Mediterranean Fisheries and Aquaculture Research

homepage: www.dergipark/medfar.gov.tr

RESEARCH PAPER

Received: 21 November 2017 | Accepted: 1 January 2018

Comparison of Biochemical, Fatty Acids and Lipid Quality Indexes of Prussian Carp (*Carassius gibelio*) Caught from Lake Çıldır on Different Seasons

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ABSTRACT

Essential fatty acids have a crucial function in human health and hence there is a growing interest in fatty acids profile and nutritional quality of fish, originating from both marine and freshwater resources. This research was performed to identify the seasonal changes in nutritional quality, fatty acids composition and energy contents of Prussian carp inhabiting in Lake Çıldır, Turkey. The fatty acids profile showed, monounsaturated fatty acids ranging from 44.82% in the spring to 41.28% in the autumn. The content of total saturated fatty acids (SFA) was changed from 30.35% (summer) to 29.40% (autumn). The highest polyunsaturated fatty acids (PUFA) content was observed in summer (25.02%) and the lowest in spring (21.52%). Major fatty acids were palmitic, oleic, linoleic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Lipid quality indexes were within the range of recommended levels for human health. According to the results, biochemical composition of Prussian carp is similar in all seasons, in terms of fatty acids, the autumn season can be the most suitable season for consumption. Despite being an underutilized fish species for its taste, odour, high string structure and unpleasant textural features, Prussian carp has a good quality by means of protein and essential fatty acids.

K E Y W O R D S: *Carassius gibelio*, DHA, EPA, fatty acids, lipid quality indexes

How to cite this article: Dagtekin (Gozu), B.B., Balcık Mısır, G., Kutlu, S., Basturk O., (2018). Comparison of Biochemical, Fatty Acids and Lipid Quality Indexes of Prussian Carp (*Carassius gibelio*) Caught from Lake Çıldır on Different Seasons, *MedFAR*., 1(1):2-14.

1. Introduction

Nowadays seafood, especially fish, with high-quality proteins, vitamins, minerals and PUFA are important part of a balanced diet (Ehsani and Jasour, 2012). Epidemiological, clinical and nutritional studies show that the consumption of food items rich in PUFA have positive impact on cardiovascular disease, diabetes, obesity, arthritis, asthma, depression, hyperactivity and some types of cancers (Ruxton et al., 2004; Gogus and Smith, 2010). In the light of this information, the consumption of omega-3 (n-3) fatty acids rich seafood is of paramount importance (Burr et al., 1999; Sargent and Tacon, 1999).

Lake Çıldır is located between the cities Kars and Ardahan (Turkey) in the northern part of East Anatolia (41° 00' north latitude and 43° 12' longitude). Lake Çıldır is a lava-set lake, with an area of 124 km^2. The maximum depth in the lake exceeds 17 metres. Its altitude is 1959 m. Fisheries is an important economic income source of income for the local people (Akbulut and Yıldız, 2002; Nur, 2006) (Figure 1).

Figure 1. Lake Çıldır (URL 1, 2014)

Prussian carp (*Carassius gibelio* Bloch, 1782), a dominant species in the Lake Çıldır, is benthopelagic, non-migratory, omnivorous fresh and brackish water fish species of Cyprinidae family (Specziar et al., 1997; Sası, 2008). Inhabits freshwater streams, ponds and lakes, Prussian carp has a wide geographic distribution extending from Europe to Asia (Kalous et al., 2004; Kottelat and Freyhof, 2007).

C. gibelio which was first introduced to Turkish waters in the early 1990s, enjoyed a rapid population increase and dominated many aquatic ecosystems, both rivers and lakes (Balik et al., 2004). However, commercially it has a low value. Because its high adaptation capability and superiority in food competition with native species inhabiting the same environment has negative impact on growth patterns of other species and also on fisheries activities in Lakes. Reproduction period of *C. gibelio* starts in early summer (June) and continue up to early autumn (September) (Zengin et al., 2013).

Several studies focus on abundance and distribution and negative effect of this species on other fish populations (Kalous et al., 2004; Innal and Erk'akan, 2006; Gaygusuz et al., 2007; Perdikaris et al., 2012; Yerli et. al., 2014), growth parameters (Sasi, 2008; Leonardos et al., 2008; Tarkan et al., 2012), reproduction (Aydin et. al., 2011), biological characteristics (Balık et al., 2004), diet composition and tropic position of *C. gibelio* (Yalcin et al., 2014). There are some studies on fatty acids composition and nutritional quality of *C. gibelio* inhabiting different freshwater sources in Turkey (Bulut, 2010; Cakmak et al., 2012; Ozparlak, 2013; Dagtekin and Basturk, 2014; Tolasa et al., 2016). However, there is limited research studies existing on seasonal distribution of biochemical and fatty acids composition of this species inhabiting in Lake Çıldır, Turkey.

The objective of this study was to investigate the seasonal changes in biochemical properties, fatty acids composition and lipid quality indexes of *C. gibelio* which is not preferred by local people because of having low economical value.

2. Materials and Methods

2.1. Materials

Samples with an average weight 264.55 g and length 22.89 cm were collected from Lake Çıldır, (Turkey) in Summer-Autumn period of 2012, (June-November) and in Spring 2013 (April) (Figure 2). Sampling was not be possible in winter because of frozen Lake during winter time. Samples were transferred to the Central Fisheries Research Institute immediately with using ice. Freezed at -40

°C and kept at -80 °C before analytical period. Analyses were realized by using edible parts of sample.

Figure 2. Prussian carp (*Carassius gibelio* Bloch, 1782) (Dagtekin and Basturk, 2014)

2.2. Biochemical composition and energy value

Crude protein, crude fat, crude ash and moisture contents were measured based on wet weight of the fish muscle tissues. For nutritional analysis thawed fish were filleted by hand, and homogenized (Tefal Smart, France). Kjeldahl method was used to determine protein content, with 6.25 as conversion factor (AOAC, 1995); solvent extraction for lipid (Soxhlet; AOAC, 1995) content; Mattissek et al., (1988) was used for ash content; and Ludorf and Meyer (1973) for moisture content.

