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Risk Assessment of Lead in Meat from Different Environments of Egypt

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***Abstract*—**Lead is among the heavy metals and it is one of the highly toxic metals, recognized in most countries. This metal accumulates in animal organs as liver and kidney. The present investigation provides the concentrations of lead in cow's meat and different animal organs collected from three Egyptian environments. The results revealed that lead levels in muscle, liver, kidney, spleen and heart in industrial areas were higher than those detected in the same organs of other two areas (heavy traffic and rural), which recorded mean values of 3.0091, 1.7070, 1.8609, 0.6401 and 0.5332 mg/kg, respectively, followed by traffic areas, 2.9166, 1.4443, 1.6967, 0.4042 and 0.4103 mg/kg, respectively. The corresponding values of rural areas were 1.8895, 0.9550, 0.9117, 0.3215 and 0.2856 mg/kg, in the same order. It could be recommended that monitoring and evaluation of lead levels in meat at regular intervals are very important.

***Keywords*—**Heavy metals, lead, meats, organs, liver, kidney, spleen, heart, environments.

I. Introduction

MEAT is one of the important foods to humans, chemically composed of water, protein (consist of essential amino acids such as arginine and histidine, which are important to maintenance and repair of body tissues in human), lipid, carbohydrate, micronutrients (as iron, zinc, magnesium and selenium) and many other minor components such as vitamins (as A, B1, B2, B6 and B12), enzymes, pigments and flavor compounds, and being a good source of energy [1]-[3].

Meat could be contaminated by lead due to car exhaust and factory waste. In general, the toxicity of metals as lead depends on the excessive levels of these elements [4], which depend on environmental conditions and the handling contamination in several steps of the manufacturing processes. Lead may interfere with the normal function of enzymes and inhibiting their action and effect on most human systems as nervous, urinary, gastric and genital [5] as well as lead is toxic to the blood. On the other hand, [6] reported that lead causes carcinogenesis and mutagenesis in experimental animals. Lead toxicity in human is closely related to the period of exposure, besides age and sex, absorption rate and efficiency of excretion [7]. In addition, inhalation of lead can permanently lower IQ [8].

Many reports from Egypt [9]-[11] and from other countries, [12], [13] indicated that lead was present in animal meats and its organs.

The present investigation proves lead levels in cow's meat and edible organs collected from industrial, heavy traffic and rural areas in Cairo, Egypt.

II. Materials and Methods

A. Materials

1. Chemicals and Reagents

Stock standard solution (1000 mg/L) of lead (Pb) from Merck (Merck, Darmstadt, Germany) and nitric acid of high grades (BDH chemical LTD) were purchased.

2. Food Samples

A total of 324 samples of cow's meat (muscle) and its organs (liver, kidney, spleen and heart), were randomly collected from three main environments in Great Cairo (Egypt), i.e., industrial (Shoubra El-Kheima and Helwan), heavy traffic (Faysal), and rural (near cultivated lands) areas during the period of 1/5/2010 to 1/11/2012. Number of samples from each area was 108. Each type (3 kg) of foodstuff and 1 kg of sub-samples are taken at random from the composite sample and prepared for analysis by the dry-ashing method. Lead contents were determined in all sample parts.

B. Methods and Procedures

1. Test Principle

Lead was extracted from different commodities according to [14]. A dry ashing method is used for the destruction of organic matter. The ashed samples are dissolved in acidic de-ionized water and lead levels are recorded by atomic absorption spectrophotometer at maximum absorbance obtained at wavelength 217.0 nm from the cathode lamb.

2. Sample Preparation

The samples were homogenized and 3-5 g of them was weighed into crucibles and dried in an oven at 100-110 °C for ~16 h and ashed in a muffle furnace at 500-550 °C. The ashed samples are cooled to room temperature and dissolved in 1 mL 10% (v/v) nitric acid and then completed to a definite volume (25 mL) with de-ionized water.

3. Determination (Instrumentation)

Lead levels in different sample solutions were measured by atomic absorption spectrophotometer, model PG-990 equipped

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with flame atomization (air-acetylene), and a 10 cm burner. Maximum absorbance was obtained by adjusting the cathode lamp at the proper wavelength (217.0 nm). Other analytical parameters were; bandwidth, 0.4 nm; filter factor, 1.0; lamp current, 5.0 ma; integration time, 3.0 sec; background, D2/SR and flame setting, oxidizing blue.

