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Comparative indicators of the chemical composition of farmed and wild common carp (*Cyprinus carpio*, L. 1758)

Dijana Blazhekovikj - Dimovska[1*], Sibel Ahmed[2]

[1]*University „St. Kliment Ohridski “, Faculty of Biotechnical Sciences, Bitola, N. Macedonia*
[2]*Food and Veterinary Agency of Republic of N. Macedonia*

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ABSTRACT

In this study, a comparative analysis of certain qualitative parameters of common carp (Cyprinus carpio L. 1758) was performed, i.e. common carp from aquaculture (warm-water fishpond) and open waters (Prespa Lake), during the autumn. The qualitative properties of the common carp were established by the determination of the chemical composition of the fish meat, the energy value of meat, and the microbiological analysis for the total number of microorganisms on fish skin and the presence of Salmonella sp. and Listeria monocytogenes. In addition to the main research, analyses of the physico - chemical properties and a microbiological quality of the water in which the common carp resides were included.

The results obtained during the examination of the chemical composition of the common carp meat from the warm-water fishpond shown the mean value of 73.580% water, 14.433% protein, 6.850% fat, and 1.036% ash, while in common carp from Prespa Lake: 73.223% water, 15.333% protein, 3.483% fat and 1.053% ash. The differences in the values of fat content between fish meat from a warm-water fish pond and Prespa Lake are statistically significant on level $p<0.05$.

The significantly higher energy value is established in the farmed common carp meat (514.546 kJ/100 gr) compared to the meat from wild carp (398.811 kJ/100 gr), as a result of significantly higher values of fat content in farmed common carp.

Introduction

The value of common carp (Cyprinus carpio L. 1758) varies considerably in different parts of the world. Common carp is especially valued in Asian countries, Europe and South America, and it is also used in the daily diet in Israel, Germany, Brazil, the Balkans, especially during the holidays. In the market of many European countries, especially Italy, Poland, Hungary, Germany, and France, in recent years common carp has been pushed out by other fish species, while in the United States there are stereotypes about carp as a less valuable fish. Carp production and consumption dominate in Southeast Asia, Central and Eastern Europe, while in developed countries of Europe and North America it is reduced to a minimum. Many studies in the world have focused on the quality of common carp meat, with a general emphasis on meat processing values and fat content.

The chemical composition of the meat of farmed or aquaculture common carp is greatly influenced by the diet (Caballero et al., 2002; Valente et al., 2007; Ljubojević et al., 2013). In general, under the same growing conditions, foods rich in n-3 fatty acids greatly increase the n-3/ n-6 PUFA ratio in fish muscle tissue (Robin and Skalli, 2007). However, the chemical composition of fish can vary within the same species, depending on different conditions, including sex, environmental conditions (Vandeputte et al., 2008; Prato and Biandolino, 2012), water temperature and its quality, type and availability of food, age and

*Corresponding author E-mail: dijanablazekovic@yahoo.com

season (Rasoarahona et al., 2004; Guler et al., 2008; Trbović et al., 2009). Common carp (*Cyprinus carpio* L. 1758) is the dominant fish species in warm-water fishponds in Macedonia. Favourable climatic conditions and numerous rivers and reservoirs contribute to a long tradition in the breeding of cyprinid species in our country, especially common carp, and the creation of habits for its consumption. Increased demands for higher productivity of carp ponds, as well as for higher quality carp meat contribute to the improvement of the conditions for its breeding.

In this study, a comparative analysis of certain qualitative parameters of common carp (*Cyprinus carpio* L. 1758) was performed, i.e. common carp from aquaculture (warm-water fishpond) and open waters (Prespa Lake), during the autumn. The qualitative properties of the common carp were established by the determination of the chemical composition of the fish meat, the energy value of meat and the microbiological analysis for the total number of microorganisms on fish skin and the presence of *Salmonella* sp. and *Listeria monocytogenes*. In addition to the main research, analyses of the physico - chemical properties and a microbiological quality of the water in which the common carp resides were included.

