Comparative Studies On Muscle Lipid Fatty Acid Profiles Of Some Cultured Indian Carp Species

Kaur M, Sehgal G.K. and Sehgal H. S

M.sc, Department of Zoology, Punjab Agricultural University Ludhiana, Punjab.

Abstract

The Polyunsaturated fatty acids (PUFAs), mainly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), help in preventing coronary heart disease. These fatty acids play an important role in reducing the risk of colon, breast and prostate cancer. Although, carps form the major chunk of harvested fish worldwide, the information about their fatty acid profiles is meager.The present study was conducted to know the seasonal variations on muscle total lipid content (MTLC) and fatty acid profiles of three Indian carp species, Labeo. rohita(Ham.), Catla. catla (Ham.) and Cirrhinusmrigala (Ham.). The MTLC varied within the species of fish (1.06±0.02% in C. mrigala to 3.00±0.06% in C. catla) and season of the year. The minima were recorded during spring except C .mrigala (summer) and maxima during winter in all species. The total PUFAs highest in C. catla (23.21±3.67%) ***)*** *and minimum in C. mrigala (18.50±4.95%)***).***The mean ratio of n3/n6 was highest (1.49) in C. catla and lowest (0.89) in C. mrigala.*

1. Introduction

Fishes are considered as high quality human food and a rich source of proteins (15-25%), minerals (Ca, P, Fe) and vitamins (A,D,E,K). Recently, interest has grown in fish and fish products as sources of polyunsaturated fatty acids (PUFAs), mainly of the n-3 family (also known as omega-3 fatty acids). Special attention is being paid to long chain omega-3 fatty acids (LC-PUFA) or highly unsaturated fatty acids (n-3 HUFA) i.e. eicosapentaenoic acid (EPA, C20:5n-3) and docosahexaenoic acid (DHA, C22:6n-3). This interest stems largely from those studies which have suggested that n-3 PUFAs may have an important role in prevention and management of cardiovascular diseases (Glomset,1985; Goodnight *et al* 1982; Kromkout*et al* 1985; Norum and Drevon, 1986) and may even decrease the risk of cancer development at certain sites (Caroll and Bradon, 1984; Herold and Kinsella, 1986). It is important to maintain an appropriate balance of omega-3 and omega-6 fatty acid in the diet as these works together to promote healthbut the typical diet tends to contain 11 to 30 times more omega-6 fatty acids than omega-3. This imbalance is a significant factor in increasing the range of human diseases which respond to n-3 HUFAs (www. fsomega.com).

Fishes vary in their ability to produce EPA and DHA endogenously.Variation in lipid and fatty acid composition between and within species, depending on factors, such as season, food availability, location, sex and age have been well documented by numerous authors (Exler*et al* 1975, Gorgun and Akpinar 2007; Rueda *et al*. 1997; Shearer 1994).

Thus, carps being the most commonly cultured fish species in India, including Punjab, need to be investigated for their fatty acid profiles. The present study was, therefore, conducted with a concept to generate information on fatty acid profiles of carp species being cultured in Punjab. Carp(s) with highest proportion of LC-PUFA and the highest omega-3 to omega-6 fatty acids also needed to be identified for human consumption. Therefore, the aim of this paper is to work out details of the fatty acid profiles of muscle lipids of some cultured carp species and to study the seasonal differences in the fatty acid profiles of these carp species.

2. Material and Methods

2.1 Sample collection

Comparative studies on muscle total lipid content and fatty acid profiles of three carp fish species cultured in Punjab belonging to order Cypriniformes, family Cyprinidae were made. The fish species were three Indian Major Carps, rohu,*Labeo. rohita*(Hamilton); catla, *Catla. catla* (Homilton); mrigal, *Cirrhinus. mrigala* (Hamilton).Table-sized (> 500 g) fresh specimens of each of the three fish species were obtained from the local fish market during each season of the year.Each fish was scaled, finned, headed and gutted. The fish sample was then cleaned with tap water and 3 x 2.5 cm pieces of flesh were taken at random from threedifferent parts of fish body *viz*. above lateral line from both the sides. Bones were removed and the flesh was thoroughly mixed together to form a composite or representative sample of edible portion of the fish. Composite sample was packed in clean labeled ziplock polythene bags and stored at -25^{0}C until analyses.