4. Method's Validity

a. Quality Assurance

Quality assurance procedures and precautions were carried out to ensure reliability of the results. All materials used for processing are screened for possible lead contamination. Acidic-cleaned volumetric flasks and other glassware are soaked in a soapy solution (2% solution isoclean detergent) for 24 h, then rinsed and soaked in 10-15% nitric acid for 48 h, then rinsed with ultrapure water and dried under clean conditions. De-ionized water was used throughout the study. The samples were carefully handled to avoid contamination.

b. Recovery and Detection Limits

The recoveries of lead in fortified cow's meat (muscle) and its organs samples by (0.1, 0.2 and 0.4 mg/kg) were ranged between 90.0 and 96.3. According to the formula of [15], detection limits were calculated and recorded which was 0.012 mg/L.

C. Statistical Analysis

The data obtained from this study was statistically subjected to analysis of variance (ANOVA) and means separation was by [16]. The least significant difference (LSD) value used to determine significant differences between means and to separate means at ($p \leq 0.05$) using SPSS package version 15.0.

III. Results

Lead levels in different collected samples from the three areas under investigation were determined and data summarized in Table I. Results indicated that lead concentrations of different collected samples are quite variable among the three areas. ANOVA revealed that highly significant differences ($p \leq 0.05$) of lead content were observed between the concentration of lead in the samples collection from industrial areas compared with traffic and rural areas. The highest mean levels of lead in muscle, liver, kidney, spleen, and heart samples collected from industrial areas were 3.0091, 1.7070, 1.8609, 0.6401 and 0.5332 mg/kg, respectively. The corresponding values of different samples of traffic areas were 2.9166, 1.4443, 1.6967, 0.4042 and 0.4103 mg/kg, in this order. On the other hand, no significant differences ($p \geq 0.05$) are observed between the lead levels in muscle and kidney samples from industrial and traffic areas. With respect to the rural area's samples, data indicated that lead levels in muscle, liver, kidney, spleen, and heart samples were the lowest than the other two areas, which recorded 1.8895, 0.9550, 0.9117, 0.3215 and 0.2856 mg/kg, respectively.

TABLE I
LEAD CONTENTS (MG/KG) IN COW'S MEAT (MUSCLE) AND ITS ORGANS SAMPLES FROM INDUSTRIAL, TRAFFIC AND RURAL AREAS DURING THE PERIOD OF 2010 TO 2012

Foodstuffs	Concentrations (mg/kg wet weight)						LSD at 5%
	Industrial areas		Traffic areas		Rural areas		
	Mean± SD	Range	Mean± SD	Range	Mean± SD	Range	
1- Muscle	$3.0091^{a}\pm0.09$	1.0768-5.0156	$2.9166^{a}\pm0.08$	1.570-6.1282	$1.8895^{b}\pm0.04$	0.3620-3.6552	0.36
2- Liver	$1.7070^{a}\pm0.03$	0.5315-2.6680	$1.4443^{ab}\pm0.02$	0.6079-3.0557	$0.9550^{b}\pm0.03$	0.2536-2.6620	0.60
3- Kidney	$1.8609^{a}\pm0.05$	0.9852-2.7281	$1.6967^{a}\pm0.05$	1.0949-2.9952	$0.9117^{b}\pm0.04$	0.4557-1.6642	0.44
4- Spleen	$0.6401^{a}\pm0.04$	0.4192-1.0039	$0.4042^{b}\pm0.04$	0.1958-0.6366	$0.3215^{b}\pm0.02$	0.0709-0.6001	0.13
5- Heart	$0.5332^{a}\pm0.03$	0.0679-1.1055	$0.4103^{b}\pm0.02$	0.1058-1.1250	$0.2856^{c}\pm0.02$	0.0685-0.5586	-

-All values are means of samples number determinations in each area ± standard deviation (SD).
-Means within columns with different letters are significantly different ($p \leq 0.05$).

