International Journal of Agriculture and Plant Science
www.agriculturejournal.in
Online ISSN: 2664-7664
Received: 26-11-2025, Accepted: 21-01-2026, Published: 05-02-2026
Volume 8, Issue 1, 2026, Page No. 112-116

Fatty acid composition of uncooked Pangasius meat studied by gas chromatography

S Dhariniswara, AU Pagarkar, DI Pathan, UM Patel, Panchakarla Sedyaaw, D Swathi, Vikas Kumar
College of Fisheries, Ratnagiri, Maharashtra, India

Abstract
Pangasius catfish culture is widely practiced in India. It has low cost of production, fast growth rate and disease resistance, more freshness, Good market potential in interior areas, especially in restaurants and hotels but it has more fat and hence has an unusual odour, when consumed in processed form affects the marketability and further value addition Also the nutritional value of catfish lipids is low because of a small amount of n-3 family PUFA and high amount of MUFA and SFA. The SFA and Trans C18:1 MUFA can increase the risk of chronic cardiovascular diseases that affect the heart, blood vessels, and brain. An effective processing method can get rid of the fat content in Pangasius catfish fillets and provide a good source of protein foods for consumers. The present project is therefore proposed to analysis of fatty acid composition from catfish fillets.This research proposed a study of saturated and monounsaturated fatty acids from different portion of raw fillets.

Keywords: Panagasius catfish, fatty acid profile, Gas chromatography

Introduction
The Pangasius genus includes the catfish varieties that are commonly found in the Southeast Asian region. It belongs to the family Pangasiidae. The most common variety of cultured fish is *Pangasianodon hypophthalmus*. This fish species is also called Sutchi catfish, striped catfish, or Tra fish. Among all the freshwater species, Pangasius catfish is the world's fastest-growing species in aquaculture. Pangasius is now traded worldwide as skinless and boneless fillets, popularly along with portions, steaks, fillets, and also as value-added products Jeyakumari et al., 2016; Thi et al., 2013)[16]. The fish attains a bodyweight of 1.2 to 1.3 kg rapidly within six months, but is usually harvested after eight months of culture. Pangasius fillets are a good substitute for white-fleshed fish in the market due to their increasing acceptability and popularity; Pangasius is usually served in the European market as skinned and boneless frozen fillets (Noseda *et al.,* 2012)[33]. Currently, these fillets are exported to over 100 countries worldwide. Fillets were characterized by high moisture levels of 80% and, low crude protein of 15.8% and lipid of 3.0% contents. Total lipids were characterized by low cholesterol levels of 40 mg/100 g, high percentages of saturated fatty acids (47.5%) of total fatty acids. Low percentages of polyunsaturated fatty acids (20%) are present in total fatty acids, mainly represented by linoleic acid (60% of total polyunsaturated fatty acids).

Materials and methods
1. Materials
Pangasianodon hypophthalmus were procured from Madurai AM fish farm and fish markets. The fish were kept in insulated iceboxes. An insulated icebox prevents dehydration and temperature fluctuation, thus delaying the spoilage of fish. Further, it is easy to handle. Flake ice produced by a flake ice machine was used for fish transportation and processing purposes. The size of the ice for a 2-3 cm level were produced to keep in the box, and fish were spread on the ice layer, then further steps were carried out.

Method
2.1. Preparation of dressed meat
The raw pangasius sp were purchased from the market and washed with water. If any foreign material adhered to the outer surface, it was removed. The weight of the cleaned fish sp. was noted down. Removal of fins, head, and evisceration was carried out, and further washed in clean water. The weight of dressed meat was noted down.

2.2. Raw of pangasius fillets
- Raw meat (pangasius sp)
- Dressed meat
- Washed with water
- analysis of fatty acid composition
- main composition of SFA and MUFA studied by GC

2.3. Sampling
Random samples were chosen.Samples were collected from raw fillets and their analysis of fatty acid composition. Mainly focus on the study of saturated and monounsaturated fatty acids from fresh fish meats.

