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Original Research Article

# Heavy metal residues in local and imported fish in Egypt

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## ABSTRACT

A total of 100 random muscle samples of Oreochromis niloticus, Claries lazera, imported Mugil cephalus and Scomber scombrus fish (25 of each) were collected from different markets in Fayoum City for determination of lead, cadmium, copper and mercury residual levels to ascertain whether these levels exceeded the prescribed legal limits. The mean mercury level in the edible muscles tissues of fish species were ranged from below detectable level to 0.29 ppm in local fish and to 0.28 ppm in imported fish. The residual levels were not exceeded the prescribed legal limits of the European Commission Regulation (EC). The highest mean levels of cadmium were recorded in Mackerel (0.119 ± 0.060, ppm) which exceeded the permitted values stipulated by European Commission (EC). The samples in this study contained copper within of the general guideline limit for copper in food. The highest mean levels of lead were also recorded in Mackerel (0.477±0.073 ppm) which exceeded the permitted value stipulated by European Commission (EC). The results were evaluated according to International standards of WHO and EC. The provisional tolerable weekly intakes used in this study to assess the relative safety of marketed in Fayoum. The public health significance of heavy metal residues in fishes were also discussed.

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## 1. Introduction

Fish is widely consumed in many parts of the world by humans because it has high protein content and low saturated fat. Contamination of fish and aqua culture by drainage of sewage effluents, industrial and agricultural untreated discharges, carless using of crude chemicals, insecticides and herbicides together with inputs from the atmosphere, are the major sources of heavy metals contamination in the river, sea and subsequently fish obtained from such water (Mason, 1991). These heavy metals come in contact with our bodies via food, drinking water and air. Heavy metals are dangerous, because they tend to bio-accumulate (increase in concentration in biological cells over time). Heavy metals enter food chain and lead to unwanted residues in food animals. These residues have a pharmacological action and conversion products, then are transmitted to the target organs in the animal body which are mainly the edible offal of the food animals (Gracey and Collins, 1992).

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Heavy metals (lead, cadmium, copper and mercury) were detected in muscles of; Oreochromis niloticus (Adeosun et al., 2015), Claries lazera (Ayeloja et al., 2014), Imported Mugil ccphalus (Shreadah et al., 2015), Mackerel (Saad et al., 2014) and canned tuna (Hassan et al., 2016).

Lead has hepatotoxic effects and showing significant increase in liver function test parameters (Adeyemi et al. 2009).

Cadmium is nephrotoxic, initially causing kidney tubular damage. Cadmium can also cause bone damage, either via a direct effect on bone tissue or indirectly as a result of renal dysfunction (Wang et al., 2008).

Copper is an essential trace element that is extremely toxic to organisms and organs at high doses. Copper sulfate toxic dose shows oxidative damage in liver in forms of granular degeneration, necrosis of hepatocytes and impairment to the cell lining of the remark cords that are confirmed biochemically by the changes in malonaldehyde and glutathione levels (Emin et al.,2010).

Mercury exist in various forms: elemental or (metallic), inorganic (e.g mercuric chloride) and organic (e.g methyle and ethyl mercury). All these forms have different toxicities and implications for health. Eating contaminated fish and shellfish is the main source of methyl mercury exposure, especially in populations that rely heavily on consumption of predatory fish (IPCS, 2000).

Therefore, the aim of this study is to determine some heavy metals residues (lead, cadmium, copper and mercury) in some native fish (Oreochromis niloticus and Claries lazera) and imported fish (Mugil cephalus and Scomber scombrus) in Fayoum City. The public health importance and the hazardous toxic effects of these heavy metals was discussed as well as the suggestive recommendations to minimize fish contamination with these heavy metals were mentioned.

## 2. Material and methods

### 2.1. Collection of samples

A total of 100 random muscle samples of Oreochromis niloticus,Claries lazera, imported Mugil cephalus and Scomber scombrus fish. (25 of each) were collected from different markets in Fayoum City for determination of lead, cadmium, copper and mercury levels.

### 2.2. Preparation of samples

The samples were prepared according to (EL-Mowafi, 1995). Containers were thoroughly washed with de-ionized water then air dried in incubator away from any source of contamination or dust.

### 2.3. Digestion procedure

The samples were digested for detection of Lead, Cadmium and Copper according to (Julshamn, 1983). One gram of each sample was macerated by sharp scalpel in a screw capped tube with 5 ml of ($HNO_3$) added to the tissue sample.

The samples were digested for detection of mercury according to (Diaz et al, 1994). Only half gram of macerated fish muscle was digested in 10 ml solution of concentrated $HClO_4/HNO_3$ 1:1 at 45 $^0$C for 15hours.

