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EFFECT OF HEAVY METALS ON SOME PHYSIOLOGICAL RESPONSES IN TWO FISH SPECIES INHABITING MEDITERRANEAN SEA COAST; DAMIETTA GOVERNORATE, EGYPT.

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ABSTRACT

T*he present study aims to determine the concentrations of heavy metals: Cadmium, Copper, Iron, Nickel, Lead and Zinc in the two fish species, Sparus aurata and Diplodus sargus, (family: Sparidae) collected from the Mediterranean Sea Coast, Damietta Governorate, in order to: compare concentrations of metals in the different organs (gonads, kidney, liver, muscles, gills, skin and bones) and their effects on the physiological parameters (total proteins, total lipids, ASAT and ALAT) in the edible organs of these species.*

Results revealed that, the highest values of heavy metals in the different organs of S. aurata and D. sargus were recorded during summer. Although, the two species have the same behavior of feeding, S. aurata showed high values of the different metals than D. sargus. Biochemical analysis indicated devastating effects in metabolic parameters and enzymes activities in S. aurata than D. sargus. ANOVA (p> 0.05) showed significant differences between the different organs and metals. Also, biochemical parameters exhibited a significant increase between seasons and the different organs and a slight difference between the studied fishes.

Key words: Heavy metals, biochemical parameters, Sparus aurata and Diplodus sargus.

INTRODUCTION

The contamination of aquatic systems with a wide range of pollutants has become a matter of concern since the last few decades (Canli *et al*., 1998; Dirilgen, 2001; Vutukuru, 2005; Amaraneni, 2006; Rao and Rao, 2007; Vinodhini &Narayanan, 2008 and Gupta *et al*., 2009). The natural water bodies may extensively be contaminated with various heavy metals released from industrial and mining effluents, combustion of fossil fuels, discharge of sewage and sewage sludge; fertilizers and residues of domestic & pesticides, dumping of hospital and anthropogenic activities, etc. (Forstner and Wittmann 1979; Conacher *et al*., 1993; Velez and Montora, 1998; Chandra-Sekhar *et al*., 2004; Vinodhini & Narayanan, 2008; Malik *et al.,* 2010 and Laxmi-Priya *et al*., 2011). Heavy metal contamination may cause devastating effects on the ecological balance of the recipient environment and its diversity of aquatic organisms (Ashraj, 2005; Vosyliene & Jankaite, 2006; Farombi *et al*., 2007 and Vinodhini & Narayanan, 2008).

Traces of heavy metals, such as Copper and Zinc play a biochemical role in the life processes of some aquatic plants and animals while it become toxic when it is present at high concentrations (Kotickhoff, 1983). Fish are often the top of aquatic food chain and is an important source of protein for human which may absorb large amounts of some metals such as Cadmium, Copper, Iron, Nickel, Lead and Zinc through epithelial or mucosal surface of the skin, gills and gastrointestinal tract. These metals accumulate differently in the fish organs (liver, kidney, muscles, gonads and brain) and caused health problems for fish consumers (Wallaert and Bobin, 1994). Low concentrations of heavy metals may not kill individuals of the fish affect on their size, reproduction and body weights, thus reducing their ability to compete for food and habitat which affect directly on the metabolic and enzymes activities correlated with changes in the rate of protein synthesis (Gomaa *et al*., 1995a&b; Fayed *et al*., 2001; Vosyliene & Jankaite, 2006; Badmus *et al*., 2007and Jovanovic *et al*., 2011).

Some heavy metals are the most uncertain environmental pollutants such as Cadmium which is toxic for living organisms. It is mostly used in manufacturing of batteries, pigments and also in plastic industries (ATSDR, 1997), thus its toxicity at low level causes poisoning in various tissues which induce kidney, liver, gills and heart malfunctioning. Heavy metals have badly influence on blood parameters in living organism and lead to hematological disorders and cause oxida-

tive stress and may due to devastating effects on cell components (McCluggage, 1991; European Union, 2002; Jarup, 2003; Yadav & Khandelwal, 2005; Young, 2005 and Yapici *et al*., 2006). The trace metals are uptake more rapidly at high temperature by marine organisms (Raymont and Shields, 1994).

Muscles is one of the most organs which are varied in composition according to the species, sex and maturity as well as seasons (Rubbi *et al*., 1985). Biochemical and physiological biomarkers are frequently used for detecting or diagnosing the harmful effects in fish exposed to different toxic substances. Transaminase enzymes play a vital role in carbohydrate and protein metabolism in fish and other organism's tissues (Eze, 1983). Changes in enzymes activity and other biomarkers have been studied as possible tools for aquatic toxicological research (Moore and Simpson 1992; Arellano *et al*, 2000 and Abou El-Naga *et al*., 2001). Therefore, in the present study attempts have been made to assess the heavy metals concentrations in the fishes caughted from Damietta Coast and their effects on biochemical parameters in the different organs of the two important commercial species.

MATERIALS AND METHODS

• *Specimens collection:*

A total of 42 specimens of sparid fishes, *Sparus aurata* and *Diplodus sargus* were collected during winter and summer, 2014 for the present study. Gill net and encircling net were the main fishing methods used to collect the fish samples. After collection however possible, fishes were freshly examined or immediately preserved in an ice box and transferred to the laboratory for latter examination. In the laboratory, standard and total length of each fish were measured to the nearest centimeter and recorded, while the body weight was determined to the nearest gram. Then, each fish was dissected and the internal organs and muscles were separated and treated as the following:

• *Heavy metals determination in the tissues:*

Equal amounts (15 ml) of concentrated nitric acid, hydrofluoric acid and perchloric acid were added to 0.5 gm of each tissue into Teflon beaker. The latter was covered, set aside for several hours, and evaporated to a few drops. 5 ml of HCIO4 were added again and evaporated just to dryness. After addition of 10 ml of concentrated HCl, beaker was placed back on a hot plate until the solution becomes clear. Deionized distilled water was added and the digested material was filtered, then residue washed several times with deionized distilled water and complete to 100 ml volumetric flask.

Heavy metals were analyzed by atomic absorption model Perkin Elmer 3150. Concentrations were expressed into µg / gm tissue according to APHA (1992).