Materials and methods

Analysis in this study was performed on samples of farmed and wild common carp, i.e. common carp from a warm-water fishpond and open waters (Prespa Lake). Carp samples have been taken in autumn. The average mass of farmed common carp samples was 1750 g, while the average length was 62 cm. The average mass of wild common carp samples was 1800 g, while the average length was 82 cm.

Figure 1. Warm-water fishpond "Zhabeni" (Macedonia) (original)

The warm-water fishpond is located in the Pelagonia region (near the city of Bitola, Macedonia). In this fishpond, the carp breeding is based on food that is naturally present in the pond (zooplankton and phytoplankton), as well as on a supplemented diet with unprocessed cereals (wheat, corn, barley).

Prespa Lake is the second largest natural lake in Macedonia and it is typically a cyprinid lake, concerning the composition of the fish settlement. The autochthonous ichthyofauna in Prespa Lake consists of several fish species including the common carp.

Figure 2. Prespa Lake (Macedonia) (original)

During the analysis of the certain qualitative properties of the common carp meat, as well as of aquatic environment, the following methods were used:

Methods for determination of the chemical composition of fish meat

- Determination of moisture content - ISO 712:2009;

- Spectrophotometric determination of total nitrogen according to Kjeldahl - HACH DR 400 procedure method 2410;
- Determination of the total fat by gravimetric method (Soxhlet extraction) - AOAC method 2003.6;
- Determination of ash in an oven at 700 °C - ISO 3593:1981;

Methods for microbiological analyses of fish meat

- Horizontal method for detection and enumeration of *Listeria monocytogenes* - ISO 11290 - 1:2008;
- Horizontal method for detection and enumeration of *Salmonella* sp. - ISO 6579 - 2008;
- Horizontal method for the enumeration of microorganisms - ISO 4833:2003.

Methods for physico-chemical properties of the water

- pH determination - ISO 1052:1994;
- Chloride determination - ISO 9297:1989;
- Spectrophotometric determination of nitrates - HACH DR 400 procedure Method 8039;
- Spectrophotometric determination of iron - HACH DR 400 procedure Method 8365;
- Spectrophotometric determination of nitrites - HACH DR 400 procedure Method 8507;
- Turbidity determination of translucency - ISO 7027:1999;
- Spectrophotometric determination of ammonia - HACH DR 400 procedure Method 8038;
- Determination of chemical oxygen demand, Merck Method Spectroquant 1.18752.0001;
- Total nitrogen determination - Merck Method Spectroquant 1.14537.0001.

Methods for microbiological analyses of the water

- Detection and enumeration of coliform bacteria and Escherichia coli - ISO 9308 - 1:2000;
- Detection and enumeration of intestinal enterococci and Streptococcus faecalis - ISO 7899 - 2:2000.

The energy value (EV) of common carp meat was calculated according to the formula:

EV (кJ/100g) = proteins (%) x 17.16 + fats (%) x 38.96 (Vitčenko et al., 1981).

Standard descriptive statistical analyses (Microsoft Office Excel 2010, Data Analysis ToolPak, and t-test) were used for results processing.

Results and discussion

Considering the results of the physico-chemical and microbiological analysis of the water samples from the warm-water fishpond and Prespa Lake, the following results were obtained:

Table 1. Physico-chemical properties of water samples

Parameters	**Fishpond**	**Prespa Lake**
Temperature	12.5 °C	22 °C
Dissolved oxygen	9.2 mg/l	7.5 mg/l
Represent of oxygen - saturation	85 %	85 %
5-day biochemical consumption of O_2 at 20 °C	3.20 mg/l	2.90 mg/l
Chemical oxygen consumption	5.00 mg/l	5.00 mg/l
Suspended matters	2 mg/l	1.86 mg/l
Dry residue of filtered water	80.0 mg/l	118.0 mg/l
pH	7.80	8.01
Nitrites	0.0700 mg/l	0.0037 mg/l
Nitrates	0.20 mg/l	0.000 mg/l
Chlorides	12.00 mg/l	10.00 mg/l
Ammonia	0.020 mg/l	0.000 mg/l
Electro conductivity	139.400 ms/cm	385.000 ms/cm
Total phosphorous	0.007 mg/I	0.003 mg/I
Total nitrogen	0.319 mg/I	0.185 mg/I

Table 2. Microbiological properties of the water samples

Parameters	Fishpond	Prespa Lake
The probable number of thermo-tolerant coliform bacteria in 100 ml	15	10
***Streptococcus* of fecal origin in 100 ml**	20	0

Based on the physico-chemical and microbiological properties of the water samples from a warm-water fishpond and Prespa Lake, the water is classified into class II (according to the Regulation on water classification Official Journal of RM 18/99), which is allowed for fish production.

