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A comparative study of chemical composition, the level of fatty acids, amino acids and mineral elements between two types of catfish (Bagrus and Muraena) found in the upper Tigris River

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ABSTRACT

Fish meat is considered the second most interesting to consume in Iraq hence, consumers always consider the sensory and nutritional profile of the fish meat. The study aimed to investigate the chemical composition and level of fatty acids and amino acids in *Bagrus* and *Muraena* fish fillets. These fish for this study were obtained from the upper Tigris river in the Tikrit region of Iraq, as the demand for these types of fish increased in recent years. In this work, High Performance Liquid Chromatography –UV (HPLC-UV) was used for quantification of amino acids, and atomic absorption was used for quantifying the elements. The extraction was performed by liquid –liquid extraction and purified by dispersive phase purification. Results showed that the moisture percentages in *Bagrus* meat were 71.36 %, while *Muraena* meat recorded as 71.10 %. Moreover, the protein percentages for both fish types were found as 21.36 and 21.43 % respectively. Lipid percentages in fillets of *Bagrus* and *Muraena* were 3.59 and 4.62 %, respectively. The proportion of ash was 3.01 % in *Bagrus* meat, while it was 2.55 % in *Muraena* meat. The results also presented that the *Muraena* has a significantly higher saturated fatty acid level (26.06 %), whereas in *Bagrus* meat was much less (16.6 %). The highest percentage of amino acids in *Bagrus* meat recorded (92.66 %), while it was 61.94 % in *Muraena* meat. The *Bagrus* meat contained essential amino acids with a higher percentage (54.04 %), compared to *Muraena* meat (28.55 %), non-essential Amino acids percentage also reached 47.56 % in *Bagrus* fish fillets. The amino acids like alanine had recorded the highest percentage among non-essential amino acids, as its level resulted in 38.62 %, while the level (33.39 %) was lower in *Muraena* meat.

1. Introduction

Fish should be considered one of the primary protein sources and the leading nutritional component of low-income social strata. It is an essential source of protein, as it provides a portion of the food in developed countries and provides bout 18.5 % animal protein. Fish meat can add nutritional value due to its high-quality proteins when compared to the nutritional value found in beef (Ochokwu et al., 2014, Osuigwe et al., 2005). This includes a good proportion of polyunsaturated fatty acids (PUFAs) which reduce the levels of cholesterol in the humans blood and minimize the incidence of heart diseases. In addition, fish is rich in proteins and fats that are easy to digest and absorb (He et al., 2017). There are several catfish in Iraqi rivers, lakes, reservoirs, and marshes. It is found in fresh and salty water like Dodd, Abu al-Hakam, Stingray Al-Jari, Al-Jumhouri, and Alza'am. (Al-Sa'adi, 2019). *Bagrus* is a species in the family Bagridae, class of Actinopterygii, and phylum of Chordata, and *Muraena* species is in the family Muraenidae, class of Anguilliformes, phylum of Chordata. These fish are unique because they have two tube-shaped swim bladders that run from the gills' cavity to the tail. The total length is approximately 34 cm. The small ones feed on the insects, larvae, and worms, while the large ones feed on fish. In case of a lack of nutrients in their environment, it

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competes with fish that are soft, like brown, for food. In India, it is considered food, and in Tehran, is used for fishkeeping, and in Iraq, it does have economic significance (Coad, 2010). Researchers reveal that the fish of the Middle East is a common in the waters of Iraq, and it has a different naming (Coad, 2010). Al-Janabi (2010) mentioned that *Muraena* feeds on baby fish, shrimp, the eggs of the fish, as well as the larvae and the algae.

The study was designed to shed light on the nutritional value and nutritional benefit to consumers. As a result, our research aims to investigate the chemical composition, the quality of fats, and the level of amino acids in two types of freshwater fish scattered in the Tigris River within the borders of Salah Al-Din Governorate- Iraq.

