Comparative Determination of Some Metals in Two Fish Species Collected from Markets at Kafr El- Zayat District, El- Gharabia Governorate, Egypt by Microwave Plasma Atomic Emission Spectrometry

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Abstract: Some metals (Cd, Cr, Cu, Mn, Pb, and Zn) were seasonally measured in muscles of catfish and tilapia fish from markets at Kafr El-Zayat district by the microwave plasma atomic emission spectroscopy (MP-AES). The fish samples were primarily digested by microwave digestion system. The concentrations of Cd in all the tested catfish samples were less than the permissible limits. The concentration of Cd and Cr in all examined muscles of tilapia fishes were less than the allowed values. The concentrations of Cu in the examined catfish samples are within the allowed limits, while the concentration of the metal in tilapia fish are higher. Nevertheless, concentrations of Pb in the majority of catfish samples were higher than the permissible limits. The concentrations of Zn, Mn and Pb in all examined samples of the two fish species were more than the reported literature. There is a statistically significant difference between the metals in each of fish species. On the other hand, all pairs of the same metal in the two species have no significant relationship between the two fish species except that between Cd in them both.

Keywords: Catfish, tilapia fish, Cd, Cr, Cu, Mn, Pb, Zn, microwave plasma atomic emission spectroscopy

1. Introduction:

Fish is considered as one of the main sources of proteins in human food and as healthy food due to its high contents of minerals and vitamins and low contents of fat in contrary to other animal protein sources **(El-Makkawi, *et al.*, 2007)**. As fish is considered as an important food for a wide area of population, fish is highly traded in the markets **(Hassan and Ahmed, 2010)**. However, fish in the markets comes from diverse sources. Fish may be brought from fresh or salty water sources. Also, fish is reared in artificial pools and farms. Fishery from upper seas is one of the other sources of fish. All of these represent a wide variety of different sources of fish sold in the markets. Fishing in the open seas brings the least contaminated fish. On the other hand, fish fished near industrial plants and other sources of pollution is considered the most dangerous to human health. Other sources of contamination to fish may be the transportation and storing. Recently, floating dead fish collected from the River Nile after throwing a deal of insecticides is displayed on TV programs. Trace metals are natural components of the aquatic environment. These metals may generally enter the environment by different ways such as industrial, agricultural and mining activities. The problem of contamination of water sources where marine organisms live may represent a serious problem, particularly metal contaminants, which are not easily removable The metals became more dangerous on human health when their concentration is more than the permissible level **(Lobban and Harrison, 1994)**. Age, feeding habits, and the trophic level to which the respective species belong determine metal concentration in seafood. However, the mechanism of metal accumulation in these living organisms is not well established yet. The levels of metals in upper members of the food chain like fish can reach values many times higher than those found in their aquatic environment or in the sediments **(Gledhill *et al.*, 1997)**. As a result, aquatic animals are exposed to elevated levels of metals at normal conditions. When metal concentrations exceed the required levels, they become toxic and cause several health problems **(Malik, 2004)**.

Toxic metals are potentially harmful to most organisms even at very low concentrations and have been reported as hazardous environmental pollutants able to accumulate along the aquatic food chain with severe risk for animal and human health. The fishes became sick then die when too much contamination happened **(Gurnham, 1975)**.

The contamination in our region is important regarding the health of the aquatic animals and in turn, health of the seafood consumers. Pollution of different environments in Egypt is due to human activities in recent years. One of such pollution is marine pollution by metals. The Kafr–El Zayat district is located near one of the biggest pesticide factories in Egypt and exposed to different types of pollutants such as metals, particularly in water sources.

The aim of the present study is to determine the concentration of Cd, Cr, Cu, Mn, Pb, and Zn in the muscles of catfish and tilapia fish samples from Kafr – El Zayat market, El- Gharabia Governorate, Egypt using microwave Plasma atomic emission spectrometry.

