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Evaluation of Heavy Metals Accumulation in Different Parts of Frozen and Fresh Fish in Dhi Qar Governorate, Southern Iraq

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ABSTRACT

In this study, the concentration level of some heavy elements, including copper, cadmium and zinc, was determined in the gills, digestive tract and muscles of carp fish. Carp fish were chosen for their availability and abundance at the study stations (Nasiriyah City and Al-Jabaish). The concentrations of heavy metals in fish and their nutritional content were measured. Differences in the concentration of heavy metals were observed between the studied parts. The highest concentrations were recorded in the digestive tract, while the lowest concentration of heavy metals was recorded in the muscles. When compared to the limits set by the World Health Organization, it was found that some of them exceeded the permissible limits because fish are important and the presence of metals in them leads to their transmission through the food chain to humans, which leads to many diseases and many serious problems resulting from the increase of heavy metals in fish and the environment**.** The aim of the study was to investigate the effect of heavy metal accumulation in frozen and fresh fish on human consumers. Based on the results of this research paper, there must be an ongoing follow-up to reduce and control the quantities of various materials released into the water, which cause an increase in the concentration of heavy metals in the water.

INTRODUCTION

Heavy metals are elements that have a large molecular weight and are described as having a high density **(Sani, 2011)**. These metals are very toxic when present in high quantities, such as cadmium, mercury, chromium and other metals. They are not biodegradable **(Appenroth, 2009)**. Heavy metal pollution is a serious threat for human health relating to their toxicity and bioaccumulation in the food chain **(Talib *et al.*, 2022)**. Lead, cadmium and others are not important to humans and are harmful to health **(Chen, 2012)**. The essential minerals, such as copper, zinc, manganese are necessary in certain quantities, but when their concentrations increase, they become fatal **(Gupta *et al.*, 2012)**. The presence of heavy metals in water results from several factors, including the use of pesticides that are washed from the soil into the water due to irrigation of agricultural crops or due to rain, in addition to the discharge of sewage into running rivers and the large number of industries near the water, which leads to the pollution of the water and the organisms in it. Moreover, it leads to their transmission to humans through the food chain **(Ahmad *et al.*, 2014)**. Heavy metals can accumulate in the body of aquatic animals

like fish, Gastropoda, inseta which can be used as a bioindicator **(Jawed *et al*., 2022)**. Heavy minerals enter the envronmrnt through many hydrocarbons and oil industries **(Abedali *et al*., 2021)**. Fish are an important source of proteins and carbohydrates in addition to fats. They also contain essential minerals and vitamins. Many scientific studies and research advise pregnant women to eat fish at least twice a week in order to obtain the vitamins and important substances found in fish **(Abdelrazek, 2019)**. Heavy metals accumulate in fish for long periods depending on the age, type, body, gender, feeding processes, environmental requirements, and chemical and biological characteristics of the fish **(Medeiros *et al*., 2012)**. Heavy metals affect humans and cause many health diseases in the nervous system, digestive system, kidney disease, heart disease, and blood disease **(Kris-Etherton *et al*., 2002)**. The presence of heavy metals for long periods in fish leads to fish deformity, and therefore when present in large quantities, it leads to the death of fish **(Demirak *et al*., 2006; Yılmaz *et al*., 2007)**. The aim of the study was to determine the accumulation of heavy elements in different parts of fresh and frozen fish during different seasons and to focus on studying the chemical content of fish in terms of proteins, carbohydrates, fats and their importance.

MATERIALS AND METHODS

1. Study area

Four stations were selected from the districts of Thi Qar Governorate, namely Al-Jabaish, and Nasiriyah City Center. Samples of frozen and fresh carp fish were collected during the winter and summer of 2024.

2. Sample collection

Carp fish samples were selected from local markets for each study station, and their weights ranged from 400 grams to 3 kilograms. The samples were placed in cork containers cooled with ice to preserve them until examining. Then, the fish were cut into several parts required for the study, which are the gills, digestive tract, and muscles. Each part was placed in a sealed plastic container cooled with ice for the purpose of transporting it to the specialized laboratory to measure the heavy metals in it.

3. Digestion of samples

The dry weight of the fish gills, muscles and digestive tract was taken after drying the samples in an oven at a temperature of 120 degrees celsius for a whole day. The samples were ground and placed in a special 250ml beaker. Then, a mixture of hydrochloric acid with a concentration of 4.5 concentrated was added to them and was heated on a hot plate at a temperature of 80 degrees celsius. After that, four moles of a mixture of perchloric acid and concentrated hydrofluoric acid were added to them in a ratio of 1:1. Distilled water was added to these fish samples necessary to measure the heavy metals in them according to the method followed in **ROPME (1983)**.