2.4. Fatty acid composition analysed by Gas chromatography
Fatty acid is very important components of lipid content. GC is the most common method, which is used for the analysis of fatty acid composition. The fatty acid is a complex structure; it contains more components of fatty acid, such as acylglycerols, cholesterol esters, waxes, and glycosphingolipids. It is extracted by use of saponification hydrolysis, which is done by alkaline medium AOAC, 1990. The FAMEs are extracted by use of the methanol and boron trifluoride. Extraction and methylation, which is done by folch method, are used to obtain the lipid components from the ten grams of fish samples. Esterification was done, take 250g lipid fraction it into toluene in the round-bottom flask. Then, added 4ml sodium hydroxide and refluxed for 5-10minutes until droplets of fat disappear. Added 5ml of methanol and refluxed for another 1min. Cool the content and add 15ml of saturated sodium chloride solution. Then, add 5ml of hexane, shake well, and then remove the upper layer of hexane. Repeat the extraction with hexane twice. It is combine hexane layer and evaporated to dryness in a rotary flask evaporator set at 55-60. The methyl esters in 1ml of HPLC-grade hexane for injection in GC. The column at 210 for 30minutes. Then, inject 0.5ml of the standard FAMEs mixture onto the GC. Then, it starts to separate FAMEs, which takes 45 minutes.

Next, inject 0.5ml of sample FAMEs. Identify the individual fatty acid in the sample by comparing the retention time of the individual fatty acid in the standard mixture. Calculated area unit value expressed as a percentage of the fatty acid of total lipids.

2.5. Statistical analysis
The SPPS 19 (IBM, 2O10) statistical package was used for analysis of experimental results. The results were produced in the mean standard deviation.

Result and discussion
1. Fatty acid composition of Pangasius meat
1.1. Fatty acid composition of uncooked Pangasius meat
Fatty acids are natural compound and it is composed with carbon, hydrogen and oxygen. Fatty acid composition of saturated fatty acid, monounsaturated fatty acid and polyunsaturated and it various with fish species (Pan 2013) [40]. Essential fatty acid supplied advantages to health. Fish contained excessive quantity of long chain polyunsaturated fatty acids (Hogberg and Pickova 2002) [14]. Especially omega-3 lengthy chain fatty acids that's vital in human weight loss program. PUFA have more than one double bond (Ekstrom 2003). Even as MUFA have one double bond SFA don't have any double bond (Pickova and Hogberg 2002) [14]. Fatty acid furnished the electricity for vegetation and animals (Pickova and Hogberg 2002) [14]. A few PUFA which are found in meals are determined as vital to humans due to linolenic acid and linoleic acid. EPA have acquired from DPA and DHA however it ought to come from specific proportion (Rust and Whelan 2006) [50]. DPA turned into commonly uncommon fatty acid determined in small amount in animals (Ratledge, 2004) [43]. Fish comprise higher amount of DHA than EPA (Rust and Whelan 2006) [50]. The EPA and DHA had been integrated to meals due to its beneficial outcomes on fitness (Mraz, 2012) [30]. Along with replacing fish raw cloth with plant based totally cloth its miles decreased the level of long chain n-3 fatty acids it's far gives to low advantages to human fitness (Trattner 2009) [47]. Fatty acid composition is affect by way of lipid content material of feed in step with fish (Henderson and Tocher 1987) [13].

Fatty fish are number one supply of long chain n-3 fatty acids EPA and DHA those are all above three fatty acids are stricken by weight loss plan, season, location, age water temperature and sex (Fleming *et al*., 2011). Fish is a primary source of PUFA for given advantages to humans however it need to contain the fatty acids composition various with equal people (Ozogul and Ozogul 2007) [38]. Many sparkling water fish have greater quantity of n-6 PUFAs and n-3/n-6 ratio (Caproni *et al* 2008). Visceral oil carries better quantity of SFA and MUFA and decrease amount of PUFA, EPA and DHA (men *et al*., 2005; Nhu, 2003) [27, 32]. The sutchi fish now not taken into consideration for dietary high-quality due to fatty acid profile (Mohan *et al*., 2008) [29]. Pangasius fillets have extra MUFA and SFA and amount of PUFA (Orban *et al*., 2008) [37]. The fish feed with the aid of fish meal and oil enriched pellets feed containing high amount of PUFAs and especially high amount of n3 fatty acids (Halilogul *et al*., 2004; Kolakowska *et al*., 2006). Fatty acid composition varies with unique part of fish (Saify *et al*., 2003) [45]. And fatty acids composition varies with fish species it became discovered through (Saify *et al*., 2003) [45]. Fish oil contained fatty acid composition variant its miles immediately affect nutritional, texture and organoleptic homes of fish (Palmeri *et al*., 2007).