2. Materials and Methods:

2.1. Samples:

The fish samples used in this study were catfish (*Clarias Garipinus*) and tilapia fish (*Tilapia Nilotica*). The determination of Cd, Cr, Cu, Mn, Pb, and Zn in fish muscle (22 and 25 samples in the two species, respectively) collected from local Market in Kafr El- Zayat city.

2.2. Chemicals and Standards:

All chemicals and standards are of Analytical grade. Metals stock standards of Cd, Cr, Cu, Mn, Pb, and Zn were obtained from Merck, Darmstadt, Germany (1000 µg/mL).

2.3. Sample preparation:

Different digestion methods were used for fish sample preparation such as: dry ashing, wet digestion **(Oliafa *et al.*, 2004)** and microwave digestive technique **(Huijuan *et al.*, 2005,)**. Microwave digestion was used to prepare the fish samples in the current study. Ten mL of HNO3 was added to accurately weighed 0.5000 g of the sample. A preloaded method for the MARS6 (CEM, Corporation, USA) microwave was used to digest the samples. Once cooled, the solution was diluted quantitatively to 25 mL using ultrapure water. The microwave digestion parameters were according to Table 1.

2.4. Instrumentation

All measurements were performed using the innovative Agilent microwave plasma atomic emission spectrometry model 4200 MP-AES with nitrogen gas plasma supplied via an Agilent 4107 Nitrogen Generator. The generator alleviates the need and expense of sourcing analytical grade gases. The sample introduction system comprised a double-pass cyclonic spray chamber and the One Neb nebulizer. The innovative 4200 MP-AES features a second-generation waveguide and torch, with mass flow controlled nebulizer gas flow. The 4200 MP-AES has a robust toroidal plasma with a central channel temperature of ≈5,000 K that eliminates many of the chemical interferences that are present in FAAS and expands the concentration working range of the 4200 MP-AES when compared with the FAAS. This means that the element specific sample preparation that is commonplace when using FAAS is not necessary when using the 4200 MP-AES, improving ease of use and reducing cost. Some modification has been performed with the first emerging model 4100 MP-AES into model 4200 MP-AES to enhance the performance and to resolve some drawbacks. An Agilent SPS 3 auto sampler was used to deliver samples to the instrument, allowing the system to be operated unattended. The instrument operated in a fast sequential mode and featured a Peltier-cooled CCD detector. Background and spectral interferences could be simultaneously corrected easily and accurately using Agilent's MP Expert software. Method parameters are given in Tables 2 and 3. The limit of detection and limit of quantification of the determination method of metals in Spices are shown in Table 4.

Table 1: Microwave Digestion System Parameters

Options	**Internal Fiber Optic Temperature Control**
	Internal Pressure Control
	DuoTemp Control
Temperature	210°C
Pressure	800 psi
Time	**Ramp** : 21 min
	Hold : 15 min
Power	400- 1800 Watt
Vessels	EasyPrep Full Starter Set, P/T Control

Table 2: Microwave Plasma Atomic Emission Parameters

Parameter	Value
Replicates	3
Pump rate	15 rpm
Sample uptake delay	15 seconds
Rinse time	30 seconds
Stabilization time	15 second
Fast Pump during Uptake and Rinse	On (80 rpm)
Nebulizer	OneNeb
Spray chamber	Double pass cyclonic
Autosampler	Agilent SPS 3
Sample pump tubing	Orange/green
Waste pump tubing	Blue/blue

2.5.Validation Procedures:

2.5.1. Linearity Factor:

The calibration curves for the 6 elements were constructed from at least 3 element concentrations and a blank (Table 3). From Table 3 the linearity of the calibration curves of the studied metals can be seen to have r^2 = 0.9904 - 0.99996

2.5.2. Limit of Detection and Quantification:

The Limit of Quantification for the 6 elements varied from 0.333 $X10^{-3}$ to 0.015 µg/mL (Table 4).

