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Evaluation of Nutritional Quality of Caspian Shad Muscle, *Alosa caspia caspia* (Eichwald, 1838) in Southern Caspian Coast

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Abstract: The main aim of this research is to identify fatty acids and nutritional quality of Caspian Shad muscle. Caspian shad muscle contains 17.1% crude protein and 2.82% crude fat. Caspian shad muscle dedicated, appropriate amino a cid, they included, Gluatamic acid (13.66%), Aspartic acid (10.65%), Valine (9.04%), Leucine (8.7%) and Argenine (6.11%). Caspian Shad muscle tissue amino acids had high nutritional value compared to other fish. The obtained results of UFA and SFA show they were, 74.14% and 36.87 %, respectively, in fresh tissue, so that, DHA (C22:6n-3) and cis vassenic (C18:1n-9) have high amounts (12.16, 22.41) of UFA and palmitic acid (23.57 %) was the most SFA. The ratio of n-3 to n-6 poly unsaturated fatty acid (PUFAs) was 2.50%, thus Caspian shad muscle is rich in n-3 PUFA. Therefore the fish can be recommended as a good source of poly unsaturated fatty acid for the health of the consumers.

Key words: Amino acid · Fatty acid · Proximate composition · n-3/n-6.

INTRODUCTION

The shads or river herring make up the genus *Alosa*, this fish related to herring in the family of *clupeidae*. Several species can be found on both sides of the Atlantic Ocean and Mediterranean Sea. Genus *Alosa* can also be found throughout the Caspian Sea. Many are found in freshwater during spawning and some are only found in landlocked freshwater. *Alosa* is generally pelagic. They are mostly anadromous or semi anadromous with the exception of strictly freshwater landlocked species. *Alosa* is generally migratory and schooling fish. There are species native to the Black Sea and Caspian Sea, as well as the Persian Gulf. *Alosa* species of the Caspian are systemically characterized by the number of rakers on the first gill arch by some scientists.

Fats supply energy and contain essential fatty acids and serve as a carrier for the absorption of the fat-soluble vitamins A, D, E and K and carotenoids [1, 2]. Fats are a source of antioxidants and numerous bioactive compounds and serve as building blocks of membranes and play a regulatory role in numerous biological functions. Dietary fat is found in foods derived from both plants and animals [3]. Proteins are major components of all muscles, tissues and organs and are necessary and crucial in every process that occurs within the body such as metabolism, digestion and transportation of nutrients and oxygen in the blood. They are also necessary for the production of antibodies, which fight against microbial infections and are the main nutrients that keep our hair shiny, nails strong, our skin fresh and are important to growing our bones strong and healthy [4]. The best sources of complete protein are found in animal foods such as meat, fish and shellfish. Muscle tissue of fish is an important source of protein for humans [5]. Fish is safer and healthier to be consumed compare with goat, mutton, buffalo and chicken meat [6]. Generally, fish has been widely accepted as a good source of protein and other elements necessary for the maintenance of healthy body [7, 8]. The nutritional quality of fish is highly associated with its content of essential fatty acids (EPAS). ω-3 polyunsaturated fatty acids cannot be synthesized effectively by human and must be obtained by diet [9,10]. Generally the main part of fish used for human nutrition is muscles.

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The long chain polyunsaturated fatty acid has gained global attention because of its role in human coronary artery disease prevention, development of retina and brain and also decrease incidence of breast cancer, rheumatoid arthritis, multiple sclerosis, psoriasis and inflammation. Omega3 fatty acids seem to have small, dose-dependent hypotensive effect, the extent of which seems to be dependent on the degree of hypertension. DHA seems to be more effective than EPA in lowering blood pressure [11]. Thus analysis of fatty acid profiles of the tissues, such as muscles from fish living in their natural ecosystem, can yield valuable information [12, 13]. There are also differences in terms of fatty acid composition between fresh water and marine fish. Fresh water fish is generally recognized to contain lower levels of ω-3 PUFA than marine fish. However, there is a big variation in fatty acid composition of different individual fish of the some species. Diet, location and season are the major factors affecting the fatty acid composition [14 - 16].

Several previous studies papers have reported the composition of fresh and marine water fish. Determining the amino acid and fatty acid profiles of Shad river muscle (anadromous fish) will improve the nutritional information available to researchers. The objectives of this study were to analyze the amino acid and fatty acid composition of *Alosa caspia caspia* muscles and determine its nutritional quality.