2.2 Lipid extraction and fatty acid analysis

Total lipid (TL) content was determined by solvent extraction method as described by AOAC (2000).

Fatty acid composition was determined by Gas Chromatography (GC) on M/s Nucon Engineers AIMIL Gas Chromatograph (solid state) model Nucon series 5700/5765 equipped with flame ionization detector fitted with SS column 1/8” outer diameter x 2M length, packed with 15% D.E.G.S on CHROMOSORB W.H.P, 80-100 mesh size. The conditions for the separation were oven temperature 200^{0}C, injector temperature 230^{0}C, detector temperature 240^{0}C, hydrogen flow 30ml/min, air flow 300ml/min and nitrogen flow 40ml/min. Identification of peaks was done by comparison of their retention time with those of standard fatty acyl esters (M P Biomedicals Inc. USA). Relative concentration of fatty acid was calculated by use of an automatic integrator-Windows based AIMIL Ltd., DASTA 710 Gas Chromatograph Datastation software, version WinAcds 7.1.

2.3 Statistical analysis

One way and Multifactor ANOVA was used to determine the inter-specific and inter-seasonal differences in the total lipids and fatty acid profiles of the three species of fish. The analyses were performed using Microsoft EXCEL and STATGRAPHICS statistical packages.

3. Results and discussion

In our study, Considerable variations in the muscle total lipid content (MTLC) during different seasons of the year.The MTLC varied from1.06±0.02 % in *C. mrigala*during summer and 3.00±0.06% in *C. catla*during winter(Table 1). These values are close to those observed by Aggelousis and Lazos (1991) in the freshwater fishes of Greece (0.6-3.5%),Varjlin*et al* (2003) in *D. vulgaris* and *C .conger* (1.3 to 3.7%).Memon*et al* (2010) reported higher lipid content ranging from 0.85-18.32% in Indus river fish species. Total lipid content of carps varied with seasons. In all carp species, higher lipid content was observed in winter and lower in all carp species were observed in spring except for *C. mrigala*(which was observed in Summer). The study therefore, supports the observations of Rasoarahona*et al* (2004) that lipid content was higher in colder than in warmer months. Guler*et al* (2011) also observed higher lipid content in winter.

A comparison of fatty acid profiles of the presently studied fish species revealed that amongst the n-3 fatty acids, the maximum mean value of Len (1.99±0.85 %) was found in *C. mrigala*and minimum (1.23±0.61%) in *C. catla*. The mean values of EPA were, however, comparable amongst *C. catla* (3.98±2.60%) and *L. rohita* (3.80±1.84%). In *L. rohita*,the EPA was minimum (2.20±2.19%)in spring andmaximum (6.46±5.74%) in winter. DHA was maximum (3.55±3.16%) in autumn and minimum (0.16±0.08%) in summer. EPA+DHA was maximum (9.96%) in winter and minimum (2.36%) in summer.In*C. catla*, EPA was maximum (10.61±10.29%) in autumn and minimum (1.73±0.91%) in spring. The DHA was minimum (0.18±0.18%) in summer and maximum (4.83±4.83%) in spring and EPA+DHA was maximum (12.79%) in autumn and minimum (2.01%) in summer. In *C. mrigala*,EPA was highest (9.74±5.21%) in summerand EPA+DHA was minimum (0.18%) in autumn and maximum (17.24%) in summer. Total n-3 PUFAs was maximum in *L. rohita* (12.98±9.79%) during autumnand minimum (8.42±6.76%) during spring. The mean total n-3 PUFA values were recorded in the order of *C. catla*(12.36±3.51%)>*L. rohita* (10.89±3.41%)>*C. mrigala*(8.51±2.12%)(Table 2,3,4).

The fishes differed in respect of their n-6 PUFAcomposition also. *L. rohita*had highest mean Lin content (10.20±2.54%) followed by *C. catla* (8.27±2.90%) and*C. mrigala*(6.58±3.45%). Lin was lowest in spring in all carp species and highest in autumn in *C. catla* (24.29±10.43%) and *C. mrigala* (18.99±13.69%).The AA was highest in *C. mrigala*

