

Evaluation of nutritive quality of common carp, *Cyprinus carpio* L.

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Abstract. Common carp is the most important commercial fish species in Serbia. This fish is a valuable source of nutritive components and plays a role in healthy human nutrition. This review evaluates the nutritive quality of common carp including proximate and fatty acid compositions as well as their effects on human health. The fat content and fatty acid composition of carp have been shown to vary due to different environmental factors and particularly due to nutrition. Technology of production and composition of planktonic and benthic organisms in fish ponds have been recognised as significant factors affecting carp meat quality and desirable chemical and fatty acid composition. Carp meat quality but also production parameters and fish health are positively influenced by a balanced feed mixture. Due to the low content of saturated fatty acids and cholesterol plus high levels of unsaturated fatty acids, common carp meat consumption could be linked with reduced risk of different heart diseases in humans. Also, fish proteins can have many beneficial roles in the preservation of human health. This paper emphasises the importance of consumption of common carp in order to prevent many diseases and preserve human health.

1. Introduction

Aquaculture has been one of the fastest growing branches of animal protein production during recent decades, and common carp is one of the most frequently farmed fish worldwide and also in Central and Eastern Europe. It is a highly esteemed fish species due to numerous desirable traits such as fast growth rate, good feed conversion ratio of both natural and supplementary feeds and relative resistance to poor environmental conditions and diseases. Common carp is the most widespread fish species on the market in Serbia and undoubtedly is a valuable nutritional source of proteins, lipids and other nutritive components which play many important roles in human health. Besides that, meat of common carp possesses a specific flavour and is easily digested. Having that in mind, information regarding factors affecting the quality of common carp meat is very necessary. The proximate composition and fatty acid composition of common carp are influenced by age, season, different environmental factors, culture systems and diet. The aim of this review is to evaluate the nutritive quality of common carp. We also highlight the importance of consuming common carp in order to promote human health.



2. Factors which affect nutritional composition of common carp

The fat content and fatty acid composition of different fish species vary significantly [1-4], even among fish belonging to the same family. The other factors which affect nutritional composition of common carp meat are environmental factors, structure of natural food present in fish ponds, cultural system including production technology and particularly, diet [1,5-7]. The use of formulated feed which contained ingredients of both animal and vegetable origin showed many positive effects on fish health, conditions, production parameters and meat quality [3,5,8]. The development of better feeding practice is important prerequisite in sustainable common carp production and enables the improvement of growth performance and chemical and fatty acid composition of carp.

3. The diet effect on meat quality of common carp

A variety of feeds are provided for carp raised in aquaculture, and the feed type mainly depends on the culture system. Traditional culture systems for carp are the extensive culture system, in which only the natural food available in the fish ponds is used, and the semi-intensive culture system, in which, to supplement natural food, cereals such as corn are used as additional feed. Also, simple mixtures of agricultural products which are easily accessible and cheap are often used. These are rice, wheat, barley, peas and defatted meals of oil-producing plants such as soya bean, sunflower, cotton or rapeseed meal. Undoubtedly, the quantity of feed given as well as the percentage of each component in the mixture varies considerably.

The main problem in traditional culture systems is that addition of corn frequently leads to increased accumulation of fat in the meat of common carp and especially around the internal organs [5,9]. That fact further leads to the prejudice that common carp is a very fatty fish. Examination of common carp muscle tissues from fish obtained from different culture systems showed that this really is prejudice, and that the accumulation of lipids in common carp meat is linked with the culture system and, consequently, with nutrition [5,7] (table 1).

During recent decades, due to the expansion and intensification of carp rearing, traditional feed consisting of locally accessible components has been replaced by industrially-produced feed which contains protein components of animal or plant origin. Such feed, used together with the exploitation of natural food, has become more common in the carp facilities in Serbia. The main result has been improvement of meat quality, particularly in terms of lowering the fat content and improving the fatty acid composition in comparison with the traditional semi-intensive system [4,5,9]. The importance of adequate preparation of fish ponds in these culture systems, which achieves a desirable structure of plankton and benthic organisms was described earlier [1]; these organisms are a significant source of nutritive components for carp [8]. Plankton and benthos contain high concentrations of n-3 polyunsaturated fatty acids (n-3 PUFA), including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) [8,10].