METHODS AND MATERIALS

Sample Preparation: The experimental fish were obtained from natural conditions. 50 pieces of Caspian Shad (*Alosa caspia caspia*) were caught by Beach Seine from Caspian southern coast line, Mahmoodabad city, Mazandaran Province, Iran. Wet body weight was 600±15g and body length was 30±5cm. Samples were transported to the laboratory under the ice at a ratio of 1 to 1.

Proximate Composition Analysis: Moisture content was measured by drying sample in an oven at 105°C until a constant weight was obtained [17]. Crude protein content was determined by kjeldahl method [17] and a conversion factor of 6.25 was used to convert total nitrogen to crude protein. Fats were determined colorimetrically according to Blight and Dyer [18]. Ash was determined by mineralization at a temperature 550-600°C [17].

Amino Acid Analyses: Amino acid composition of samples was measured according to high performance liquid chromatography (HPLC) and fluorescence detector (USA, CA. San Clara, series 1100, A gilet). The 0.2 gram of sample was hydrolyzed for 20 hours at 110°C with 6 N HCl in sealed glass tubes filled with nitrogen gas, without oxygen. Fluorescence detector at wavelengths of 250 and 395 nm and a temperature of 40°C was activated. Fluorescence detector using a combination of specific amino acids from 12.5 to 75 Pykvmvl was calibrated. The content of tryptophan was determined by colorimetric method [19] after alkaline hydrolysis of each sample. All measurement was carried out in triplicate.

Determination of Fatty Acid Profile: Total lipid was extracted by chloroform-methanol (1:1v/v) and estimated gravimetrically [14]. The fatty acids in the total lipids were esterified into methyl esters by saponification with 0.5 N methanolic NaOH and transeserified with BF3[1] (w/v) methanol [17].

The FAMEs[2] were analyzed on HP5890 Series II GC[3] equipped with gas chromatograph with a FID[1] and a 30m capillary column with an internal diameter of 0.25 mm, liquid phase Supelco wax 10, film thickness 0.25 μm. Separation conditions: nitrogen carrier gas, flow rate of 1μL/min. Temperature of the detector was 260 °C; of the injector 250 °C and of the column, 155°C. The individual fatty acids were identified by comparing their retention times with the standards of Supelco.

Statistical Analysis: Calculations made were the mean, standard deviation and coefficients of variation in percent. Statistical comparisons among data were made using statistical software SPSS version 13 for windows.

RESULTS AND DISCUSSION

Proximate Composition: The proximate composition of Caspian Shad is shown in Table1. Crude protein, crude fat and crude ash content of the Caspian Shad muscles were 17.1, 2.82 and 1.7%, respectively. The crude fat content

[1]: Tri Fluoride Bore
[2]: Fatty Acids Methyl Esters
[3]: Gas Chromatograph
[4]: Flame Ionizing Detector

Table 1: Proximate composition of Caspian Shad muscle

Component	Moisture (%)[a]	Crude protein (%)[a]	Crude Fat(%)[a]	Crude Ash (%)[a]
Mean	77.35	17.1	2.82	1.7
SD	0.03	0.03	0.01	0.03

Table 2: Essential Amino acid composition of Caspian Shad muscle

Non Essential amino acid	*Content (DW%) Mean±SD*
Argeinine	6.1±0.02
Histidine	1.15±0.01
Isoleusine	6.84±0.02
Leucine	8.7±0.05
Lysine	2.98±0.05
Phenyalanine	3.42±0.04
Taurine	5.89 ±0.01
Valine	9.04±0.02
Metionine	4.06±0.05
Total	48.18±0.02

Table 3: Non Essential Amino acid composition of Caspian Shad muscle

NonEssential amino acid	*Content (DW%) Mean±SD*
Gluatamic acid	13.66±0.03
Serine	7.03±0.01
Aspartic acid	10.65±0.04
Glycine	5.48±0.07
Alanine	9.31±0.09
Tyrosine	2.61±0.04
Total	48.74±0.04

was higher than the amount found in *Aspius aspius, Exoux lacius, Mugil cephalus* and *Zander luciperca* [20 - 22]. The crude fat content was lower than the amount found in *Rutilus frisii kutum* (anadromous fish Caspian Sea) [23]. The varied content of fat was compensated by the content of water. Low fat fish have higher water contents and as a result, their flesh is in color [24]. Based on fat and moisture Caspian Shad is a lean fat fish, with a fat content 2-5% by weight. Fat content is influenced by species, seasons, geographical regions, age and maturity [25].