Considering the results of the microbiological analysis for the total number of microorganisms on fish skin and the presence of *Salmonella* sp. and *Listeria monocytogenes*, the following results were obtained:

Table 3. Microbiological analysis of common carp

Parameters ($\bar{X}$)	Total number of microorganisms (log CFU/cm^2)	*Salmonella* sp.	*Listeria monocytogenes*
Farmed common carp	3.83	0	0
Wild common carp	2.90	0	0

Legend: $\bar{X}$ *- mean value*

Considering the results of the chemical composition and energy value of the farmed and wild common carp meat, the following results were obtained:

Table 4. Chemical composition (%) of the common carp meat

Chemical components	Farmed common carp				Wild common carp			
	$\bar{X}$ ± SD	min	max	CV	$\bar{X}$ ± SD	min	max	CV
Water	73.580 ± 0.078	73.49	73.68	0.001	73.223 ± 0.274	72.90	73.57	0.003
Proteins	14.433 ± 0.262	14.20	14.80	0.018	15.333 ± 0.047	15.30	15.40	0.003
Fats	6.850 ± 0.356	6.55	7.35	0.051	3.483 ± 0.190	3.22	3.65	0.054
Ash	1.036 ± 0.050	0.98	1.10	0.048	1.053 ± 0.004	1.05	1.06	0.003

Legend: $\bar{X}$ *- mean value; SD – standard deviation; min – minimum value; max – maximum value; CV – coefficient of variation.*

From the results obtained during the examination of the chemical composition of farmed common carp, an average value of 73.580% water, 14.433% protein, 6.850% fat, and 1.036% ash was determined. On the other hand, the following results were obtained for wild common carp: 73.223% water, 15.333% protein, 3.483% fat, and 1.053% ash (Table 4).

In the autumn, the meat from farmed common carp contains almost identical water content (73.580%) compared to wild common carp (73.223%). Regarding the protein content, there is also no significant difference between the amounts of it in the farmed common carp (14.433%) compared to wild common carp (15.333%). The fat content of farmed common carp meat is 6.850%, which is significantly higher than that of wild common carp (3.483%). The average amount of ash is slightly lower in farmed common carp (1.036%) compared to wild common carp (1.053%). (Table 5)

According to the results obtained during the examination of the chemical composition of farmed common carp, the established protein content is almost