TABLE II
MEAN LEAD CONTENTS (MG/KG) IN COW'S MEAT (MUSCLE) SAMPLES FROM INDUSTRIAL, TRAFFIC AND RURAL AREAS DURING THE PERIODS OF SAMPLE COLLECTION

Areas	Mean concentrations (mg/kg wet weight) ± SD					LSD at 5%
	1	2	3	4	5	
Industrial	$4.3948^{a}\pm0.10$	$3.0652^{b}\pm0.25$	$2.1867^{c}\pm0.25$	$2.6042^{c}\pm0.04$	$3.1105^{b}\pm0.05$	0.67
Traffic	$2.5604^{b}\pm0.10$	$2.2445^{b}\pm0.17$	$1.9737^{c}\pm0.25$	$3.0241^{a}\pm0.04$	$3.0774^{a}\pm0.03$	0.59
Rural	$0.5860^{c}\pm.0.10$	$0.9447^{ab}\pm0.25$	$0.9196^{ab}\pm0.25$	$1.6094^{b}\pm0.03$	$2.5865^{a}\pm0.06$	0.29

-All values are means of samples number determinations in each period from each area ± standard deviation (SD).
-Means within columns with different letters are significantly different ($p \leq 0.05$).
1:1/5/2010 to 26/10/2010, **2**: 1/11/2010 to 30/4/2011, **3**:1/5/2011 to20/10/2011**4**:1/11/2011 to 30/4/2012, **5**:1/5/2012 to 1/11/2012.

Lead levels of muscle and cow's organs were determined throughout five periods of samples collection during the period of 1/5/2010 to 1/11/2012 (about 6 months in each period). Data in Table II indicated that the highest mean lead level (4.3948 mg/kg) in muscle samples collected from industrial areas was detected during the period of 1/5/2010 to 26/10/2010. However, the highest mean lead levels in the samples collection from traffic (3.0774 mg/kg) and rural

(2.5865 mg/kg) areas were detected during the period of 1/5/2012 to 1/11/2012. The corresponding values of liver samples were 2.2076, 2.6475 and 1.9284 mg/kg, in the three investigated areas, respectively (Table III). On the other hand, the highest mean levels of lead in kidney were observed in the samples collection of industrial (2.3665 mg/kg), traffic (1.9492 mg/kg) and rural (1.4417 mg/kg) areas during the period of 1/5/2011 to 20/10/2011, 1/11/2011 to 30/4/2012 and 1/5/2012 to 1/11/2012, respectively (Table III). With respect to spleen samples, data indicated that the highest mean levels of lead were detected in the samples collection of industrial and traffic areas during the period of 1/11/2010 to 30/4/2011, which recorded 0.7190 and 0.5629 mg/kg, respectively (Table III). However, the highest mean values of lead (0.4507 mg/kg) in rural areas were detected in the period of 1/5/2012 to 1/11/2012. In heart samples, data revealed that the highest mean level of lead (0.9053 mg/kg) was found in industrial areas samples during the period of 1/5/2011 to 20/10/2011. Besides, the highest mean levels of lead in both traffic (0.8827 mg/kg) and rural (0.4922 mg/kg) areas were detected in the samples collection during the period of 1/11/2010 to 30/4/2011 (Table III). ANOVA proved that significant differences ($p \leq 0.05$) observed between lead contents in the most period of samples collection of the three collected areas.

TABLE III
MEAN LEAD CONTENTS (MG/KG) IN LIVER, KIDNEY, SPLEEN AND HEART SAMPLES FROM INDUSTRIAL, TRAFFIC AND RURAL AREAS DURING THE PERIODS OF SAMPLE COLLECTION

Areas	Mean concentrations (mg/kg wet weight) ± SD					LSD at 5%
	1	2	3	4	5	
Liver						
Industrial	-	1.1714^{b}±0.03	1.3004^{b}±0.07	2.1488^{a}±0.03	2.2076^{a}±0.04	0.74
Traffic	-	1.0592^{b}±0.04	0.8092^{c}±0.03	1.3742^{b}±0.07	2.6475^{a}±0.05	0.74
Rural	-	0.7917^{b}±0.02	0.6018^{c}±0.03	0.4313^{c}±0.04	1.9284^{a}±0.05	0.70
Kidney						
Industrial	-	1.2949^{b}±0.04	2.3665^{a}±0.03	2.2666^{a}±0.02	1.5160^{b}±0.04	0.63
Traffic	-	1.4848±0.03	1.8550±0.05	1.9492±0.04	1.4737±0.05	-
Rural	-	0.8591^{b}±0.02	0.7592^{b}±0.02	0.5869^{b}±0.02	1.4417^{a}±0.05	0.43
Spleen						
Industrial	-	0.7190±0.02	0.5971±0.02	0.5744±0.03	0.6697±0.03	-
Traffic	-	0.5629^{a}±0.02	0.3926^{ab}±0.02	0.2471^{b}±0.02	0.4142^{ab}±0.02	0.17
Rural	-	0.4339^{a}±0.02	0.2796^{b}±0.02	0.1218^{c}±0.02	0.4507^{a}±0.02	0.14
Heart						
Industrial	-	0.7049^{ab}±0.02	0.9053^{a}±0.02	0.2381^{c}±0.02	0.2844^{bc}±0.02	0.46
Traffic	-	0.8827^{a}±0.03	0.4101^{b}±0.02	0.1263^{c}±0.02	0.2221^{bc}±0.02	0.21
Rural	-	0.4922^{a}±0.02	0.3609^{b}±0.02	0.0816^{d}±0.02	0.2079^{c}±0.03	0.13