Amino Acid Composition: The essential amino acid composition of Caspian Shad muscle is shown in Table 2. Caspian Shad protein has a high amount of essential amino acid; they include Valine (9.04%), Leucine (8.70%), Isoleusine (6.84%) and Argenine (6.01%). Caspian Shad is also reach in valine and leusine.

They are not produced by the body and must be extracted from food. Valine is an essential amino acid and is required for muscle metabolism, repair and growth of tissue and maintaining the nitrogen balance in the body. Valine also assists to regulate blood sugar and energy levels. Leucine is an essential amino acid which assists to regulate blood sugar and energy levels, production of the human growth hormone, wound healing as well as the growth and repair of muscle tissue. Leucine can also assist in the prevention of the breakdown of muscle proteins that may occur after severe stress or trauma. Valine is part of the three branched chain amino acids (BCAA) - the other two are Leusine and Isoleousine [26].

Low amount of essential amino acid have contained Metionine (4.06%), Phenyalanine (3.42%), Lysine (2.98%) and Histidine (1.15%). Histidine is an essential amino acid that your body needs during periods of growth, stress and recovery from illness and injury, but minimum amount of an essential amino acid in Caspian Shad muscle was Histidine (1.15%).

Histidine is one of the basic amino acids due to its aromatic nitrogen-heterocyclic imidazole side chain. This amino acid is metabolized into the neurotransmitter histamine and the set of genes that produce the enzymes responsible for histidine synthesis. Histidine is also a precursor of histamine, a compound released by immune system cells during an allergic reaction. It is needed for growth and for the repair of tissue, as well as the maintenance of the myelin sheaths that act as protector for nerve cells. The non essential amino acid composition of Caspian Shad muscle is shown in Table 3.

Caspian Shad proteins have contained a high amount of non essential amino acid, they are included Glutamic acid (13.66%), Asparticacid (10.65%), Alanine (9.31%) and Argenine (6.01%). Caspian Shad proteins have contained a high amount Glutamic acid. Glutamic acid, a non-essential amino acid is synthesized from a number of amino acids including Ornithine and Argenine, it helps with the transportation of potassium across the blood-brain barrier, although it does not pass this barrier that easily. Glutamic acid can be used as fuel in the brain and can attach itself to nitrogen atoms in the process of forming glutamine and this action also detoxifies the body of ammonia. This action is the only way in which the brain can be detoxified from ammonia [20]. Low amount of non essential amino acids have contained Glyscine (5.48%) and tyrosine (2.61%).

Fatty Acid Composition: Fatty acid composition is shown in Table 4. The fatty acid profile of the Caspian Shad was dominated by saturated fatty acid (SFAs), which comprised about 36.87% of total fatty acid. Among, the SFAs, palmitic acid (16:0) was the dominated saturated

Table 4: Fatty acid composition of Caspian Shad muscle

	Fatty acid	*Mean±SD*
Saturated fatty acid (%)[a]	C14:0	2.85 ±0.05
	C16:0	23.57±0.05
	C17:0	4.11±0.05
	C18:0	5.76±0.10
	C24:0	0.58±0.07
	ΣFA	36.87±0.06
Mono saturated fatty acid (%)[a]	C18:1n-9	22.41±0.07
	C18:1n-7	3.27 ±0.09
	ΣMUFA	25.68±0.08
Poly unsaturated fatty acid (%)[a]	C18:2n-6	5.72 ±0.06
	C18:3n-3	1.01±0.04
	C20:4n-6	1.05±0.06
	C20:5n-3	3.11±0.05
	C22:6n-3	12.16±0.07
	ΣPUFA	48.73±0.06
Other fatty acid (%)[a]	ΣPUFAn-3	16.76
	ΣPUFAn-6	6.73
	PUFAn-3/ ΣPUFAn-6	2.50

[a]*Percentage of total fatty acid*

fatty acid, according for 23.57 of total fatty acid. These results are in agreement with previous studies on SFAs of other species [5,20, 27- 29].

Mono saturated fatty acids (MUFAs) and poly unsaturated fatty acids (PUFAs) accounted for 25.68% of the total fatty acids and 48.73% of the total fatty acids, respectively. The main mono saturated fatty acid was Oleic acid (C18:1n-9), accounting for 22.41% of the total fatty acids, followed by cis-vaccenic acid (C18:1n-7) (3.27%). 8 fresh water species (*Rutilusfrisi kutum, Clupeonella cultiventris, Cyprinus carpio, Sander luciperca, Salmo salar, Onchorhynchus mykiss, Mugil cephalus* and *Liza aurata*) were investigated and results showed, Oleic acid of MUFAs was dominated fatty acid in species [30].