2.5.3. Recovery and Uncertainty:

Recovery percentage of 5 spiked samples with element concentrations at the level of LOD and 5 spiked samples with element concentrations at the level of 10 X LOD and the relative standard deviations of the replicated samples were calculated. The recovery % ranged from 96% to 103% at % SD of < 10%.

2.6.Statistical analysis:

Significances of variances between the results of both catfish and tilapia samples with each metals and the correlation between the concentrations of the group fish samples for both fish species and the six determined metals (Kruskal-Wallis One Way Analysis of Variance on Ranks) were calculated by means of **(SigmaStat computer software, 2012)**.

Table 3: Metals Determined in Fish Samples and their Wavelengths and Calibration Ranges.

Metal	Wavelength (nm)	Calibration Range (µg/mL)	Correlation Coefficient (r^2)
Cd	228.8	0 – 2.500	0.9992
Cr	425.4	0 – 2.000	0.9998
Cu	324.8	0 – 2.500	0.9992
Mn	403.1	0 – 2.000	0.9999
Pb	405.9	0 – 2.500	0.99996
Zn	213.9	0 – 1.500	0.9904

Table 4: Limit of Detection (LOD) and Limit of Quantification (LOQ) of Metals Determined in Fish.

Metal	LOD (µg/mL)	LOQ (µg/mL)
Cd	2.100 $X10^{-3}$	7.000$X10^{-3}$
Cr	0.100 $X10^{-3}$	0.333 $X10^{-3}$
Cu	0.700 $X10^{-3}$	2.333 $X10^{-3}$
Mn	0.200 $X10^{-3}$	0.667 $X10^{-3}$
Pb	3.300 $X10^{-3}$	0.011
Zn	4.500 $X10^{-3}$	0.015

LOD: The Limit Of Detection (=3X standard deviation of 10 measurements in blank matrix).
LOQ: The Limit Of Quantification (= 10/3 X LOD).

3.Results and Discussion:

Several techniques have been used for determination of metal concentration in fish species such as: flame atomic absorption spectrometry **(Abedien, 1986** and **Bermejo *et al.*, 2002)**, electro–thermal atomic absorption spectrometry **(Sperling, 1988** and **Botson *et al.*, 2004, Perez *et al.*, 2001 and Mendez *et al.*, 2002),**, ICP-AES, and ICP-MS. ICP-AES **(Chirila *et al.*, 1999** and **Petisleam *et al.*, 2005)** and ICP-MS **(Sanchez *et al.*, 2003** and **Petisleam *et al.*, 2005)**. We used microwave plasma atomic emission spectrometry, which was recently invited with a similar detection limits as those with ICP-AES and a low cost nitrogen.

3.2. Determination of Cd, Cu, Cr, Mn, Pb and Zn, in fish samples:

The maximum tolerable concentration limits of Cd, Cu, Cr, Mn, Pb and Zn, in fish as reported by EOSQC, WHO / FEPA, IAEA–407, NHMRC and CEFAS, (µg/g) are presented in (Table 5).

The concentrations of Cd in most of the samples of catfishes (Table 6) were not detected except 5 samples ranging between 0.25 - 0.50 µg/g (Table 8). Only 3 samples were at the border of allowed limit at 0.5 µg/g (Table 5). In the case of tilapia fish (Table 7) 14 samples have non-detectable concentrations of Cd. The range of Cd concentrations in the other 11 tilapia fish samples (Table 11) were between 0.75 and 6.75 µg/g **NHMRC, 1987**. Similarly, **Hassan and Ahmed (2010)** determined As, Cd, Cu, Fe, Mn, Pb and Zn in tilapia fish from different Egyptian markets at Shoubra Al-Khaima, Mostord, Torra, Wadi Hof, Helwan and Al-Hawamedia regions, during November, 2009. They found that cadmium was highly elevated in the fish samples from the Egyptian markets at those regions. The Egyptian Organization for Standarization and Quality Control pointed that maximum allowed limit for Cd, must not exceed 0.1 µg/g **(Labib *et al.*, 2008).**

Table (5): Maximum accepted limits of the studied metals in fish.