• Physiological studies:

After the dissection of the collected fishes, a known weight of the target organs (liver, kidney, gonads and muscles) was homogenized by using the electric homogenizer for 2 min. The homogenated specimens were centrifuged at 4000 r.p.m. for 15 min. at 2 C^o in a refrigerator centrifuge. The supernatant solution was used directly or stored at 4 C^o until the use for the biochemical analysis.

Total protein content of the different organs was determined according to Doumas Method (1975), while total lipids was detected according to the method of Knight *et al.*, (1972) by using a kit of Bioadwic Company. Enzymes activities were measured according to the method of Reitman and Frankel (1957) by using a kit of Bioadwic Company.

• *Statistical analysis:*

Results were expressed in tables as mean ±S.D. Data were analyzed by using analysis of variance (ANOVA) according to Bailey (1981).

RESULTS AND DISCUSSION

§ Heavy metals determinations:

The present study attempts to create awareness concerning the potential severe public health issues resulting from the toxic effects of heavy metals as pollutants from different sources. The toxic effects of heavy metals on fish involve hepatotoxicity, neurotoxicity and nephrotoxicity (Valko *et al*., 2005). Bioaccumulation of heavy metals and consequent alterations in gills, liver, kidney and flesh of the two species were examined. Results (Tables 1&2 and Figures 1&2) indicated that, the highest values of heavy metals (Cadmium, Copper, Iron, Nickel, Lead and Zinc)

in the **gonads** of *S. aurata* and *D. sargus* were observed during summer than the winter with maximal values (34.55±6.20 and 20.13 ±8.14 µg/g wet wt, respectively) for Iron concentration while the minimal values (1.65±0.43 and 1.11± 0.30 µg/g wet wt, respectively) were detected for Cadmium concentration.

Kidney is one of the most important metabolic organs which can accumulate large quantities of metals than the other organs. **Kidneys** of the two species showed the same trend with high peak for Iron level in *S. aurata* followed by Zinc ions during summer and winter, respectively; being 145.00±7.10 and 130.03±4.60 µg/g wet wt in the former and 60.23±4.11 & 56.08±3.50 µg/g wet wt, respectively in the latter. It showed a depletion concentration (1.00±0.07 µg/g wet wt) during winter in Copper ion than the other metals. Kidney of *D. sargus*, showed the highest values of Iron ion concentration followed by Zinc ion during summer and winter, respectively; being 122.50 ± 8.90 and 114.10 ±6.71 µg/g wet wt in the former and 57.22 ±8.50 & 50.60 ±6.50 µg/g wet wt, respectively in the latter. The highest value copper ion concentration (0.50 ±0.11µg/g wet wt) was recorded during winter (Tables 1&2 and Figures 3&4).

Liver plays an important role in the detoxification and toxicants storage, and this explains the high levels of heavy metals in this organ. Although, the two species in the present study have the same feeding behavior, *S. aurata* showed high values of the different metals than *D. sargus*. Results (Tables 1&2 and Figures 5&6) exhibited that, the maximum values of the heavy metals in **livers** of *S. aurata* and *D. sargus* were recorded for Iron ion during summer; being 103.00 ± 14.30 and 94.15 ±9.20 µg/g wet wt, respectively, while the lowest values (1.60±0.20 and 0.70± 0.21 µg/g wet wt) were measured during winter, respectively, in the two species for cadmium concentration.

Muscle compositions are varied according to the species, sex and maturity as well as seasons (Rubbi *et al*., 1985). Data in Tables (1&2) and Figures (7&8) revealed that, heavy metals concentration in the **muscles** of *S. aurata* were fluctuated between 1.75± 0.63 µg/g wet wt for Copper ions during winter and 44.09± 0.12 µg/g wet wt for Iron ions during summer. On the other hand, determination of heavy metals in the muscles of *D. sargus* exhibited that, they were varied from 0.50 ±0.12 µg/g wet wt for Copper ion and 0.50 ±0.11 µg/g wet wt for Lead ion concentrations during winter to 28.40 ±6.44 µg/g wet wt for Iron ion during summer.

It is well known that, heavy metals are taken up by the fish directly from the water, especially by gills (Skidmore, 1964). The present study (Tables 1&2 and Figures 9 &10) indicated that, **gills** are the more organs affected by contaminants. The highest peak of heavy metals in the gills of *S. aurata* was recorded during summer for Iron ion concentrations and the depletion was observed during winter in the Copper ions; being 119.03± 6.14 and 1.65 ±0.22 µg/g wet wt, respectively. Regarding gills of *D. sargus*, it exhibited the highest value (64.88 ±6.25 µg/g wet wt) during summer for iron ion and the lowest (1.10 ±0.10 µg/g wet wt) during winter for copper ion concentration. Concentrations of heavy metals in the skin of *S. aurata* and *D. sargus* during summer showed a slight high values than the winter. Results indicated that, the concentration of iron ions during summer in the **skin** of the two species was the higher compared with other metals and the lower values were observed during winter for the copper; being 94.12± 6.25 & 43.56 ±7.14 µg/g wet wt, respectively in the former and 1.80± 0.30 & 0.50 ±0.13 µg/g wet wt, respectively in the latter (Tables 1&2 and Figures 11&12).

On contrast to all results of iron concentration in the previous organs, a sharp decline in Iron levels was detected in bone of *S. aurata* during both summer and winter. Results declared that, heavy metals concentrations in the **bones** of *S. aurata*, was ranged between 1.65± 0.21 µg/g wet wt during winter for Copper ions and 28.14±6.81 µg/g wet wt during summer for Zinc ions. In *D. sargus*, however, the maximum value of heavy metals concentration in the bones was recorded during summer for Iron ion and the minimum value was observed during winter for the Copper; being 33.10 ±6.16 in the former and 1.50 ±0.34 µg/g wet wt in the latter (Tables 1&2 and Figures 13&14).

