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Research Article Araştırma Makalesi

# Evaluation of the Nutritional Quality of Farmed Common Carp (*Cyprinus carpio* L.) Based on Fatty and Amino Acids Profile

## Çiftlikte Yetiştirilen Sazan Balığının (*Cyprinus Carpio* L.) Besinsel Kalitesinin Yağ ve Amino Asit Profiline Göre Değerlendirilmesi

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**Abstract:** The common carp (*Cyprinus carpio*) is the main species of carp being cultured in mid and southern Iraq. The consumer believes that the farmed fish is less nutritious than the wild fish, which affects its market value. The current study was designed to investigate the nutritional value of the common carp cultivated in the Basrah province based on the fatty and amino acid profile. Fatty acids were determined by Gas chromatography (GC), while an Amino Acid Analyzer was used for the determination of amino acids. The results revealed that the tested fish is rich in polyunsaturated fatty acids (especially essential omega-3 fatty acids), including α-linolenic acid (14.08±3.92%), docosahexaenoic acids (7.98 ±2.82 %), and eicosapentaenoic acid (2.81 ±0.34 %). Seven essential amino acids which are significant for the human body and the other ten non-essential amino acids were identified in the samples tested. Thus, it was established that the nutritional value of the farmed *Cyprinus carpio* is not less than the wild fish of the same species or family.

**Keywords**
- Common carp
- Farmed fish
- Fatty acid
- Amino acids

**Özet:** Sazan (*Cyprinus carpio*), orta ve güney Irak'ta yetiştirilen başlıca sazan türüdür. Tüketici, pazar değerini etkileyen çiftlik balıklarının, yabani balıklardan daha az besleyici olduğunu düşünmektedir. Çalışma, Basra İli'nde yetiştirilen sazan balığının besin değerini yağ ve amino asit profiline dayalı olarak araştırmak için tasarlanmıştır. Yağ asitleri, gaz kromatografisi (GC) ile belirlenirken, amino asitlerin belirlenmesi için bir Amino Asit Analizörü kullanıldı. Sonuçlar, test edilen balığın α-linolenik asit (%14.08±3.92), dekosaheksaenoik asitler (%7,98 ±2.82) ve eikosapentaenoik asit (2.81 ±) dahil olmak üzere çoklu doymamış yağ asitleri (özellikle esansiyel omega-3 yağ asitleri) açısından zengin olduğunu ortaya koydu. %0.34). Test edilen örneklerde insan vücudu için önemli olan yedi esansiyel amino asit ve diğer on esansiyel olmayan amino asit tespit edildi. Böylece çiftlikte yetiştirilen *Cyprinus carpio*'nun besin değerinin aynı tür veya familyaya ait yabani balıklardan daha az olmadığı tespit edilmiştir.

**Anahtar kelimeler**
- Sazan
- Çiftlik balıkları
- Yağ asidi
- Amino asitler

## 1. INTRODUCTION

The content of fatty acids, amino acids, vitamins, and minerals in meat reflects its nutritional value and its impact on human health (Sarma et al., 2013). Fishes are the primary source of polyunsaturated fatty

acids such as eicosapentaenoic acid (EPA) and docosahexaenoic (DHA) (an essential omega-3 fatty acid) in humans (Vannice and Rasmussen, 2014). Omega-3 is necessary for cardiovascular and brain health (Bennett et al., 2018). Besides, omega-3 plays a beneficial role in a few human pathologies, such as obesity and type-2 diabetes (Sokoła-Wysocza'nska et al., 2018).

It has been reported that fish protein intake is useful in regulating blood cholesterol levels and positively influences patients with hypercholesterolemia (Hosomi et al., 2011). Dale et al. (2019) suggested that fish proteins may enhance the gut microbiota composition, and affect body weight, and lipid status in humans. The amino acid composition is one of the most important nutritional qualities of the protein (FAO/WHO, 1990).