Metals	Concentration µg/g	Reporting Agency	References
Cd	0.5000	WHO / FEPA	**Edward *et al.*, 2013**
	0.100	EOSQC	**EOSQC, 1991, 1993**
	10.00	NHMRC	**NHMRC, 1987**
Cr	0.7300	IAEA – 407	**Wyse *et al.*, 2003**
Cu	3.000, 3.280	WHO / FEPA, IAEA – 407	**Edward *et al.*, 2013, Wyse *et al.*, 2003**
	20.00	EOSQC	**EOSQC, 1991, 1993**
Mn	0.5000	WHO / FEPA CEFAS	**Edward *et al.*, 2013 CEFAS, 1997**
	2.600	WHO / FEPA	**Edward *et al.*, 2013**
Pb	2.000	EOSQC FAO	**EOSQC, 1991, 1993 FAO, 1983**
	0.100		
Zn	30.00		
	50.00	EOSQC	**EOSQC, 1991, 1993**

The Centre for Environment, Fisheries and Aquaculture Science limit the cadmium level in fish to 5 µg/g **(CEFAS, 1997)**. The National Health and Medical Research Council National for Food Standard **(NHMRC, 1987)** allows up to 10 µg/g in fish. **Ackacha *et al.* (2010)** used flame atomic absorption spectrometry technique for determination of the concentration of Cd, Co, Cu, Fe and Pb in the tissues of six samples of fishes. They found that the concentrations of Co, Cd and Pb in all examined tissues were more than the reported official values by WHO.

The concentration of Cr in different catfish samples exceeded the approved values by IAEA – 407 (tables 5 and 6) which ranged from 1.15 to 1.57 µg/g, while in tilapia fish 15 samples were little less than the accepted values, which have concentrations ranged from 0.15 to 0.525 µg/g while samples 1, 4, 5, 10, 13, 14, 21, 22, 23 and 25 samples were higher than the allowed limits (table 7) with a concentration range of Cr from 0.77 to 2.25 µg/g in these samples.

The concentrations of Cu in all different muscle of catfish samples are shown in (Table 6). These Cu concentrations ranged from 3.35 µg/g to 7.18 µg/g Cu and were higher than those reported by WHO / FEPA (Table 5) except samples number 8, 16 and 21 which were little lower than the maximum and values. The Egyptian Organization for Standarization and Quality Control pointed that maximum allowed limit for Cu in fish must not exceed 20 µg/g **(Labib *et al*, 2008)**.

Table (6): Monitoring of some metal concentration (µg/g) in Cafish samples collected from Kafr El- Zayat market during fishing season 2015.

Metal / Sample	Cd	Cr	Cu	Mn	Pb	Zn
1	ND	1.45	7.18	3.12	2.75	41.5
2	ND	1.52	3.36	2.25	2	31.4
3	ND	1.55	3.37	2.45	2.5	31.9
4	ND	1.45	3.73	3.2	2.25	45.9
5	ND	1.42	3.165	3	3	30.97
6	ND	1.32	3.69	2.8	2.75	28.2
7	ND	1.6	3.165	2.125	3	39.5
8	ND	1.5	2.905	2.45	2	35.95
9	ND	1.27	3.315	2.9	3	27.125
10	ND	1.25	3.79	1.825	2.5	34.57
11	ND	1.27	6.61	2.2	3.25	31.35
12	ND	1.2	3.55	3.55	3	44.7
13	0.5	1.2	3.12	3.02	2.75	28.05
14	ND	1.45	3.35	5.75	6.75	37.07
15	0.25	1.37	4.60	6.1	2.5	52
16	0.25	1.32	2.96	2.725	2	28.35
17	ND	1.15	4.35	2.825	2.75	24.67
18	0.5	1.57	3.98	4.3	2.5	33
19	0.5	1.2	4.55	3.2	3	26.07
20	ND	1.22	3.06	4.22	2.25	31.57
21	ND	1.2	2.97	3.15	3.75	25.42
22	ND	1.35	3.53	3.2	2.75	25.47

ND: Not detectable

While the concentrations of Cu in tilapia fish ranged from 2.01 to 6.16 µg/g (Table 11). **Hassan and Ahmed (2010)** showed that the concentrations of copper in tilapia fish samples were within the range (2.260–5.425µg/g) with the mean of 3.827 µg/g.