Exchange in fatty acid composition in particular level EPA and DHA in fish products reduces its acceptability (Coello *et al*, 1999) and it additionally dietary benefits to the customers (Trushenski *et al*., 2006) [48]. It's miles centred on studied on fatty acid composition of three extraordinary fish species of marine fishes *Tenualosa toli* (Terubok), *Rastrelliger kanagurta* (Kembong), *Stolephorus baganensis* (Bilis) and 3 freshwater fishes *Channa striatus* (Haruan), *Pangasius hypothalamus* (Patin), *Clarias macrocephalus* (Keli) have been done. Studies on marine fishes it is contained extra unsaturated fatty acids with 3,4,5 and 6 double bonds comparatively than in freshwater fishes. Another fatty acid composition n-three polyunsaturated fatty acids (PUFAs); eicosapentaenoic acid (EPA) and docasahaexaenoic acid (DHA) had been observed greater in marine fishes PUFAs than in freshwater fishes. Based totally on the fatty acids content of DHA, EPA and arachidonic acid (AA), *Stolephorus baganensis* offers the exceptional source of it (4.68%,10.5%, 4. 68%) observed by way of *Rastrelliger kanagurta* (10.62%, 4.85 %, 3.17%) and *Tenualosa toli* (9.93%, 2.50%,0. 16%). However, freshwater fishes showed small variety of DHA (0. 63% - 1.41 %), EPA (0.11 % -0.25%) and AA (1.41% - 4. 46%). SFA particularly palmitic is a main fatty acid composition its miles located in all fishes. Majid *et al*. (2003) [26], reported a fatty acid methyl ester as used to synthesize via one step extraction-trans esterification method.

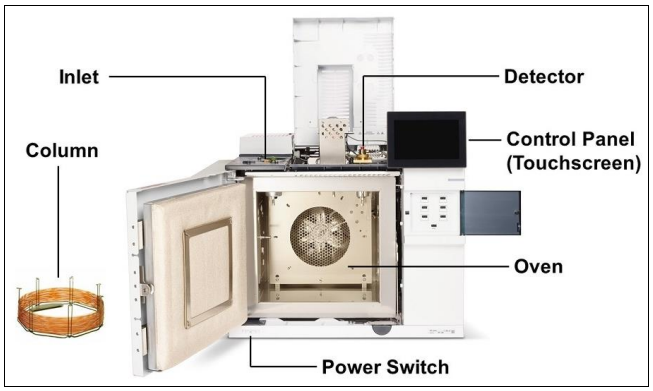
The present study used gas chromatography to estimate different portions of fat from fish meat and their fatty acid composition. Uncooked Pangasius meat carries head portion of saturated fatty acid-53.04%, monounsaturated fatty acid-40.7% and polyunsaturated fatty acid-7.06%. Body portion of saturated fatty acid-51. 77%, monounsaturated fatty acid-40.44% and polyunsaturated fatty acid-7.06%. Ventral portion of saturated fatty acid-50.37%, monounsaturated fatty acid-40.47% and polyunsaturated fatty acid-7.07%. Tail part of saturated fatty acid-46.79 %, monounsaturated fatty acid-39.83 % and polyunsaturated fatty acid-6.94 %.

Table 1: Fatty acid composition of Pangasius fillets

Compounds	Fatty acids	Raw head portion	Raw body portion	Ventral portion	Tail portion
C 4:0	Butyric acid	0.46	0.47	0.44	0.39
C 12:0	Lauric acid	0.42	0.3	0.35	0.2
C 14:0	Myristic acid	7.20	7.15	6.87	5.38
C 14:1	Myristoleic acid	0.91	0.73	0.84	0.87
C 15:0	Pentadecanoic acid	0.18	0.37	0.24	0.42
C 15:1	Cis-10 Pentadecanoic acid				
C 16:0	Palmitic acid	34.23	34.62	33.78	32.16
C 16:1	Palmitoleic acid	1.85	1.91	1.97	1.89
C 17:0	Heptadecanoic acid	0.16	0.18	0.24	0.14
C 17:1	Cis-10 Heptadecanoic acid	0.00	0.16	0.15	0.18
C 18:0	Stearic acid	6.74	6.98	6.34	6.25