identical compared to the results reported by Ćirković et al. (2012) (16.21%), Ćirković et al. (2011) (15.81%), Afkhami et al. (2011) (15.2%), and lower, compared with those of Marcu et al. (2010) (17.79%).
In terms of fat content, our results show similar values compared to those presented by Yeganeh et al. (2012) (5.1%) and Marcu et al. (2010) (5.07%), higher values than the data published by Ćirković et al. (2012) (2.42%) and Afkhami et al. (2011) (3.53%), as well as drastically lower values compared to the results published by Ćirković et al. (2011) (11.73%).
The determined water content is lower compared to the results of Yeganeh et al. (2012) (76.7% - 81.4%), Marcu et al. (2010) (76.06%), Ćirković et al. (2012) (80.36%), Afkhami et al. (2011) (75.48%), while higher than Ćirković et al. (2011) (70.67%).
In terms of ash content, our results are similar compared to the results obtained by Ćirković et al. (2012) (1.02%) and Marcu et al. (2010) (1.07%), lower with those of Afkhami et al. (2011) (1.5%), while higher than those of Ćirković et al. (2011) (0.93%).
According to the results obtained during the examination of the chemical composition of wild common carp, in terms of fat content, our results show approximately the same values compared to those of Yeganeh et al. (2012) (3.8% - 2.8%) and drastically lower values compared to the results published by Ljuboević et al. (2013) (7.13%), Bud et al. (2008) (8.97%) and Hadjinikolova (2008) (8.3%).
The determined water content is higher than the results published by Yeganeh et al. (2012) (75.5%), Ljuboević et al. (2013) (73.73%), Bud et al. (2008) (73.22%), and Hadjinikolova (2008) (74.55%).
The protein content is lower compared to Yeganeh et al. (2012) (18.2% - 17.9%), Ljuboević et al. (2013) (16.69%), Bud et al. (2008) (16.69%), and Hadjinikolova (2008) (16.21%).
The obtained results for the ash content are higher compared to those of Ljuboević et al. (2013) (0.88%) and Hadjinikolova (2008) (0.94%), while they are lower compared to Bud et al. (2008) (1.20%).
The composition of fish varies greatly from species to species, as well as from individual to individual within a species, depending on age, sex, environment, and season (Huss, 1988; 1995). In addition, variations in the average chemical composition of fish meat are also closely related to the amount of food consumed. In the period of increased food intake, the amount of protein in the muscle tissue increases slightly and later the amount of fat can manifest a noticeable and rapid increase. On the other hand, fish may experience a period of starvation, because of natural or physiological causes (spawning or migration) or due to external factors such as the lack of food. In these cases, the fat content gradually decreases, and later a decrease in protein is observed. It is therefore especially important to monitor its chemical composition and variations throughout the year. Therefore, it can be concluded that the chemical composition of fish meat varies depending on the fish species, breeding conditions, as well as biological and physiological aspects.
The water quality, pH, temperature, oxygen content, season, fish age, type of food, diet, etc. have a certain influence on the chemical composition of fish meat, in addition to genetic factors (Buchtova et al., 2007; Menoyo et al., 2007). Raising fish in quality water, with well-balanced food and properly implemented health care will give better results compared to insufficient nutrition, too dense plantations, large food particles, etc.
The obtained results for the chemical composition of common carp in our study are characterized by variable fat and water contents. The same findings have been noted by Luczynska et al. (2008) and Ćirković et al. (2012). Variations in fat content are compensated by water content, which is consistent with the results obtained by Żmijewski et al. (2006), which found an inverse correlation between fat and water content, as a common feature of many fish species. Changes in the composition of water and fat indicate that, in case of a decrease in water content, the fat content is increased, because of the increased food intake during this period, which is consistent with previously published results by Huss (1988; 1995).

Table 5. Comparative indicators of the chemical composition (%) and energy value (кJ/100 g) of the common carp meat

Parameters	Water	Proteins	Fats	Ash	Energy value
Farmed common carp	73.580 ± 0.078	14.433 ± 0.262	6.850[a] ± 0.356	1.036 ± 0.050	514.546
Wild common carp	73.223 ± 0.274	15.333 ± 0.047	3.483[a] ± 0.190	1.053 ± 0.004	398.811

[a]The differences in the values with the same superscripts are statistically significant on level p<0.05

On the other hand, according to the research of Salihoğlu & Mutlu (2000), the concentration of plankton in the lakes is the highest in November and December, which explains the increase in fat and protein content of fish meat in that period.

There is a direct consequence of the increasing potential for fat deposition over the years. There is also an effect of size/growth rate due to the wide variability in fat composition in fish of the same age. In general, if the growth rate is stimulated at a certain stage in either the offspring or the consumed size of the carp, there is a simultaneous increase in the fat content of the whole fish. However, any (large) stimulation of the growth rate due to various factors is generally associated with the increased food intake. Therefore, the main factor that controls the fat content is diet. The fat content of the whole body increases in direct proportion to the size of the carp and is associated with a decrease in water content.

Regarding common carp breeding, research shows that changes in fish muscle mass that affect its nutritional value are caused by genetic factors, diet, and environmental conditions (Fauconneau et al., 1995). It has been found that as soon as carp are given energy-rich foods to stimulate growth and shorten the breeding time, it all leads to an increase in fat content, while the protein content remains the same (Kaushik, 1995).