-All values are means of samples number determinations in each period from each area ± standard deviation (SD).
-Means within columns with different letters are significantly different ($p \leq 0.05$).
1-1/5/2010 to 26/10/2010, **2**- 1/11/2010 to 30/4/2011, **3**- 1/5/2011 to 20/10/2011, **4**-1/11/2011 to 30/4/2012, **5**-1/5/2012 to 1/11/2012

TABLE IV
MEAN LEAD CONTENTS (MG/KG) IN COW'S MEAT (MUSCLE) SAMPLES FROM INDUSTRIAL, TRAFFIC AND RURAL AREAS DURING SUMMER AND WINTER COLLECTION

Areas	Mean concentrations (mg/kg wet weight) ±SD		LSD at 5%
	Summer	Winter	
Industrial	3.2211^{a}±0.05	2.7507^{b}±0.02	0.59
Traffic	2.8381^{a}±0.04	2.9754a±0.04	-
Rural	2.1304^{a}±0.02	1.5951b±0.04	0.48

-All values are means of samples number determinations in each period from each area ± standard deviation (SD).
-Means within columns with different letters are significantly different ($p \leq 0.05$).

The present investigation studied lead levels in the samples collection during summer and winter seasons (Tables IV and V), data indicated that the highest mean values of lead in muscle, liver, kidney, spleen, and heart samples from the industrial areas were detected in summer season, which recorded 3.2211, 1.7540, 1.9412, 0.6334 and 0.5949 mg/kg, respectively. ANOVA proved significant differences ($p \leq 0.05$) between the industrial areas samples during summer and winter. Regarding to traffic areas samples during summer, data revealed that muscle (2.8381) and liver (1.7284 mg/kg) contained the highest mean values of lead. Significant differences ($p \leq 0.05$) are observed between lead levels in the samples collection of summer and winter. On the other hand, the samples collection of muscle, liver, kidney and spleen from rural areas contained the highest mean levels of lead during summer, which recorded 2.1304, 1.2653, 1.1004 and 0.3651 mg/kg, respectively. Significant differences ($p \leq 0.05$) are observed between lead levels in the studied samples collected during summer and winter. Data proved that insignificant differences ($p \geq 0.05$) between the lead levels in kidney and spleen samples collected from industrial and traffic areas as well as heart samples from rural areas during summer or winter.

TABLE V
MEAN LEAD CONTENTS (MG/KG) IN LIVER, KIDNEY, SPLEEN AND HEART SAMPLES FROM INDUSTRIAL, TRAFFIC AND RURAL AREAS DURING SUMMER AND WINTER COLLECTION

Areas	Mean concentrations (mg/kg wet weight) ±SD		LSD at 5%
	Summer	Winter	
Liver			
Industrial	1.7540ᵃ±0.03	1.6601ᵇ±0.03	-
Traffic	1.7284ᵃ±0.04	1.1603ᵇ±0.03	-
Rural	1.2653ᵃ±0.02	1.0265ᵇ±0.02	-
Kidney			
Industrial	1.9412ᵃ ±0.02	1.7808ᵃ ±0.02	-
Traffic	1.6787ᵃ ±0.03	1.7170ᵃ ±0.03	-
Rural	1.1004ᵃ±0.03	0.7230ᵇ±0.02	0.12
Spleen			
Industrial	0.6334ᵃ±0.02	0.6476ᵃ ±0.02	-
Traffic	0.4034ᵃ±0.02	0.4050ᵃ ±0.02	-
Rural	0.3651ᵃ±0.02	0.2779ᵇ±0.02	-
Heart			
Industrial	0.5949ᵃ±0.03	0.4714ᵇ ±0.02	-
Traffic	0.3161ᵇ±0.02	0.5045ᵃ ±0.02	-
Rural	0.2844ᵃ±0.02	0.2869ᵃ ±0.02	-

- All values are means of samples number determinations in each period from each area ± standard deviation (SD).
- Means within columns with different letters are significantly different ($p \leq 0.05$).