C 18:1t	Vaccenic acid	36.64	36.48	35.21	35.78
C 18:2t	Linolelaidic acid	4.86	4.78	4.63	4.79
C 18: 2 n6c	Linoleic acid	0.16	0.19	0.21	0.14
C 18:3n3	α-Linolenic acid	0.34	0.49	0.41	0.31
C 13:3 n6	Ɣ-Linolenic acid	0.25	0.29	0.31	0.28
C 20:1	Cis-11 Eicosenoic acid	1.14	1.16	1.17	1.11
C 20:2	Eicosadienoic acid	0.2	0.23	0.25	0.19
C 20:4n6	Arachidonic acid	1.25	1.08	1.26	1.23
C 20:3	Dihomo-γ-linolenic acid	0.00	0.00	0.00	0.00
C 21:0	Henicosanoic acid	2.26	0.41	0.6	0.58
C 22:0	Behenic acid	0.17	0.19	0.21	0.15
C 22:1n9	Erucic acid	0	0	0	0
C 22:2	Docosadienoic acid	0	0	0	0
C 22:6n3	Docosahexanoic acid	0	0.0	0.0	0.0
C 23:0	Tricosanoic acid	0.05	0.07	0.09	0.03
C 24:0	Lignoceric acid	1.10	1.03	1.21	1.09
C 24:1	Nervonic acid	0	0.0	0.0	0.0
Unknown		4.39	0.73	1.04	4.44
Total		100	100	100	100

Samples	Raw meat head portion (%)	Raw body portion (%)	Raw ventral region(%)	Raw tail portion (%)
Saturated fatty acids	53.04	51.77	50.37	46.79
Mono-unsaturated fatty acids	40.7	40.44	40.47	39.83
Poly-unsaturated fatty acids	7.06	7.06	7.07	6.94



Conclusion

The different portion of Pangasius meat had been envisioned the fatty acid composition together with saturated and mono-unsaturated fatty acid from the Pangasius fillets. Saturated fatty acid extra present inside the head location evaluate than different quantities. Mono-un-saturated fatty acid has contained more quantity on the head region evaluate than other component. Poly-unsaturated fatty acid is to be discovered in higher amount ventral element examine than other portions.

Acknowledgement

The authors express their sincere gratitude to the Department of Fish Processing Technology, College of Fisheries for providing the necessary laboratory facilities and technical support to carry out this research work. The authors also acknowledge the assistance received from Madurai AM Fish Farm and local fish markets for the supply of Pangasius samples. The support and guidance provided by faculty members and technical staff during sample collection, analysis and data interpretation are gratefully acknowledged.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

Data Availability

The data generated and analyzed during the present study are included in this published article. Additional data related to the study are available from the corresponding author upon reasonable request.

Ethics Statement

The present study did not involve any live animal experimentation or human participants. Pangasius (*Pangasianodon hypophthalmus*) samples used in this study were procured from commercial fish farms and local fish markets. All procedures were conducted in accordance with institutional guidelines and standard laboratory practices for food and fish product analysis. Therefore, ethical approval was not required for this study.

Reference

1. Ahmed J, Ramaswamy HS, Ayad A, Alli I, Alvarez P. Effect of high-pressure treatment on rheological, thermal and structural changes in Basmati rice flour slurry. Journal of Cereal Science,2007:46(2):148-156.
2. AOAC, AOAC Official methods of analysis, 2000.
3. Asmah R, Sumaiyah SS, Nurul SR. Comparison of protein, total fat, and omega-3 fatty acids content in yellowtail catfish (*Pangasius pangasius*) and long tail shad (Hilsa (clupea) macrura) in raw and pressurized fish. International Food Research Journal,2014a:21(6): 2147.
4. Asmah R, Sumaiyah SS, Nurul SR. Comparison of protein, total fat, and omega-3 fatty acids content in yellowtail catfish (*Pangasius pangasius*) and long tail shad (Hilsa *Clupea macrura*) in raw and pressurized fish. International Food Research Journal,2014b:21(6):2147.
5. Bochi VC, Weber J, Ribeiro CP, Victório ADM, Emanuelli T. Fishburgers with silver catfish (*Rhamdia quelen*) filleting residue. Bioresource Technology,2008:99(18):8844-8849.
6. Dreeling N, Allen P, Butler F. Effect of cooking method on sensory and instrumental texture attributes of low-fat beef burgers. LWT-Food Science and Technology,2000:33(3):234-238.
7. El-Shimi NM. Influence of microwave and conventional cooking and reheating on sensory and chemical characteristics of roast beef. Food chemistry,1992:45(1):11-14.