2. Materials and Methods

2.1. Sources of obtaining laboratory samples

The study included two species of Iraqi freshwater fish that are frequently found in the Tigris River. The two fish species are *Bagus and Muraena*. The fish samples were identified using a finfish-based global biodiversity information system called Fish Base. The study area includes the Tigris River in the province of Salah al-Din from the beginning of February until the end of April of 2023. These fish were taken with a gill net, causing little stress to other aquatic animals, and they were overseen and caught in accordance with animal ethics and legislation. The surgical procedure was conducted in a Tikrit University laboratory. The fish samples were kept at 8 °C until the lipid extractions were performed.. Most of the measurements and testing were conducted in the Graduate Laboratory of the Department of Food Science at the University of Tikrit's College of Agriculture. To produce the meat, the skull, viscera, skin, and bones were manually removed, and the meat pieces of one type were thoroughly combined and crushed in a mortar to obtain well-crushed meat.

2.2. Determination of chemical composition

Chemists (1990) approach was used to determine the percentage of Chemical composition in fish fillets.

2.3. Fatty acids profile

2.3.1. Oil Extraction

According to the procedure given by Chemists (1990), cold oil extraction was accomplished using a mixture of hexane, chloroform, ether, and petroleum ether in equal amounts to avoid exposure to any heat treatment.

2.3.2. Preparation of fatty acids

Methyl Ester method of Simionato et al. (2010) were used to transmethylation fatty acids into fatty acid methyl ester.

2.4. Estimate amino acids

2.4.1. Amino acid analyses

Methods of Schuster (1988) was used, in which, 25 g of flesh were taken and homogenized with 10 to 20 ml of distilled water by a laboratory mixer to obtain a homogenate digested with 6 N-HCL at 110 °C (Chemists, 1990). The digest was filtered through a Buchner funnel (0.45 μm micropore seized filter) and a metallic vacuum pump. There were 10–20 ml of distilled water added, and the mixture was filtered again. This procedure was repeated until 100 ml was collected. A 10 ml of an aliquot of the extract and 2 ml of trichloroethylene were added to a centrifuge tube, stirred, and centrifuged at 3000 rpm for 15 min. The organic phase was discarded; the aqueous was used for chromatography analysis.

2.4.2. High Performance liquid chromatography

To detect the amino acids, it is necessary to extract with dansyl chloride (DNS), the purification was by HCL and neutralizing the solution by amounts of sodium bicarbonate (5 %), the PH level of the supernatant was adjusted from 7.50 to 8.0. A small sample (0.50 ml) was transferred to a test tube, and 10 μl of DNS was added; then, the mixture was shaken in the dark at 40 °C for three hours in a shaking incubator. The excess DNS was removed by extracting with a diethyl ether. The remaining aqueous fraction was acidified by 50 μl of 6 M HCL. The DNS-amino acid was extracted with a diethyl ether until the ether no longer became colored. The ether was evaporated, and the residue was taken up in 0.50 ml of methanol and injected into the HPLC apparatus. All tests were conducted at a solvent flow rate of 1.2 ml/min at a temperature of 25 °C. The wavelength of the ultraviolet detector was set at 254 nm, 25 percent acetonitrile, and 75 percent glacial acetic acid (1 percent w/v) were used to make the mobile phase. The calibration curve was set using different aliquots of standard solutions of amino acids that need to be assay by subjected to pre-chromatography derivation and processed as the samples. The concentrations used ranged from 14.45 to 144.50 mg /100 g of 25 g of meat samples. The samples spiked with a known amount of standard solution were processed using the same conditions mentioned above. It was necessary to use the values obtained in the calibration curve, considering the peak, where the retention time agrees with a standard solution retention time of 9.2 min, Equation (1).

$$\text{Concentration} = \text{area of peak} / \text{area of standard peak} \times \text{conc. of standard} \times \text{dilution.} \tag{1}$$

The quantity of each amino acid (Lysine, Methionine, Tryptophan, Phenylalanine, Leucine, Isoleucine, Threonine, and Valine) was obtained as concentration (% of protein).

2.5. Element estimation

Chemical elements were estimated in the samples using atomic absorption after incineration of samples at 600 °C by a muffle furnace (Chemists, 1990).

About 1 g of ash weight and put in a 100 ml beaker, and nitric acid (15–20 ml) was added to form a 1:1 (V/W) suspension, covered by a watch glass, the mixture heated on a hotplate until the ash was solubilized, and then left to cool at room temperature, later it was transferred quantitatively to a volumetric flask (100 ml volume) and was completed with distilled water, and thus became a model ripe for estimating the Cu, Ca, Fe and Mg by an atomic absorption spectrometer.