In general, common carp (*C. carpio*) is a good source of fat-soluble vitamins and n-3 polyunsaturated fatty acid (Stancheva et al., 2014), and can be recommended for consumers as a high-quality protein diet (Mohanty et al., 2014)

The aquaculture industry has become an essential and rapidly growing industry providing fish for human consumption. Carp is the most important fish species cultured worldwide, and 97.3% of its global production is originated from aquaculture (Karnai and Szűcs, 2018). Farmed carp species contributed (26 percent) to total Near East and North Africa aquaculture output in 2014 (FAO, 2015). Iraq is considered a medium-scale producer, with an annual production of 5.000 to 35.000 tonnes (El-Sayed, 2015). The common carp (*C. carpio*) is the major species currently cultured in mid and southern Iraq. In Basrah, the number of licensed fish farms increased to 327 farms in 2016 to provide protein to the growing community (Ahmed et al., 2020). However, there is a preference among some consumers for wild fish (Runge et al., 2021). This is because the nutritional value of wild fish is thought to be higher than that of farm-raised fish (López-Mas et al., 2021). In Basrah, the consumer has the same perception about the farm-raised carp, which affects its market value. Therefore, the current study was designed to investigate the quality of farmed carp meat depending on fatty and amino acid profile compared to the wild fish caught from the local or external water bodies.

## 2. MATERIALS and METHODS

In the present study, fishes were reared in (12× 3× 2) $m^3$ tanks made from an iron frame, lined on the inside with thick fabrics made from a waterproof material. The farming process started by placing 3000 fish in each tank with an initial weight of 100 g per fish, and fishes were fed on processed imported feed (floating pellets). The feed ingredients include fish meal, amino acids, vitamins, minerals, antioxidants, and fungicide. The calculated analysis (crude protein = 28%, crude fat = 4.0%, crude fiber = 4.0%) was as recorded on the feed package. The fish were fed to satiation daily during the rearing period.

### 2.1. Samples Collection

A total of 15 adults fresh common carp (C. *carpio*) samples were obtained from a local farm in Basrah Province, southern Iraq. The fish samples were stored in an icebox and brought to the laboratory at the Marine Science Center, University of Basrah, Iraq. The length of the fish was measured from tip to tail using a measuring board. The weight was measured using a QUA electronic scale (China), and the individual data of the fish were recorded. The fish samples were divided into three groups (five fish in each group). Samples were cleaned using a stainless-steel knife; the edible part of fish tissue from the body's dorsal side was taken without skin and cut into small pieces. Muscle samples of each group (five fish) were mixed and stored in plastic containers, labeled, and kept in a refrigerator at -20 ºC until further analyses.

### 2.2. Proximate Composition Analyses

The proximate composition of the fish meat was determined according to the AOAC protocol (AOAC, 1990). Moisture content was determined by drying the sample in an oven at 105 °C until a constant weight was obtained. Crude ash was determined by incineration in a muffle furnace at 550 °C for 24 hrs. Crude protein content was determined by the Kjeldahl method, and a conversion factor of 6.25 was used to convert the total nitrogen to crude protein. Crude fat was determined by the Soxhlet extraction method.

### 2.3. Fatty Acids Analysis

Total lipids in fish meat were determined by the ISO standard method (2000). After acid hydrolysis of the sample with hydrochloric acid, lipids were extracted from the fish meat with petroleum ether. Fatty acids were extracted with a mixture of n-hexane and isopropanol (60, 40, v/v). The extracts were collected, and the solvent was removed. Fatty acid methyl esters (FAMEs) were prepared by dissolving lipid extract with tertbutyl methyl ether. Transesterification was performed by 0.25 M trimethyl sulfonium hydroxide (TMSH) in methanol. FAMEs were analyzed by Gas chromatography (GC)-17 A- Shimadzu/ Class GC 10, (column: 30 m ×0.25 mm I.D., 0.5 µm film thickness. Flame ionization was detected at 210 °C; carrier gas nitrogen at a flow rate of 1.0 ml/min; injector temperature at 210 °C; oven temperature programmed from 180 to 250 °C). Quantitative data were calculated using the peak area ratio (% total fatty acids).