The lipid content of common carp fillets can differ greatly, from 6.3 to 15% [3] and from 1 to 13% [11,12] in commercially-sized fish, mainly depending on diet. Furthermore, the high average lipid content in carp fillets was probably the result of the fact that the energy-protein ratio in the fish diet was not well balanced [3]. It is known that feed rich in saccharides leads to an increased percentage of lipids in fish and a simultaneous decrease in the percentage of protein. Unsuitably high levels of carbohydrates and fats in common carp feed negatively affects the meat quality of this fish. Common carp deposits fats mainly around the organs, but also stores it in muscular tissue [13]. When carp were fed only natural food from their fish pond, their fillets contained only 1.76% fat, while fillets of carp fed supplementary maize contained 13.26% fat; fillets of carp fed supplementary wheat contained 11.22% fat and fillets of carp fed supplementary triticale contained 9.72% fat [14].

The fatty acid composition of fish meat corresponds to that of the feed which is ingested. The relatively undesirable composition of fatty acid profile in the lipids of common carp reported earlier [3] is connected with the diet. Also, the ratio of n-3/n-6 fatty acids in common carp varied by feed [5]. Carp grown on natural food had a high content of both n-6 and n-3 fatty acids [1,15]. Supplementary

feeding with grains leads to reduced amounts of essential fatty acids in fish meat, and this is due to the lower proportion of natural food in the diet of the carp which received additional grains. Moreover, the PUFA/SFA ratio was the most favourable in the carp fed complete feed mixtures and the least in those fish fed with maize and wheat (table 1) [5]. The recommended ratio of PUFA/SFA, which is an important indicator of the quality of fish fat, should be above 0.4 [16]. Since some meats of terrestrially-farmed animals naturally have a PUFA/SFA ratio of around 0.1 [16], meat has been implicated in causing the imbalanced fatty acid intake of today's consumers. The ratio of unsaturated fatty acids and SFA (USFA/SFA) is also of great importance for assessing the quality of fats. It is assumed that the favourable ratio is above 0.35 [17]. Generally, fish fats contain relatively low percentages of SFA, less than 30% (table 1), with the exception of a few species [18]. Oleic acid was reported as the dominant MUFA in common carp (table 1) [3-6,18]. This fatty acid also plays an important role in the prevention of cardiovascular diseases [19]. High levels of oleic acid, arachidonic acid and palmitoleic acid are characteristic for fat of freshwater fish [3-6,18] (table 1).

Table 1. Content of protein (%), fat (%) and selected fatty acids (% of total fatty acids) of the muscle of common carp fed different diets, adapted from Ćirković et al. [1] and Ljubojević et al. [4,5,6].

	Wild carp caught in Danube	Carp reared in polyculture on natural food	Carp reared in monoculture on natural food	Carp fed supplementary grains (80% corn and 20% wheat)	Carp fed feed mixtures in earthen ponds	Carp fed feed mixtures in cages
Protein content	16.69	16.21	15.4	15.59	17.1	16.23
Fat content	7.13	2.42	2.07	6.85	3.19	9.79
C16:0	19.4	18.35	20.99	17.31	16.89	12.52
C18:1, cis-9	30.2	19.39	32.58	51.35	34.45	33.55
C18:2, n-6	8.79	10.29	13.49	8.7	22.57	38.43
C18:3, n-3	2.71	5.96	4.59	0.61	2.12	3.16
C20:4, n-6	2.42	6.21	2.79	0.73	1.44	1.13
C20:5, n-3	1.36	4.05	1.17	0.2	0.93	0.20
C22:6, n-3	0.87	5.75	2.22	0.25	1.86	0.43
SFA^a	27.59	27.15	28.82	24.19	22.4	17.18
MUFA^b	52.94	28.79	43.49	64.31	45.12	37.25
PUFA^c	19.7	44.08	27.69	11.53	32.48	45.46
n-6	13.73	22.96	17.93	10.24	26.01	41.56
n-3	5.97	21.12	9.75	1.29	6.48	4.00
n-3/n-6	0.44	0.92	0.54	0.13	0.25	0.1
n-6/n-3	2.30	1.09	1.84	7.99	4.02	10.79
PUFA/SFA	0.71	1.62	0.64	0.18	0.72	2.65
USFA^d/SFA	2.63	2.68	0.96	0.48	1.45	4.82

^a SFA – saturated fatty acids.

^b MUFA – monounsaturated fatty acids.

^c PUFA – polyunsaturated fatty acids.