Standard solutions: intermediate standards were diluted with 1 % nitric acid in a volumetric flask and stored in plastic bottles. As the sample solutions and calibration curves were generated, the blanks and calibration standard solutions were also examined. Flame atomic emission spectroscopy (FAES) with a flame photometer was used to examine Na and K at 589.0 nm and 766.5 nm (wavelengths), respectively. Using the spectrophotometric vanadium phosphomolybdate technique, total phosphorus was measured.

2.6. Statistical analysis

The experiment's outcomes were statistically examined using the completely randomized design (CRD) statistical tool (Institute, 1999). Duncan's multiple range tests were used to look for differences between the means. The significance threshold was set at $P < 0.05$.

3. Results and Discussion

3.1. Chemical Composition

Results showed that there were no significant differences ($P < 0.05$) in moisture and protein composition between the two types of fish species in this study(Table 1). The moisture percentages in *Bagrus* meat was 71.36 %, while *Muraena* meat recorded 71.10 %. These results were consistent with the results of Babaei et al. (2017), who indicated that the moisture reached 72.0 % in sturgeon fillets. This moisture percentage is within the range of moisture found by Khidhir (2011), who found that moisture percentages in Grass carp, Bizz and Shabbout Silver, and Common carps were 74.69, 74.56, 74.15, 71.20, and 69.19 %, respectively. The protein in *Bagrus* meat was 21.36 %, while the protein in *Muraena* steaks was 21.43 %. These results are consistent with the findings of Chukwu and Shaba (Chukwu and Shaba, 2009). As shown in Table 1, there were significant differences ($P < 0.05$), in the percentage of meat fat between the two fish species, as the percentage of fat in the fish fillets was 3.59 % compared to the *Muraena* meat, which contained a higher fat percentage of (4.62 %). This may be due to the nature of the feeding of the species and the availability of food. In addition, the proportion of ash reached 3.01 % in *Bagrus* meat, while it was 2.55 % in *Muraena* meat. These results are consistent with the findings of Sharma et al. (Sharma et al., 2019). Results in this study are consistent with the records of Albashr et al. (2021), which found moisture, protein, fat, and ash percentages in *Barbus luteus* meat were 72.13, 19.74, 5.07, and 1.60 %, respectively, while those *Chondrostoma regium* meat were 71.63, 19.98, 4.96 and 2.04 %, respectively.

The proximate composition difference could be attributable to the content of the diet, the time of catch, or the surrounding medium (Tulgar and Berik, 2012).

3.2. Fatty acids profile

Table 2, represents the quality and quantity of fatty acids in the studied fish fillets; the results showed that the *Muraena* had a significantly higher level of saturated fatty acids (26.06 %) than in *Bagrus* (16.6),. The percentage ranking of saturated fatty acids in *Bagrus* in terms of Stearic acid (C18:0) was > Palmitic acid (C16:0) > Behenic acid > Margaric acid (C17:0) > Myristic acid (C14:0) which were 7.65, 3.66, 2.9, 1.43 and 1.33 %, respectively. The percentage of saturated fatty acids in *Muraena* including Stearic acid (C18:0) > Behenic acid (C22:0) > Palmitic acid (C16:0) > Margaric acid (C17:0) > Myristic acid (C14:0) that were 12.00, 6.93, 4.60, 1.66 and 0.86 %, respectively. These results converge with the findings of the researcher Özyurt et al. (2013). The percentages of unsaturated fatty acids in *Bagrus* and *Muraena* meat reached (36.0 and 45.96 %), respectively, while in *Muraena* the C14:1, C16:1, C18:1, C18:3, C20:1, C20:4 presented a percentage of 0.30, 3.46, 13.23, 16.20, 3.63 and 0.8 %, respectively. Moreover, α-Linolenic acid was > Oleic acid > Gondoic acid > Palmitoleic acid > Myristoleic acid > Arachidonic acid. In contrast, in *Muraena*, the C14:1, C16:1, C18:1, C18:3, C20:1, and C20:4 formed percentages of 1.30, 1.46, 22.26, 17.9, 2.0 and 0.43, respectively, which means Oleic acid > α-Linolenic acid > Gondoic acid > Palmitoleic acid > Myristoleic acid > Arachidonic acid, these results converge with what Suloma and Ogata (2007) found.