Although some heavy metals are essential

elements at low concentrations for many organisms; it becomes toxic at the higher concentrations (Clark and Keasling, 2002 and Faria *et al*. 2010). From the above findings, it can be concluded an increasing of heavy metals in the different organs of *S. aurata* than that in *D. sargus*. Iron ion concentration exhibited a high level in all organs along the study period except the bone of *S. aurata* showed a higher level of Zinc during the two seasons; this may be due to the increase of heavy metals in the drainage waters, decomposition of organic matter and discharge remnants of fertilizer factories and other chemicals lead to this fact, the uptake of metals is influenced by many factors including fish species, age, type of fish organs, season and various environmental factors. This findings agree with Badsha & Goldspink (1982&1988); Gomaa *et al*. (1995a&b); Nagdi & Shaker (1998); Ptashynski & Klaverkamp (2002); El-Serafy *et al*. (2003a) and Ghanem (2006&2011) whom attributed the increase of metals during hot seasons to the effect of temperature and winds on the solubility and distribution of these metals and differ with Yacoub and Gad (2012) whom reported that, cold season exhibited the high level of these metals than the hot one. Also, Said & El-Agroudy (2003) and El-Serafy *et al*. (2003b) mentioned that, no marked seasonal variations in the concentration of metals in *Patella Caerulea* lived in polluted area of Alexandria Coast were detected.

Results indicated that, the heavy metals accumulate mainly in the gills and metabolic organs such as liver that stores metals to be detoxificated as its main function by production metallothionein. Similar observations were in agreement with Kargin & Erdem (1991); Zyadah (1995); Ahmed & Al-Ghais (1996); Adeyeye *et al*.(1996); Shakweer & Abbas (1997); Ibrahim *et al*. (1999 a&b); Ghanem (2006&2011) and Jovanovic *et al*. (2011) whom reported that, the differences of heavy metals concentrations in the fish organ were related to their tendency of absorption and accumulation of heavy metals through epithelial, mucosal surface, gastrointestinal tract, metabolic organs with relation to their mode of living and feeding behaviour.

In the present study, the concentrations of heavy metals were increased during summer than winter; this may be attributed to the low water level and the inefficient removal of trace metals by organisms or to the low degree of nutrient recycling and to the discharge of sewage, industrial wastes and paints into this location. This finding are agree with UNEP (1993) and Abdel-Monem *et al*. (1994) whom stated that, the concentration of heavy metals may be associated with high trophic level predators, filter and bottom feeder with increased consumption of particulate matter along with absorbed metals.

The present results showed high concentration in some heavy metals than the other indicated to the lower values of one metal accompanied by high concentration of other in the same season, this may be due to the fact that, the presence of one metal deletes or reduce the accumulation of another metal. Similar observation was detected by El-Sharnouby *et al*. (1986); Cossa *et al*. (1992) and Ghanem (2006&2011).

§ Biochemical parameters:

The present study (Table 3 and Figures 15&16) revealed that, total proteins in the different organs of *S. aurata*, attained its highest value (208.46±15.90 mg/g wet wt) in the muscles during winter. It decreased gradually in the gonads and kidney during winter (124.76±22.50 and 112.16±7.80 mg/g wet wt, respectively) and reached its lowest value (96.17±12.40 mg/g wet wt) in the liver during summer. Concerning *D. sargus*, it was varied from 100.64±6.55 mg/g wet wt in the kidney during summer to 204.33 ±10.56 mg/g wet wt in the muscles during winter.

The lowered levels of protein in the fish organs during summer may be due to metabolic adaptation to food shortage in the environment. This finding was agreed with White *et al*. (1986) and Haggag *et al*. (1999) whom stated that, during the period of inadequate food supply, energy required for metabolic maintenance may be provided from utilization of protein reserves which mainly accumulate in the muscle and metabolic tissues. In addition, protein depletion could be attributed to change in the water quality as a result of the discharged effluents from different sources (Zaghloul, 2000). This may be explained that the exposure to metals may lead to high accumulation in gills that cause a structural damage and a reduction in oxygen consumption

causing sharp reduction in the metabolic rate of fish and consequently decrease protein contents in tissues.

Total lipids in the different organs of *D. sargus* are slightly increased during the study period than *S. aurata*, with increasing during winter compared with summer. Data in Table (3) and Figures (17&18) mentioned that, the maximum values of total lipids for the samples of *S. aurata* were recorded during winter in the muscles and liver (30.46±4.36 and 28.60±4.54 mg/g wet wt, respectively) while the minimum values were determined during summer in the gonads and kidneys; being 14.79±7.90 mg/g wet wt in the former and 16.88±2.49 mg/g wet wt in the latter. At *D. sargus*, however, it was varied from 18.20 ±7.30 mg/g wet wt during summer in the gonads to 34.66 ±2.40 mg/g wet wt during winter in the muscles. The depletion in total lipids in the different organs during summer than the winter may be due to the use of energy-rich lipids for energy production during toxic stress. Similar observations were recorded by Sancho *et al*. (1998); Chandra *et al*. (2004) and Blaner *et al*. (2005).

Aspartate aminotransferase (ASAT) in the two species, *S. aurata* and *D. sargus* exhibited the highest values during summer in the liver and gonads; being 530.22±4.76 & 480.26±8.46 U/g wet wt, respectively in the first species and 476.36±7.46 & 425.32±10.88 U/g wet wt, respectively in the second one. While, the lowest values of ASAT were detected in the muscles of two species, *S. aurata* and *D. sargus* during winter; being 306.17±27.56 U/g wet wt and 248.58±18.33 U/g wet wt) (Table, 3 and Figures 19&20). Alanine aminotransferase (ALAT) in the collected fishes, *S. aurata* and *D. sargus* exhibited the higher levels during summer in the liver and gonads (338.40±16.72 & 364.20±15.63 U/g wet wt, respectively in the first species and 325.61±5.63 & 342.62±26.10 U/g wet wt, respectively in the second one). While, the lowest values of ALAT (218.53±17.82 and 207.17±14.76U/g wet wt) were measured during winter, respectively in the muscles of two species (Table, 3 and Figures 21&22).