The energy value was computed by using the mean values of protein and lipid in muscle tissues. Energy values were estimated according to the equation given below;

Energy value (estimated) (kcal) = (4 x protein) + (4x carbohydrate) + (9x lipid) (FAO, 2003 Atwater System).

Carbohydrate data on seafood samples were theoretically indicated with zero values (TurKomp, 2014).

2.3. Fatty acids analysis and lipid quality indexes

2.3.1. Fatty acids analysis

Preparation fatty acids methyl esters

Fatty acids methyl esters were analysed using gas chromatography (GC). Obtained from lipid analysis 0.1 g of sample was weighted into 5 ml tube with screw cap, 2 ml hexan was added to dissolve the sample and 0.2 ml 2 N methanolic KOH was introduced to the tube. The mixture was vortexed for 30 second and waited for a while, until the upper layer clarified. Hexane solution was put into vials to be analysed (UIPAC, 1979).

GC conditions

GC-17 A GC Shimadzu (with FID- flame ionization detector) was used to analysed the fatty acids composition. Capillary column was Supelco Omega wax 320 (30 m X 0.32 mm) and oven temperature of column was 240 °C, Helium, Nitrogen and dry air mix (30 ml/min) was the carrier gas. Temperatures of detector and injection block were adjusted to 250-260 °C and 250 °C respectively. Total gas flow rate was arranged to 50 ml, Split ratio was 1/25, range 1. Hexane was used as solvent and it was adjusted as pour 1µl sample for each time. Supelco™ 37 Component FAME Mix (Cat. No. 47885-U) was used as standard.

After analyzing, fatty acids methyl esters were represented in GC area percent as mean± standard error.

2.3.2. Lipid quality indexes

To find out the quality indexes of lipids (S/P, Atherogenic index-AI, Trombogenic index-TI (Ulbricht and Southgate (1991)), Flesh lipid quality-FLQ (Abrami et al., 1992), and hypocholesterolemic/hypercholesterolemic-h/H (Santos-Silva et al., 2002**)** following formulas were used;

S/P= [(C14:0 + C16:0 + C18:0) / (∑MUFA + ∑PUFA)]

AI = [(C12:0) + (4 x C14:0) + (C16:0)] / [∑n6 + ∑n3 + ∑MUFA]

TI =[(C14:0) + (C16:0) + (C18:0)] / [0.5 x + ∑MUFA)+(0.5 x ∑ n6)+(3 x ∑n3)+(∑n3 / ∑ n6)]

FLQ= 100 x [(EPA% + DHA%) / (Total fatty acids%)]

h/H=[(C18:1 + C18:2 + C18:3 + C20:3 + C20:4 + C20:5 + C22:4 + C22:5 + C22:6) / (C14:0 + C16:0)]

2.4. Statistical Analysis

Data were analyzed by one-way analysis of variance (ANOVA) test. MedCalc 13.0 for Windows was used for this purpose. Duncan multiple range test was used to identify significant differences between seasonal changes. Results were regarded significant according to (p<0.05) significance level. Analysis applied in three parallels.

3. Results and Discussion

3.1. Biochemical composition and energy value

Data on seasonal changes in biochemical composition and energy value of *C. gibelio* living in Lake Çıldır are presented in Table 1.

Table 1. Seasonal changes in biochemical composition of *C. gibelio.*

Biochemical composition	Summer	Autumn	Spring
Protein (%)	16.47 ± 0.36^{a}	15.60 ± 0.08^{a}	16.01 ± 0.21^{a}
Lipid (%)	2.01 ± 0.07^{a}	2.39 ± 0.24^{a,b}	3.49 ± 0.66^{a,b}
Moisture (%)	77.76 ± 0.46^{a}	76.54 ± 1.15^{a}	75.64 ± 0.40^{a}
Ash (%)	1.04 ± 0.04^{a}	1.07 ± 0.05^{a}	1.11 ± 0.01^{a}
Energy value (kcal)	83.96 ± 2.09^{a}	83.90 ± 2.40^{a}	95.50 ± 5.27^{a}

Values given Mean ± Standard error (n=3). Different superscript letters (a, b, c) denote significant differences ($p<0.05$) in the same raw.

As it is known, lipid and moisture contents are in inverse relation (Katikou et al., 2001). A similar relation was observed between lipid and moisture contents in this study. The lipid content was the highest (3.49%) and moisture content was the lowest (75.64%) in spring season. The lowest lipid content was observed in summer. This could be due to the warm season, when waters were poor in nutrient and mineral contents. At the same time, the slightly decrease can be associated with the reproduction activity of the fish. Because spawning season of this species starts in the June. No significant difference was determined (p>0.05) between proximate composition values related to seasonal difference. Similar results were found by previous studies carried in Turkey and other countries. Ozogul et al. (2007), studied commercially important marine and freshwater fish species. According to their results, lipid contents of freshwater species changed from 0.39% to 3.21%. Yu et al. (2017) investigated the proximate 0.93% respectively. Sule (2011) also studied on the same fish (*Carassius gibelio)* in Lake Eğirdir and found as 16.75%, 16.92%, 61.38% and 1.01% respectively. Shargh et al. (2017) reported the protein content in flesh of *Carassius gibelio* as 19.01%. Ozyilmaz et al. (2016) determined the values of protein, lipid, moisture, dry matter and energy of *C. gibelio* as 19.43%, 3.43%, 76.24%, 0.81% and 458 kj, respectively in Seyhan River, (Adana, Turkey). İzci (2010) worked on *C. gibelio* obtained from Lake Eğirdir (Isparta, Turkey), researcher reported protein, lipid, moisture and ash contents of fish as 17.99%, 4.63%, 76.24% and the protein, lipid, moisture and ash contents as 18.51%, 3.78%, 83.84% and 1.13% respectively. In terms of lipid content, there is a minor difference between findings of this study and other studies; this difference may be caused by the effect of different environmental conditions or the season of sampling. Energy values were calculated as 83.96, 83.90 and 95.50 kcal for summer, autumn and spring respectively. Depending on the lipid levels, increase in energy values was observed in Spring period.