The dominate PUFA was DHA (C22:6n-3), accounting for 12.60% of the total fatty acids, followed by LA (C18:2n-6), EPA (C20:5n-3), ALA (C18:3n-3) and AA (C20:4n-6). However, except for LA (5.72%) all of these three fatty acids were present in minor (1.01-3.11%).

In last decades, PUFAs of ω_3 family have been recognized to be essential components of human diet [31]. These acids, particularly EPA (C20:5n-3) ω3 & DHA (C22:6n-3) ω6, appeared to play key role in ontogenesis□especially neural development Functioning of cardiovascular system and immune system.

Regular consumption of food with appropriate content of EPA and DHA provides prevention and treatment of depression cardiovascular and some other diseases [32- 33]. The benefits effects of fish consumption are depending on both fat content and PUFA composition [34].

Researches on marine fat and oils begun from several decades. The fatty acid of Rainbow trouth (*Onchorhynchus mykiss*), Atlantic salmon(*Salmo salar*) and Herings(*Clupeidae heringus*) fish tissue have been identified in this regards [35].

Previous researches have been reported that diet rich in poly unsaturated fatty acid increase the amount of serum glucose, because decline insulin secretion, feeding dietary fish and fish oil/meal to human and animals, decreased blood pressure, glucose content were higher [36].

Sixty percent of heart attacks occur without due to irregular heartbeats which the fatty acid DHA can prevent. Some studies have indicated that that EPA is more effective for lowering blood triglycerides. Both DHA and EPA lower triglycerides by reducing the rate of fatty acid synthesis in the liver [37].

The n-3 and n-6 PUFA of the Caspian Shad accounted for 16.63% and 6.73% of total fatty acids, respectively. The results of this study showed that total n-3 fatty acids were higher than n-6 fatty acid. The n-3/n-6 ratio is good index for comparing relative nutritional value of fish oil of different species and a higher ratio of n-3/n-6 PUFAs has often been cited as an index of nutritional value. The ratio of n-6/n-3 PUFAs found in this study was lower than the value (4.0 at maximum) recommended by the UK Department of Health [38]. Values higher than the maximum are harmful to health and may promote cardiovascular disease [39].

This was confirmed by data obtained by Zmijewski *et al*. [21] who found that, freshwater carnivorous fish can be characterized by greater n-3/n-6 fatty acid ratio than phytophagous and benthophagous cyprinoid fish (tench, ide, crucian carp, grass carp). Differences in fatty acids of marine and freshwater fishes should not only be considered with respect to species habitat but also based on their natural diet, especially whether a species is herbivorous, omnivorous or carnivorous [40]. Apart from that, size, age, reproductive status of fish, environmental conditions and especially water temperature, influence lipid content and fatty acid composition of fish muscle to a lipid content and fatty acid composition of fish muscle to a certain extent [41-42].

CONCLUTION

Determination of fatty acid composition indicated the palmitic acid (C16:0) and oleic acid (C18:1n-9) more abundant SFA and MUFA in Caspian Shad muscle. Caspian Shad muscle is high quality protein source with

a well-balanced composition of essential amino acids. Caspian Shad fish muscle consumption growth and development of children with cerebral neurons due to the amount of protein and fatty acids is recommended.