The concentrations of Mn in all catfish muscle samples were higher than the maximum accepted levels with concentrations of Mn ranged from 1.825 to 6.1 µg/g (Tables 5 and 8). The concentrations of Mn in the tilapia fish muscle samples were much higher than the accepted levels having Mn concentrations range of 7.05 - 20.75 µg/g (Tables 5 and 11). The limit of Mn allowed in fish by the Centre for Environment, Fisheries and Aquaculture Science is 2.6 µg/g **(CEFAS, 1997)**. Tilapia fishes from Egyptian markets were found to have Mn concentrations higher than the maximum allowed limits by **Hassan and Ahmed (2010)**.

The concentrations of Pb in the muscles of catfishes were more than the accepted values (Tables 5 and 6). The range of Pb in catfish samples were from 2.25 to 6.75 µg/g except samples 2, 8 and 16 were equal to the accepted value at 2.00 µg/g (Table 5). Also the concentrations of Pb in different muscle tilapia fish samples were higher than the accepted values (Table 7) which concentration ranged from 2.5 to 53 µg/g (Table 11), while values of sample 13, which was 0.52 µg/g, was less than the allowed limits in Table 5. **Hassan and Ahmed (2010)** mentioned an extremely high range of lead concen

Table (7): Concentrations of some metals (µg/g) in tilapia fish samples collected from Kafr El- Zayat district during fishing season 2015.

Metal / Sample	Cd	Cr	Cu	Mn	Pb	Zn
1	ND	1.45	3.93	10.6	3.75	58.8
2	ND	0.5	6.16	12.42	6.25	58.85
3	ND	0.15	3.32	13	2.75	49.05
4	ND	0.725	3.245	18.15	2.5	50.95
5	ND	1.125	3.065	17.32	3.5	57.95
6	ND	0.25	3.657	14.37	3.25	53.87
7	ND	0.525	3.647	13.65	4.5	46.8
8	ND	0.125	3.317	19.2	3	43.75
9	ND	0.175	4.100	6.25	3	49.6
10	2.5	0.775	4.012	20.75	14.75	38.47
11	ND	0.45	4.377	10.025	6.25	51.3
12	1.00	0.125	2.57	12.75	7.25	39.45
13	0.75	0.975	2.88	11.35	0.52	51
14	1.00	2.25	3.85	8.1	13.25	53.17
15	5.5	0.425	2.48	16.85	31.25	123.12
16	4.25	0.225	3.95	10.82	23	57.55
17	2.00	0.375	4.212	9.7	13.25	51.97
18	2.5	0.65	3.257	14	13.5	49.2
19	ND	0.7	5.267	7.05	2.75	76.82
20	2.25	0.3	2.07	14.05	15	53.47
21	ND	0.95	3.127	10.75	6	66.55
22	ND	0.97	2.925	24.4	4.25	48
23	ND	1.00	4.257	9.6	9.75	61.52
24	1.25	0.275	3.537	12.125	10.75	62.123
25	6.75	0.975	4.60	10.95	53	60.4

ND: Not detectable

trations (50.61- 146.0 µg/g) in fishes collected from the Egyptian markets.They attributed it to that fishes at the mar kets were of unknown different sources. At Hussania fish farms the lead concentrations in tilapia fishes were at the levels of 0.1178 to 1.035 µg/g, while at Abbassa fish farms, the lead concentration values were from 0.1009 to 0.4333 µg/g **(El -Makkawi *et al.*, 2007)**.