3.2. Fatty acids composition and lipid quality indexes

Fatty acids composition of *C. gibelio* are shown in Table 2. Among ∑SFA, summer and spring results were similar (p>0.05). However; in autumn there was a significant difference compared to other seasons (p<0.05). For ∑MUFA and ∑PUFA, summer and autumn results were similar (p>0.05), with a significant difference in spring (p<0.05). Palmitic acid (C16:0), oleic acid (C18:1n-9) and EPA were predominantly, SFA, MUFA and PUFA, respectively. Several previous studies also support our results that palmitic acid and the oleic acid are predominant SFA and MUFA (Ackman, 1980; Ackman, 1989; Jaben and Chaudhry 2011; Andrade et al., 1995; Özogul et al., 2007; Mahmoud et al., 2007). Bulut (2010) studied on *C.gibelio* population living in Seyitler Dame Lake (Afyon, Turkey) and reported that *C. gibelio* had high ∑PUFA content (40.93%) compared to ∑SFA (23.34%) and ∑MUFA (31.27%) in winter. In summer, the highest value was found in ∑MUFA (34.57%) and was followed by ∑PUFA (31.09%) and ∑SFA (25.99%). Palmitic acid was the predominant SFA (summer 14.94% and winter 13.22%). Oleic acid (summer 16.98% and winter 11.78%) was found to be higher in summer but, lower than palmitoleic acid (C16:1) (summer 11.06% and winter 12.12%).

Ozparlak (2013) investigated fatty acids composition of *C. gibelio* found in Apa Dame Lake (Konya, Turkey). The researcher reported higher ∑PUFA content (45.95%) compared to ∑SFA (26.76%) and ∑MUFA (27.29%) in winter. In summer, the highest value was found in MUFA (38.89%) followed by PUFA (30.67%) and SFA (30.44%). In the study entitled "Lipid contents, fatty acid profiles and nutritional quality of nine freshwater fish species of wild caught in the Yangtze Basin, China" in May, 2013, *C. auratus* had the highest PUFA (45.60%) content, but it had the lowest MUFA (21.83%) among nine freshwater species (Zhang et al., 2014). Farkas (1984) expressed that temperature is an effective factor on saturation degree of fatty acids; when temperature rises, saturation degree also increases. Findings of present study are in well agreement (PUFA values were lower than SFA and MUFA) with these previous studies. Luzzana et al. (1996) stated that PUFA starts to move from muscle to gonads during gonad development. Parallel to this statement, in this study the value of PUFA was low in spring season due to the fact that it starts to transfer from muscle to gonads onset of reproduction. After this period, the amount of PUFA started to increase in the muscle.

Among PUFA, EPA and DHA have an important function in preventing coronary artery disease (Leaf and Weber, 1988). The American Heart Association (AHA) (2003) recommends the consumption of 1 g of EPA and DHA every day for persons with diagnosed coronary heart disease (CHD. According to the same source, for prophylactic reasons persons not suffering any symptoms of cardiovascular disease (CVD) should also consume approximately 500 mg of these acids daily. Furthermore; according to AHA, a daily intake of approximately 2-4 g of EPA+ DHA could lower triglycerides by 20-40% (Kris-Etherton et al., 2003). In present study, in general EPA values showed parallel distribution with PUFA values. The values of EPA were similar in summer (8.75%) and autumn (8.86%) (p>0.05), but a little bit lower in spring (7.88%) (p<0.05). DHA was the highest in autumn (6.25%) (Table 2). When the reproduction season is over (in early September) fish starts to collect lipid and fatty acids in the flesh. Thus, the ratio of DHA increase in flesh. It is necessary for the fish to adapt to decreasing water temperature in autumn, and DHA has an important role in adaptation to low temperatures.

According to AHA recommendations about 200 g edible flesh of *C. gibelio* would cover daily requirement for people without any symptoms of CVD. EPA+DHA values measured in present study were found to be lower than those reported by Bulut (2010) and Cakmak et al. (2012). Bulut (2010) calculated average EPA+DHA as 18.21% for *C. gibelio* inhabiting in Seyitler Dame Lake. Cakmak et al. (2012) reported EPA+DHA as 18.66% for same species occuring in Lake Suğla (Konya, Turkey). Ozogul et al. (2007) found ∑PUFA as 34.3% for *Cyprinus carpio* sampled from Seyhan Dame Lake, Turkey, which is higher than present studies findings, but EPA+DHA values were similar to our findings (14.07%). It is obviously known that freshwater fish species have lower EPA+DHA values than marine fish species (Tanakol et al., 1999; Visentainer et al., 2007; Saglik and İmre, 2001; Özogul and Özogul, 2007; Balcik Misir et al., 2014). Vlieg and Body (1988) also reported that PUFA is lower in freshwater fish compared to marine species, which is in accordance with the findings of this study. Freshwater fish feed mainly on phytoplankton and plant materials while marine fish consume zooplanktons, which are rich in PUFA (Osman et al., 2007). This fact can justify the differences between freshwater and marine species.

et al., 2008). Considering the nutritional benefits, FAO/WHO (1994) suggested a high ratio (>0.2) for n-3/n-6. This ratio is affected by environmental conditions and especially feeding habits of the fish.