3.3. Amino acids profile

Table 3 shows the total amino acid content in the *Bagrus* and *Muraena*. The results showed a difference in amino acids level between the two fish species' meat. The highest percentage of amino acids in *Bagrus* meat was 92.66 %, while the percentage was 61.94 % in *Muraena* meat. The *Bagrus* meat contained essential amino acids with a high percentage of 54.04 %, while it was 28.55 % in *Muraena* meat, the amino acid of leucine formed 5.07 %. In comparison, the lowest level of the lysine formed at 1.85 %, this is a sign of the high grade of meat proteins, and percentages of glutamic and aspartic acid are consistent with results found by Ozden and Erkan (2008), and Peng et al. (2013), who indicated that fish contain a high percentage of protein, and the most abundant amino acid is glutamic and aspartic acid, and showed that the amino acids in the fish meat are essential to human health. It formed the proportion of amino acids, availability of essential Amino acids in fish meat was a good indicator of higher protein feed value(Yang et al., 2010). Non-essential Amino acids percentage reached 47.56 % in *Bagrus* fish fillets. The amino acid Alanine recorded the highest percentage among non-essential amino acids, as its level reached (38.62 %), while the level of (33.39 %) was in *Muraena* meat. The findings of Kaya et al. (2014) study also resulted that the amino acid content in salmon fillets and found that glutamic acid, aspartic acid, and lysine are the highest among the studied amino acids and in agreement with the findings of Tenyang et al. (2014) who studied amino acids on six types of fish, who indicated that the most abundant amino acid was palmitic. Due to the limited feeding scope, these noteworthy disparities in amino acid levels necessitated more balanced diets (Ashraf et al., 2011). Huss (1995) mentioned that the content of arginine, tryptophan, tyrosine, methionine, and phenylalanine differs according to the season of fishing. This also noticed in this study in which both *Bagrida and Muraena* were different in amino acid percentages, however both fish living in same environment, water, and feeds, means feeding may not affect the percentages of amino acids for that reason same feeding type showed different amino

Table 1
Chemical Composition of *Bagrus* and *Muraena* in the upper of Tiger River.

Fish type	Moisture	Protein	Lipid	Ash
Bagrus	71.36 ± 0.78a	21.36 ± 0.71a	3.59 ± 0.22b	3.01 ± 0.22a
Muraena	71.10 ± 0.15a	21.43 ± 0.37a	4.62 ± 0.15a	2.55 ± 0.23b

[1]Different letters in the same row mean significant differences ($P < 0.05$).

Table 2
Levels of Fatty Acids of *Bagrus* and *Muraena* in the Upper Tiger River.

Fatty acid	*Bagrus*	*Muraena*
C14:0	1.33 ± 0.20 a	0.86 ± 0.08 a
C16:0	3.66 ± 0.35b	4.60 ± 0.15 a
C17:0	1.43 ± 0.08 a	1.66 ± 0.08 a
C18:0	7.65 ± 1.53b	12.00 ± 0.40 a
C22:0	2.9 ± 0.40b	6.93 ± 0.80 a
Σ SAT	16.6 ± 0.28b	26.06 ± 0.53a
C14:1	0.30 ± 0.05b	1.30 ± 0.05 a
C16:1	3.46 ± 0.26 a	1.46 ± 0.21b
C18:1	13.23 ± 0.24b	22.26 ± 0.21 a
C18:3	16.20 ± 0.36 a	17.9 ± 0.75 a
C20:1	3.63 ± 0.23b	2.0 ± 0.23 a
C20:4	0.8 ± 0.05 a	0.43 ± 0.08b
Σ MUFA	36.0 ± 0.77b	45.96 ± 0.42 a

* Different letter in the same column means significant differences ($P < 0.05$).

Table 3
Levels of amino acids of *Bagrus* and *Muraena* in the upper Tiger River.

