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Seasonal Variation of Chemical Composition and Fatty Acid Profile of Fillet in Wild Common Carp (*Cyprinus carpio*) in Caspian Sea

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Abstract: In this research, the seasonal variation in the chemical composition and fatty acid profile of fillets from wild common carp were assessed. The protein, lipid and moisture content as well as the fatty acid profile were determined. The results showed that the lipid and protein content in wild carp samples decreased from Summer to Spring and the moisture content of fillets increased from Summer to Spring. Monounsaturated Fatty Acids (MUFA) in carp were found to be higher than levels of Saturated Fatty Acids (SFA) and Polyunsaturated Fatty Acids (PUFA) in all seasons. The PUFA content of fillets was found to be higher than that of SFA in Winter and Spring. Palmitic acid was the major SFA (12.99-16.18%) in all seasons. Oleic acid was identified as the major MUFA (19.05-25.11%). Docosahexaneoic Acid (DHA) was the major PUFA (5.98-11.61%) in all seasons. The maximum concentration of DHA was found in Autumn and Winter but the Eicosapentaneoic Acid (EPA) concentration did not fluctuate in different seasons. The maximum concentrations of lipids and protein were found in Summer. Poly-unsaturated fatty acids increased in the cold season.

Key words: *Cyprinus carpio*, wild common carp, fillet, fatty acid composition, Caspian sea

INTRODUCTION

The potential health benefits related to fish consumption are due to the presence of proteins, unsaturated essential fatty acids, minerals and vitamins. Fish and shellfish provide an almost unlimited variety of fatty acids with beneficial roles in human health. Additional health benefits from the consumption of fish or fish lipids may be related to Polyunsaturated Fatty Acids (PUFA), especially ω3 PUFA (Sidhu, 2003). Polyunsaturated fatty acids are known to diminish blood cholesterol levels (Itakura, 1993). They also play an important role in the structure and function of cellular membranes and are the precursors of lipid mediators which are key factors in cardiovascular and inflammatory diseases (Carlier *et al.*, 1991). Long chain ω3 PUFA cannot be synthesised by humans and must be obtained from the diet (Alasalvar *et al.*, 2002). If researchers attempt to maintain or enhance the present day health, researchers must take a proactive aproach to ensure the sustained access to essential fatty acids and in particular to Eicosapentaneoic Acid (EPA), Docosahexaneoic Acid (DHA) and Arachidonic Acid (AA) (Arts *et al.*, 2001). It has been reported that the type and amount of fatty acids in fish tissues vary mainly with the feeding habits of the fish but other factors may also influence their fatty acid composition. For example, size or age, reproductive status, geographic location and season all influence fat content and the composition of fish muscle (Ackman, 1989; Alasalvar *et al.*, 2002; Henderson and Tocher, 1987; Satio *et al.*, 1999). The fatty acid profile of fish is certainly influenced by temperature (Leger *et al.*, 1977). Therefore, it is known that the biochemical content of marine organisms undergoes changes due to seasonal changes (Ackman, 1995). The chemical parameters of wild fish are strongly influenced by the sea environmental conditions which determine nutrient availability (Izquierdo *et al.*, 2003). However, flesh protein content is less influenced by external feeding since, it is mainly dependent on intrinsic factors such as the fish species, variety and size (Borresen, 1992; Shearer, 1994). *Cyprinus carpio*, carp as a freshwater fish species has been one of the most widely cultured species all over the world due to its fast growth rate and easy cultivation and *C. carpio* is one of the most abundant freshwater fish in the Caspian sea which is the largest brackish water lake in the world.

People who live near this body of water consume carp abundantly. No reports have yet been published on

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the effects of seasonal variations in the fatty acid composition of this important species in the Caspian sea. In view of these facts, it seemed necessary to carry out a study on the protein, moisture and lipid content as well as the lipid profile of this highly consumed fish, *C. carpio* in this location. The objective of this research was therefore to characterise carp in terms of their chemical composition and fatty acid profile in different seasons of the year.

MATERIALS AND METHODS

C. carpio used in this study was obtained from the Caspian sea seasonally. The Caspian sea is located North of Iran. Carp is one of the most abundant fish in all seasons.