8. Ezhil C. Superheated steam drying of foods—A review. World journal of dairy and food sciences,2010:5(2):214-217.
9. Fito P, Chiralt A, Martin ME. Current state of microwave applications to food processing. Novel food processing technologies, 2005, 525-537.
10. Folch J, Lees M, Stanley GS. A simple method for the isolation and purification of total lipides from animal tissues. Journal of biological chemistry,1957:226(1): 497-509.
11. Gall KL, Otwell WS, Koburgier JA, Appledorf H. Effects of four cooking methods on the proximate, mineral and fatty acid composition of fish fillets. Journal of Food Science,1983:48(4):1068-1074.
12. Harris K, Fleming J, Kris-Etherton P. Challenges in estimating omega-3 fatty acid content of seafood from US nutrient databases: A salmon case study. Journal of Food Composition and Analysis,2011:24(8):1168-1173.
13. Henderson RJ, Tocher DR. The lipid composition and biochemistry of freshwater fish. Progress in lipid research,1987:26(4):281-347.
14. Hogberg A, Pickova J. Dublirvad duater: fettsyro i foder, kottoch manniska. Sveriges Lantbruksuniversitet, 2002.
15. Idrus NFM, Yang TA. Comparison between roasting by superheated steam and by convection on changes in colour, texture and microstructure of peanut (*Arachis hypogaea*). Food Science and Technology Research,2012:18(4):515-524.
16. Jeyakumari A, Janarthanan G, Chouksey MK, Venkateshwarlu G. Effect of fish oil encapsulates incorporation on the physico-chemical and sensory properties of cookies. Journal of food science and technology,2016:53(1):856-863.
17. Kjeldahl C. A new method for the determination of nitrogen in organic matter. Z Anal Chem,1883:22:366.
18. Kołakowska A, Domiszewski Z, Kozłowski D, Gajowniczek M. Effects of rainbow trout freshness on n-3 polyunsaturated fatty acids in fish offal. European Journal of Lipid Science and Technology,2006:108(9):723-729.
19. Koubaa A, Mihoubi NB, Abdelmouleh A, Bouain A. Comparison of the effects of four cooking methods on fatty acid profiles and nutritional composition of red mullet (*Mullus barbatus*) muscle. Food Science and Biotechnology,2012:21(5):1243-1250.
20. Kremelberg D. Practical statistics: A quick and easy guide to IBM® SPSS® Statistics, STATA, and other statistical software. SAGE publications, 2010.
21. Kucukgulmez A, Celik M, Yanar Y, Ersoy B, Cikrikci M. Effects of different cooking methods on the proximate composition and mineral contents of sea bass (*Dicentrarchus labrax*). Advances in food sciences,2006:28(4):223-227.
22. Larsen D, Quek SY, Eyres L. Effect of cooking method on the fatty acid profile of New Zealand King Salmon (*Oncorhynchus tshawytscha*). Food Chemistry,2010:119(2):785-790.
23. Lee JS. Commercial Catfish Farming, 337, Interstate Publishers, Danville, IL, 1991.
24. Long NV, Yang Y, Thi CM, Van Minh N, Cao Y, Nogami M, *et al*. The development of mixture, alloy, and core-shell nanocatalysts with nanomaterial supports for energy conversion in low-temperature fuel cells. Nano Energy,2013:2(5):636-676.
25. Lovkvist S. An investigation of the lipid content and lipid composition in Atlantic salmon, pink salmon and striped catfish, obtained at the local retailers in Uppsala, Sweden, 2014.
26. Majid MIA, Endarti E, Hashim R, Chong A. Direct FAME Synthesis for Rapid Total Lipid Analysis from Fish Oil and Cod Liver Oil. Journal of Food Composition and Analysis,2003:18:161-171.
27. Men LT, Thanh VC, Hirata Y, Yamasaki S. Evaluation of the genetic diversities and the nutritional values of the Tra (*Pangasius hypophthalmus*) and the Basa (*Pangasius bocourti*) catfish cultivated in the Mekong river delta of Vietnam. Asian-australasian journal of animal sciences,2005:18(5):671-676.
28. Mizrahi S. Mechanisms of objectionable textural changes by microwave reheating of foods: a review. Journal of food science,2012:77(1):R57-R62.
29. Mohan CO, Ravishankar CN, Srinivasagopal TK. Effect of O2 scavenger on the shelf-life of catfish (*Pangasius sutchi*) steaks during chilled storage. Journal of the Science of Food and Agriculture,2008:88(3):442-448.
30. Mraz J. Lipids in common carp *(Cyprinus carpio)* and effects on human health, 2012, 2012(75).
31. Neff MR, Bhavsar SP, Braekevelt E, Arts MT. Effects of different cooking methods on fatty acid profiles in four freshwater fishes from the Laurentian Great Lakes region. Food chemistry,2014:164:544-550.
32. Nhu DH. 'DHA (Docosahexaenoic acid) source from Basa (*Pangasius bocourti*) catfish oil (in Vietnamese)', Procedings of Scientific Report of the Chemistry Society, Ho Chi Minh City, Ho Chi Minh City Chemistry Society, 2003.
33. Noseda B, Islam MT, Eriksson M, Heyndrickx M, De Reu K, Van Langenhove H, *et al*. Microbiological spoilage of vacuum and modified atmosphere packaged Vietnamese *Pangasius hypophthalmus* fillets. Food Microbiology,2012:30(2):408-419.
34. Noseda B, Islam MT, Eriksson M, Heyndrickx M, De Reu K, Van Langenhove H, *et al*. Microbiological spoilage of vacuum and modified atmosphere packaged Vietnamese *Pangasianodon hypophthalmus* fillets. Food Microbiology,2012a:30(2):408-419.
35. Nurhan U. Change in proximate, amino acid and fatty acid contents in muscle tissue of rainbow trout (*Oncorhynchus mykiss*) after cooking. International journal of food science technology,2007a:42(9):1087-1093.
36. Nurhan U. Change in proximate, amino acid and fatty acid contents in muscle tissue of rainbow trout (*Oncorhynchus mykiss*) after cooking. International journal of food science technology,2007b:42(9):1087-1093.
37. Orban E, Nevigato T, Di Lena G, Masci M, Casini I, Gambelli L, *et al*. New trends in the seafood market. Sutchi catfish (*Pangasianodon hypophthalmus*) fillets from Vietnam: Nutritional quality and safety aspects. Food Chemistry,2008:110(2):383-389.
38. Ozogul Y, Ozogul F. Fatty acid profiles of commercially important fish species from the Mediterranean, Aegean and Black Seas. Food Chemistry,2007:100(4):1634-1638.