### 2.4. Amino Acids Analysis

The amino acids were analyzed depending on the method described by Osibona et al., (2009). Briefly, 0.5 g of sample was weighed into a 100 ml flask. Norleucine standard solution (1ml) and 5 ml of performic acid were added to the sample in an ice bath. Sodium metabisulphite (0.84g) and 6N HCl (30 ml) with anti-bumping granules were added, and the oxidation process was carried out in a fridge for 16 hrs. The mixture was allowed to cool, 30 ml of 4 M lithium hydroxide was added, and the mixture was left to hydrolyze for 24 hrs in a bath set at 130°C. The pH was adjusted to 2.1, and the combination was made up of 100 ml of deionized water. About 5 ml of the sample was filtered through a 2 µm filter, and the product was run through an Amino Acid Analyzer LC3000 (Eppendorf-Bio-tronik; Germany). Replicate determinations were carried out on each sample.

### 2.5. Statistical Analysis

Data are the mean values of two replicates ±SD. Microsoft Excel 2019 for Windows was used to calculate the mean and standard deviation.

## 3. RESULTS

The mean length of the tested fish is 29.5 ± 2.8 cm, and the mean weight is 750 ± 63 g. The proximate composition of the farmed common carp muscle is shown in Table 1. Crude protein, crude fat, moisture, and crude ash contents of the carp muscle were 22.08 %, 3.24%, 70.2%, and 2.12%, respectively.

**Table 1**. Proximate composition of the common carp muscle. Values are mean ±SE from duplicate determination.

| Crude protein (%) | Crude fat (%) | Moisture (%) | Crude ash (%) |
|---|---|---|---|
| 22.08±0.64 | 3.24±0.31 | 70.2±0.32 | 2.12±0.04 |

The fatty acid composition as a percentage of the common carp's total fatty acids is summarized in Table 2.

**Table 2**. Fatty acids quality indices in the muscles of farmed common carp (*C. carpio*) and their comparison with the results of other studies (% of total fatty acids). Values for the current study are mean SD from duplicate determination.

| | Fatty Acid Name | Chemical Formula | This Study | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|
| **SFA** | **Myristic acid** | C14:0 | 3.64±1.05 | 2.02 | 1.23 | 1.69 | 1.07 | 2.27 | 2.87 | - |
| | **Palmitic acid** | C16:0 | 17.38±2.13 | 16.18 | 29.03 | 14.97 | 17.11 | 35.19 | 19.4 | 16.98 |
| **MUFA** | **Oleic acid** | ω-9/C18:1 | 21.66±3.05 | 25.11 | 36.53 | 22.23 | 32.35 | 14.84 | 30.2 | 34.45 |
| **n-3 PUFA** | **α-Linolenic acid (ALA)** | ω-3/C18:2 | 14.08±3.92 | 3.9 | 11.34 | 2.95 | 15.1 | 10.04 | 8.79 | 22.57 |
| | **Eicosapentaenoic acid (EPA)** | C20:5 | 2.81±0.34 | 4.75 | 0.93 | 4.36 | 1.93 | ND | 1.36 | 0.93 |
| | **Docosahexaenoic acid (DHA)** | C22:6 | 7.98±2.82 | 11.6 | 1.63 | 8.37 | 2.89 | 5.13 | 0.87 | 1.86 |
| **n-6 PUFA** | **Linoleic acid** | ω-6/C18:3 | 3.66±0.76 | 0.33 | 1.8 | 0.53 | 2.64 | 0.24 | 0.23 | 2.12 |
| | **Arachidonic acid** | C20:4 | 8.45±2.17 | 5.5 | 0.75 | 5 | 3.09 | 3.62 | 2.42 | 1.44 |
| **∑SFA** | | | 21.02±2.11 | 18.2 | 30.26 | 16.66 | 18.18 | 37.46 | 22.27 | 16.98 |
| **∑MUFA** | | | 21.66±3.05 | 25.11 | 36.53 | 22.23 | 32.35 | 14.84 | 30.2 | 34.45 |
| **∑PUFA** | | | 36.98±2.00 | 26.08 | 16.45 | 21.21 | 25.65 | 19.03 | 13.67 | 28.92 |
| **∑PUFA/∑SFA** | | | 1.75±2.05 | 1.43 | 0.54 | 1.27 | 1.41 | 0.50 | 0.61 | 1.70 |
| **∑n-3** | | | 24.87±2.36 | 20.25 | 13.9 | 15.68 | 19.92 | 15.17 | 11.02 | 25.36 |
| **∑n-6** | | | 12.11±1.46 | 5.83 | 2.55 | 5.53 | 5.73 | 3.86 | 2.65 | 3.56 |
| **n-3/ n-6** | | | 2.04±1.09 | 3.47 | 5.45 | 2.83 | 3.47 | 3.93 | 4.15 | 7.12 |
| **EPA+ DHA** | | | 10.79±1.72 | 16.35 | 2.56 | 12.73 | 4.32 | 5.13 | 2.23 | 2.79 |
| **Total fatty acids** | | | 79.66±2.38 | 69.39 | 83.24 | 60.1 | 76.18 | 71.33 | 66.14 | 80.35 |
| **Unidentified** | | | 20.34 | 30.61 | 16.76 | 39.9 | 23.82 | 28.67 | 33.86 | 19.65 |

Saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), n-3 polyunsaturated fatty acids (n-3 PUFA), n-6 polyunsaturated fatty acids (n-6 PUFA).

Swapna et al., 2010 (the tested fish were purchased from the market).

1-Stancheva and Merdzhanova (2011) source of fish/ Dam Lake –Bulgaria (wild fish).

2-Yeganeh et al., 2012 wild fish from the Caspian Sea) (values are the mean of 4 seasons).

3-Yeganeh et al., 2012 farmed fish (values are the mean of 4 seasons).

Note: Yeganeh et al., 2012 tested wild and farmed fish in the same study.

4-Sarma et al., 2013 wild fish from Bhimtal lake, India.

5-Ljubojević et al., 2013 wild fish from Danube River.

6-Ljubojević et al., 2017 farmed fish fed on feed mixture.

The amino acid composition (% of total protein) is presented in Table 3. Seventeen different amino acids were determined in the edible parts of the common carp (*C. carpio*). Seven essential amino acids that are very important for the human body and ten other non-essential amino acids were detected in the samples tested, as presented in Table 3.

Common carp protein contained a high amount of essential amino acids Tryptophan = 4.64 ± 0.98 g/100g of crude protein, followed by threonine, valine, phenylalanine, leucine, histidine, isoleucine in decreasing level.