The seasons chosen for analysis were Summer, Autumn, Winter and Spring. The samples were collected in middle month of each season during the year. All representative fish (n = 3 at each determination) used in the experiments were almost the same size (average length and weight of 30.28 cm and 588.41 g, respectively) and age (3 years old). Female fish were selected by gonad histology and the Gonadosomatic Index (GSI = Gonadal weight ×100/total weight) determination. The reproductive period of carp in the Caspian sea is between late April and July (the water temperature should be between 17-23°C) (Abdoli, 1999). After being caught, they were transported on ice to the laboratory and filleted; the fillets were frozen. At the beginning of each analysis, the samples were allowed to equilibrate to room temperature, ground and homogenised. The lipid content was analysed according to the procedure of Bligh and Dyer. The Fatty Acid Methyl Esters (FAMEs) were separated and quantified using a Shimdzu GC-17 gas chromatograph equiped with a flame ionisation detector (250°C) and column BPX70 (50×0.32 mm ID). Nitrogen was used as the carrier gas and the initial oven temperature was 125°C for 1 min followed by an increase at a rate of 4°C min^{-1} to a final temperature of 215°C. Individual FAMEs were identified by reference to authentic standards and to well-characterised fish oil (Cronin *et al*., 1991).

The amount of protein was determined by the Kjeldahl Method (with a nitrogen to protein conversion factor of 6.25) and the moisture content was determined by drying at 105±1°C to a constant weight (Hernandez *et al*., 2003).

Statistical analysis: All analyses were performed at least in triplicate. Ten carp samples were analysed in each season. The average results are presented as mean±SD. The results were submitted to Analysis of Variance (ANOVA) at a significance level of $p<0.05$ using SPSS 11.5. The mean values were compared by Duncan's test.

RESULTS AND DISCUSSION

The biometric measurements are shown in Table 1. The weight, standard length, body depth and Gonadosomatic Index (GSI) varied between 481-630 g, 29.1-30.68, 7.68-9.35 cm and 1.114-12.04%, respectively. The protein content underwent a few variations during the experimental period (Fig. 1a) and reached a maximum (18.21%) in Summer and fell to a minimum (17.43%) in Winter and then slightly increased in Spring (spawning season) (17.87%) ($p>0.05$). It has been shown for many species of fish (Lapin, 1973; Lapin and Shahunovskii, 1981; Gershanovich *et al.*, 1991) that during gonadogenesis, the chemical composition of tissues, developing gonads and other organs changes. Komova (2001) reported that some portion of protein and muscular lipids is spent on energy needs and the complete maturation of genital products (Komova, 2001). Sorvachev (1957) studied the dynamics of protein fractions of carp during the spawning period and found that the protein content decreases mainly due to albumins, i.e., the water-soluble fraction (Sorvachev, 1957). Analysis of the fraction composition of the proteins in muscle during spawning has demonstrated that with a decrease in the condition of the walleye pollock, there is also a decrease in the protein content in muscles due to the decrease in its water-soluble fraction (Abramova and Balykin, 1997). These researchers showed that the process of spending protein was accompanied by the development of gonads. Celik (2008) reported that protein fluctuations were observed in chub mackerel (*Scomber japonicus*) and horse mackerel (*Trachurus trachurus*) which were investigated in all seasons.

According to this data, the muscular fatness of common carp slightly decreased from Summer to Spring ($p>0.05$) (Fig. 1b). Many fish species tend to reduce their food intake during sexual maturation (Jobling, 1995; Saether *et al.*, 1996; Jobling *et al.*, 1998) so, the final stages of gonadal growth are dependent upon the mobilisation and re-allocation of endogenous reserves. In white sea bream (*Diplodus sargus*), muscular lipid was highly mobilised during spawning period, presumably in suport of the reproductive effort (Perez *et al.*, 2007).