Table 2. Seasonal changes of fatty acids composition of *C. gibelio* (%)

Fatty Acids	Summer	Autumn	Spring
C12:0	0.14±0.01^b	0.52±0.01^c	0.10±0.01^a
C14:0	3.07±0.01^a	2.98±0.03^a	3.32±0.05^b
C15:0	0.82±0.01^b	0.85±0.00^c	0.66±0.01^a
C16:0	15.87±0.11^a	16.16±0.04^b	16.99±0.03^c
C17:0	0.80±0.01^b	0.56±0.03^a	0.78±0.01^b
C18:0	3.46±0.01^b	3.54±0.01^b	3.26±0.06^a
C20:0	5.76±0.04^c	4.24±0.13^a	4.72±0.07^b
C22:0	0.30±0.01^a	0.40±0.01^b	0.41±0.00^b
C24:0	0.15±0.00^b	0.15±0.00^b	0.14±0.00^a
SFA	**30.35±0.06^b**	**29.4±0.09^a**	**30.27±0.16^b**
C14:1	0.12±0.00^a	0.72±0.02^c	0.19±0.01^b
C15:1	0.78±0.01^c	0.39±0.01^a	0.69±0.01^b
C16:1	14.02±0.05^a	13.39±0.12^a	14.81±0.32^b
C17:1	0.50±0.12^a	0.66±0.09^a	0.69±0.02^a
C18:1n9	24.62±0.02^b	23.86±0.06^a	26.01±0.09^c
C20:1	0.93±0.01^a	0.96±0.03^a	1.06±0.03^b
C22:1n-9	0.30±0.01^a	0.90±0.02^b	1.02±0.01^c
C24:1	0.30±0.01^a	0.41±0.01^c	0.34±0.00^b
MUFA	**41.55±0.15^a**	**41.28±0.20^a**	**44.82±0.34^b**
C182n6	4.76±0.01^c	3.45±0.02^a	4.22±0.06^b
C18:3n6	2.04±0.01^c	1.45±0.02^a	1.68±0.02^b
C18:3n3	0.82±0.02^a	0.98±0.02^b	1.06±0.03^b
C20:2	0.21±0.00^a	0.28±0.01^b	0.32±0.01^c
C22:2	0.39±0.01^b	0.19±0.01^a	0.45±0.00^c
C20:3n6	0.41±0.01^b	0.08±0.00^a	0.08±0.00^a
C20:4n6	2.66±0.01^b	3.12±0.01^c	2.42±0.03^a
C20:5n3	8.75±0.02^b	8.86±0.10^b	7.88±0.12^a
C22:6n3	4.99±0.02^b	6.25±0.06^c	3.42±0.02^a
PUFA	**25.02±0.07^b**	**24.65±0.22^b**	**21.52±0.28^a**
others	3.08±0.02^a	4.66±0.06^c	3.39±0.11^b
EPA+DHA	13.73±0.04^b	15.11±0.16^c	11.3±0.14^a
PUFA/SFA	0.82±0.01^b	0.84±0.01^b	0.71±0.01^a
∑n3	14.55±0.07^b	16.09±0.14^c	12.35±0.17^a
∑n6	9.87±0.01^c	8.10±0.07^a	8.39±0.10^b
∑n3/∑n6	1.47±0.01^a	1.99±0.01^b	1.47±0.00^a

Values given Mean ± Standard error (n=3). Different superscript letters (a, b, c) denote significant differences (*p<0.05*) in the same raw.

The ratio of ∑n-3/∑n-6 fatty acids is commonly used as an index for assessing the nutritional quality of fisheries products (Chen and Zhang, 2007; Kuley In present study ∑n-3 ratio was found higher than ∑n-6 ratio. Total n-3 was the highest in autumn (16.09%), and the lowest in spring (12.35%) (p<0.05). Total n-6 ratio was the highest in summer (9.87%), and the lowest in autumn(8.10%) (p<0.05). Accordingly, ∑n-3/∑n-6 ratio was maximum in autumn (1.99%) (p<0.05), minimum and the same in summer and spring (1.47%). Cakmak et al. (2012) studied six freshwater fish species in Lake Suğla. They found ∑n-3/∑n-6 ratio for *C. gibelio* as 2.02. Ozparlak (2013) calculated ∑n-3/∑n-6 value as 2.36 in winter and 1.58 in summer for *C. gibelio* in Apa Dame Lake, Turkey. Zhang et al. (2014) studied nine freshwater fish species sampled from Ganjiang River in the Yangtze Basin; they calculated the ∑n-3/∑n-6 ranging from 0.25 to 1.16 which were lower than our results. This inconsistency was greatly attributed to the environmental factors especially locality and feed availability (Zhang et al., 2012; Zhang et al., 2014). Although ∑n-3/n-6 is low compared to marine species, it is within the recommended values mentioned above. This indicates that, *C. gibelio* is a good food item for human consumption.

In this study, PUFA/SFA ratios were similar in summer (0.82%) and autumn (0.84%)(p>0.05), but it was lower in spring (0.71%) (p<0.05). Ozogul et al. (2007) studied six freshwater fish species sampled from Seyhan Dame Lake, they reported the PUFA/SFA ratios ranging between 0.78 and 1.56. They calculated higher values of PUFA/SFA for marine fish species than freshwater fish species. PUFA/SFA ratio of marine fish ranged from 0.66 for *Epinephelus aeneus* to 1.85 for *Scomber scombrus*. On the other hand, PUFA/SFA ratio among freshwater fish varied from 0.78 for *Clarias gariepinus* to 1.56 for *Tinca tinca*, in their study. The recommended minimum value of PUFA/SFA ratio is 0.45 (HMSO, 1994). In the present study, PUFA/SFA ratio is low compared to marine fish species, however; it is within the range of recommended values. Dietetic value of the fish is evaluated by certain lipids and quality indexes depending on relative proportions of saturated fatty acids to unsaturated fatty acids (Senso et al., 2007; Jankowska et al., 2010; Stanec et al., 2011). Nutritional lipid quality indexes of fish have been found to be higher than egg, dairy products, red meat and chicken meat (Kołakowska and Kołakowski, 2001). Table 3 shows seasonal changes in nutritional quality indexes of lipids of *C. gibelio*.

Table 3. Seasonal changes in lipid quality indexes of *C. gibelio.*

Lipid Quality Indexes	Summer	Autumn	Spring
S/P	0.34±0.00^{a}	0.34±0.00^{a}	0.36±0.00^{b}
AI	0.43 ±0.00^{a}	0.44±0.00^{a}	0.46±0.00^{b}
TI	0.32±0.00^{b}	0.30±0.00^{a}	0.36±0.00^{c}
FLQ	14.17±0.05^{b}	15.85±0.18^{c}	11.69±0.13^{a}
h/H	2.59±0.01^{c}	2.51±0.01^{b}	2.30±0.01^{a}

Values given Mean ± Standard error (n=3). Different superscript letters (a, b, c) denote significant differences (*p<0.05*) in the same raw.