The present study revealed that, ASAT and ALAT activities in all examined organs are relatively increased during summer. This finding agree with those observed by Cullen *et al*. (2003) whom reported that, enzyme activity appeared to increases during the summer season. The present study showed an increase in ASAT and ALAT activities in the liver, kidney and gonads of the two species examined. Such elevation might reflect the early toxic effects of heavy metals on the hepatic enzyme activities. Similar observations have been reported by many authors notably Oluah (1998); Oluah (1999); Zikic *et al*. (2001); Rao (2006) and Ghanem (2006&2011) and differ with Shakoori *et al*. (1990); Begum & Vijayaragharan (1995); Abu El-Ella (1996); Zaghloul (1997); Salah El-Deen *et al*. (2000) and Shalaby (2000) whom declared that, the decrease of ASAT and ALAT in the liver and muscles may be attributed to a number of reasons such as leakage from liver and muscles into the blood, actual liver and muscles enzymes inhibition by the effect of toxicant, disturbance in Kreb's cycle and damage of liver and kidney cells (necrosis) that affect the membrane permeability which in turn liberate the enzymes to extra-cellular fluid and blood. On the other hand, the opposite effects on hepatic ASAT and ALAT activities might be due to the liver necrosis induced by toxicants.

Concerning the effect of different pollutants on physiological parameters of the studied fish, results showed significant differences between the different organs and metals. Also, biochemical parameters exhibited a significant increase between seasons and the different organs. A slight difference between the two studied species was also recorded.

- Results recommended that, treatment of drainage industrial wastes water, sewage and other sources of metals must be conducted before discharge into the study area. The advisable for public health that human must be use only muscles of fish for food and that the internal organs must not be used as fish meal for other purposes. Also, it is advisable for public health that human must eat the fish during winter and avoid eating them at the summer which contains high concentrations of heavy metals. This is may be due to that the fish can regulate its biochemical properties at the less polluted seasons. Making a research lab with latest scientific techniques to monitor any defect in the physiology of the fish, which in turn affects human health.

Table (1): Bioaccumulation of heavy metals (µg/g wet wt.) in the different organs of *Sparus aurata,* collected from the Mediterranean Sea Coast; Damietta Governorate, Egypt.

Organs	Gonads		Kidney		Liver		Muscles		Gills		Skin		Bone	
Metals	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Cd	1.65 ±0.43	2.10 ± 0.14	3.64 ±0.17	4.40 ± 0.62	1.60 ±0.20	2.11 ± 0.15	3.05 ± 0.17	4.60 ± 1.00	2.25 ± 0.70	3.50 ± 0.19	1.85 ± 0.18	2.40 ± 0.15	4.05 ± 1.11	7.30 ± 2.41
Cu	1.70 ±0.50	1.94 ± 0.13	1.00 ±0.07	1.40 ± 0.11	7.72 ± 0.13	10.74 ± 0.80	1.75 ± 0.63	2.09 ± 0.11	1.65 ±0.22	3.00 ± 0.82	1.80 ± 0.30	2.64 ± 1.20	1.65 ± 0.21	1.98 ± 0.34
Fe	23.00 ±2.40	34.55 ± 6.20	130.03 ±4.60	145.00 ± 7.10	98.11 ± 1.50	103.00 ± 14.30	35.10 ± .14	44.09 ± 0.12	102.70 ±6.80	119.03 ± 6.14	86.21 ± 4.75	94.12 ± 6.25	3.50 ± 1.08	4.78 ± 0.54
Ni	1.74 ±0.20	2.01 ± 0.16	4.18 ± 0.66	5.40 ±0.43	1.90 ± 0.09	2.30 ± 0.46	3.05 ± 0.62	4.90 ± 0.19	4.50 ±1.01	6.38 ± 1.40	7.80 ± 0.47	8.71 ± 0.56	8.60 ± 0.79	11.50 ± 2.14
Pb	1.75 ±0.30	1.97 ± 0.15	4.40 ± 0.18	5.18 ±0.61	1.96 ±0.17	2.64 ± 0.15	4.85 ±0.45	6.00 ± 0.20	7.80 ± 1.20	9.15 ± 1.34	3.80 ± 1.01	5.14 ± 1.20	6.60 ± 1.18	7.83 ± 1.35
Zn	18.75 ±1.40	26.00 ± 3.40	56.08 ± 3.50	60.23 ± 4.11	24.00 ± 1.16	27.00 ± 1.99	14.85 ± 1.83	17.66 ± 0.88	27.60 ± 3.40	36.10 ± 5.16	17.85 ± 2.30	23.43 ± 7.36	24.30 ± 3.16	28.14 ± 6.81

Table (2): Bioaccumulation of heavy metals (µg/g wet wt.) in the different organs of *Diplodus sargus*, collected from the Mediterranean Sea Coast; Damietta Governorate, Egypt.

Organs	Gonads		Kidney		Liver		Muscles		Gills		Skin		Bone	
Metals	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Cd	1.11 ± 0.30	1.24 ±0.15	2.25 ±0.32	3.50 ±1.04	0.70 ± 0.21	0.94 ±0.12	1.40 ±0.32	1.75 ±0.37	2.15 ±0.13	2.55 ±0.62	1.55 ±0.43	1.67 ±0.68	2.95 ±0.33	3.26 ±0.17
Cu	1.30 ± 0.82	1.48 ±0.40	0.50 ±0.11	0.84 ±0.08	5.25 ±1.14	7.30 ±1.64	0.50 ±0.12	0.68 ±0.08	1.10 ±0.10	1.34 ±0.23	0.50 ±0.13	0.86 ±0.15	1.50 ±0.34	1.58 ±0.42
Fe	19.00 ± 3.40	20.13 ±8.14	114.10 ±6.71	122.50 ±8.90	89.25 ±6.30	94.15 ±9.20	23.05 ±2.35	28.40 ±6.44	48.15 ±4.85	64.88 ±6.25	20.75 ±2.16	43.56 ±7.14	28.10 ±2.98	33.10 ±6.16
Ni	1.40 ±0.32	1.56 ±0.28	2.50 ±0.46	3.60 ±0.28	1.50 ±0.34	1.82 ±0.50	1.80 ±0.46	2.40 ±0.53	4.00 ±1.00	4.36 ±0.28	3.50 ±1.16	4.96 ±0.48	4.75 ±1.72	6.40 ±1.36
Pb	1.34 ±0.36	1.30 ±0.40	2.30 ±0.35	3.28 ±1.17	1.50 ±0.17	1.83 ±0.18	0.50 ±0.11	1.94 ±0.15	6.80 ±1.24	7.30 ±1.12	3.55 ±1.04	3.60 ±0.48	4.85 ±0.30	5.20 ±0.87
Zn	12.16 ±1.30	14.20 ±2.70	50.60 ±6.50	57.22 ±8.50	19.50 ±3.60	23.40 ±5.62	4.30 ±1.22	6.86 ±2.40	23.00 ±3.20	26.40 ±6.42	9.55 ±1.90	14.80 ±4.16	18.95 ±3.66	21.63 ±3.62