(3.63±0.94%) followed by *C. catla* (2.15±0.90%), *L. rohita*(1.60±0.63%). The mean values of EDA also differed amongst different fish species *viz.L. rohita* (0.34±0.18%),*C.mrigala* (0.18±0.08%), and *C. catla* (0.05±0.04%). The mean total n-6 values were comparable, although highest values were observed in *L. rohita* (12.14±2.55%), followed by *C. catla* (11.31±3.12%) and *C. catla*(10.06±3.44%). The n-3/n-6 ratio differed in different fishes. The highestmean of n-3/n-6 (1.49±0.63) was found in *C. catla*and the lowest (0.89±0.20) in *C. mrigala*. The ratio of n-3:n-6 PUFA contents ranged from 2.67 to 12.61 in selected 12 marine fish species living in Turkish waters (Bayir*et al* 2006). Compared with freshwater fish, marine fish contains higher levels of n-3 PUFAs (Vlieg and Body,1988). Therefore, in our study, this ratio did not fall in these ranges in carp species.

The most abundant monounsaturated fatty acid (MUFA) was oleic acid in all the carp species. The high level of oleic acid and Total MUFAs (33.31±4.95%) was found during autumn except *L. rohita*which was found in summer (1.80±1.80%).

In the present study, major saturated fatty acid (SFA) was palmitic acid and other predominant SFAs were stearic acid in all carp species. Celik*et al* (2005) and Ozogul*et al* (2007) also reported similar results. In our study stearic acid was lower in spring (0 to 1.38%) than in winter (18.05% to 32.03%). Total SFAs was minimum (13.89% to 18.54%) in spring and maximum (47.01% to 63.69%) in winter in all the carp species.

Table 1 Seasonal variations in muscle total lipid content (%) of different fish species.

Season (Month/Year)	Fish species		
	***Labeorohita* (rohu)**	***Catlacatla* (catla)**	***Cirrhinusmrigala* (mrigal)**
Spring (April,2009)	2.01±0.03^{a}	1.50±0.06^{a}	1.15±0.23^{a}
Summer (July,2009)	2.05±0.07^{ab}	2.29±0.04^{b}	1.06±0.02^{a}
Autumn (October,2009)	2.22±0.04^{b}	2.24±0.05^{b}	1.82±0.05^{b}
Winter (January,2010)	2.44±0.02^{c}	3.00±0.06^{c}	2.17± 0.02^{b}
Mean	**2.18±0.02**	**2.26±0.03**	**1.55±0.06**

Values with same alphabetic superscript in a column do not differ significantly (p>0.05).

Table 2Seasonal differences in fatty acids of *Labeo. rohita*(Hamilton).

Fatty Acid	Season				Mean (of the four seasons)
	Spring (April, 2009)	Summer (July, 2009)	Autumn (October, 2009)	Winter (January, 2010)	
(C18:3 n-3)	—	4.88±2.45[a]	1.02±0.79[a]	0.43±0.27[a]	1.58±0.65
(C20:5 n-3)	3.49±2.79[a]	2.20±2.19[a]	3.05±2.98[a]	6.46±5.74[a]	3.80±1.84
(C22:5 n-3)	3.64±2.95[a]	2.82±2.55[a]	5.35±4.12[a]	1.71±1.56[a]	3.38±1.47
(C22:6 n-3)	1.29±1.04[a]	0.16±0.08[a]	3.55±3.16[a]	3.50±1.44[a]	2.13±0.91
∑ n-3	8.42±6.76[a]	10.06±2.38[a]	12.98±9.79[a]	12.11±6.21[a]	10.89±3.41
(C18:2 n-6)	0.76±0.48[a]	18.99±8.75[a]	11.62±3.44[a]	9.42±3.86[a]	10.20±2.54
(C20:4 n-6)	2.84±2.19[a]	0.47±0.25[a]	2.31±1.16[a]	0.76±0.37[a]	1.60±0.63
(C20:2 n-6)	0.47±0.47[a]	0.32±0.32[a]	0.43±0.43[a]	0.16±0.16[a]	0.34±0.18
∑ n-6	4.06±2.37[a]	19.78±8.87[a]	14.36±2.05[a]	10.35±3.98[a]	12.14±2.55
n-3:n-6	2.08±0.85[a]	0.73±0.28[a]	1.03±0.80[a]	1.21±0.56[a]	1.26±0.33
∑ PUFAs	14.87±8.86[a]	30.50±8.39[a]	27.81±8.90[a]	19.46±6.73[a]	23.16±4.13
(C16:1 n-7)	1.80±1.80[a]	0.16±0.09[a]	0.07±0.03[a]	1.05±1.00[a]	0.77±0.52
(C18:1 n-9)	—	28.89±3.11[b]	9.73±7.21[ab]	7.71±3.88[a]	11.58±2.19
∑ MUFAs	1.80±1.80[a]	29.06±3.17[b]	22.17±9.23[ab]	8.73±4.12[ab]	15.44±2.69
(C10:0)	0.37±0.37[a]	0.35±0.35[a]	—	0.02±0.02[a]	0.18±0.13
(C11:0)	—	0.04±0.04[a]	2.70±1.81[a]	—	0.69±0.45
(C12:0)	5.53±3.59[a]	0.07±0.07[a]	0.05±0.05[a]	0.21±0.07[a]	1.46±0.90
(C14:0)	5.03±3.46[a]	0.24±0.16[a]	1.11±0.55[a]	2.16±1.07[a]	2.13±0.92
(C15:0)	0.68±0.68[a]	0.11±0.11[a]	0.85±0.79[a]	0.38±0.19[a]	0.51±0.27
(C16:0)	4.07±3.35[a]	24.42±4.43[ab]	32.63±2.30[b]	22.33±10.54[ab]	20.86±3.03
(C17:0)	2.57±1.97[a]	1.49±1.12[a]	1.54±1.39[a]	3.34±3.34[a]	2.24±1.07
(C18:0)	—	4.34±0.99[a]	4.48±2.29[a]	18.05±11.61[a]	6.72±2.97
(C20:0)	0.30±0.30[a]	0.12±0.12[a]	—	0.42±0.27[a]	0.21±0.10
∑ SFAs	18.54±9.13[a]	31.21±5.57[a]	43.80±2.36[a]	47.01±19.35[a]	35.14±5.56