Table 1: Biometric measurements of sampled individuals of wild common carp

Date	Weight (g)		Standard length (cm)		Body depth (cm)		GSI (%)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Summer	481.00	70.3	29.10	0.94	7.68	0.37	1.114	0.52
Autumn	594.17	95.05	30.35	1.70	9.33	0.44	6.190	3.64
Winter	639.00	101.18	30.90	1.07	9.35	0.75	10.112	3.56
Spring	630.00	71.85	30.68	1.19	8.92	0.31	12.040	2.77

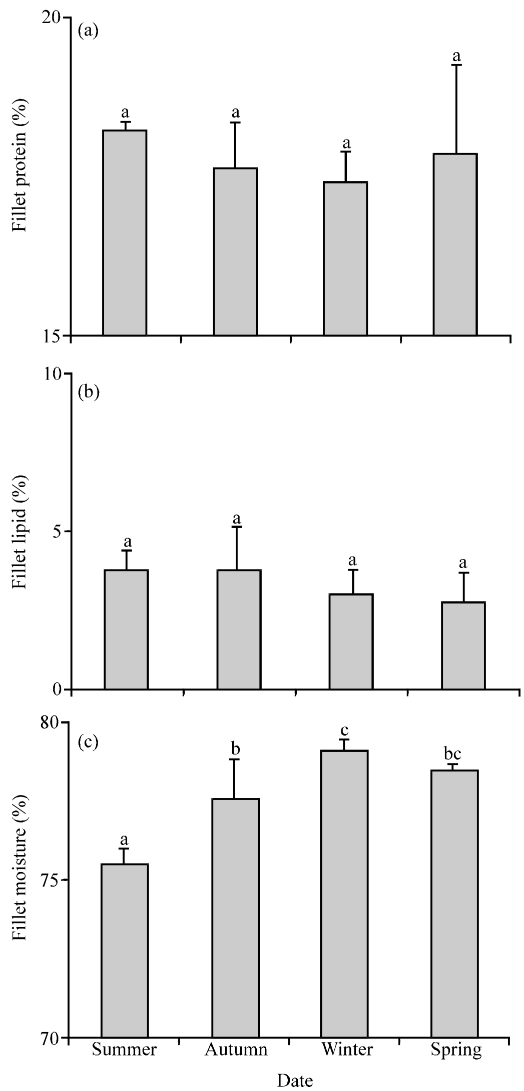

Fig. 1: a) Mean protein, b) Mean lipid percent and c) Mean moisture percent of common carp (*Cyprinus carpio*) fillet in all seasons. Mean values (n = 3) of three independent determinations; bars denote standard deviations of the mean. Different letters show significantly different at $p<0.05$

Similarly, Kminkova *et al.* (2001) found that the lipid content of carp decreased insignificantly from Summer to Spring (Kminkova *et al.*, 2001). Previous research has shown that the total lipid content of common carp (gender differences were not investigated) in Winter (4.45%) were determined to be higher than in other seasons (2.94% in Spring, 1.09% in Summer and 1.31% in Autumn) (Guler *et al.*, 2008). Fat content is influenced by species, season, geographical region, age and maturity (Pigott and Tucker, 1990). The lipid content of *Dentex dentex* does not show significant differences during maturation (Ozyurt *et al.*, 2006) but in gilthead sea bream, there is a seasonal variation in lipid content which falls to a minimum in late Spring and reaches a maximum in late Summer (Grigorakis *et al.*, 2002). Tzikas *et al.* (2005) reported that the lipid content in mackerel, *Trachurus mediterraneus*, decreased in the spawning season (Tzikas *et al.*, 2005). Celik (2008) found that the lipid content of chub mackerel (*Scomber japonicus*) and horse mackerel (*Trachurus trachurus*) was lower in Winter than in Autumn and Spring (Celik, 2008). According to the Panetsos (1978) classification of moderately fat fish (3-8% lipid), it seems that common carp in the Caspian sea is a moderately fat fish (3.33% lipid) (Panetsos, 1978) although, some researchers have reported that common carp is a low fat fish (lipid variation: 2.08-5.92% lipid) (Kminkova *et al.*, 2001).