REFERENCES

1. Abd Rahmans, S., S.H. The, H. Osman and N.M. Daud, 1995. Fatty acid composition of some Malaysian freshwater fish. Journal of Food Chemistry, 90: 45-49.
2. Abourg, S. and C. Pineiro, 2004. Biochemical changes and quality chilled storage of farmed turbot (*Psetta maxima*). Journal of Food Chemistry, 90(3): 445-452.
3. Abourg, S. and I. Medina, 1999. Influence of storage time and temperature on lipid deterioration during Cod (*Gadus morhua*) and Haddock (*Melnogrammus aeglefinus*) frozen storage. Journal of the Science of Food and Agriculture. 79(13): 1943-1948.
4. Camposp, R., C. Martino and L.C. Trugo, 2006. Amino acid composition of Brazilian surbim fish (*Pseudoplatystoma coruscans*) fed diets with levels and sources of fat. Journal Food Chemistry, 96: 126-130.
5. Feng, Z., Z. Ping and S. Chao, 2010. Amino acid and fatty acid composition and nutritional quality of muscle in the pomfret (*Pampus punctatissimus*). Journal Food Chemistry, 2: 224-227.
6. Aberoumand, A. and K. Poursharifi, 2010. Chemical and proximate composition properties of different fish species obtained from Iran. World Journal of Fish and Marine Science, 2(3): 237-239.
7. Aberoumand, A. and H. Jooyandeh, 2010. Storage quality and chemical and structural changes of fresh and frozen- thawed fish. World Journal of Fish and Marine Science, 2(3): 251-253.
8. Taghiof, M., M. Nikoo and K.H. Pourshamsian, 2012. Proximate and fatty acid composition of salted Caspian kutum (*Rutilus frisii*) rose influenced by storage temperature and vacuum-packaging. World Journal of Fish and Marine Science, 4(5): 525-529.
9. Cherif, S., F. Frikha, Y. Gargour and N. Miled, 2008. Fatty acid composition of green crab (*Carcinus mediterraneus*) from the Tunisian Mediterranean Coasts. Journal of Food Chemistry, 111(4): 930-933.
10. Smida, M.A., M. Ben, E. Band and M. Cafsi, 2009. The composition of fatty acids in the tissues of Tunisian swordfish (*Xiphias gladius*). Journal of Food Chemistry, 115(2): 522-.528.
11. Aberoumand, A., 2010. The effects of fish oil and marine omega-3 fatty acids on human health. World Journal of Fish and Marine Science, 2(3): 226-231.
12. Gulzar, S. and M. Zuber, 2000. Determination of omega-3 fatty acid composition in freshwater fish. International Journal of Agriculture and Biology, 2: 342-373.
13. Ferreira de Castro, F., H. Pinheiro Sant'Ana, F. Campos, M. Brunoro Costa, M. Coelho Silva and S. Castro Franceschini, 2007. Fatty acid composition of three freshwater fishes under different storage and cooking processes. Journal of Food Chemistry, 103(45): 1080-1090.
14. Rasoarahona, J.R.E. and G. Barnathan, 2005. Influence of season on the lipid content and fatty acid profiles of three Tilapia species (*Oreochromis niloticus*, *O. macrochir* & *Tilapia rendalli*) from Madagascar. Journal of Food Chemistry, 1: 230-235.
15. Ozogul, Y., F. Ozgoul and S. Alagoz, 2006. Fatty acid profiles and fat contents of commercially important seawater and freshwater fish species of Turkey: A comparative study. Journal Food Chemistry, 103(1): 217-223.
16. Latyshev, N.A., S.P. Kasyanov, V.I. Kharlamenkoand and V.I. Svetashev, 2009. Lipids and of fatty acids of edible crabs of the north-western Pacific. Journal of Food Chemistry, 116(3): 657-661.
17. AOAC, 1990. Official Methods of Analysis (15th edition), Association of Official Analytical Chemists, Arlington, V.A. The Association, USA.
18. Blight, E.G. and W.J. Dyer, 1959. A rapid method of total lipid extraction. Journal of Biochemistry. 37: 911-917.
19. Bash, S.M.M. and R.M. Roberts, 1977. A simple colorimetric method for the determination of tryptophan. Analytical Biochemistry, 77: 378-386.
20. Celick, M. and A. Diler, 2005. A comparison of the proximate composition and fatty acid profiles of Zander (*Sander lucioperca*) from two different region and climatic condition. Journal of Food Chemistry. 92: 637-641.
21. Zmijewski, T. and R. Kujawa, 2006. Slaughter yield Proximate and fatty acid composition and sensory properties of Rapfen (*Aspius aspius*), with tissue of Bream (*Abramis brama* L.) and Pike (*Esox lucius* L.). Journal of Food Composition and Analysis, 19: 176-181.
22. Ozogul, Y. and F. Ozgoul, 2007. Fatty acid profiles of commercially important fish species from the Mediterranean, Aegean and Black seas. Journal of Food Chemistry, 100: 1636-1638.