39. Palmeri G, Turchini GM, Caprino F, Keast R, Moretti VM, De Silva SS, *et al*. Biometric, nutritional and sensory changes in intensively farmed Murray cod (*Maccullochella peelii*, Mitchell) following different purging times. Food chemistry,2008:107(4):1605-1615.
40. Pan J. Effects of non-fish based raw materials on the fish muscle quality of salmonids, 2013, 2013(91).
41. Perez-Coello MS, Sanz J, Cabezudo MD. Determination of volatile compounds in hydroalcoholic extracts of French and American oak wood. American Journal of Enology and Viticulture,1999:50(2):162-165.
42. Raj AJA, Haniffa MA, Seetharaman S, Appelbaum S. Utilization of various dietary carbohydrate levels by the freshwater catfish *Mystus montanus* (Jerdon). Turkish Journal of fisheries and aquatic sciences,2008:8(1):31-35.
43. Ratledge C. Fatty acid biosynthesis in microorganisms being used for single cell oil production. Biochimie,2004:86(11):807-815.
44. Regulska-Ilow B, Ilow R. Comparison of the effects of microwave cooking and conventional cooking methods on the composition of fatty acids and fat quality indicators in herring. Food/Nahrung,2002a:46(6):383-388.
45. Saify ZS, Akhtar S, Khan KM, Perveen S, Ayattollahi SAM, Hassan S, *et al*. A study on the fatty acid composition of fish liver oil from two marine fish, *Eusphyra blochii* and *Carcharhinus bleekeri*. Turkish Journal of Chemistry,2003:27(2):251-258.
46. Şengor GFU, Alakavuk DU, Tosun ŞY. Effect of cooking methods on proximate composition, fatty acid composition, and cholesterol content of Atlantic Salmon (*Salmo salar*). Journal of aquatic food product technology,2013:22(2):160-167.
47. Trattner S. Quality of lipids in fish fed vegetable oils, 2009, 2009(31).
48. Trushenski JT, Kasper CS, Kohler CC. Challenges and opportunities in finfish nutrition. North American Journal of Aquaculture,2006:68(2):122-140.
49. Weber J, Bochi VC, Ribeiro CP, Victório ADM, Emanuelli T. Effect of different cooking methods on the oxidation, proximate and fatty acid composition of silver catfish (*Rhamdia quelen*) fillets. Food Chemistry,2008a:106(1):140-146.
50. Whelan J, Rust C. Innovative dietary sources of n-3 fatty acids. Annu. Rev. Nutr,2006:26:75-103.S