Values are mean±S.E. and are presented as %age of total lipids; Values with same superscripts in a row do not differ significantly (p>0.05).

Table 3Seasonal differences in fatty acids of *Catla. catla*(Hamilton).

Fatty Acid	Season				Mean (of the four seasons)
	Spring (April, 2009)	Summer (July, 2009)	Autumn (October, 2009)	Winter (January, 2010)	
(C18:3 n-3)	—	1.47±1.33[a]	2.81±2.02[a]	0.63±0.31[a]	1.23±0.61
(C20:5 n-3)	1.73±0.91[a]	1.83±0.91[a]	10.61±10.29[a]	1.75±0.76[a]	3.98±2.60
(C22:5 n-3)	7.51±3.69[a]	3.52±2.39[a]	2.51±2.30[a]	2.07±1.23[a]	3.90±1.28
(C22:6 n-3)	4.83±4.83[a]	0.18±0.18[a]	2.19±2.05[a]	1.93±1.28[a]	2.28±1.35
∑ n-3	17.91±2.04[a]	7.01±1.56[a]	18.12±13.50[a]	6.38±2.87[a]	12.36±3.51
(C18:2 n-6)	—	5.16±5.05[a]	24.29±10.43[a]	3.64±0.37[a]	8.27±2.90
(C20:4 n-6)	2.18±2.18[a]	3.69±2.86[a]	1.02±0.39[a]	1.73±0.18[a]	2.15±0.91
(C20:2 n-6)	—	0.01±0.01[a]	0.16±0.15[a]	0.02±0.02[a]	0.05±0.04
∑ n-6	2.18±2.18[a]	12.19±6.71[a]	25.46±10.29[a]	5.40±0.35[a]	11.31±3.12
n-3:n-6	1.12±1.12[a]	2.22±1.75[a]	1.42±1.29[a]	1.21±0.53[a]	1.49±0.63
∑ PUFAs	19.43±4.61[a]	17.62±7.98[a]	43.64±11.09[a]	12.17±2.69[a]	23.21±3.67
(C16:1 n-7)	2.20±2.20[a]	2.58±2.42[a]	0.09±0.06[a]	0.08±0.05[a]	1.24±0.82
(C18:1 n-9)	—	14.17±7.58[a]	19.98±9.74[a]	12.57±3.35[a]	11.68±3.20
∑MUFAs	2.20±2.20[a]	16.75±7.89[a]	20.07±9.77[a]	12.65±3.39[a]	12.92±3.30
(C10:0)	0.48±0.48[a]	0.20±0.20[a]	—	0.06±0.06[a]	0.19±0.13
(C11:0)	4.33±2.29[a]	—	0.30±0.30[a]	—	1.16±0.58
(C12:0)	0.76±0.76[a]	0.27±0.19[a]	0.09±0.05[a]	1.04±0.73[a]	0.54±0.27
(C14:0)	—	4.33±2.92[a]	0.88±0.47[a]	1.05±0.21[a]	1.56±0.74
(C15:0)	—	0.96±0.56[a]	0.05±0.05[a]	0.87±0.43[a]	0.47±0.18
(C16:0)	4.17±4.17[a]	18.75±10.67[a]	16.52±7.54[a]	25.11±3.90[a]	16.14±3.56
(C17:0)	—	0.10±0.10[a]	7.38±7.38[a]	0.07±0.04[a]	1.89±1.84
(C18:0)	—	7.48±5.08[a]	4.38±2.28[a]	32.03±3.68[b]	10.97±1.67
(C20:0)	10.02±10.02[a]	0.27±0.23[a]	0.04±0.04[a]	0.21±0.12[a]	2.64±2.50
∑ SFAs	19.88±14.90[a]	37.36±9.98[a]	23.80±1.21[a]	60.72±8.05[a]	35.44±4.92