The AI and TI demonstrated very low values when compared to those above mentioned food items. The h/H ratio changed between 2.59 in summer to 2.30 in spring (p<0.05). Ulbricht and Southgate (1991) emphasized that AI and TI values should be low to prevent cardiovascular diseases associated with lipid intake. Ouraji et al., (2009) stated that high ratio of h/H represents high quality lipids. In this study, AI and TI indexes were measured to be lower than 1.0 and h/H higher than 1.0. Dal Bosco et al. (2012), calculated AI, TI and h/H values of *Carassius auratus* as 0.44, 0.41, 0.35; 0.24, 0.30, 0.22 and 2.78, 1.78, 3.35 in summer, autumn and spring respectively. It was reported that high h/H ratio shows high quality of lipid from nutritional point of view (Santos-Silva et al., 2002; Sousa Bentes et al., 2009). In present study, AI and TI indices were lower than 1.0 but high in h/H ratio.

Tonial et al. (2014) found AI, TI and h/H values in larvea of *Orechromis niloticus* as 0.55, 0.82 and 1.63; for juvenile of *Orechromis niloticus* as 0.60, 0.87 and 1.56, respectively. In the present study, the maximum FLQ value was calculated (15.85) in autumn and the minimum (11.69) in spring (p<0.05). Stancheva et al. (2014), studied *Cyprinus carpio* and *Sillurus glanis*; they calculated FLQ value as 6.84 for *Cyprinus carpio* and 8.02 for *Sillurus glanis*. It is thought that the differences between two studies are caused by factors such as environmental conditions, sampling time, gender, reproduction time, feeding regime etc. Lipid quality of flesh is directly related with EPA and DHA ratios. Relatively high FLQ value was obtained in this study. Omega-3 fatty acids are beneficial for both healthy, and people suffering from cardiovascular diseases. It is reported that omega-3 fatty acids lower the risk of arrhythmias (abnormal heartbeats), which can lead to sudden death (URL 2, 2016). Within this context, C. gibelio enjoys a good nutritional quality for human consumption.

4. Conclusion

Despite its characteristic features such as taste, smell, high stringy structure and unpleasant textural properties compared to other fish species, *C. gibelio* is a valuable source of food with essential fatty acids and protein content. In terms of fatty acids, biochemical composition of Prussian carp is similar in summer, autumn and spring seasons,. The autumn season can be the most suitable season for consumption of Prussian carp. Nevertheless; it should be underlined that alternative processing technologies should be used to obtain more desirable products from this species. This would only help to promote demand and consumption of C. *gibelio*, but also faclilitate the use of this species and as an economic raw material for processing industry. The result of this study reveal that *C. gibelio* enjoys a promising potential to become an important source of raw material for different processed products. Therefore, the development of processing methods to explore and promote the economic value of this species is highly recommended.

Acknowledgements

The authors would like to thank Murat Dagtekin (PhD) for fish samples and Central Fisheries Research Institute (Trabzon, Turkey) for providing the laboratories to carry out this study.

References

Abrami, G., Natiello, F., Bronzi, P., McKenzie, D., Bolis, L., Aggrade E. (1992). A comparison of highly unsaturated fatty acid levels in wild and farmed eels (*Anguilla anguilla*). Comparative Biochemistry and Physiology, 101B (1/2): 71–82. doi: 10.1016/0305-0491(92)90161-J.

Ackman, R. G. (1980). Fish Lipids. Part 1. In J. J. Connell (Ed.), Advances in Fish Sciences and Technology (pp. 86–103). Farnham, Surrey: Fishing News Books. Ltd.

Ackman, R. G. (1989). Fatty Acids. In R. G. Ackman (Ed.), Marine Biogenic Lipids, Fats and Oils (pp. 145–178). Boca Raton: CRC Press.

Akbulut, A., Yıldız, K. (2002). The planktonic diatoms of Lake Çıldır (Ardahan-Turkey). Turkish Journal of Botany, 26: 55- 75.

Andrade, A. D., Rubira, A. F., Matsushita, M., Souza, N. E. (1995). ω- 3 Fatty acids in freshwater fish from south Brazil. Journal of American Oil Chemistry, 72(10): 1207–1210.

AOAC, (1995). Official Methods of Analysis of AOAC International, Association of Official Analytical Chemists, Arlington, VA.

Aydin, H., Gaygusuz, O., Tarkan, A. S., Top, N., Emiroğlu, Ö., Gaygusuz, Ç. G. (2011). Invasion of freshwater bodies in the Marmara region (northwestern Turkey) by nonnative gibel carp, *Carassius gibelio* (Bloch, 1782). Turkish Journal of Zoology, 35(6): 829-836. doi:10.3906/zoo-1007-31.

Balcik Misir, G., Tufan, B., Kose, S. (2014). Monthly variation of total lipid and fatty acid contents of Atlantic bonito, *Sarda sarda* (Bloch,1793) of Black Sea. International Journal of Food Science and Technology, 49: 2668–2677. doi:10.1111/ijfs.12578.

Balık, I., Ozkok, R., Cubuk, H., Uysal, R. (2004). Investigation of some biological characteristics of the silver crucian carp, *Prussian carp* (Bloch 1782) population in Lake Eğirdir. Turkish Journal of Zoology, 28: 19–28.

Bulut, S. (2010). The variation of the fatty acid composition in muscle tissue of Carassius gibelio living in Seyitler Dam Lake (Afyonkarahisar). Electronic Journal of Food Technologies, 5(2): 69-75.

Burr, M., Gilbert, J., Holliday, R. M., Elwood, P, Fehily, A., Rogers, S., Sweetnam, P. M., Deadman, N. M. (1989). Effects of changes in fat, fish, and fibre intakes on death and myocardial reinfarction: diet and reinfarction trial (DART). The Lancet, 334: 757–761. doi: 10.1016/S0140-6736(89)90828-3.