^d USFA – unsaturated fatty acids.

4. Consumer preference regarding meat quality of common carp

In some countries (Asia, Israel, Central and Eastern Europe), common carp is a highly esteemed fish species, and carp meat is highly regarded due to its specific savoury flavour and its high digestibility. In contrast, in other parts of the world, especially in North America and Australia, this species is considered as a weed-inhabiting fish that is not desirable for human consumption. However, many dishes can be prepared using this fish, undoubtedly confirming the gastronomic quality of carp [2].

Common carp meat contains highly valuable proteins, fats and other nutritive substances. It is a medium fatty fish and stores most of its fats as adipose tissue in the abdominal wall [11]. The amount of fat in muscle tissue contributes to its sensory properties, including organoleptic properties, texture and flavour. Meat which is rich in fat is juicy, while lean tissue is dry and often perceived as thickly fibrous [20]. The fat content in fish can sometimes exceed the protein content [21]. Such excessive fat content (>10%) has a negative effect on the sensory properties of common carp meat, which becomes soapy. This can occur when fish are cultured in earthen ponds where the amount of natural food is insufficient and a lot of grain is given as a supplementary feed [21]. On the other hand, an excessively low fat content in carp muscle has a negative impact on the sensory properties, and also consumption of so lean a fish reduces the intake of fatty acids in the human diet.

5. Cholesterol content in common carp and other fish

The amount of total cholesterol was 48.9 mg/100 g in one-year old carp in April and 54.3 mg/100 g in the same aged fish harvested in June [22]. The cholesterol content in female and male carp fillets was 69.4 mg/100g to 77.6 mg/100g [23], and was 55.8 mg/100g in two-year-old carp [1]. The total cholesterol content of common carp was 47mg/100g [24], and cholesterol in carp muscle varied considerably, from 38 to 120 mg/100g, depending on fish breed and age, husbandry system, and harvest season [25]. In other literature on cholesterol in fish, the cholesterol content of many freshwater fish species ranged between 40.99 and 52.79 mg/100g [26], while the total cholesterol in freshwater fish is lower than in marine fish [27]. In humans, daily intake of cholesterol is currently recommended not to exceed 300 mg [4].

6. The beneficial effects of common carp in human diet

Common carp should be included in human diets for at least three reasons: as a general source of nutritional components; as low fat, high protein food; and as source of PUFA. In carp meat, all nutrients and especially essential fatty acids are present in optimum quantities for human needs [1,3,5]. Consumption of n-3 PUFA from fish meat has positive effects on human health, especially in the prevention of heart attack, stroke, atherosclerosis and high blood pressure. Furthermore, there are positive effects on the circulatory system, the process of remembering and learning, reproductive system and photoreceptors [28].

It is well known that fish are the most important source of n-3 long-chain fatty acids and highly unsaturated fatty acids (n-3 HUFA) in human diets. A favourable n-3/n-6 ratio has a positive impact on human health [28]. There are various recommendations from world organizations related to fish consumption and intake of n-3 fatty acids, as well as of appropriate ratios of different groups of fatty acids. The optimal range of n-3/n-6 ratio for human health recommended by WHO/FAO is 0.5 to 0.25 [28]. There are various data regarding the n-3/n-6 ratio of common carp which varies between 0.8 and 2.4 [29]. Other studies reported this ratio is about 0.5 [5,25], or about 0.2 [5,22] (table 1).

The importance of fats and fatty acids from common carp for human health is highlighted in this review, but it is impossible to explain the beneficial effects of fish meat on the human health only in terms of fats, because the edible parts of fish include also muscle tissue, which provides a many other nutritional ingredients, such as proteins. Fish protein, in relation to casein, lowered the level of blood cholesterol in laboratory animals, showed anti-hypertensive properties and other beneficial effects related to cardiovascular diseases as well as showed favourable effects against obesity [30,31]. The percentage of essential amino acids in fish meat is very high, especially, for example, tryptophan, the precursor of serotonin that likely contributes to feelings of well-being in humans [31].

7. Conclusion

Common carp meat is an important source of nutrients in human nutrition. It provides not only n-3 fatty acids but a variety of other nutrients that are important for health. The chemical and fatty acid composition in carp meat varies significantly, which is due to different nutrition and environmental

factors. Overall, however, data on the nutritional composition of common carp meat highlight the relative value of this food in balanced healthy human nutrition.

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