Values are mean±S.E. and are presented as %age of total lipids; Values with same superscripts in a row do not differ significantly (p>0.05).

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 7, July - 2013

Table 4 Seasonal differences in fatty acids of *Cirrhinusmrigala*(Hamilton).

Fatty Acid	Season				Mean (of the four seasons)
	Spring (April, 2009)	Summer (July, 2009)	Autumn (October, 2009)	Winter (January, 2010)	
(C18:3 n-3)	2.83±2.76^{a}	2.22±1.18^{a}	1.87±1.48^{a}	1.04±0.48^{a}	1.99±0.85
(C20:5 n-3)	—	9.74±5.21^{a}	0.14±0.14^{a}	0.81±0.42^{a}	2.67±1.31
(C22:5 n-3)	0.35±0.35^{a}	3.86±1.96^{a}	0.60±0.44^{a}	0.84±0.60^{a}	1.41±0.53
(C22:6 n-3)	0.52±0.37^{a}	7.50±1.50^{b}	0.04±0.02^{a}	1.79±0.77^{a}	2.46±0.43
∑ n-3	3.69±3.47^{a}	23.32±7.45^{b}	2.64±1.87^{a}	4.38±1.01^{ab}	8.51±2.12
(C18:2 n-6)	—	3.20±1.55^{a}	18.99±13.69^{a}	4.11±0.58^{a}	6.58±3.45
(C20:4 n-6)	2.28±2.28^{a}	5.42±2.57^{a}	0.89±0.46^{a}	5.91±1.48^{a}	3.63±0.94
(C20:2 n-6)	0.01±0.01^{a}	0.46±0.27^{a}	0.26±0.18^{a}	—	0.18±0.08
∑ n-6	2.30±2.28^{a}	9.08±0.91^{a}	20.14±13.43^{a}	8.72±1.82^{a}	10.06±3.44
n-3:n-6	0.50±0.50^{a}	2.50±0.63^{b}	0.12±0.02^{a}	0.44±0.10^{a}	0.89±0.20
∑ PUFAs	6.02±5.73^{a}	32.40±8.19^{a}	20.96±16.97^{a}	14.60±1.90^{a}	18.50±4.95
(C16:1 n-7)	2.29±2.29^{a}	3.21±3.21^{a}	0.03±0.02^{a}	0.43±0.24^{a}	1.49±0.99
(C18:1 n-9)	3.45±3.45^{a}	16.11±4.00^{a}	33.27±4.94^{b}	4.05±0.90^{a}	14.22±1.82
∑MUFAs	5.74±5.74^{a}	19.33±1.70^{ab}	33.31±4.95^{b}	4.47±0.94^{a}	15.71±1.96
(C10:0)	0.97±0.97^{a}	1.53±0.77^{a}	0.03±0.03^{a}	2.00±0.71^{a}	1.13±0.36
(C11:0)	3.68±3.68^{a}	0.88±0.88^{a}	0.06±0.06^{a}	0.21±0.13^{a}	1.21±0.95
(C12:0)	2.33±2.33^{a}	1.77±1.25^{a}	0.04±0.04^{a}	0.29±0.29^{a}	1.11±0.67
(C14:0)	—	1.87±0.94^{ab}	0.99±0.51^{ab}	3.40±0.99^{b}	1.57±0.36
(C15:0)	1.64±1.61^{ab}	0.19±0.19^{a}	0.30±0.20^{ab}	4.46±0.85^{b}	1.65±0.46
(C16:0)	3.87±3.46^{a}	34.17±3.18^{c}	18.67±2.22^{b}	35.26±2.56^{c}	22.99±1.45
(C17:0)	—	0.17±0.17^{a}	0.07±0.04^{a}	0.34±0.27^{a}	0.14±0.08
(C18:0)	1.38±1.38^{a}	3.71±0.41^{a}	20.73±8.10^{a}	19.48±2.11^{a}	11.33±2.12
(C20:0)	0.02±0.02^{a}	0.79±0.79^{a}	0.36±0.28^{a}	0.30±0.29^{a}	0.36±0.22
∑ SFAs	13.89±13.42^{a}	44.49±4.51^{ab}	41.28±10.47^{ab}	63.69±2.23^{b}	40.84±4.44