23. Jalili, S., 2012. Influence of frozen storage time on unsaturated fatty acid and proximate composition Caspian Sea white fish (*Rutilus frisii kutum*) fillets. Journal of Agriculture Science and Technology. 2(3): 378-384.
24. Guler, G.O., B. Kiztanir, A. Aktumsek, O.B.Citil and H. Ozparlak, 2008. Determination of the seasonal changes on total fatty acid composition and ω3/ω6 ratios of Carp (*Cyprinus carpio* L.) muscle lipids in Beysehir Lake (Turkey). Journal of Food Chemistry, 108(2): 991-996.
25. Jabeen, F. and A. Chaudhry, 2010. Chemical compositions and fatty acid profiles of three freshwater fish species. Journal of Food Chemistry, 125(37): 991-996.
26. Hoyle, N.T. and T.T.S.H. Merri, 1994. Quality of fish protein hydrolysis from Herring (*Clupea harengus*). Journal of Food Science, 59: 76-79.
27. Zuraini, A. and M.N. Somchit, 2006. Fatty acid and amino acid composition of three local Malaysian *Channa spp*. fish. Journal of Food Chemistry, 97: 674-678.
28. Mnari, A. and I. Bouhle, 2007. Fatty acid in muscle and liver of Tunisian Wild and farmed Gilthead Sea Bream (*Sparus aurata*). Journal of Food Chemistry, 100: 1393-1397.
29. Ahmed Louly, A. El-Gaydou and E. Kebir, 2011. Muscle lipids and fatty acid profiles of three edible fish from the Mauritanian Coast: *Epinephelus aeneus*, *Cephalopholis taeniops* and *Serranus scriba*. Journal of Food Chemistry, 124(1): 24-24.
30. Hajirostamloo, B. and M. Hajirostamloo, 2010. The omega-3 fatty acids content of some Iranian fresh water fish species. World Journal of Fish and Marine Science, 2(4): 258-290.
31. Arannilewa, S.T., S.O. Salawu and A. Sorungbe, 2006. Effect of frozen period on the chemical microbiological and sensory quality of frozen Tilapia fish (*Sarotherodun galiaenus*). Journal Nutr. Health, 18(2): 185-192.
32. Gladysher, M.I., O.N. Nushchik and G.S. Kalachova, 2008. Content of essential poly unsaturated fatty acid three flat head fish species. International Journal of Food Science and Nutrition, 108(8): 1-7.
33. Mayneris-Perxachs, J., I. Bondia-Pons, L. Serra-Majem, A. Castellote and M. López-Sabater, 2010. Long-chain n-3 fatty acids and classical cardiovascular disease risk factors among the Catalan population. Journal of Food Chemistry, 119(1): 54-61.
34. Moini, S., Z.H. Khoshkhoo and R. Hematimatin, 2012. The fatty acid profile in Mackerel (*Scomberomorus gattatus*) and its shelf life in cold storage at -18°C. Global Veterinaria, 8(6): 665-669.
35. Moini, S., Z.H. Khoshkhoo and R. Hematimatin, 2012. The Iranian (*Asipencer persicuse*) and Russian (*Asipencer guldenstaedtii*) sturgeons fatty acid changes during cold storage. Global Veterinaria, 9(1): 38-41.
36. Chekani-Azar, S., H. Aghdamshahryar and N. Maheri-sis, 2012. Effects of fish oil supplementation on cholesterol and blood glucose levels of diabetic rats. Global Veterinaria, 4(6):558-561.
37. Jankowska, B., Z.Z. Akęś, T. Żmijewski and M. Szczepkowski, 2010. Fatty acid profile of muscles, liver and mesenteric fat in wild and reared Perch (*Perca fluviatilis* L.). Journal of Food Chemistry, 118(3): 764-768.
38. HMSO, U.K., 1994. Nutritional aspects of cardiovascular disease (report on health and social subjects). No, 46, London: HMSO.
39. Leaf, A. and P.C. Webber, 1998. Cardiovascular effects of n-3 fatty acids, New England Journal of Medicine, 318: 549-555.
40. Badii, F. and N. Howell, 2001. A comparison of biochemical changes in Cod (*Gadus morhua*) and Haddock (*Melanogrammus aeglefinus*) fillets during frozen storage. Journal of the Science of Food and Agriculture, 82: 87-97.
41. Simoenidou, S. and A. Govaris, 1998. Quality assessment of seven Mediterranean fish species' during storage on ice. Journal Food Research International, 30(7): 479-484.
42. Bryhni, E.A., 2002. Poly unsaturated fat and fish oil in diets for growing-fishing pigs: effects on fatty acid composition and meat, fat and sausae quality. Journal of Meat Science, 62(1): 1-8.