The results of moisture determinations showed that the moisture content of fillets increased during the sampling period (from Summer to Spring) (Fig. 1c). Similarly, Komova (2001) found that the moisture content of *Abramis brama* (Cyprinidae) increased from Summer to Spring (Komova, 2001). According to Love (1976), the process of spending protein in non-fatty fish is accompanied by an increase in the moisture content which is an index of the emaciation level (Love, 1976). Thus, in immature cod (*Gadus morhua*) in the North Sea, the moisture content is constant in all seasons. In fish spawning for the first time, the moisture content during the spawning season increases and then returns to the initial level (Abramova and Balykin, 1997). The same results were reported in mackerel (*Trachurus mediterraneus*) and walleye pollock (*Theragra chalcogramma*) (Tzikas *et al.*, 2005; Abramova and Balykin, 1997). The inverse relationship between the fat content and water content described by Love (1970) is also observed in common carp.

The fatty acid composition of the carp which were captured in different seasons is shown in Table 2. The major fatty acids identified in the carp were 18:1 (oleic: 21.86%), 16:0 (palmitic: 14.57%), 22:6 (Docosahexaneoic Acid, DHA: 8.03%), 16:1 (palmitoleic: 6.53%), 18:0 (stearic: 5.39%), 20:4 (arachidonic, AA: 5.03%), 20:5 (eicosapentaenoic acid, EPA: 4.44%) and 18:2 (linoleic: 3.08%) in all seasons. The fatty acid profile had a higher degree of unsaturation in Winter. Palmitic, palmitoleic, oleic, arachidonic, eicosapentaneoic and docosahexaneoic acid fatty acids have been found to be the major fatty acids in smelt, sucker, rainbow trout and lake trout muscle. The same results were by Kminkova *et al.* (2001) for common carp muscle. The major fatty acids in carp have

Table 2: Seasonal variations on total fatty acid composition of fillets of carps (*Cyprinus carpio*) in Caspian sea*

Fatty acids	Summer	Autumn	Winter	Spring
C 14:0***	$2.02\pm0.06^{a**}$	1.76 ± 0.31^{b}	1.35 ± 0.53^{b}	1.66 ± 0.45^{b}
C 15:0	1.14 ± 0.03^{a}	1.02 ± 0.29^{ab}	0.80 ± 0.01^{b}	0.96 ± 0.03^{ab}
C 16:0	16.18 ± 0.36^{a}	12.99 ± 6.50^{a}	16.16 ± 1.79^{a}	14.56 ± 4.92^{a}
C 18:0	5.54 ± 0.03^{a}	5.36 ± 0.57^{a}	5.78 ± 0.77^{a}	5.05 ± 1.56^{a}
C 20:0	0.45 ± 0.03^{a}	0.38 ± 0.03^{a}	0^{b}	0.26 ± 0.01^{a}
ΣSFA	25.33	21.51	24.09	22.49
C 14:1 ω5	0.35 ± 0.01^{a}	0.50 ± 0.17^{b}	0.02 ± 0.04^{c}	0.21 ± 0.05^{a}
C 16:1 ω7	6.15 ± 0.13^{a}	7.02 ± 0.97^{a}	5.99 ± 0.14^{a}	6.45 ± 2.01^{a}
C 18:1 ω9	25.11 ± 0.43^{a}	22 ± 3.67^{a}	22.07 ± 0.84^{a}	19.05 ± 1.39^{a}
C 20:1 ω9	1.23 ± 0.01^{a}	0.97 ± 0.59^{a}	1.64 ± 0.44^{a}	1.44 ± 0.25^{a}
ΣMUFA	32.84	30.49	29.72	27.15
C 18:2 ω6	2.19 ± 0.12^{a}	3.92 ± 1.78^{a}	3.72 ± 1.38^{a}	1.99 ± 1.26^{a}
C 18:3 ω3	0.33 ± 0.02^{a}	0.78 ± 0.72^{a}	0.57 ± 0.09^{a}	0.45 ± 0.17^{a}
C 20:2 ω6	0.6 ± 0.03^{a}	0.33 ± 0.37^{b}	0.6 ± 0.03^{a}	0.78 ± 0.06^{a}
C 20:3 ω3	0^{a}	0^{a}	0^{a}	0^{a}
C 20:4 ω6	3.3 ± 0.04^{a}	5 ± 1.21^{b}	6.20 ± 0.97^{b}	5.5 ± 1.17^{b}
C 20:5 ω3	4.15 ± 0.07^{a}	4.62 ± 1.4^{a}	3.95 ± 0.53^{a}	4.75 ± 0.23^{a}
C 22:6 ω3	5.98 ± 0.11^{a}	6.08 ± 2.42^{a}	11.61 ± 1.54^{b}	9.81 ± 0.63^{b}
ΣPUFA	16.55	20.73	26.65	23.28
ω3	10.46	11.48	16.13	15.01
ω6	6.09	9.25	10.52	8.27
ω3/ω6	1.72	1.24	1.53	1.81
ΣUSFA/ΣSFA	1.95	2.38	2.34	2.24