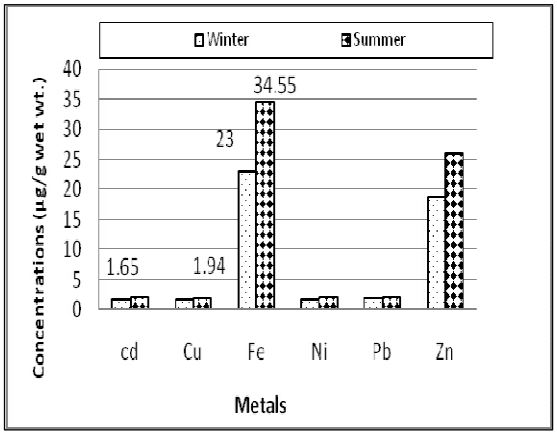

Fig. (1): Concentration of heavy metals (µg/g wet wt) in the gonads of *Sparus aurata*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

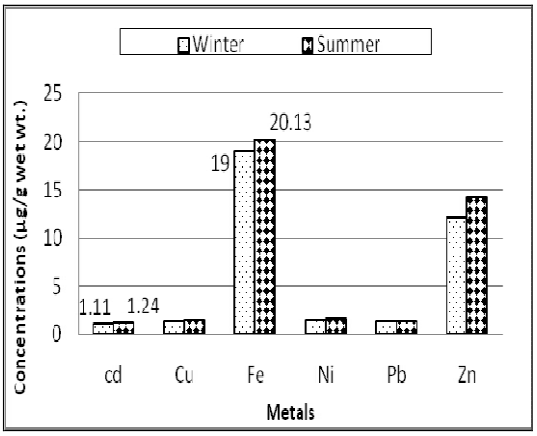

Fig. (2): Concentration of heavy metals (µg/g wet wt) in the gonads of *Diplodus sargus*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

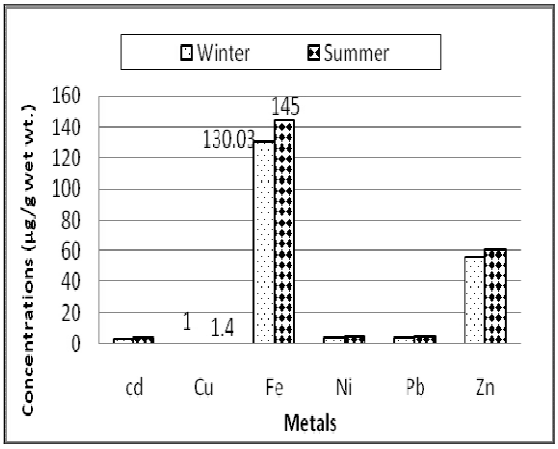

Fig. (3): Concentration of heavy metals (µg/g wet wt) in the kidney of *Sparus aurata*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

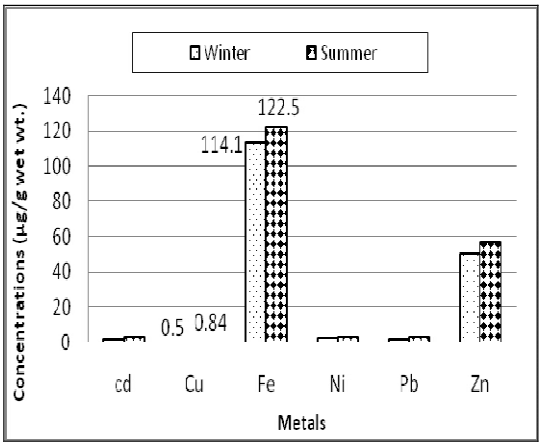

Fig. (4): Concentration of heavy metals (µg/g wet wt) in the kidney of *Diplodus sargus*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

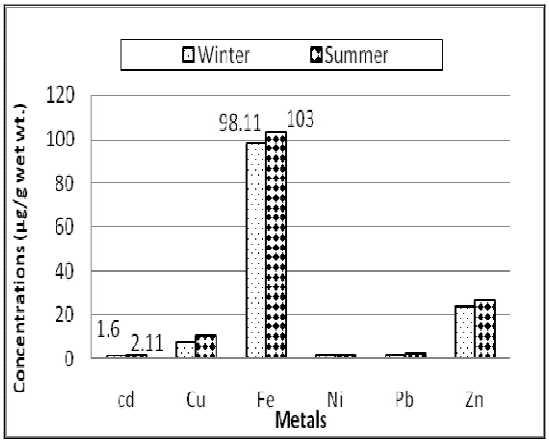

Fig. (5): Concentration of heavy metals (µg/g wet wt) in the liver of *Sparus aurata*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

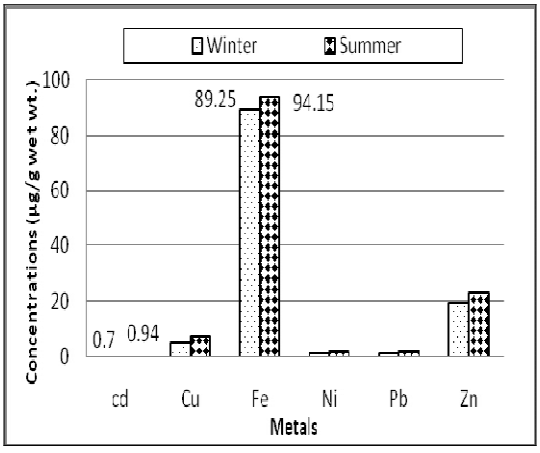

Fig. (6): Concentration of heavy metals (µg/g wet wt) in the liver of *Diplodus sargus*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