Amino acid	*Bagrus*	*Muraena*
Arginine	1.56 ± 0.11a	1.38 ± 0.07a
Alanine	8.87 ± 0.30 a	5.56 ± 0.10b
Glycine	2.61 ± 0.30 a	1.03 ± 0.03b
Asparagine	4.43 ± 0.24b	5.56 ± 0.10a
Aspartic Acid	7.02 ± 0.14 a	5.60 ± 0.12b
Tyrosine	6.64 ± 0.0.07 a	4.25 ± 0.46b
Glutamic	7.49 ± 0.17 a	10.01 ± 0.07a
Histidine	8.72 ± 0.36b	7.42 ± 0.17a
Tryptophan	3.31 ± 0.21 a	2.26 ± 0.57b
Isoleucine	4.10 ± 0.51 a	5.83 ± 0.34a
Methionine	4.33 ± 0.11a	3.20 ± 0.33ab
Threonine	2.81 ± 0.36b	2.71 ± 0.34a
Valine	3.58 ± 0.04 a	2.26 ± 0.21a
Lysine	1.85 ± 0.03b	1.02 ± 0.04b
Leucine	5.07 ± 0.12 a	3.85 ± 0.39b
Total essential amino acids	54.04	28.55
Total non-essential amino acids	38.62	33.39
Total amino acids	92.66	61.94

*Different letter in the same column means significant differences ($P < 0.05$).

acids percentages in the inspected fish. Regarding the nature of water on the chemical composition, it seems have effects on mineral elements because the water has been tested by governmental sectors and found high level of Na, P, K, Cu, and Mg in 2017–2021.

3.4. Elements Content

Mineral elements are inorganic elements that can be divided into two parts, namely; phosphorous, potassium, and trace mineral elements of iron, zinc, copper, and manganese. Copper levels in this study were 1.00 and 1.53 mg/100 gm in *Bagrus* and *Muraena* meat, respectively. Copper is involved in the activity of numerous enzymes, according to animal and human studies. Although copper is needed for optimum health, excessive amounts can create complications such as liver and kidney damage (Health and Services, 2004). Cu values of 2.07 μg/g (dry weight) in fish muscle which have been found in other investigations (Ronagh et al., 2009). Copper concentrations also found in 15 fish species from Lake Chini, Pahang, Malaysia, ranged from 76 to 12.52 g/g (dry weight) (Ahmad and Shuhaimi-Othman, 2010).Moreover, Yilmaz (2009) found levels ranging from 7.88 to 32.98 g/g (dry weight) in fish muscle, while Etesin and Benson (2007)found an average concentration of 1.93 g/g (dry weight) in the muscle of fish collected in Nigeria's Imo River.

The iron level in our study was (3.3 and 4.91 mg/100gm) in *Bagrus* and *Muraena* meat respectively, Iron functions as a carrier of oxygen from the lungs to the tissues via red blood cell hemoglobin, as a medium for electron transport inside cells, and as a component of essential enzyme systems in many organs. Adequate iron in the diet is critical for reducing the occurrence of anemia, which is a serious health concern, particularly among young children. The iron level in this study is similar to the level of iron values in the study by Kasozi et al. (2014) that found the iron level range of 1.1——3.58 mg/100 g in *Alestes baremoze* fish, therefore, it can be considered that these two species of fish are a good source of iron for the human body.

The results in this study also showed that Phosphorus (P) levels were (180 and 98 mg/100gm) in *Bagrus* and *Muraena* meat respectively, there were statistically significant differences between these values. Phosphorus is a vital mineral in fish, as it is required for optimal growth, bone mineralization, reproduction, and energy metabolism (Albrektsen et al., 2009).