IV. DISCUSSION

The present investigation proved that lead content of cow's meat samples (muscle) in the present investigation were higher than the maximum permissible levels (0.5 µg/g) reported by [17]. Also, these levels were higher than those detected in Egypt during 2001-2008. Abou-Donia [9] reported that mean lead concentrations in buffalo's muscle from Egyptian industrial, heavy traffic and rural areas were, 0.106, 0.048 and 0.077 mg/kg, respectively. On the other hand, Abou-Arab [11] reported that mean lead levels were 0.081 and 0.052 mg/kg in muscle from industrial and rural areas, respectively. However, Abou-Arab and Abou Donia [10] reported that buffalo's meat contained mean lead levels of 0.095 mg/kg. The different levels of lead in various samples from the three areas probably due to the contamination of diets by lead. Our results were compared with the values recommended for liver and kidney from cattle [17]. The maximum lead concentrations of cattle have been proposed to 0.5 mg/kg. With regard to this limit, the lead concentrations in liver and kidney were high in some samples of the present study. It was surprising that lead contents in different organs from industrial areas were higher than in the same organs from rural areas. These results were confirmed by statistical analysis which clearly showed that significant differences ($p \leq 0.05$) were detected among the analyzed samples. The difference probably results from different diets, whereas the animals are exposed to the influence of air pollution for longer periods, which they accumulated lead. These results confirmed by [18] who reported that significantly higher amounts of lead in liver and kidneys were found in cattle sampled around the refineries than those in cattle in rural area, respective means were 0.10 and 0.05 mg/kg in muscle, 0.21 and 0.13 mg/kg in liver and 0.70 and 0.50mg/kg in kidney. Comparing lead levels of liver and kidney in the present investigation with the same types of organs collected from industrial, heavy traffic and rural areas in Egypt during the period of January to December (2006) [9], data revealed that mean lead levels in buffalo's liver was 0.586, 0.061 and 0.274 mg/kg in the samples collection from industrial, heavy traffic and rural areas, respectively. The corresponding lead values of kidney samples were 0.790, 0.122 and 0.456 mg/kg, respectively. On the other hand, Egyptian samples of liver and kidney analyzed for lead concentrations of the period of March 1999 to January, 2000 by [11] and reported that buffalo's liver samples contained mean lead levels of o.401 and 0.110 mg/kg in the samples collection from industrial and rural areas, respectively. The corresponding lead levels in kidney samples were 0.721 and 0.211 mg/kg, respectively. With respect to mean lead levels of spleen and heart, data in the present study indicated that lead levels were higher than those reported by [9], [11]. The author reported that mean lead levels in buffalo's spleen from industrial, traffic and rural areas were 0.056, 0.010 and 0.021 mg/kg, respectively. However, buffalo's heart samples contained 0.185, 0.016 and 0.101 mg/kg, respectively. On the other hand, Abou-Arab [11] reported that buffalo's spleen from industrial and rural areas contained mean lead levels, 0.032 and 0.011 mg/kg, respectively. With respect to heart samples from industrial and rural areas, mean lead values were 0.141 and 0.020 mg/kg, respectively. In this respect, it could be seen that lead levels in organs samples were far higher than the previous study.

V. CONCLUSION AND RECOMMENDATION

From the available data, it could be concluded that lead concentration of cow's meat and organs are relatively high. Levels of lead in different samples of industrial areas are much higher as compared to those from rural areas. The highest concentrations of lead were detected in liver and kidney samples. Residents near heavy traffic areas are at high-risk for lead pollution. The elevated levels of lead in the people bodies may result in various health and developmental problems. It could be recommended that monitoring and evaluation of lead levels in foods at regular intervals is very important. Also, put plans according to specified organizations of preventing exposure to controlling or eliminating lead sources. Besides, careful washing and peeling of foodstuffs before eating. Also, the consumption of animal's organs from industrial areas should be avoided.

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