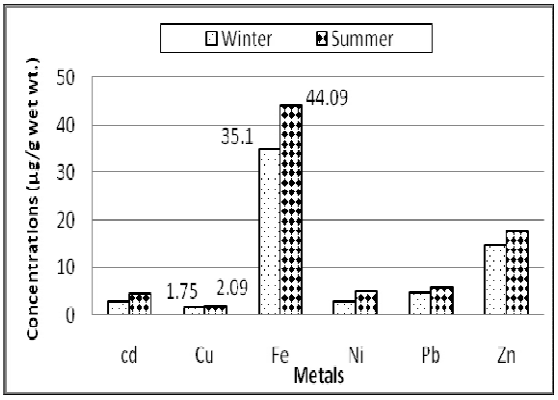

Fig. (7): Concentration of heavy metals (µg/g wet wt) in the muscles of *Sparus aurata*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

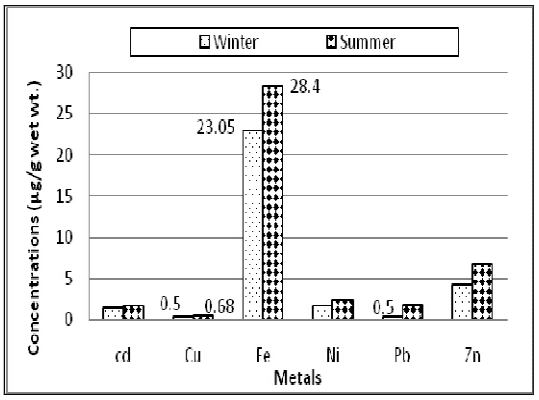

Fig. (8): Concentration of heavy metals (µg/g wet wt) in the muscles of *Diplodus sargus*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

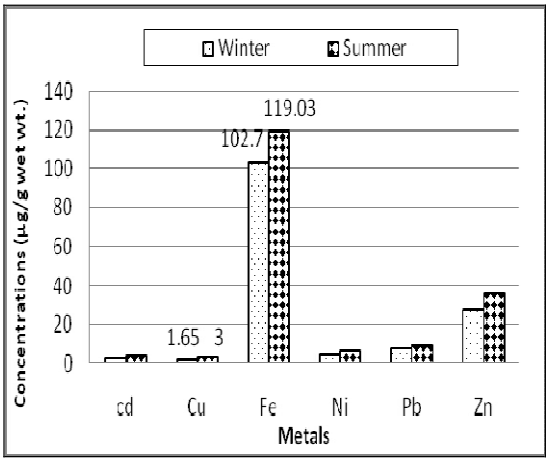

Fig. (9): Concentration of heavy metals (µg/g wet wt) in the gills of *Sparus aurata*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

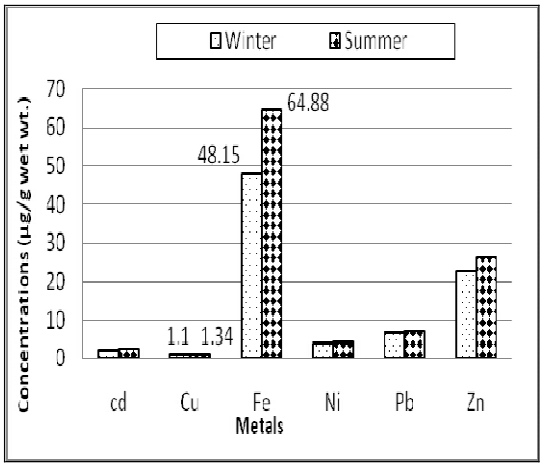

Fig. (10): Concentration of heavy metals (µg/g wet wt) in the gills of *Diplodus sargus*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

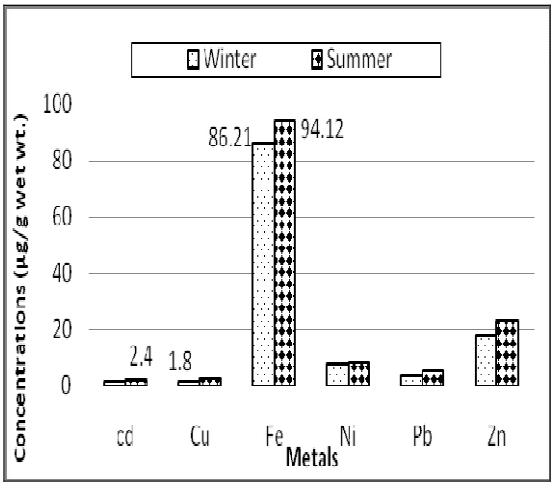

Fig. (11): Concentration of heavy metals (µg/g wet wt) in the skin of *Sparus aurata*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

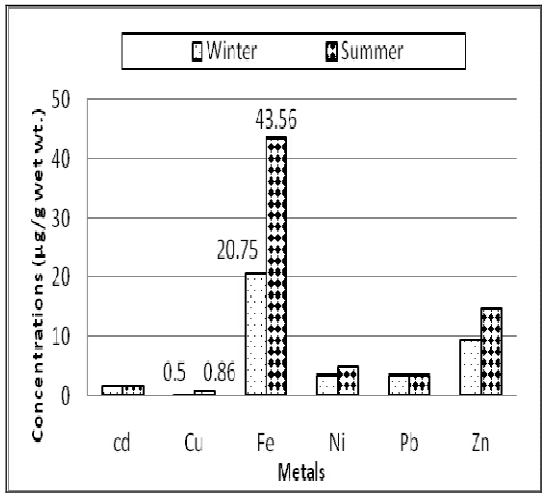

Fig. (12): Concentration of heavy metals (µg/g wet wt) in the skin of *Diplodus sargus*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