Ljuboević et al. (2013) in their research found that open water carp has a fat content of 7.1 g/100 g, which is much higher compared to farmed common carp (Ćirković et al., 2011, 2012). An exception is farmed carp, which is additionally fed with cereals, as in our study, where we found that the fat content of farmed common carp is higher compared to that of wild common carp. This confirms that the chemical composition of carp meat largely depends on the diet.

Significant variations in the total fat content of fish muscle tissue within a species, as well as from two different locations, are consistent with the findings of other authors (Grela and Dudek, 2007; Kolakowska et al., 2000; Luczynska et al., 2008).

Regarding the quality and texture of muscle tissue, a very important parameter is the protein content. Fish muscles that contain small amounts of protein tend to lose more water during heat treatment, which will destroy the meat texture. In our research, the protein content of carp ranged from 14.433 to 15.333, which correlates with the findings of Khorramgah et al. (2007).

The identified differences in ash content may be due to the presence of small bones in the fish fillets. Namely, the calcium that is released during the demineralization of the bones, can contribute to a higher fat fraction of ash in the total chemical composition of the fish meat.

The energy value (EV) of common carp meat was calculated according to the formula. The significantly higher energy value is established in the farmed common carp meat (514.546 kJ/100 gr) compared to the meat from wild carp (398.811 kJ/100 gr), as a result of significantly higher values of fat content in farmed common carp. The fat content can vary within the same fish species. Meat in two-year-old carp can contain less than 2% fat, while the meat in older individuals can contain more than 8% and sometimes more than 20% fat. The energy value of fish meat depends on the fat content, which is conditioned by the diet and age category.

Conclusions

The meat from farmed common carp contains almost identical water content (73.580%) compared to wild common carp (73.223%). Regarding the proteins content, there is also no significant difference between the amounts of it in the farmed common carp (14.433%) compared to wild common carp (15.333%). The fat content of farmed common carp meat is 6.850%, which is significantly higher than that of wild common carp (3.483%). The differences in the values of fat content between fish meat from a warm-water fish pond and Prespa Lake are statistically significant on level $p<0.05$. The average amount of ash is slightly lower in farmed common carp (1.036%) compared to wild common carp (1.053%).

The significantly higher energy value is established in the farmed common carp meat (514.546 kJ/100 gr) compared to the meat from wild carp (398.811 kJ/100 gr), as a result of significantly higher values of fat content in farmed common carp.

The production of fat in meat, which correlates with the growth of carp, is stimulated by the use of high-energy artificial diets or foods enriched with lipids. Fat accumulates in specific fatty tissues, and analyses of the development of these tissues can provide valuable information about the excessive accumulation of fat and its distribution throughout the body. Fat accumulation has positive and negative consequences for sensory characteristics, depending on the source and the composition of fat.

Despite the high demand, commercial value and wide availability of common carp, there is a need to obtain accurate information about its chemical and fatty acid composition, due to their unavailability. In the future, the fishing industry and consumers will have an increasing need for information and guarantees about the chemical and fatty acid composition of fish meat. Analyses of the chemical and fatty acid composition

of common carp are essential, primarily since they provide useful information for nutritionists, who constantly look for readily available sources of low-fat, high-protein foods, as well as for scientists conducting research on food values and are interested in developing high protein and safe foods, but with retained quality, taste, colour, smell and texture.
Common carp should be included in the human's diet, because of its low-fat content, as well as high protein content, which has been confirmed in our research.

