox D, Cowey CB. Studies on the nutrition of marine flatfish. The pyridoxine requirement of turbot (*Scophthalmus maximus*). British Journal of Nutrition. 1978; 40:261-268.
50. Agrawal NK, Mahajan CL. sNutritional deficiency disease in an Indian major carp, *Cirrhina mrigala* Hamilton, due to avitaminosis C during early growth. Journal of Fish Disease. 1980; 3:231-248.
51. Akiyama T. Threonine, histidine and lysine requirements of Chum salmon fry. Bulletin of the Japanese Society of Scientific Fisheries. 1985; 51:635-639.
52. Anderson J. Effects of dietary carbohydrate and fibre on

the tilapia (*Oreochromis niloticus*). Aquaculture. 1984; 37:303-314.
53. Wang L, Hu S, Lou B, Chen D, Zhan W, Chen R *et al*. Effect of Different Dietary Protein and Lipid Levels on the Growth, Body Composition, and Intestinal Digestive Enzyme Activities of Juvenile Yellow Drum Nibea albiflora (Richardson). Journal of Ocean University of China volume. 2018; 17:1261-126.
54. Ackman RG. Characteristics of the fatty acid composition and biochemistry of some freshwater fish oils and lipids in comparison with marine oils and lipids. Composition Biochemical Physiology. 1967; 22:907-22.