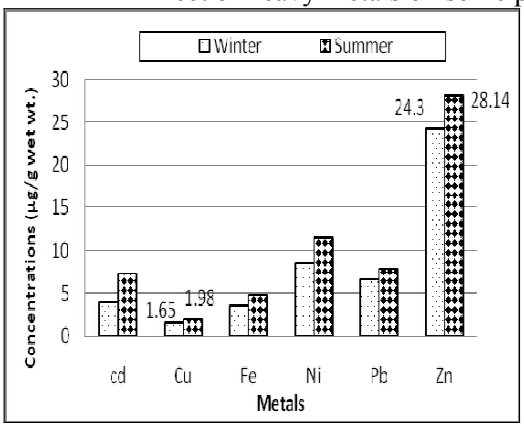

Fig. (13): Concentration of heavy metals (µg/g wet wt) in the bones of *Sparus aurata*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

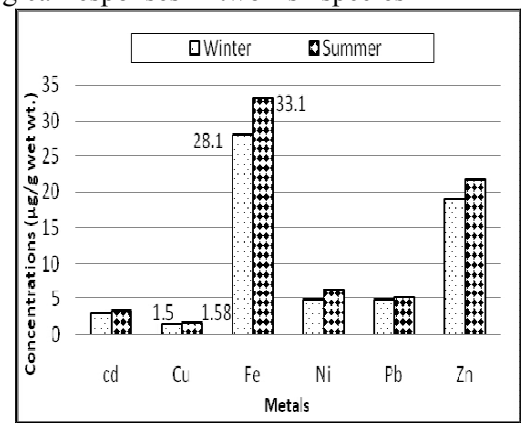

Fig. (14): Concentration of heavy metals (µg/g wet wt) in the bones of *Diplodus sargus*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

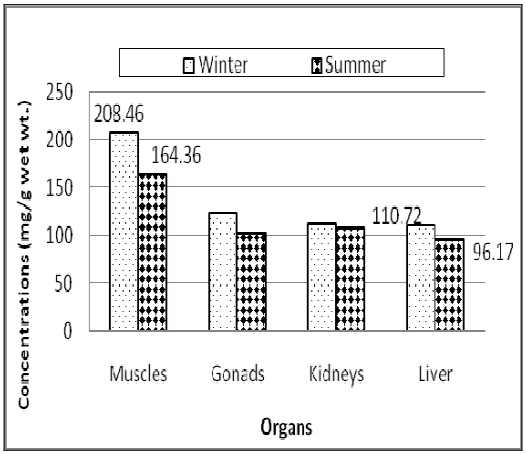

Fig. (15): Changes in total proteins (mg/g wet wt) in the different organs of *Sparus aurata*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

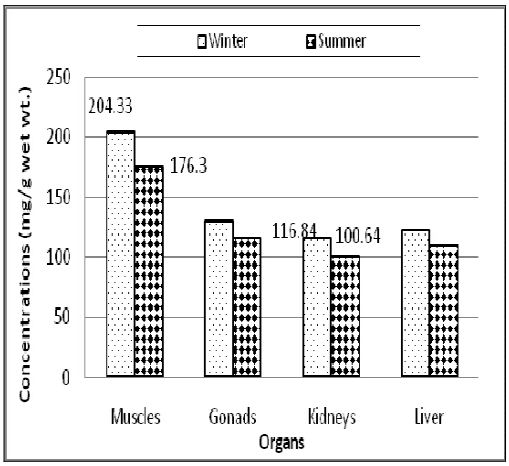

Fig. (16): Changes in total proteins (mg/g wet wt) in the different organs of *Diplodus sargus*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

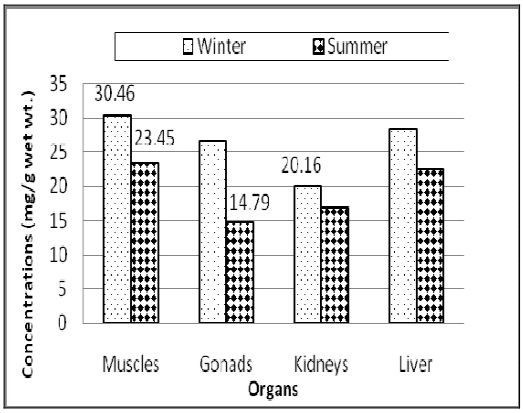

Fig. (17): Changes in total lipids (mg/g wet wt) in the different organs of *Sparus aurata*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

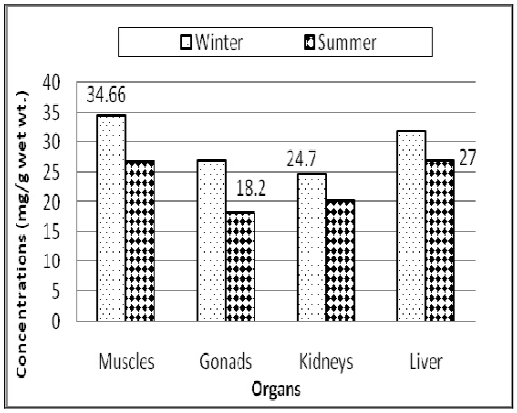

Fig. (18): Changes in total lipids (mg/g wet wt) in the different organs *of Diplodus sargus*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

Table (3): Biochemical analysis in the different organs of *Sparus aurata* and *Diplodus sargus* collected from the Mediterranean Sea Coast; Damietta Governorate, Egypt.