### 2.4. Quantitative determination

The determination of heavy metals was carried out by "Buck scientific 210VGP Atomic Absorption Spectrophotometer (AAS). The metal residual levels were directly recorded from the digital scale of AAS and they were calculated according to the following equation:

$$\textbf{Element (ppm)} = R \times D / W$$

Where; R= Reading of element concentration by ppm from digital scale of AAS. D= Dilution of prepared sample. W= Weight of the sample.

### 2.5. Estimation of weekly intake

EWI: estimated weekly intakes from consumption of 12 ounces (approximately 340 g) of fish every week by adult person of 60 kg body weight according to US EPA (2004).

Estimated weekly intakes (EWI) calculated from the following equation:

$$\textbf{EWI} = \text{mean} \times \text{average intake of adult person} = (340\text{ g})$$

## 3. Results and discussion

In the present study, the results in table (1) revealed that lead levels were 0.2497, 0.4276, 0.3226 and 0.4773(ppm), in Oreochromis niloticus, Claries lazera, imported Mugil cephalus and Scomber scombrus fish, respectively.

It is worth to mention that the lead residual level in Oreochromis niloticus was significantly ($P < 0.05$) lower than the Scomber scombrus fish, while there was no significant differences ($P < 0.05$) with other fish species (Claries lazera and imported Mugil cephalus). On the other hand, there was no significant difference (P<0.05) between the examined fish species in relation to cadmium, copper and mercury residual level. These results are nearly similar to that obtained by EL-Kewaiey et al. (2011). Low results were recorded by Sireli et al. (2006) and Ekpo et al. (2008). The examined samples exceeded the permissible limits of EC (2006), which mentioned that lead level should not more 0.3 ppm, (Table, 2).

**Table 1. The mean values of heavy metal residues in examined local and imported fish samples.**

| Metals | Oreochromis niloticus | Claries lazera | Imported Mugil cephalus | Scomber scombrus |
|---|---|---|---|---|
| Lead | 0.2497±0.03542[a] | 0.4276±0.04382[ab] | 0.3226±0.05108[ab] | 0.4773±0.07348[b] |
| Cadmium | 0.0518±0.01105[a] | 0.04988±0.01207[a] | 0.04628±0.01931[a] | 0.119±0.06006[a] |
| Copper | 2.497±0.224[a] | 2.331±0.3257[a] | 2.229±0.2945[a] | 2.061±0.2286[a] |
| Mercury | 0.03793±0.01157[a] | 0.07496±0.01707[a] | 0.05696±0.01459[a] | 0.05816±0.01208[a] |

Result expressed as mean ± S.E

Means with no common superscripts are significantly different at P< 0.05

**Table (2): The residual levels of heavy metal in examined fish samples as compared with the permissible limit**

| **Metal** | **Fish species** | **FAO/WHO (1989)** (mg/kg) | **EC (2006)** (mg/kg) | **Samples below & within permissible limits** | | **Samples above permissible limits** | |
|---|---|---|---|---|---|---|---|
| | | | | No | % | No | % |
| **Lead** | Oreochromis niloticus | - | 0.3 | 16 | 64 | 9 | 36 |
| | Claries lazera | - | 0.3 | 9 | 36 | 16 | 64 |
| | Imported Mugil cephalus | - | 0.3 | 14 | 56 | 11 | 44 |
| | Scomber scombrus | - | 0.3 | 11 | 44 | 14 | 56 |
| **Cadmium** | Oreochromis niloticus | - | 0.05 | 14 | 56 | 11 | 44 |
| | Claries lazera | - | 0.05 | 17 | 68 | 8 | 32 |
| | Imported Mugil cephalus | - | 0.05 | 19 | 76 | 6 | 24 |
| | Scomber scombrus | - | 0.05 | 14 | 56 | 11 | 44 |
| **Copper** | Oreochromis niloticus | 30 | - | 25 | 100 | 0 | 0 |
| | Claries lazera | 30 | - | 25 | 100 | 0 | 0 |
| | Imported Mugil cephalus | 30 | - | 25 | 100 | 0 | 0 |
| | Scomber scombrus | 30 | - | 25 | 100 | 0 | 0 |
| **Mercury** | Oreochromis niloticus | - | 0.5 | 25 | 100 | 0 | 0 |
| | Claries lazera | - | 0.5 | 25 | 100 | 0 | 0 |
| | Imported Mugil cephalus | - | 0.5 | 25 | 100 | 0 | 0 |
| | Scomber scombrus | - | 0.5 | 25 | 100 | 0 | 0 |

The mean cadmium levels were 0.0518, 0.0498, 0.04628 and 0.119 (ppm), in Oreochromis niloticus, Claries lazera, imported Mugil cephalus and Scomber scombrus fish, respectively. These results are nearly similar to that obtained by Ayeloja et al. (2014). However, Ekpo et al. (2008) and Badret et al. (2014) recorded higher results. It is worth to mention that the samples were exceeding the permissible limit (0.05 ppm) reported by EC. (2006).