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References

Afkhami, M., Amin, M., Kazem, D. B., Reza, K., Nasrin, E., Maryam, E. (2011): Survey of some Chemical Compositions and Fatty Acids in Cultured Common Carp (*Cyprinus carpio*) and Grass Carp (*Ctenopharyngodon idella*), Noshahr, Iran. *World Journal of Fish and Marine Sciences* 3 (6), 533-538. https://doi.org/10.13140/2.1.4317.2640

Buchtová, H., Svobodová, Z., Křĭţek, M., Vácha, F., Kocour, M., Velíšek, J. (2007): Fatty acid composition in intramuscular lipids of experimental scaly crossbreds in 3-year-old common carp (*Cyprinus carpio*, Linnaeus 1758). *Acta Vet Brno* 76, 73-81. https://doi.org/10.2754/avb201079040551

Bud, I., Ladosi, D., Reka, S.T., Negrea, O. (2008): Study concerning chemical composition of fish meat depending on the considered fish species. *Zoorehnie si Biotehnologii* 42 (2), 201-206.

Caballero, M. J., Obach, A., Rosenlund, G., Montero, D., Gisvold, M., Izquierdo, M. S. (2002): Impact of different lipid sources on growth lipid digestibility tissue fatty acid composition and histology of rainbow trout *Oncorhynchus mykiss*. *Aquaculture* 214, 253–271. https://doi.org/10.1016/S0044-8486(01)00852-3

Ćirković, M., Ljubojević, D., Ţupan, B., Bogut, I., Đordjević, V., Novakov, N., Matekalo - Sverak, V. (2012): Usporedni prikaz kvalitete mesa nekih vrsta riba iz porodice šaranki u Republici Srbiji. *Croatian Journal of Fisheries* 70 (1), 79-88.

Ćirković, M., Trbović, D., Ljubojević, D. (2011): Meat quality of fish farmed in polyculture in carp ponds in Republic of Serbia. *Meat Technology* 52, 106–121.

Fauconneau, B., Alami-Durante, H., Laroche, M., Marcel, J., Vallot D. (1995): Growth and meat quality relations in carp. *Aquaculture* 129, 265–297. https://doi.org/10.1016/0044-8486(94)00309-C

Grela, E. R., Dudek, R. (2007): Nutrient content and fatty acids profile in the muscle tissue of some marine and freshwater fish. *Zyw Czlow Metabolism* 34, 561–566.

Guler, G.O., Kiztanir, B., Aktumsek, A., Citil, O.B., Ozparlak, H. (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. *Food Chemistry* 108, 689–694. https://doi.org/10.1016/j.foodchem.2007.10.080

Hadjinikolova, L. (2008): Investigations on the chemical composition of carp (*Cyprinus carpio* L.), bighead carp (*Aristichthys nobilis* Rich.) and pike (*Esox lusius* L.) during different stages of individual growth. *Bulgarian Journal of Agriculture Science* 14, 121-126.

Huss, H.H. (1988): Fresh fish: quality and quality changes. FAO. Rome, Italy, pp. 132.

Huss, H.H. (1995): Quality and Quality Changes in Fresh Fish. FAO. Rome, pp. 348.

Kaushik, S. J. (1995): Nutrient requirements, supply and utilization in the contest of carp culture. *Aquaculture* 129, 225–241. https://doi.org/10.1016/0044-8486(94)00274-R

Khoramgah, M., Rzaei M., Egagh, S. M., Babakhani lashkan, A. (2007): Comparative study of nutritional value and omega3 fatty acids in dorsal and ventral mussels of *Cyprinus carpio* (wild and cultured). *Iran J. Science and Marine Technology*, 31-37.

Kolakowska, A., Szczygielski, M., Bienkiewicz, G., Zienkowicz, L. (2000): Some of fish species as a source of n-3 polyunsaturated fatty acıds. *Acta Ichthyologica Et Piscatoria* 30 (2), 59-70. https://doi.org/10.3750/AIP2000.30.2.06

Ljuboevic, D., Trbovic, D., Lujic, J., Bjelic-Cabrilo, O., Kostic, D., Novakov, N., Cirkovic, M. (2013): Fatty acid composition of fishes from inland waters. *Bulgarian Journal of Agricultural Science* 19 (1), 62–71.

Luczyńska, J., Borejszo, Z., Luczyński, M. (2008): The composition of fatty acids in muscles of six freshwater fish species from the Mazurian Great Lakes (Northeastern Poland). *Archives of Polish Fisheries* 16 (2), 167–178.