4. Measurement of heavy elements

The heavy elements of the samples required in the study were measured using flame atomic absorption spectroscopy (FAAS), then standard solutions of heavy elements were prepared and examined according to the method described by the Pan American Health Organization **(APHA, 2003)**.

5. Analysis of the chemical content of fish

Fat measurement was performed using suxilate to find the percentage of fat in it, as for proteins, the micro caldahl method was used. While for measuring carbohydrates, the anthro method was used to find the percentage of carbohydrates in fish **(Boel *et al.*, 1988; BlighEG, 1989)**. The results and variables of the current study were statistically evaluated using the Statistical Package for Social Sciences program (SPSS) program version 26 (2019), two way ANOVA at a probability of $P \leq 0.05$ as a significant level.

RESULTS

In this study, the concentration of three heavy metals in fish (copper, cadmium, zinc) was measured in some types of fish, including the carb inhabiting the water of rivers in abundance. Table (1) shows the concentration of copper in frozen carp fish during the winter in Al-Jabayesh was 0.84µg/ g dry weight. The lowest concentration of copper was in the summer in Al-Jabayesh at 0.72µg/ g dry weight. The results of the statistical analysis show that there are significant differences at the level of $P \leq 0.05$. In fresh carp only, the highest concentration of copper in the muscles of fresh carp reached 0.95µg/ g dry weight during the summer in Al-Jabayesh, while the lowest concentration was during the winter in Al-Jabayesh amounted to 0.59µg/ g dry weight. Table (1) also shows the concentration of copper in the gills, as it reached a concentration of copper during the winter in the city of Nasiriyah amounted to 8.23µg/ g dry weight. The lowest concentration of copper in frozen fish was 6.53µg/ g dry weight during the summer in Nasiriyah, while in fresh carp, it reached the highest value in the city of Nasiriyah during the winter season (7.30µg/ g dry weight) while the lowest concentration reached 6.13µg/ g dry weight in winter in Al-Jabayesh. The results of the statistical analysis show that there are significant differences at the level of $P \leq 0.05$. In addition, Table (1) shows the concentration of copper in the digestive tract, the highest concentration of copper during summer for the preference was 12.42µg/ g dry weight, while the lowest concentration was in winter, the preference was 7.10µg/ g dry weight, while in fresh carp, the highest concentration during the summer in the preferred season was 13.67µg/ g dry weight in Nasiriyah, while the lowest concentration was during winter in the preferred season amounted to 10.60µg/ g on gram dry weight in Nasiriyah. The results of the statistical analysis show that there are significant differences at the level of $P \leq 0.05$.

Table (2) exhibits the concentration of cadmium in frozen carp muscle. The concentration of cadmium reached its maximum value of 3.16µg/ g dry weight during winter in Nasiriyah and Al-Jabayesh, while the lowest concentration of cadmium in the muscles was detected during summer in the city of Nasiriyah, with a value amounting to 2.16µg/ g dry weight, while in fresh carp the highest concentration during the winter in Nasiriyah reached 2.56µg/ g dry weight. The lowest concentration of cadmium was 1.65µg/ g dry weight during summer in the city of Nasiriyah. The results of the statistical analysis showed that there are significant differences at the level of $P\leq 0.05$. Table (2) displays the concentration of cadmium in the gills, with the highest concentration recorded at 10.17µg/ g dry weight during summer in Al-Jabayesh, while the lowest concentration was during the winter in the Al-Jabayesh, reaching 7.13µg/ g dry weight. In terms of the fresh carp, it reached a concentration of 8.00µg/ g in winter in the city of Nasiriyah, while the lowest concentration of cadmium in fresh carp was registered in summer for Al-Jabaish amounting to 6.60µg/ g dry weight. The results of the statistical analysis show that there are significant differences at the level of $P\leq 0.05$. On the other hand, Table (2) shows the concentration of cadmium in the digestive tract, the highest concentration during winter in the gastrointestinal tract reaching 12.40µg/ g dry weight in Al-Jabayesh, while the lowest concentration during the summer in the city of Nasiriyah was 10.70µg/ g dry weight. For the fresh carp, the highest concentration during the winter in the city of Nasiriyah was 11.50µg/ g dry weight, while the lowest concentration was during the summer in Nasiriyah amounting the value of 8.92µg/ g dry weight. The results of the statistical analysis show that there are significant differences at the level of $P\leq 0.05$.