Cakmak, Y. S.,, Zengin, G., Guler, G. O., Aktumsek, A., Ozparlak, H. (2012). Fatty acid Composition and ω3/ω6 ratios of the muscle lipids of six fish species ın Sugla Lake, Turkey. Archives of Biological Sciences, 64(2): 471-477. doi: 10.2298/ABS1202471C.

Chen, D. W., Zhang, M. (2007). Non-volatile taste active compounds in the meat of Chinese mitten crab (*Eriocheir sinensis*). Food Chemistry, 104: 1200–1205.doi:10.1016/j.foodchem.2007.01.042

Dagtekin, B. B., Basturk, O. (2014). The determination of meat yield and chemical composition of Prussian Carp (*Carassius gibelio* (Bloch, 1782)) in The Çıldır Lake. Yunus Research Bulletin, 14(2), 15-22. doi: 10.17693/yunusae.vi.235394

Dal Bosco, A., Mugnai, C., Mourvaki, E., Castellini, C. (2012). Seasonal changes in the fillet fatty acid profile and nutritional characteristics of wild Trasimeno Lake goldfish (*Carassius auratus* L.). Food Chemistry, 132: 830–834. doi: 10.1007/s11746-007-1070-4

Ehsani, A., Jasour, M. S. (2012). Microbiological properties and biogenic amines of whole pike-perch (Sander lucioperca, Linnaeus 1758): a perspective on fish safety during postharvest handling practices and frozen storage. Journal of Food Science, 77(12): M664–M668. doi: 10.1111/j.1750-3841.2012.02970.x.

FAO (Food and Agriculture Organization) (2003). Food energy–methods of analysis and conversion factors. Report of a technical workshop, Food and Nutrition Paper, 77, Rome, 3–6 December 2002, 18-56.

FAO/WHO (1994). Fats and oils in human nutrition. Report of a Joint FAO/WHO Expert Consultation, Rome, 19 -26 October 1993, 168 pp.

Farkas, T. (1984). Adaptation of fatty acid composition to temperature-a study on carp (*Cyprinus carpio L.*) liver slices. Comparative Biochemistry and Physiology, 79 B (4): 531-535. doi: 10.1016/0305-0491(84)90361-4.

Gaygusuz, O., Tarkan, A. S., Gaygusuz, C. G. (2007). Changes in the fish community of the Ömerli Reservoir (Turkey) following the introduction of non-native gibel carp *Carassius gibelio*(Bloch, 1782) and other human impacts. Aquatic Invasions, 2: 117–120, http://dx.doi.org/10.3391/ai.2007.2.2.6

Gogus, U., Smith, C. (2010). n-3 Omega fatty acids: a review of current knowledge. International Journal of Food Science and Technology,45: 417–436. doi:10.1111/j.1365-2621.2009.02151.x

HMSO (1994). Nutritional aspects of cardiovascular disease. Report of the cardiovascular review group committee on medical aspects of food policy. Report on Health and Social Subject (Lond). 46: 1-186. Department of Health. Her Majesty`s Stationery Office.

IUPAC (International Union of Pure and Applied Chemistry) (1979). Standard Methods for Analysis of Oils, Fats and Derivatives, 6th Edition (Fifth Edition Method II.D.19) Pergamon Pres, 96-102. Oxford. UK.

Innal, D., Erk'akan, F. (2006) Effects of exotic and translocated fish species in the inland waters of Turkey. Reviews in Fish Biology and Fisheries, 16: 39-50. doi: 10.1007/s11160-006-9005-y

Izci, L. (2010) Utilization and quality of fish fingers from prussian carp (*Carassius gibelio* Bloch, 1782), Pakistan Veterinary Journal, 30(4): 207-210.

Jabeen, F., Chaudhry, A. S. (2011). Chemical compositions and fatty acid profiles of three freshwater fish species, Food Chemistry, 125: 991–996. doi:10.1016/j.foodchem.2010.09.103.

Jankowska, B., Zakes, Z., Zmijewski, T., Szczepkowski, M. (2010). Fatty acid profile of muscles, liver and mesenteric fat in wild and reared perch (*Perca fluviatilis*). Food Chemistry, 118: 764–768. doi: 10.1016/j.foodchem.2009.05.055.

Kalous, L., Memis, D., Bohlen, J. (2004). Finding of triploid *Prussian carp* (Bloch, 1780) (Cypriniformes, Cyprinidae) in Turkey. Cybium, 28: 77-79.

Katikou, P., Hughes, S. I., Robb, D. H. F. (2001). Lipid distribution within Atlantic salmon Salmo salar/ fillets. Aquaculture, 202: 89–99. doi: 10.1016/S0044-8486(01)00562-2

Kołakowska, A., Kołakowski, E. (2001). The specific nutritional properties of fish. Przemysł spożywczy, 6: 10–13.

Kottelat, M., Freyhof, J. (2007). Handbook of European Freshwater Fishes. Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany, 646 pp.

Kris-Etherton, P. M., Harris, W. S., Appel, L. J. (2003). Omega-3 fatty acids and cardiovascular disease new recommendations from the American Heart Association. Arteriosclerosis, Thrombosis, and Vascular Biology, 23: 151-152. doi: 10.1161/01.ATV.0000057393.97337.AE

Kuley, E., Ozogul, F., Ozogul, Y., Olgunoglu, A. I. (2008). Comparison of fatty acid and proximate compositions of the body and claw of male and female blue crabs *(Callinectes sapidus)* from different regions of the Mediterranean coast. International Journal of Food Science and Nutrition, 59: 573–580. doi: 10.1080/09637480701451201

Leaf, A., Weber, P. C. (1988). Cardiovascular effects of n-3 fatty acids. The New England Journal of Medicine, 318: 549-557. doi: 10.1056/NEJM198803033180905

Leonardos, I. D., Kagalou, I., Tsoumani, M., Economidis, P. S. (2008). Fish fauna in a Protected Greek lake: biodiversity, introduced fish species over a 80-year period and their impacts on the ecosystem. Ecology of Freshwater Fish, 17: 165–173. doi: 10.1111/j.1600-0633.2007.00268.x

Ludorff, W., Meyer, V. (1973). Fische und Fisherzeugnisse, Z. Auflage. Verlag Paul Parey in Berlin und Hamburg, 209-210.