**Table 3.** Amino acid profile of common carp (C. carpio) g/100g of crude protein (mean value ± SD).

| **Amino acids** | **Results of the current study** | **Sarma et al., 2013** | **Mohanty et al., 2014** | **Pyz-Łukasik & Kowalczyk-Pecka,2017** | **Pyz-Łukasik & Kowalczyk-Pecka, 2017** |
|---|---|---|---|---|---|
| **Essential amino acid** | Common carp Farmed | Common carp Wild | Common carp Wild | Grass carp Wild | Bighead carp Wild |
| **Tryptophan** | 4.64 ± 0.98 | 0.06 | 0.8 | 3.02 | 3.04 |
| **Threonine** | 4.57 ± 1.66 | 0.41 | 0.9 | 4.75 | 4.71 |
| **Valine** | 4.44 ± 0.97 | 0.52 | 1.30 | 4.91 | 4.93 |
| **Phenylalanine** | 3.83 ± 1.09 | 0.33 | 0.7 | 3.97 | 4.02 |
| **Leucine** | 3.51 ± 0.41 | 0.76 | 1.6 | 7.81 | 7.89 |
| **Histidine** | 3.39 ± 1.07 | 0.29 | 0.4 | 2.69 | 2.67 |
| **Isoleucine** | 3.38 ± 0.83 | 0.42 | 0.8 | 4.28 | 4.24 |
| **∑EAA** | 27.76 | 2.79 | 6.5 | 31.43 | 31.5 |
| **Non-essential amino acid** | | | | | |
| **Aspartic acid** | 12.23 ± 2.68 | 2.72 | 6.2 | 10.30 | 10.28 |
| **Glycine** | 5.84 ± 0.93 | 1.49 | 3.2 | 5.45 | 5.67 |
| **Glutamic acid** | 5.01 ± 0.77 | 1.90 | 4.2 | 15.06 | 15.11 |
| **Serine** | 4.54 ± 1.39 | 2.44 | 5.5 | 4.17 | 4.21 |
| **Glutamine** | 4.82 ± 0.96 | 2.44 | 4.2 | - | - |
| **Arginine** | 4.58 ± 0.63 | 1.01 | 2.1 | 6.59 | 6.63 |
| **Alanine** | 2.91 ± 0.73 | 1.55 | 3.70 | 6.09 | 6.20 |
| **Asparagine** | 0.96 ± 0.02 | 0.13 | - | - | - |
| **Serine** | 4.54 ± 1.76 | 2.44 | 5.5 | 4.17 | 4.21 |
| **Tyrosine** | 5.10 ± 1.14 | 0.33 | 0.8 | 3.26 | 3.35 |
| **∑NEAA** | 50.53 | 16.45 | 35.4 | 55.09 | 55.66 |
| **∑EAA /∑NEAA** | 0.48 | 0.47 | 0.47 | 0.48 | 0.48 |

## 4. DISCUSSION

In the present study with farmed common carp, the results of the body composition are close to those recorded by Al-Humairi et al. (2019) on the wild common carp caught from the Iraqi waters. Hossain (2011) reported that farmed fish can provide the consumers with a nutritional composition that is at least as beneficial as that provided by the wild fish when those fishes were raised under appropriate conditions and dietary regimes.

The current study included measuring the essential fatty acids in the muscles of the common carp, which play a positive role in improving human health. Due to the absence of local studies related to the nutritional value of the *C. carpio*, the results of the current research (fatty and amino acids values) were compared with the results of other studies that were conducted on farmed or wild *Cyprinus carpio* caught from natural waters in different areas around the world.

In the current study, the myristic acid recorded a high value, while the palmitic and oleic acid values were within the levels recorded in the fish tested in other studies (Table 2). The fatty acid composition varies even among fish belonging to the same species or family due to the differences in age, season, different environmental factors, geographic location, reproductive status, culture systems, and diet composition (Alasalvar et al., 2002; Memon et al., 2011; Ljubojević et al., 2013). The percentage of α-linolenic acid in the tested samples (mean value =14.08±3.92) was within the values recorded by studies mentioned in Table 2. All freshwater fish use α-linolenic acid as a precursor to producing EPA and DHA acid (Sargent et al., 2002). The common carp from the present study was a good source of EPA (2.81 ±0.34) and DHA (7.98 ±2.82).

Since terrestrial plants and animals have relatively low levels of EPA and DHA, this index (EPA+DHA) is usually used to evaluate the nutritional value of seafood, mainly fish. In this study, the EPA+DHA index (10.79%) was within the range reported by other researchers (Table 2). The ratio of ω-3 to ω-6 fatty acids in the current study was lower than in other studies. However, daily intake (about 500 mg) of EPA+DHA/day is enough to meet an adult requirement, according to ISSFAL, (2004).