*Average of three lots analysed; **Values reported are means±SD; ***a-c values for each sample with different letters in the same fraction are significantly different at $p<0.05$

been reported to be 18:1 ω9 (oleic), 16:0 (palmitic), 16:1 (palmitoleic), 22:6 ω3 (Docosahexanoic Acid, DHA), 18:2 ω6 (linoleic), 20:4 ω6 (Arachidonic, AA), 18:0 (stearic) and 20:5 ω3 (eicosapentaenoic acid, EPA), in all seasons (Guler *et al*., 2008). In all seasons, the major fatty acids in chub mackerel (*Scomber japonicus*) and horse mackerel (*Trachurus trachurus*) were found to be palmitic acid (16:0), stearic acid (18:0), oleic acid (18:1 ω9), eicosapentaenoic acid (20:5 ω3) and docosahexaneoic acid (20:6 ω3). Chub mackerel and horse mackerel exhibited seasonal fluctuations in their fatty acid contents. The fatty acid profile of the two species had a higher degree of unsaturation during Winter (Celik, 2008). The carp muscles analysed in this study were found to be a superior source of oleic acid, the content of which varied insignificantly during the year. According to some reports, this fatty acid has been shown to prevent cardiovascular diseases (Chong and Ng, 1991; Peterson *et al*., 1994). Palmitic acid was the primary Saturated Fatty Acid (SFA) at 12.99-16.18% in carp in all seasons. Similar results for carp (Kolakowska *et al*., 2000; Guler *et al*., 2008) and other fish species (Celik *et al*., 2005; Rahnan *et al*., 1995) have also been reported in the literature. In general, fish are relatively low in SFA (<30%) except for certain species (Ackman, 1989). Similar results were identified in this study for all seasons (21.51-25.33%). The concentration of some SFA (14:0, 15:0 and 20:0) varied significantly during all seasons.

Oleic acid was identified as the primary MUFA in carp in all seasons (19.05-25.11%). Csengeri and Farkas (1993), Kim and Lee (1986), Kolakowska *et al*. (2000) and Paaver *et al*. (2002) found similar results in carp and Haliloglu *et al*. (2004) also found similar results for other freshwater fish. Palmitoleic acid was the second most abundant MUFA (5.99-7.02%) in the present study. The high levels of oleic, palmitoleic and arachidonic acids had been reported as a characteristic property of freshwater fish oils (Andrade *et al*., 1995). Similarly, Guler *et al*. (2008) found that carp is low in SFA (26.6-29.6%) in all seasons and oleic and palmitoleic acids were found to be the primary and secondary MUFA in carp in all seasons (15.1-20.3 and 5.11-13.2%, respectively) (Guler *et al*., 2008). Previous research has shown similar results in carp muscle during four seasons (palmitic, 398.3-1117.1 (18.22-19.97%); oleic acid, 763.6-2473 (38.34-46.67%); palmitoleic, 206.3-501.5 (10.36-11.10%); all mg/100 g of tissue) (Kminkova *et al*., 2001).