Luzzana, U., Serrini, G., Moretti, V. M., Grimaldi, P., Paleari, M. A., Valfre, F. (1996). Seasonal variations in fat content and fatty acid composition of male and female coregonid ‘bondella’ from Lake Maggiore and landlocked shad from Lake Como (Northern Italy). Journal of Fish Biology, 48: 352–366. doi: 10.1111/j.1095-8649.1996.tb01433.x

Mahmoud, B. S. M., Kawai, Y., Yamazaki, K., Miyashita, K., Suzuki T. (2007) Effect of treatment with electrolyzed NaCl solutions and essential oil compounds on the proximate composition, amino acid and fatty acid composition of carp fillets. Food Chemistry, 101 (4):1492–1498. doi:10.1016/j.foodchem.2006.03.057.

Mattissek, R., Shengel, F.M., Steiner, G. (1988). Lebensmittel-Analytick, Springer Verlag Berlin, Tokyo, 440p.

Nur, G. (2006). Karyotype Analysis in *Acanthalburnus microlepis* (DE FİLİPPİ, 1863) and *Alburnus filippii* (Kessler, 1877) endemic to Kura-Aras River Basin, Kafkas University Graduate School of Natural and Applied

Sciences Department of Biyology, MSc. Thesis, Kars, Turkey, 85 pp.

Osman, F., Jaswir, I., Khaza'ai, H., Hashim, R. (2007). Fatty acid profiles of fin fish in Langkawi Island, Malaysia. Journal of Oleo Science, 56(3): 101–113. doi: 10.5650/jos.56.107

Ouraji, H., Shabanpur, B., Abediankenari, A., Shabani, A., Nezami, A., Sudagar, M., Faghanid, S. (2009). Total lipid, fatty acid composition and lipid oxidation of Indian white shrimp (*Fenneropenaeus indicus*) fed diets containing different lipid sources. Journal of the Science of Food and Agriculture, 89: 993–997. doi: 10.1002/jsfa.3545

Ozyilmaz, A., Alagoz Erguden, S., Erguden, D., Özeren, A., Semerci, R. S. N. (2016). The proximate compositions, carbohydrate contents and energy values of three freshwater fish from Seyhan River in Adana/Turkey. Journal of Entomology and Zoology Studies; 4(4): 1153-1155.

Ozogul, Y., Ozogul, F., Alagoz, S. (2007). Fatty acid profiles and fat contents of commercially important seawater and freshwater fish species of Turkey: A comparative study. Food Chemistry, 103(1): 217-223. doi:10.1016/j.foodchem.2006.08.009.

Ozogul, Y., Ozogul, F. (2007). Fatty acid profiles of commercially important fish species from the Mediterranean, Aegean and Black Seas. Food Chemistry, 100(4): 1634–1638. doi:10.1016/j.foodchem.2005.11.047

Ozparlak, H. (2013). Effect of seasons on fatty acid composition and n-3/n-6 ratios of muscle lipids of some fish species in Apa Dam Lake, Turkey. Pakistan Journal of Zoology, 45(4): 1027-1033.

Perdikaris, C., Kozak, P., Kouba, A., Konstantinidis, E., Paschos, I. (2012). Socio-economic drivers and non-indigenous freshwater crayfish species in Europe. Knowledge and Management of Aquatic Ecosystems, 404: 01. doi: 10.1051/kmae/2011077

Ruxton, C., Reed, S. C., Simpson, M., Millington, K. (2004). The health benefits of omega-3 polyunsaturated fatty acids: a review of the evidence. Journal of Human Nutrition and Dietetics, 17, 449–459. doi: 10.1111/j.1365-277X.2004.00552.x

Saglik, S., Imre, S. (2001). ω3-Fatty Acids in Some Fish Species from Turkey. Journal of Food Science, 66, 210–212. doi:10.1111/j.1365-2621.2001.tb11318.x

Santos-Silva, J., Bessa, R. J. B., Santos-Silva, F. (2002). Effect of genotype, feeding system and slaughter weight on the quality of light lambs. II. Fatty acid composition of meat. Livestock Production Science, 77, 187–194. http://dx.doi.org/10.1016/S0301-6226(02)00059-3

Sargent, J., Tacon, A. (1999). Development of farmed fish: a nutritionally necessary alternative to meat. Proceedings of the Nutrition Society, 58: 377–384. doi: 10.1017/S0029665199001366

Senso, L., Suarrez, M. D., Ruiz-Cara, T., Garcıra-Gallego, M. (2007). On the possible effects of harvesting season and chilled storage on the fatty acid profile of the fillet of farmed gilthead sea bream (*Sparus aurata*). Food Chemistry, 101: 298–307. doi: 10.1016/j.foodchem.2006.01.036

Shargh, A. S., Rahimabadi, E. Z. Alizadeh, E., Gheybi, F. (2017). Amino acid and fatty acid profiles of materials recovered from Prussian carp, *Carassius gibelio* (Bloch, 1782), using acidic and basic solubilization/ precipitation technique, Caspian Journal of Environmental Sciences, 15(3): 285-294.

Sousa Bentes, A., Souza, H. A. L., Simões, M. G., Mendonca, X. M. F. D. (2009). Caracterização física e química e perfil lipídico de três espécies de peixes amazônicos. Revista Brasileira de

Tecnologia Agroindustrial, 3: 97-108. doi: 10.3895/S1981-36862009000200011

Specziár, A., Tölg, L., Bíró, P. (1997) Feeding strategy and growth of cyprinids in the littoral zone of Lake Balaton. Journal of Fish Biology, 51: 1109–1124. doi:10.1111/j.1095-8649.1997.tb01130.x

Stancheva, M., Merdzhanova, A., Dobreva, D. A., Makedonski, L. (2014). Common carp *(Cyprinus caprio*) and European Catfish (*Silurus glanis*) from the Danube River as sources of fat soluble vitamins and fatty acids. Czech Journal of Food Science, 32(1): 16-24.