Table (3) shows the concentration of zinc element in the frozen carp muscles, the highest concentration during the winter in Al-Jabayesh reached 53.33µg/ g dry weight, while the lowest concentration during summer in Al-Jabayesh amounted to 43.00µg/ g dry weight. In fresh carp, the concentration during the summer in Al-Jabayesh was 76.33µg/ g dry weight, while the lowest concentration during the winter in the Al-Jabayesh was 48.67µg/ g dry weight. The results of the statistical analysis show that there were significant differences at the level of $P \leq 0.05$. Tables (3, 4) depict the concentration of zinc in fresh carp, the highest of which in the gill during summer in Nasiriyah was 165.66µg/ g dry weight, while the lowest concentration was during the winter in Nasiriyah and Al-Jabayesh amounting to 128.33µg/ g dry weight, in frozen carp. The highest concentration of zinc in the gill during the summer in Al-Jabayesh was 131.33µg/ g dry weight, while the lowest concentration was during winter in Nasiriyah amounting 44.00µg/ g dry weight. The results of the statistical analysis showed that there were significant differences at the level of $P\leq 0.05$. Table (3) shows in the digestive tract, the highest concentration of frozen carp during winter in Al-Jabayesh was 147.00µg/ g dry weight, while the lowest concentration during summer in the preferred season and Al-Jabayesh amounted to 106.33µg/ g dry weight. For the fresh carp, the highest concentration during the summer for the city of Nasiriyah was 134.66µg/ g dry weight, while the lowest concentration was during the winter season for the preferenced season amounted to 102.00µg/ g dry weight in Al-Jabayesh.

The results of the statistical analysis show that there are significant differences at the level of $P \leq 0.05$.

Table (4) shows the percentage of carbohydrates in frozen carp. The highest percentage of carbohydrates during summer in the city of Nasiriyah amounted to 1.30µg/ g, while the lowest percentage of carbohydrates was during winter in Nasiriyah (0.94µg/ g). As for fresh carp, the highest percentage of carbohydrates during winter in Al-Jabayesh amounted to 0.84µg/ g, while the lowest percentage was during the winter in the city of Nasiriyah amounting to 0.25 µg/g. Table (4) also shows the percentage of proteins in frozen carp. The highest percentage of protein in frozen carp during winter in the city in Al-Jabayesh amounted to 21.97µg/ g, while the lowest was during winter in the city of Al-Jabayesh amounting to 17.22µg/ g. As for fresh carp, the highest percentage during the summer in the city of Nasiriyah amounted to 20.26, while the lowest concentration was during the winter in Al-Jabayesh reaching 17.65µg/ g. Table (4) illustrates that the concentration of fat in frozen carp had the highest concentration during the summer in the city of Nasiriyah with the percentage of 6.53µg/ g and the lowest percentage was during the winter in the city of Nasiriyah (2.02µg/ g). While for the fresh carp, the highest percentage during summer season in the city of Nasiriyah was 5.28, while the lowest concentration was during winter in Al-Jabayesh amounting to 1.78µg/ g.

Table 1. Effect of geographical location and season on copper accumulation in carp fish

Location	Season	Sample	Part used		
			Muscle	Gills	Digestive tract
Nasiriyah		frozen	0.76±0.52 C a	8.23±0.30 A a	7.10±0.55 B d
	winter	fresh	0.80±0.07 C a	7.30±0.10 B b	10.60±0.40 A c
		frozen	0.74±0.05 C a	6.53±0.78 B c	12.42±0.07 A b
	summer	fresh	0.85±0.04 C a	6.46±0.02 B c	13.67±0.20 A a
Al-		frozen	0.84±0.02 C a	6.90±0.60 B bc	7.63±0.47 A d
Jabayesh	winter	fresh	0.59±0.02 C a	6.13±0.75 B c	10.83±0.65 A c
	summer	frozen	0.72±0.08 C a	6.76±0.47 B c	12.38±0.09 A b
		fresh	0.95±0.03 C a	6.54±0.32 B c	13.53±0.15 A a
L.S.D	0.55				

Different alphabet letters within one column mean significant differences below the probability level 0.05.

Table 2. Effect of geographical location and season on cadmium accumulation in carp fish

Location	Season	Sample	Part used		
			Muscle	Gills	Digestive tract
Nasiriyah		frozen	3.16±0.30 C a	7.73±1.12 B d	12.20±0.17 A a
	winter	fresh	2.56±0.35 C b	8.00±0.26 B c	11.50±0.20 A b
		frozen	2.16±0.02 C b	9.50±0.06 B b	10.70±0.20 A c
	summer	fresh	1.65±0.03 C c	6.88±0.08 B e	8.92±0.02 A e
Al-		frozen	3.16±0.47 C a	7.13±0.75 B d	12.40±0.77 A a
Jabayesh	winter	fresh	2.13±0.25 C b	7.23±0.30 B de	11.16±0.65 A b
	summer	frozen	2.18±0.23 C b	10.17±0.14 B a	12.28±0.72 A a
		fresh	1.67±0.02 C c	6.60±0.11 B e	9.03±0.15 A d
L.S.D	0.58				

Different alphabet letters within one column mean significant differences below the probability level 0.05.