The mean copper residual levels were 2.497, 2.331, 2.229 and 2.061 ppm in muscles of Oreochromis niloticus, Claries lazera, imported Mugil cephalus and Scomber scombrus fish, respectively. These results are nearly similar to that obtained by AL-Kahtani (2009) and Kaoud and EL-Dahshan (2010). High results were obtained by Ali and Fishar (2005). None of the examined muscle samples exceeded the limit of FAO/WHO (1989) which stated that the permissible limit of copper should not be more than 30 ppm (table, 2).

The mean mercury residual levels in muscles of Oreochromis niloticus, Claries lazera, imported Mugil cephalus and Scomber scombrus fish were 0.0379, 0.0749, 0.0569 and 0.05816 ppm, respectively. These results are nearly similar to that obtained by Hussein and Abd El-Rahaman (2008). High results were detected by Soliman (2006) and Shreadah et al. (2015). None of the examined samples exceeded the limit of EC (2006) which stated that the permissible limit of mercury should not exceed 0.5 mg/kg. On the other hand, the calculated weekly intake of lead (Pb) estimated by µg/kg. b.w for adult person of 60 kg body weight in this study from eating 12 ounces (approximately 340 g) of each Oreochromis niloticus, Claries lazera, imported Mugil cephalus and Scomber scombrus are 1.41, 2.42, 1.82 and 2.70, respectively. These values were lower than the provisional tolerable weekly intake recommended by JECFA (2004) which is 25µg/kg b.w. while for cadmium it is 0.29, 0.28, 0.26, and 0.67 respectively. These values were lower than the provisional tolerable weekly intake recommended by JECFA (2004) which is 7µg/kg b.w.

It is obvious from table (3) that the calculated weekly intake of copper (Cu) are 14.14, 13.209, 12.631, and 11.679 respectively, which were lower than the maximum provisional tolerable weekly intake recommended by JECFA (2004) which is 3500 µg/kg b.w. while for mercury it is 0.21, 0.42, 0.32, and 0.329 respectively. These values were lower than the maximum provisional tolerable weekly intake which is 5µg/kg b.w recommended by JECFA (2004). According to the estimated daily and weekly intake, there is no risk of normal fish consumption originating from the local market on public health in Fayoum City. Although the residual level of copper and mercury is not high, care must be taken considering some people regularly consume large quantities of fish as heavy metals especially mercury have the ability of bioaccumulation and biomagnifications.

**Table (3) Estimated weekly intakes of consuming fish for adult person based on mean level of heavy metal found in fish samples.**

| Heavy metal | Fish species | Mean residual level (mg/kg) | EWI µ/adult person | EWI µ/kg b.w | Provisional permissible tolerable weekly intakes (PTWI) (µg/kg bw) |
|---|---|---|---|---|---|
| **Lead** | Oreochromis niloticus | 0.2497 | 84.898 | 1.41 | |
| | Claries lazera | 0.4276 | 145.384 | 2.42 | 25 |
| | Imported Mugil cephalus | 0.3226 | 109.684 | 1.82 | |
| | Scomber scombrus | 0.4773 | 162.282 | 2.70 | |
| **Cadmium** | Oreochromis niloticus | 0.0518 | 17.612 | 0.29 | |
| | Claries lazera | 0.0498 | 16.932 | 0.28 | 7 |
| | Imported Mugil cephalus | 0.04628 | 15.735 | 0.26 | |
| | Scomber scombrus | 0.119 | 40.46 | 0.67 | |
| **Copper** | Oreochromis niloticus | 2.497 | 848.98 | 14.14 | |
| | Claries lazera | 2.331 | 792.54 | 13.209 | 3500 |
| | Imported Mugil cephalus | 2.229 | 757.86 | 12.631 | |
| | Scomber scombrus | 2.061 | 700.74 | 11.679 | |
| **Mercury** | Oreochromis niloticus | 0.03793 | 12.89 | 0.21 | |
| | Claries lazera | 0.07496 | 25.48 | 0.42 | 5 |
| | Imported Mugil cephalus | 0.05696 | 19.36 | 0.32 | |
| | Scomber scombrus | 0.05816 | 19.77 | 0.329 | |

## 4. Conclusion

From the present data it could be concluded that the Scomber scombrus fish has the highest level of lead and cadmium comparing with other species, but there was no single type of fish that was consistently high for all metals. From the present data it was recommended that people should choose smaller fish within a species as they may have lower contaminant levels, while the larger fish may be more contaminated because they have had more time to accumulate contaminants in their bodies, especially the mercury which has the ability of bioaccumulation and biomagnifications through the food chain, also people should eat a diversity of sea food to avoid consuming unhealthy quantities of heavy metals.

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