Stanec, M., Borejszo, Z., Dabrowski, J., Janicki, B. (2011). Fat and cholesterol content and fatty acid profiles in edible tissue of spiny-cheek crayfish, *Orconectes limosus* (Raf.) from Lake Goplo (Poland). Archives of Polish Fisheries, 19: 241–248. doi: 10.2478/v10086-011-0030-7

Sule, O. (2011). Determination of chemical and microbiologic quality of surimi produced from *Carassius gibelio*, M. Sc., Thesis, Süleyman Demirel University Graduate School of Applied and Natural Sciences Fishing and Fishing Processing Technology Department, Isparta, Turkey, 46 p.

Sası, H. (2008). The length and weight relations of some reproduction characteristics of prussian carp *Carassius gibelio* (Bloch, 1782) in the South Aegean Region(Aydın-Turkey), Turkish Journal of Fisheries and Aquatic Sciences, 8: 87-92.

Tanakol, R., Yazici, Z., Şener, E., Sencer, E. (1999). Fatty acid composition of 19 species of fish from the Black Sea and the Marmara Sea. Lipids, 34(3): 291-297. doi: 10.1007/s11745-999-0366-8

Tarkan, A. S., Gaygusuz, Ö., Gaygusuz, Ç. G., Saç, G., Copp, G. H. (2012). Circumstantial evidence of gibel carp, *Carassius gibelio*, reproductive competition exerted on native fish species in a mesotrophic reservoir. Fisheries Management and Ecology, 19(2): 167–177, http://dx.doi.org/10.1111/j.13652400.2011.00839.x

Tolasa, S., Cakli, S., Dincer, T., Sargin, H., Ucok, C. (2016). Evaluation of nutritional value of *Carassius gibelio* (Bloch, 1782). Journal of Food Safety and Food Quality, 67: 139–146. doi: 10.2376/0003-925X-67-139

Tonial, I. B., Francielly de Oliveira, D., Coelho, A. R., Matsushita, M., Garcia Coró, F. A., Evelazio de Souza, N., Visentainer, J. V. (2014). Quantification of essential fatty acids and assessment of the nutritional quality indexes of lipids in tilapia alevins and juvenile tilapia fish (*Oreochromis niloticus*). Journal of Food Research; 3(3): 105-114. doi: 10.5539/jfr.v3n3p105

TurKomp. (2014). Turkish Food Composition Database, version 1.0 Food Institute, TÜBİTAK Marmara Research Center, Gebze / Kocaeli.

Ulbricht, T., Southgate D. (1991). Coronary heartdisease: seven dietary factors. Lancet, 338: 985–992.

URL 1. (2014) Google earth, (24.05.2014).

URL2.(2016). http://www.heart.org/HEARTORG/HealthyLiving/HealthyEating/ Healthy Diet Goals/Fish-and-Omega-3-Fatty Acids_UCM_303248_Article.jsp#.Wjtw499l-M8., (19.12.2017).

Visentainer, J. V., Noffs, M. D. A., Carvalho, P. O., Almeida, V. V., Oliveira, C. C., Souza, N. E. (2007). Lipid content and fatty acid composition of 15 marine fish species from the Southeast Coast of Brazil. Journal of American Oil Chemistry Society, 84: 543–547. doi: 10.1007/s11746-007-1070-4

Vlieg, P., Body, D. B. (1988). Lipid content and fatty acid composition of some New Zealand freshwater fin fish, shell fish and roes. Journal of Marine Freshwater Research, 22: 151-162.

Yalcın Ozdilek, S., Jones, R. I. (2014). The diet composition and trophic position of introduced prussian carp *Carassius gibelio* (Bloch, 1782) and native fish species in a Turkish River. Turkish Journal of Fisheries and Aquatic Sciences, 14: 769-776. doi:10.4194/1303-2712-v14_3_19

Yerli, S. V., Mangıt, F., Emiroglu, O., Yegen, V., Uysal, R., Unlu, E., Alp, A., Buhan, E., Yıldırım, T., Zengin, M. (2014). Distribution of invasive *Prussian carp* (Bloch, 1782) (Teleostei:Cyprinidae) in Turkey. Turkish Journal of Fisheries and Aquatic Sciences, 14: 581-590. doi: 10.4194/1303-2712-v14_2_30.

Zhang, D. P., Zhang, X. Y., Yu, Y. X., Li, J. L., Yu, Z. Q., Wang, D.Q, Wuc,M. H., Sheng, G. Y., Fu, J. M. (2002). Intakes of omega-3 polyunsaturated fatty acids, polybrominated diphenyl ethers and polychlorinated biphenyls via consumption of fish from Taihu Lake, China: A risk–benefit assessment. Food Chemistry, 132: 975-981. doi:10.1016/j.foodchem.2011.11.082

Zhang, Z., Liu, L., Xie, C., Li, D., Xu, J., Zhang, M., Zhang, M. (2014). Lipid contents, fatty acid profiles and nutritional quality of nine wild caught freshwater fish species of the Yangtze Basin. China Journal of Food and Nutrition Research, 2(7): 388-394. doi:10.12691/jfnr-2-7-10

Zengin, M., Akpınar-Ozcan, İ., Dagtekin, M., Gumus, A., Kılıç, Ç. C. (2013). Çıldır Gölü ekosistemine yerleşerek dinamik bir stok oluşturan Gümüşi Havuz Balığı (*Carassius gibelio*, Bloch, 1782)'nın avcılık-populasyon ilişkileri", Türkiye İstilacı Tatlısu Türleri Çalıştayı: Ulusal Eylem Planı,12-14 Haziran 2013, s.5-6, İstanbul. (in Turkish).

Yu, L. C., Zzaman, W., Akanda, M. J. H., Yang, T. A., Easa, A. M. (2017). Influence of superheated steam cooking on proximate, fatty acid profile, and amino acid composition of Catfish (*Clarias batrachus*) fillets. Turkish Journal of Fisheries and Aquatic Sciences, 17: 935-943. doi: 10.4194/1303-2712-v17_5_09