Table 3. Effect of geographical location and season on zinc accumulation in carp fish

Location	Season	Sample	Part used		
			Muscle	Gills	Digestive tract
Nasiriyah	winter	frozen	47.33±6.11 C e	115.00±4.58 B f	142.67±2.51 A b
		fresh	60.67±2.51 C c	128.33±3.51 A d	111.00±3.00 B d
	summer	frozen	44.00±2.00 B f	44.00±2.00 B g	108.67±3.05 A e
		fresh	74.67±1.52 C b	165.66±2.08 A a	134.67±2.51 B c
Al-Jabayesh	winter	frozen	53.33±3.21 C d	131.33±3.51 A c	147.00±3.60 A a
		fresh	48.67±1.52 C e	128.33±3.51 A d	102.00 ±2.64 B g
	summer	frozen	43.00±3.60 C f	117.33±2.51 A e	106.33±3.05 B f
		fresh	76.33±3.05 C a	161.66±1.52 A b	132.67±4.16 B c
L.S.D	2.18				

Different alphabet letters within one column mean significant differences below the probability level 0.05.

Table 4. Effect of geographical location and season on chemical content accumulation in carp fish

Location	Season	Sample	Carbohydrates	Protein	Fat
Nasiriyah	winter	frozen	0.94±0.03 b	20.33±0.12 b	2.02 ±0.83 de
		fresh	0.25±0.08 c	18.30±0.75 d	2.84±0.45 d
	summer	frozen	1.30±0.30 a	20.10±0.72 b	6.53±0.10 a
		fresh	0.68±0.34 b	20.26±0.28 b	5.28±0.59 b
Al-Jabayesh	winter	frozen	1.12±0.12 a	17.22±0.50 e	2.06±0.23 d
		fresh	0.84±0.19 b	17.65±2.08 e	1.78±0.34 e
	summer	frozen	0.98±0.02 b	21.97±1.02 a	3.70±1.55 c
		Fresh	0.83±0.10 b	19.85±0.56 c	2.23±0.38 d
	L.S.D		0.22	0.53	1.07

Different alphabet letters within one column mean significant differences below the probability level 0.05.

DISCUSSION

The results show that the gut was more affected by heavy metals **(Al-Najare *et al.*, 2015)**, followed other organs. Moreover, heavy metals can enter the fish's body through food ingestion and direct contact of the gut with contaminated water, both of which negatively affect fish health **(Busaidi *et al*., 2011)**. The presence of heavy metals indicates their accumulation over long periods of time in the muscles **(Rahman *et al*., 2012)**. A comparison of muscle tissue with other body parts revealed that muscles contained lower concentrations of heavy metals. This is likely due to their lower metabolic activity and reduced capacity for metal accumulation, which is consistent with the findings of **Amini and Sotodehnia (2005)**. The high concentrations of

heavy metals in fish indicate the ability of carp to adapt to unfavorable environmental conditions from the presence of heavy resources and other pollutants. This result is consistent with the findings of **Said *et al.* (2004)** and **Pandey *et al.* (2017)**, who reported that the accumulation of heavy metals followed the order: gastrointestinal tract > gills > muscles. These findings are also in agreement with the study of **Naghipour *et al.* (2016)**. The results of the chemical content of fish showed that the proportion of carbohydrates **(Al-Najare *et al.*, 2015)**, fats and proteins could range between the winter and summer seasons. Fluctuations in levels, including periods of both decrease and increase, have been observed **(APHA, 2003)**. The higher values are attributed to the protein content in the fish diet, which plays a significant role in enhancing the nutritional value of fish. Notably, this increase is associated with the elevated levels of protein and fat, as reported by **Gedran *et al.* (2012)** and **Hani (2023)**.

CONCLUSION

In conclusion, the results showed that heavy metals are toxic when they exceed the permissible limits, but when they are present in small quantities, some metals are useful. Heavy metals are detected as a result of human and natural materials and are transmitted through the air and soil to the water, as well as through sewage waste, and subsequently having an impact on the aquatic environment and fish. Therefore, the activities from which heavy metals are produced must be minimized.

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