Finally the concentrations of Zn in all examined samples of the two fish species were higher than the the approved one (Tables 5, 6 and 7) with a range of 24.67 - 52.00 µg/g in catfish samples and 38.47 - 123.12 µg/g in tilapia fish. Tilapia fish samples from Egyptian markets showed normal levels of zinc in comparison with the maximum allowed limits by both the Egyptian and Australian organizations **(Hassan and Ahmed, 2010)**.

3.2. Data Statistical Analysis:

Statistical analysis of the result data (mean, standard deviation, and Shapiro-Wilk, and Tukey Tests, was estimated using **SigmaStat computer software, (2012).**

Table (8): Statistical data of studied metals in Catfish samples (µg/g).

Metals	Cd	Cr	Cu	Pb	Mn	Zn
Mean	0.5000	1.356	3.832	3.198	2.864	33.40
SD	0.000	0.1394	1.109	1.070	0.9689	7.403
Min	0.25	1.15	2.91	2.00	1.83	24.67
Max	0.50	1.60	7.18	6.75	6.10	52.00

Min = Minimum Max = Maximum SD = Standard Deviation

Table (9): Normality Test of Catfish Samples (Shapiro-Wilk) at (P < 0.050)

Metal	Median	25%	75%
Cd	0.000	0.000	0.125
Cr	1.335	1.215	1.463
Cu	3.450	3.154	4.073
Mn	3.010	2.450	3.288
Pb	2.750	2.438	3.000
Zn	31.485	27.819	37.678

The multiple comparisons on ranks do not include an adjustment for ties.

The differences in the median values among the treatment groups are greater than would be expected by chance; hence there is a statistically significant difference at P = <0.00.

Table (10): Catfish Samples Pairwise Multiple Comparison Procedures (Tukey Test)

Comparison	Diff of Ranks	q	P<0.05
Zn vs Cd	2420.000	13.489	Yes
Zn vs Cr	1936.000	10.791	Yes
Zn vs Pb	1215.500	6.775	Yes
Zn vs Mn	1023.500	5.705	Yes
Zn vs Cu	665.000	3.707	No
Cu vs Cd	1755.000	9.782	Yes
Cu vs Cr	1271.000	7.085	Yes
Cu vs Pb	550.500	3.068	No
Cu vs Mn	358.500	1.998	-
Mn vs Cd	1396.500	7.784	Yes
Mn vs Cr	912.500	5.086	Yes
Mn vs Pb	192.000	1.070	-
Pb vs Cd	1204.500	6.714	Yes
Pb vs Cr	720.500	4.016	No
Cr vs Cd	484.000	2.698	No

In cases of "-" sign they should be treated as if there is no significant difference between the rank sums, even though one may appear to exist.

Table (11): Statistical data of studied metals in tilapia fish samples (µg/g).

Metals	Cd	Cr	Cu	Mn	Pb	Zn
Mean	1.19	0.66	3.59	13.13	10.28	56.55
SD	1.96	0.49	0.89	4.34	11.44	16.17
Min	0.75	0.13	2.01	6.25	0.52	38.47
Max	6.75	2.25	6.16	24.40	53.00	123.12

Min = Minimum Max = Maximum SD = Standard Dviation

Table (12): Normality Test (Shapiro-Wilk) at (P < 0.050)

Metal	Median	25%	75%
Cd	0.000	0.000	2.125
Cr	0.525	0.263	0.972
Cu	3.647	3.096	4.156
Mn	12.420	10.313	15.610
Pb	6.250	3.125	13.375
Zn	53.170	49.125	59.625

H = 125.106 with 5 degrees of freedom (P) = <0.001

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference at P = <0.001

Table (13): Tilapia Samples Pairwise Multiple Comparison Procedures (Tukey Test).