The PUFA content in carp muscle was 16.25-26.65% for all seasons and was generally much higher than the SFA content in Winter and Spring, at 26.65 and 23.25%, respectively. The MUFA contents of carp fillets were higher than the SFA and PUFA contents in all seasons, at 32.84, 30.49, 29.72 and 27.15% (Summer, Autumn, Winter, and Spring, respectively). In Winter, a high ratio of DHA (11.61%) increased the PUFA content and in Summer, the low level of DHA (5.98%) and AA (3.3%) lowered the PUFA content. The PUFA content in carp muscle has been reported to be in a very wide range: 11.6-15.7% of total fatty acids (Bieniarz *et al*., 2000) to 32.3-34.5% (Geri *et al*., 1995). In Guler *et al*. (2008), the PUFA contents of carp muscle were generally much higher than the SFA levels in Spring, Summer and Autumn (37.8, 42.8

and 35.9%, respectively). The MUFA content of carp fillets was higher than the SFA content in Spring, Autumn and Winter (35.7, 37.3 and 41.1%, respectively). In Summer, a high ratio of DHA (11.0%) increased the PUFA content and a low level of palmitoleic acid lowered the MUFA content of carp fillets. In Winter, a low level of 18:2 ω6 lowered the PUFA content in this species. According to the results of Kminkova *et al.* (2001), the MUFA content of carp fillets is higher than SFA and PUFA levels in all seasons 1021.5 (51.28%), 3220.4 (55.22%), 3234.7 (5.93%) and 2890.7 (60.04%) all mg/100 g of tissue; Spring, Summer, Autumn and Winter, respectively). The PUFA content was lower than the SFA content (PUFA: 445.8 (22.38%), 1097.6 (18.82%), 884 (16.20%) and 670 (13.92); SFA: 524.5 (26.33%), 1513.7 (25.96%), 1337.3 (24.51%) and 1253.9 (26.04%) all mg/100 g of tissue). In all seasons, a high level of oleic acid increased the MUFA content. One reason for the observed results is likely the feeding habits of the fish. The percentage of PUFA such as EPA and DHA, in fish muscle is dependent on the diet (Arts *et al.*, 2001; Sargent, 1997). Variations in the fatty acid composition might be related to changes in the nutritional habits of the fish (Norrobin *et al.*, 1990). The levels of EPA in chub mackerel in Winter, Spring and Autumn were 5.96, 4.86 and 4.33%, respectively while those of DHA were 24.94, 18.75 and 17.12%, respectively. The levels of EPA in horse mackerel in Winter, Spring and Autumn were 5.42, 5.03 and 4.86%, respectively while those of DHA were 14.96, 13.31 and 11.10%, respectively. The PUFA (polyunsaturated fatty acids) values and ω3/ω6 ratios in these two species were highest in Winter (Celik, 2008).

In the study, LAω6 (2.19-3.92%), EPA (3.95- 4.75%), AA (3.3-6.20%) and DHA (5.98-11.61%) were the most obvious PUFA in carp in all seasons. Kim and Lee (1986) reported that LAω6 (3.9%), EPA (6%), DHA (5%), LnAω3 (6%) and AA (3.5%) were the most obvious PUFA in carp. Similarly, Guler *et al.* (2008) reported that LAω6 (3.64-10.5%), EPA (4.10-5.69%), AA (4.38-6.99%) and DHA (4.94-11.0%) were the most obvious PUFA in carp in all seasons. Similarly, Rasoarahona *et al.* (2004) found that oleic (17.0-21.5%), palmitic (13.1-16.1%) and linoleic (9.6-13.2%) acids were the dominant fatty acids and AA (2.9-5.9%), DHA (2.9-6.7%), EPA (1.9-3.4%) and docosapentaneoic acid (22:5 ω3, DPA, 1.6-4.3%) were also present. Kminkova *et al.* (2001) found that LAω6 (6.14-7.5%), linolenic acid (2.49-5.4%), EPA (1.89-4.13%), AA (0.68-1.84%) and DHA (0.80-3.67%) were the most obvious PUFA in carp in all seasons.