Marcu, A., Ileana, N., Nicula, M., Marcu, A., Kelciov, B. (2010): Studies regarding the meat quality of the species *Cyprinus carpio*. *Lucrari Stinifice Medicina Veterinara*. XLIII (2).

Menoyo, D., Lopez-Bote, C. J., Diaz, A., Obach, A., Bautista, J. M. (2007): Impact of n-3 fatty acid chain length and n-3/ n-6 in Atlantic salmon (*Salmo solar*) diets. *Aquaculture* 276, 248–259.

Prato, E., Biandolino, F. (2012): Total lipid content and fatty acid composition of commercially important fish species from the Mediterranean Mar Grande Sea. *Food Chemistry* 131 (4). https://doi.org/10.1016/j.foodchem.2011.09.110

Rasoarahona, J. R. E., Barnathan, G., Bianchini, J. P., Gaydou, E. M. (2004): Annual evolution of fatty acid profile from muscle lipids of the common carp (*Cyprinus carpio*) in Madagascar inland waters.

Journal of Agriculture and Food Chemistry 52, 7339–7344. https://doi.org/10.1021/jf048993y

Robin, J., Skalli, A. (2007): Incorporation of dietary fatty acid in European sea bass (*Dicentrarchus labrax*) - A methodological approach evidencing losses of highly unsaturated fatty acids. *Aquaculture* 263 (1-4). https://doi.org/10.1016/j.aquaculture.2006.09.044

Salihoğlu, İ. Mutlu, E. (2000): Ulusal Deniz Araştırma ve İzleme Programı, Akdeniz, Marmara Denizi, Türk Boğazlar Sistemi, Karadeniz ve Atmosfer Altprojeleri. 1995-1999 Dönemi Sentez Raporu. Orta Doğu Teknik Üniversitesi, Deniz Bilimleri Enstitüsü, İçel, pp. 449.

Trbović, D., Vranić, D., Đinović, J., Borović, B., Spirić, D., Babić, J., Spirić, A. (2009): Fatty acid profile and cholesterol content in muscle tissue of one year old common carp (*Cyprinus carpio*) during growth. *Meat technology* 50 (5-6), 276-286.

Valente, L. M. P., Bandarra, N. M., Figueiredo-Silva, A. C., Rema, P., Vaz-Pires, P., Martins, S., Prates, J. A. M., Nunes, M. L. (2007): Conjugated linoleic acid in diets for large-size rainbow trout (*Oncorhynchus mykiss*): effects on growth, chemical composition and sensory attributes. *British Journal of Nutrition* 97, 289–297. https://doi.org/10.1017/s000711450733729x

Vandeputte, M., Kocour, M., Mauger, S., Rodina, M., Launay, A., Gela, D., Dupont- Nivet, M., Hulak, M., Linhart, O. (2008): Genetic variation for growth at one and two summers of age in the common carp (*Cyprinus carpio*) heritability estimates and response to selection. *Aquaculture* 277, 7–13. https://doi.org/10.1016/j.aquaculture.2008.02.009

Vitčenko, A., Kopilov, Â., Lebedov, M., Sljusarenko, E., Opackaja, E. (1981): Rìbopromìslovoe delo. Izdatelstvo „Legkaja i piščevaja promišlenost“, Moskva, pp. 175.

Yeganeh, S., Bahareh, S., Hedayat, H., Mohammad, R. I., Ali, S. (2012): Comparison of Farmed and Wild Common Carp (*Cyprinus carpio*): Seasonal Variations in Chemical Composition and Fatty Acid Profile. *Czech J. Food Sci*. 30 (6), 503–511. https://doi.org/10.17221/455%2F2011-cjfs

Zmijewski, T., R. Kujawa, B. Jankowska, A. Kwiatkowska and A. Mamcarz, (2006): Slaughter yield, proximate and fatty acid composition and sensory properties of rapfen (*Aspius aspius* L.) with tissue of bream (*Abramis brama* L.) and pike (*Esox lucius* L.). *J. Food Comp. Anal*. 19, 176-181. https://doi.org/10.1016/j.jfca.2005.03.006