Comparison	Diff of Ranks	q	P<0.05
Zn vs Cd	2739.000	12.609	Yes
Zn vs Cr	2729.500	12.565	Yes
Zn vs Cu	1755.000	8.079	Yes
Zn vs Pb	1293.000	5.952	Yes
Zn vs Mn	786.500	3.621	No
Mn vs Cd	1952.500	8.988	Yes
Mn vs Cr	1943.000	8.945	Yes
Mn vs Cu	968.500	4.458	Yes
Mn vs Pb	506.500	2.332	No
Pb vs Cd	1446.000	6.657	Yes
Pb vs Cr	1436.500	6.613	Yes
Pb vs Cu	462.000	2.127	No
Cu vs Cd	984.000	4.530	Yes
Cu vs Cr	974.500	4.486	Yes
Cr vs Cd	9.500	0.0437	No

The multiple comparisons on ranks do not include an adjustment for ties.

All pairs have no significant relationship between the two fish species except that between Cd in them both.

Conclusion:

High accumulation of Cr, Cu, Mn, Pb and Zn were observed in more Catfish sample market Kafr El- Zayet exceeded the permissible limits in more samples except concentrations of Cd were less the permissible limits.

In conclusion, accumulation of Mn and Pb and Zn were higher than the maximum and tolerable limits in tilapia fish

Table (14): Correlations between Metals in Catfish versus Tilapia Fish Samples.

Metal*	Cd	Cr	Cu	Mn	Pb	Zn
Correlation Coefficient	0.5743	0.1245	0.2487	-0.0806	-0.0127	0.3189
P Value	0.0052	0.5810	0.2640	0.7210	0.9550	0.1480

Metal* in catfish versus the same metal in tilapia fish samples

sample of Kafr El – Zayat market . Otherwise, concentration of Cd, Cr and Cu were higher the reported in some samples except in some sample were less than the maximum limits. There is a statistically significant difference between the metals in each of fish species. On the other hand, all pairs of the same metal in the two species have no significant relationship between the two fish species except that between Cd in them both.

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التقدير المقارن لبعض المعادن في نوعين من الأسماك التي تم جمعها من الأسواق في منطقة كفر الزيات، محافظة الغربية ، مصر بواسطة جهاز مطياف الإنبعاث الإشعاعي بواسطة ميكروويف البلازما

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الملخص العربى:

تم قياس بعض المعادن (الكادميوم ، الكروم ، النحاس ، المنجنيز، الرصاص ، الخارصين) بشكل موسمي في أنسجة أسماك القرموط وأسماك البلطي من الأسواق في منطقة كفر الزيات عن طريق التحليل الطيفي للانبعاث الذري بالميكروويف (MP-AES) ، تم هضم عينات الأسماك أولاً عن طريق نظام الهضم بالميكروويف. كانت تركيزات الكادميوم في جميع عينات أسماك القرموط التي تم اختبارها أقل من الحدود المسموح بها، وكان تركيز الكادميوم و الكروم في جميع أنسجة أسماك البلطي التى تم فحصها أقل من القيم المسموح بها. كانت تركيزات النحاس في عينات أسملك القرموط التى تم فحصها ضمن الحدود المسموح بها ، في حين أن تركيز المعدن في أسماك البلطي أعلى من النسب المسموح بها، ومع ذلك كانت تركيزات الرصاص في غالبية عينات أسملك القرموط أعلى من الحدود المسموح بها ،بينما كانت تركيزات الخارصين ، كانت تركيزات الخارصين و الرصاص و المنجنيز في جميع العينات التي تم فحصها من النوعين من الأسماك أكثر من المراجع المذكورة بالبحث . يوجد فروق ذات دلالة إحصائية بين المعادن في كل نوع من أنواع الأسماك. من ناحية أخرى ، كل الأزواج من نفس المعدن في النوعين لم يكن لها دلالات إحصائية ما عدا تركيزات الكاادميوم فى كل من النوعين.