This investigation has indicated that the farmed common carp was rich in linoleic acid which is in line with the findings of (Yeganeh et al., 2012) and (Ljubojević et al., 2017) on farmed fish. All freshwater fish can convert linoleic acid to arachidonic acid (Sargent et al., 2002). The percentage of arachidonic acid in our tested fish was high compared to the values recorded by other studies. The current results indicate that humans can consider the farmed common carp as a good source of polyunsaturated fatty acids, which may originate from the feed (Memon et al., 2011).

A PUFA/SFA index is normally used to assess the effect of diet on cardiovascular health. It has been reported that all PUFAs can lower low-density lipoprotein cholesterol and lower serum cholesterol levels, while all SFAs can increase serum cholesterol levels. Therefore, the higher this ratio, the greater the effect (Chen and Liu, 2020). The present study found that PUFA/SFA (1.75 %) is similar to the value previously reported for farmed fish fed on feed mixture (Ljubojević et al., 2017).

The levels of amino acids tested in the edible part of the farmed *Cyprinus carpio* were higher than that of the wild fish recorded by Mohanty et al., (2014) and Sarma et al., (2013) (Table 3). Many studies reported that the formulated feed, which contained animal and vegetable ingredients, showed an apparent positive influence on fish meat quality (Ljubojević et al., 2013). The levels of the essential amino acids are close to the results reported by (Pyz-Lukasik and Kowalczyk-Pecka., 2017) for grass carp and bighead carp, which belong to the same family (Cyprinidae).

Regarding the non-essential amino acids, the results suggested that aspartic acid is the most abundant compared to the other non-essential amino acids, and the mean value was (12.23 ± 2.68). At the same time, the asparagine recorded the lowest value (0.96 ± 0.02). Aspartic acid is the antecedent of

methionine, threonine, isoleucine, and lysine and has a crucial role in regulating the secretion of essential hormones (Mohanty et al., 2014). Compared with some studies conducted on wild carp presented in Table 3, the farmed carp tested in the present study had high amounts of the non-essential amino acids, which may again reflect the quality of the formulated feed. Table 3 presents the high variation in the amount of amino acids in fish samples belonging to the same family and even the same species. The protein composition of the fish is affected by different factors such as sexual changes and environmental conditions, but the amount and quality of feed consumed by the fish are fundamental (Kasozi et al., 2019). In the present study, the ratio of essential/non-essential amino acid (EAA/NEAA) was observed to be 0.48, which is the same value recorded in other studies on wild common carp, Grass carp, and Bighead carp (Table 3). Compared to the wild fish, the muscles of the farmed *Cyprinus carpio* had high-quality protein and were considered a good source of fatty acids that have a positive effect on human health. Nevertheless, these results cannot be generalized to all the farmed fish in the province. Some farms depend on fodder rich in carbohydrates (barley, wheat bran, and maize powder) with a low-quality fish meal to reduce production costs (Ahmed et al., 2020). The reduction of fish meal in the diet of farmed fish would diminish the Omega-3 content of cultivated fish and, thereby, the fish's dietary benefits (Sokoła-Wysocza'nska et al., 2018).

In conclusion, this research indicated that cultured common carp is a good source of PUFA (especially DHA, and EPA) that have beneficial health effects. In addition, farmed carp is a valuable food containing the majority of essential amino acids. Thus, it was established that the nutritional value of the farmed *Cyprinus carpio* is not less than the wild fish of the same species or family. Further, the demand for high-protein food such as fish is increasing, and aquaculture presents an enormous opportunity for any country's economy. Therefore, further studies are recommended on farmed fish meat to provide the consumers with scientific data related to these aquaculture products.

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## ETHICAL STATEMENTS

All applicable international, national, and/ or institutional guidelines for the care and use of animals were followed. Ethical approval for this study (Document N0. 8/13 January/ 2020) was obtained from the MSC ethics committee/ Marine Science Center, University of Basrah, Iraq.

## CONFLICT of INTEREST

The author declares that there are no financial interests or personal relationships that may affect this work.

## AUTHOR CONTRIBUTIONS

Single author.

## DATA AVAILABILITY STATEMENT

The data used to support the findings of this study are included within the article.

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