Parameters	Organs	Muscles		Gonads		Kidney		Liver	
		Winter	Summer	Winter	**Summer**	Winter	**Summer**	Winter	Summer
Total protein (mg/g wet wt.)	*Sparus aurata*	208.46 ±15.90	164.36 ±8.40	124.76 ±22.50	102.40 ±13.42	112.16 ±7.80	108.30 ±8.60	110.72 ±9.50	96.17 ±12.40
	Diplodus sargus	204.33 ±10.56	176.30 ±17.46	130.42 ±9.96	116.88 ±12.50	116.84 ±18.20	100.64 ±6.55	122.60 ±5.30	109.70 ±4.46
Total lipids (mg/g wet wt.)	*Sparus aurata*	30.46 ±4.36	23.45 ±6.40	26.70 ±9.47	14.79 ±7.90	20.16 ±6.20	16.88 ±2.49	28.60 ±4.54	22.63 ±4.76
	Diplodus sargus	34.66 ±2.40	26.75 ±7.30	26.90 ±7.94	18.20 ±7.30	24.70 ±4.72	20.33 ±1.62	31.76 ±7.13	27.00 ±7.45
ASAT (U/g wet wt.)	*Sparus aurata*	306.17 ±27.56	336.76 ±20.17	340.68 ±12.88	480.26 ±8.46	312.50 ±13.67	460.44 ±9.76	320.60 ±16.50	530.22 ±4.76
	Diplodus sargus	248.58 ±18.33	302.77 ±24.00	312.58 ±17.89	425.32 ±10.88	298.34 ±20.56	348.30 ±8.70	304.60 ±14.36	476.36 ±7.46
ALAT (U/g wet wt.)	*Sparus aurata*	218.53 ±17.82	267.74 ±22.41	330.12 ±24.70	364.20 ±15.63	324.32 ±14.46	318.47 ±14.78	300.78 ±40.56	338.40 ±16.72
	Diplodus sargus	207.17 ±14.76	235.36 ±23.44	305.72 ±19.30	342.62 ±26.10	308.40 ±32.60	312.77 ±13.47	304.60 ±20.46	325.61 ±5.63

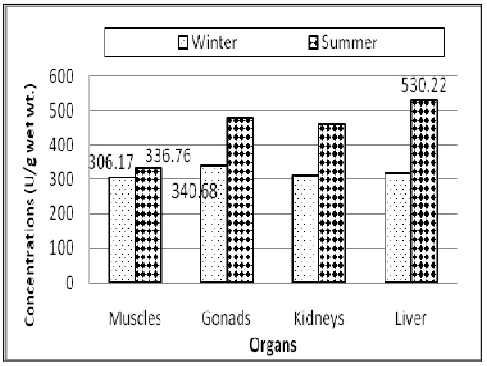

Fig. (19): Changes in ASAT (U/g wet wt) in the different organs of *Sparus aurata*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

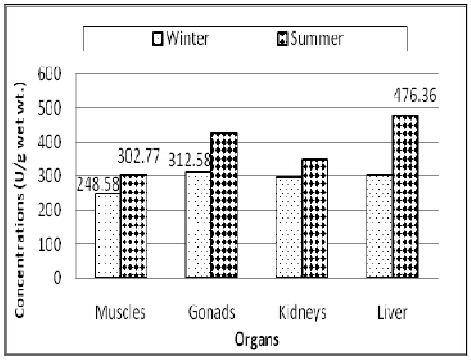

Fig. (20): Changes in ASAT (U/g wet wt) in the different organs of *Diplodus sargus*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

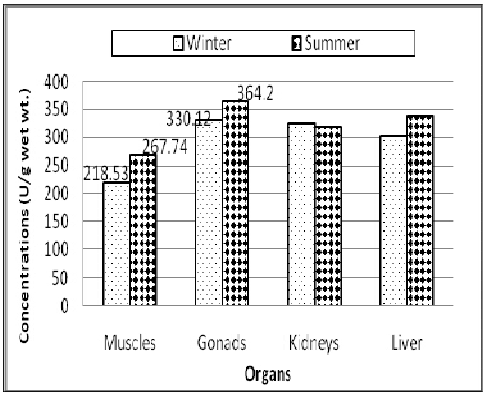

Fig. (21): Changes in ALAT (U/g wet wt) in the different organs of *Sparus aurata*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

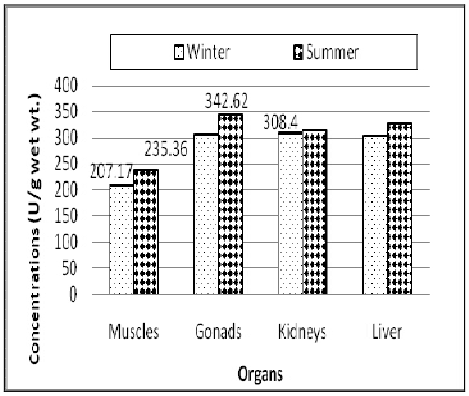

Fig. (22): Changes in ALAT (U/g wet wt) in the different organs of *Diplodus sargus*, collected from Mediterranean Sea Coast, Damietta Governorate, during winter and summer, 2014.

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الملخص العربى:

تهدف هذه الدراسة إلى تقدير تركيزات المعادن الثقيلة لكل من الكادميوم، النحاس، الحديد، النيكل، الرصاص والزنك في سمكتى الدنيس والشرغوش المجمعتين من ساحل البحر الأبيض المتوسط (محافظة دمياط) وذلك لمقارنة تركيزات تلك المعادن في أجهزة هذين النوعين ممثلة فى المناسل، الكلى، الكبد، العضلات، الخياشيم، الجلد وكذلك العظام والتي تؤثر بدرجة كبيرة علي المعايير الفسيولوجية من المحتوي الكلى للبروتينات، و الدهون و الكربوهيدرات و كذلك النشاط الإنزيمى لإنزيمىASAT وALAT واللذان يلعبان دوراً كبيراً فى طعم و صلاحية هذه الأسماك للإستهلاك الآدمى و التي قد تؤدي إلي الفهم الصحيح لكثير من النواحي البيولوجية مثل معدلات النمو، السلوك الغذائي، و نسبة الوفيات.

أظهرت النتائج أن أعلى قيم للمعادن الثقيلة في مختلف أجهزة هاتين السمكتين قد سجلت خلال فصل الصيف, وعلى الرغم من أن هذين النوعين لهما نفس السلوك الغذائي، إلا أن سمكة الدنيس قد سجلت أعلى معدلات لها فى معظم العناصرمقارنة بسمكة الشرغوش فى مختلف أجهزة الجسم. كما أشارت التحاليل البيوكيميائية إلى وجود آثار مدمرة في بعض المعايير الفسيولوجية سابقة الذكر. وأوضحت نتائج التحاليل الإحصائية وجود إختلافات معنوية بين مختلف الأجهزة والمعادن. كما أظهرت وجود زيادة كبيرة في القياسات البيوكيميائية لموسمى الصيف والشتاء فى أجهزة الجسم المختلفة، مع وجود تفاوت طفيف بين سمكتى الدراسة.