EPA and DHA, found only in fish and seafood, possess extremely beneficial properties for the prevention of human coronary artery disease (Leaf and Weber, 1988). Therefore, fish have been suggested as a key component for a healthy human diet (Rahnan *et al.*, 1995). Among the ω3 series, carp are good sources of EPA and DHA. The percentages of EPA+DHA in carp were 15.56, 14.56, 10.13 and 10.07% in Winter, Spring, Summer and Autumn, respectively. Kim and Lee (1986) found that the EPA+DHA level was 11.1%, Csengeri and Farkas (1993) found them at 15.3%, Kminkova *et al.* (2001) found them at 2.87-6.93% and Guler *et al.* (2008) found them at 8.42-15.9% in carp. The amounts of EPA+DHA in carp in the present study were found to be higher with respect to the results of Fajmonova *et al.* (2003) and reports on other freshwater fish species (Turon *et al.*, 2005). According to the results, ω3 PUFA increased from Summer to Spring (10.46, 11.48, 16.13 and 15.01%, respectively). The increase in ω3 PUFA in the muscle of female common carp during gonadal maturation confirms the importance of muscle as a fatty acid reserve in suport of reproductive effort in this species, Perez *et al.* (2007) reported the same results in white sea bream muscle during gonadal maturation (*Diplodus sargus*).

Bowman and Rand (1980) and Sargent *et al.* (2002) reported that AA is a precursor for prostaglandin and thromboxane which influence blood clot formation and red blood cell attachment to endothelial cells during wound healing. Apart from that this fatty acid also plays a role in growth. In the study, carp had high contents of AA in Summer, Autumn, Winter and Spring at 3.3, 5, 6.20 and 5.5%, respectively. Kminkova *et al.* (2001) found AA at 0.68-1.84% and Guler *et al.* (2008) found it at 4.38-6.99% in carp.

The ω3/ω6 ratio has been suggested to be useful indicator for comparing the relative nutritional value of fish oils (Pigott and Tucker, 1990). An increase in the human dietary ω3/ω6 fatty acid ratio is essential in the diet to help prevent coronary heart disease by reducing plasma lipids and to reduce the risk of cancer (Kinsella *et al.*, 1990). The increase in the dietary ω3/ω6 fatty acid ratio in favour of ω3 fatty acids also seems to be effective in preventing shock syndrome and cardiomyopathy (Bell *et al.*, 1991). In the study, the average ω3/ω6 fatty acid ratios in carp were 1.53, 1.81 and 1.72 in Winter, Spring and Summer, respectively and decreased to 1.24 in Autumn. The ratio of ω3 PUFAs/ω6 PUFAs in terms of the total lipids in freshwater fish varies mostly between 0.5 and 3.8 whereas for marine fishes, this ratio is 4.7-14.4 (Henderson and Tocher, 1987). The muscle of common carp reared in warm water showed a higher ω3/ω6 PUFA ratio at 1.52 in comparison with carp of the same age reared in water at a natural temperature with a ration of 0.47 (Geri *et al.*, 1995). Fajmonova *et al.* (2003) found this ratio to be 0.5 in carp fillets. In a recent study, the average ratio carp in was near 1 in Winter, Spring and Summer and decreased to 0.5 in Autumn. This was explained by the decreasing levels of ω3 PUFA from 18.9-11.8 in Autumn.

The ratio of unsaturated vs. saturated fatty acids is of great importance in edible fat. A value >0.35 is usually believed to be beneficial (Kminkova *et al*., 2001). In the study, these values in carp muscle were 1.95-2.3 thus from this point of view, carp fat is beneficial for human nutrition. Kminkova *et al*. (2001) found that the variation in this ratio was in the range from 2.16-2.38.

This study showed that carp from the Caspian sea North of Iran is a desirable item in the human diet when the levels of protein, lipids, EPA and DHA and the ω3/ω6 ratio are considered. This condition can be regarded as an explanation for the fact that carp in the Caspian sea are richer in ω3 fatty acids in Winter, Spring and Autumn taking into consideration the fatty acid profile of the fish. As a consequence when human health is taken into account, carp from the Caspian sea appears to be quite nutritious in terms of the chemical composition and especially the fatty acid composition and ratio.

CONCLUSION

This study has identified seasonal fluctuations of fatty acid profile of wild common carp fillet. The maximum concentrations of lipids and protein were found in Summer. The maximum concentration of DHA was found in Autumn and Winter but the Eicosapentaneoic Acid (EPA) concentration did not fluctuate in different seasons. The average ω3/ω6 fatty acid ratios in carp were 1.53, 1.81 and 1.72 in Winter, Spring and Summer, respectively and decreased to 1.24 in Autumn.

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