Values are mean±S.E. and are presented as %age of total lipids; Values with same superscripts in a row do not differ significantly (p>0.05).

4. Conclusion

Seasonal variations affected fatty acid composition of carp species. The MTLC was found maximum in *C. catla* during winter and minimum in *C. mrigala* during summer. Total PUFAs was obtained maximumin *C. catla*(43.64±11.09%) during autumn season and minimum in *C. mrigala* (6.02±5.73%)during spring season. The n-3:n-6 ratio may not have high nutritional value.

5. References

AOAC (2000) Official Methods of Analysis (17th Edition). Meat and meat products Ch. 39, pp: 3. 481 North Frederick Avenue Gaithersburg, Maryland 20877-2417 USA.

Aggelousis G and Lazos ES (1991).Fatty acid composition of the lipids from eight freshwater fish species from Greece.*J Fd Compos Anal*4: 68-76.

Bayir A, Haliloglu HI, SirkeciogluAN and Aras NM (2006). Fatty acid composition in some selected marine fish species living in Turkish waters. *J SciFdAgr*86: 163-8.

Body DR and Vlieg P (1988).Distribution of the lipid classes and eicosapentaenoic (20:5) and docosahexaenoic (22:6) acids in different sites in blue mackerel (*Scomberaustralasicus*).fillets. *J FdSci*54: 569-72.

Bhuiyan HR, Nath KK, Seal P and Hossain ME (2006). Fatty acid profile and proximate composition of three marine fishes of the Bay of Bengal.*Bangladesh J SciInd Res* 41 (1-2): 47-54.

Bimbo AP (1998).Microencapsulation of fish oil by spray drying-impact on oxidative stability. Part I. *Inform* 5: 180-88.

Carroll KK and Braden LM (1984). Dietary fat and mammary carcinogenesis.*Nutr Cancer* 6: 254.

Celik M, Diler A and Kucukgulmez A (2005). A comparison of the proximate composition and fatty acid profiles of zander (*Sander lucioperca*) from two different regions and climatic conditions. *FdChem*92: 637-41.

Exler J, Kinsella J E and Watt B K (1975) Lipid and fatty acids of important finfish: New data for nutrient tables. *J Am Oil Chemist's Society* 52: 154-59.

Givens D I, Cottrill B R, Davies M, Lee P A,Mansbridge R J and Moss A R (2000) Sources of n-3 polyunsaturated fatty acids additional to fish oil for livestock diets – A review. *NutrAbstr Rev* (Series B) 2000, 70: 4-59.

Glomset J A (1985). Fish fatty acids and human health.*New England J Med* 312: 1253.

Goodnight SH, Harris WS, and Coonor WE (1982). Polyunsaturated fatty acids, Hyperlipidemia and thromboisis.*Arteriosclerosis* 2: 87.

Gorgan S and Akpinar MA (2007). Liver and muscle fatty acid composition of mature and immature rainbow trout (*Oncorhynchusmykiss*) fed two differentdiets. *BiologiaBratislava* 62 (3): 351-55.

Guler GO, Aktumsek A, Cakmak YS, Zengin G and Citil OB (2011). Effect of season on fatty acid composition and n-3/n-6 ratios of Zander and Carp muscle lipids in Altinapadam lake. *J fdSci*76: 594-97.