Calcium is vital for the formation of the bone (Kawarazuka and Béné, 2011). Calcium and phosphorus engage in the development and maintenance of the skeletal system and play a key role in various physiological processes. Calcium is complexed with phosphorus in hydroxyapatite to form the main component of bone in animals (Ye et al., 2006). An adult's daily phosphorus intake should be 800 mg, and calcium intake should be about 1000 mg (1200 mg per day for women and men aged 25 years and younger, and 1100 mg per day for women over 60 years old due to progressing loss in bone mineral pass (Lidwin-Kazmierkiewicz et al., 2009), in our study, this 2 fish species were a good source of P for the human body. The ratio of Ca/P in our study was about 2:1 and 3:1 in *Bagrus* and *Muraena* meat, respectively. According to the various findings, an excess amount of phosphorus in the body produces calcium malabsorption, which can lead to bone decalcification. The most essential indicator of healthy bone health is the Ca/P ratio. According to several studies, the value of this ratio in ingested goods should be 1:1, because when calcium exceeds phosphorus, phosphorus is not absorbed because this form of calcium phosphates is not biologically available (Chavez-Sanchez et al., 2000).

Magnesium level was also recorded (81.3 and 63.3 mg / 100 gm) as presented in Table 4, for *Bagrus* and *Muraena* fish respectively, these results are within the limits of the Food and Nutrition Organization and the level of our results was lowest than levels found by Kiczorowska et al. (2019), that found Mg levels range were between 16 to 100.9 mg/ 100 gm.

The potassium concentration ranges were 283 and 326 mg /100 g in *Bagrus* and *Muraena* meat, respectively. High potassium levels in the fish samples in this study may be due to the pace at which potassium is available in the water body, as well as the fish's ability to absorb these inorganic elements from their feed and the habitat in which they dwell, these results less than the Potassium level that finding by Erkan and Özden (2007), who indicated that Potassium level was (459) mg / 100 g of bass fillets. *Bagrus* and *Muraena* samples showed a good amount of sodium content of (89.0 and 100.0 mg / 100 gm), respectively in this research. This result falls within the average range of the Food and Agriculture Organization, which specifies the content from 30–134 mg / 100 g. The quantities of bio-elements and toxic metals in the carp body is vary depending on the culture method, water quality, and feed type (Brucka-Jastrzebska and Protasowicki, 2006).The rate at which metals influence the body is determined by the blood's ability to carry metals.

Table 4
The level of mineral elements of *Bagrus* and *Muraena* fillets (mg / 100 gm) in the upper of Tiger River.

Fish type	Cu	Fe	P	Ca	Mg	K	Na
Bagrus	1.0 ± 0.05b	3.3 ± 0.12b	180.3 ± 0.33a	372.6 ± 0.8a	81.3 ± 0.8 a	283.6 ± 0.8b	89 ± 1.15b
Muraena	1.53 ± 0.03a	4.91 ± 0.07a	98 ± 0.5b	313.6 ± 0.3b	63.3 ± 0.8b	326.6 ± 0.8 a	100 ± 1.0 a

*Different letter in same row means significant differences ($P < 0.05$).

Differences in the concentration of various nutrients in the analyzed fish species are due to a variety of factors, including species variability in mineral element accumulation in tissues, nutrient availability in the aquatic environment or feed, and the ability to absorb and transform compounds into essential nutritional components (Fawole et al., 2007).

4. Conclusions

Current study revealed that *Bagrus* and *Muraena* were contain acceptable percentages of several chemical composition such as unsaturated fatty acids, amino acids, and different minerals which are important as a source of food and supplement for human nutrition. However, the level of minerals were different between fish species. Both *Bagrus* and *Muraena* species were good source of essential and non-essential amino acids and low source of fatty acids. Besides, both type of fish were rich in source of Cu, Fe, P, Ca, Mg, K and Na. The only significant difference between the two type of fish was the level of saturated fats in which *Muraena* showed that significantly higher saturated fatty acid than *Bagrus* meat. This study recommends that *Bagrus* species are good source of essential and non-essential amino acids and can be consumed as a source of amino acids and can be consumed as a good source of energy. Both type of fish were rich in source of Cu, Fe, P, Ca, Mg, K and Na, hence, they can be consumed especially in the case of mineral deficiency in humans. This study also recommends further studies on physiological, behavioral, and biological aspect of these important fish in the upper of Tigris River in Iraq.

CRediT authorship contribution statement

Tariq Kh. Albashr: Formal analysis. **Ahmed Y. Hamadamin:** . **Karzan F. Namiq:** . **Miran H. Salih:** Investigation. **Zaid K. Khidhir:** . **M.A. Suhaib:** .

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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