Hanus LO, Rezanka T and Dembitsky V M (2008). Fatty acid and phospholipid profile of freshwater sardine *Mirogrexterraesanctae*from the sea of Galilee. *J Fd Lipids* 15: 150-63.

Herold P and Kinsella JE (1986). Fish oil consumption and decreased risk of cardiovascular disease: A comparison of findings from animal and human trials. *Am J ClinNutr*43:566.

Kromkout D, Boschieter EB and Coulander CD (1985). The inverse relationship between fish consumption and 20-year mortality from coronary heart disease.*New Eng J Med*312: 1205.

Meimaroglu SM, Dimizas C, Loukas V, Moukas A, Vlachos A, Thomaidis N, Paraskevopoulou V and Dasenakis M (2007). Proximate composition, fatty acids, cholesterol, minerals in frozen red porgy.*ChemPhy Lipids* 146: 104-10.

Memon NM, Talpur FN and Bhanger MI (2010).A comparison of proximate composition and fatty acid profile of Indus river species.*Int J Fd Properties* 13 (2):328-37.

Nazeer RA, Kumar NS, Nagash SY, Radhika R, Kishore R and Bhatt SR (2009). Lipid profiles of threadfin bream (*Nemipterusjaponicus*) organs. *Ind J Marine Sci*34 (4): 461-63.

Norum KR and Drevson CA (1986).Dietary n-3 fatty acids and cardiovascular diseases.*Arteriosclerosis*6:352.

Osibona AO, Kusemiju K and Akande GR (2009). Fatty acid composition and amino acid profile of two freshwater species, African catfish (*Clariasgariepinus)* and Tilapia (*Tilapia zillii). African J Agri Nut Dev*9: 608-21.

Osman F, Jaswir I, Khaza'ai H and Hashim R (2007). Fatty acid profiles of fin fish in Langkawi Island, Malaysia. *J Oleo Sci* 56: 107-13.

Ozogul Y, Ozogul F and Alagoz S (2007). Fatty acid profiles and fat contents of commercially important seawater and freshwater fish species of Turkey.*FdChem* 103: 217-23.

Patrick SI, Malek B, Joly G and Nada L (2007).Seasonal variation in highly unsaturated fatty acid composition of muscle tissue of two fishes endemic to the Eastern Mediterranean.*EcolFdNutr*46: 77-89.

Rasoarahona J R E, Barnathan G, Bianchini J P and Gaydou E M (2004) Annual evolution of fatty acid profile from muscle lipids of the common carp (*Cyprinuscarpio*) in Madagascar inland water. *J AgricFdChem*52: 7339-7344.

Rueda F M, Lopez JA, Martinez FJ, Zamora S, Divanach P and Kentouri M (1997). Fatty acid in muscle of wild and farmed red porgy (Pagruspagrus).*Aqua Nutr*1: 161-65.

Simopoulos AP (1991). Omega-3 fatty acids in health and disease and in growth and development.*Am J ClinNutr*54: 438-43.

Shearer KD (1994).Factor affecting the proximate composition of cultured fishes with emphasis on salmonids.*Aqua* 119: 63-88.

Stanek M, Dabrowski J, Roslewska A, Kupcewicz B and Janicki B (2008).Impact of different fishing seasons on the fatty acids profile, cholestrol content, and fat in the muscles of perch, *Percafluviatils*L.from the wloclawski reservoir (Central Poland). *Arch Pol Fish* 16: 213-20.

Turan H, Sonmez G and Kaya YU (2007). Fatty acid profile and proximate composition of the thornback ray (*Raja clavata, L* 1758) from the Sinop coast in the Black sea. *J of Fisheries Sci.com* 1 (2): 97-103.

Ugoala C, Ndukwe GI and Audu TO (2008).Comparison of fatty acids profile of some freshwater and marine fishes.*Intr J Fd Safety* 10: 9-17.

Ugoala C, Ndukwe GI and Audu TO (2009). Fatty acids composition and nutritional quality of some freshwater fishes.*Natureprecedings: doi:10.1038/npre.2009.3239.1.*

Varljen J, Sulic S, Brmalj J, Baticic L, Obersnel V and Kapovic M (2003). Lipid classes and fatty acid composition *Diplodus vulgaris* and *Conger conger*originating from the Adriatic sea. *FdTechnolBiotechnol* 41 (2): 149-56.

www.fsomega.3.com.