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### Detection of lead and cadmium residues in beef before and after cooking in ceramic, glass and granite pots

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#### ABSTRACT

In the current study, migration of heavy metals represent by lead (pb) and cadmium (Cd) were investigated before and after cooking using different cooking made pots (ceramic, glass and granite). Fifteen raw beef samples were tested for the presence of both two elements residues before cooking. Lead was observed in all raw meat samples out of which, 11 samples (73.3%) were accepted and 4 samples (26.7%) were not-accepted. On the other side, cadmium was mostly not detected (lower than 0.01 mg/kg) in all tested raw meat samples according to the Egyptian Standards (ES,7136/2010). Three of tested beef samples that had lower content of both elements were divided into three portions to be cooked in ceramic, glass and granite cooking pots. Lead noticed to have migrated level from ceramic pots exceeding the acceptable limit (0.1 mg/kg) with a mean value of  $0.32 \pm 0.21$  mg/kg followed by granite which recorded  $0.093 \pm 0.01$  mg/kg and lastly for glass pots with mean of  $0.072 \pm 0.005$  mg/kg, while cadmium was within the acceptable limit for all tested samples after cooking (0.05 mg/kg) except for one sample which was cooked in ceramic pot with 33.3% not accepted. This study demonstrated that ceramic pots was the most leachable of lead followed by granite and lastly glass pots. The current study supported the need to use a good quality material in cooking pots manufacturing.

#### INTRODUCTION:

In food processing, cooking is an important step of concern. Pots quality which contacted with food throughout the process of cooking is attributed to food safety. Lead and cadmium are found on a large-scale in materials of pots (Papanikolaou et al. 2005 and Godt et al. 2006). Cooking pots are mainly composed of combination of metals with different ratios which could be melted under heat and corroded

finally under extreme pH ((Weidenhamer et al. 2014 and Stahl et al. 2017).

Realization, the harmful effect of exposure to metals from cooking pots is of great importance to public health, so occurrence of food contaminants by cooking pots more likely to be taken forward with the food as cooking is the last step of food preparation (WHO, 2001 and Kamerud et al. 2013).

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Lead and cadmium are considered to be the most harmful metals to human health by leaching from cooking pots to contact food during cooking process. (Monika et al. 2018). Ceramic cook-wares are generally used all over the world. Moreover, article of ceramic can be a huge source of harmful element intake to human health by lead and cadmium (Rebeniak et al. 2014 and Aderemi et al. 2017). Several studies have been proceeded on pb and Cd migration from ceramic and granite to food. (Rebeniak et al. 2014 and Elatrash et al. 2014). Liability to high temperature or using worn pots may lead to releasing of lead into food, (Villalobos et al. 2009). Many aspects have been affected this phenomenon including the quality of used raw materials in pots production, the procedure of the technological process, the food contacting type, temperature and time of contact. (Omolaoye et al. 2010 and Rebeniak et al. 2014).

Of the most systemic toxicant, lead is considered the highest serious element that affects the central nervous system, endocrine system, kidneys, liver, reproductive and hematopoietic systems, (Tchounwou, 2012). Lead and cadmium constitute a health hazard to human health via the dietary intake so accurate measures should be attempted to reduce their risk. (Rebeniak et al. 2014). Intake of Pb and Cd considered the most dangerous elements on consumer health.

A heavy metal like cadmium is massively available in earth's crust and it has a great importance in industry, it is mainly used in ceramics, pigments and alloys productions. Contaminated food with cadmium considered the most possible route of consumer health hazard. Prolonged liability to cadmium seriously affects the blood vessels, pulmonary function and chest radiographs that are consistent with emphysema (Khan, 2013 and Harris, 2015). Sickness, anorexia, gastrointestinal irregularities and dermatitis problems are promoted by intense exposure to heavy metals (Järup, 2003 and Lieberzeit, 2011).

EFSA (2011) has established the lowest limit for lead by 0.50 µg/kg b.w./day for children with increasing the probability of neuro-

toxic effect when subjected to consume more than the aforementioned limit, while adults, the limit shouldn't exceed 63 µg/kg b.w./day with probability of nephrotoxicity in higher dose intake, when the consumed amounts of pb reached to 1.50 µg/kg b.w./day, it may be led to cardiovascular disorders, and 2.5 µg/kg b.w./week for cadmium was established. Lead and cadmium have an accumulative effect in the body so clinical and visible symptoms at low levels of exposure do not be obvious immediately, their toxic effect is clear after a few months or even few years (carcinogenic effect) or in a next generation (mutagenic effect). The actual estimation of population dietary exposure levels to metals harmful to health do not take into consideration such important source of oral heavy metals intake as migration from food preparation articles which contacted with foodstuffs.

Food-contact containers should not transfer any abnormal, color, flavor, odor, toxicity, or other unwanted characters to food (USDA, 2001). Further intake of lead and cadmium through migration from glass and ceramic articles should be massively controlled to safeguard consumer health. (Schnaas et al. 2004 and Sinha et al. 2007). Manufacturers of ceramics and glassware articles are obliged to follow the requirements of the good manufacturing practice (GMP) for materials proposed to be in contact with food (Commission Regulation, EC, 2023/2006).

The aim of this study was to investigate the effect of cooking process on the lead and cadmium content migration to beef meat samples before and after cooking.

## MATERIALS and METHODS

### Sample collection:

Fifteen raw beef samples were collected from Giza Governorate markets. Each sample was kept in sterile polyethylene bag. The samples were transferred to the Food Hygiene Department, Animal Health Research Institute (AHRI) to carry out the experiment.

### Sample preparation:

The raw beef samples were digested to be analyzed for lead and cadmium.

**Cooking:**

Cooking pots (ceramic, glass and granite) were used for cooking of meat samples. Each sample was divided into 3 portions to be cooked as one sample for each pot. Generally, the heating was carried out using the gas stove for 45 minutes as well as the same volume of water was added to each pot. All cooked samples were drained from the pot, allowed to cool and coded for analysis.

The samples were digested according to (AOAC, 2019).

**Determination of lead and cadmium:**

Lead (pb) and cadmium (cd) we reanalyzed using **Agilent 5100 Inductivity Coupled Plasma-Optical Emission Spectrometer (ICP-**

**OES)** with synchronous Vertical Dual View (SVDV). Constructed calibration curve was consisted of three or more standards and a blank from Merk (standard reference material for trace elements in water and quality control sample for each series of measurement intensity) from National Institute of Standards and Technology (NIST) which used to confirm the instrument reading.

**Statistical analysis:**

The experiment was repeated three times and IBM SPSS v.27(IBM company) were used to analyze data, mean using One Way ANOVA and LSD at  $\alpha=0.05$ .

**RESULTS:**

Table (1): Statistical analysis of examined raw beef samples for lead and cadmium (n=15)

Heavy Metals	Min	Max	Mean ( $\mu\text{g}/\text{kg} \pm \text{SD}$ )	Permissible limit	Accepted		Not accepted	
					No	%	No	%
lead	0.06	0.2	0.07 $\pm$ 0.047	0.1	11	73.3	4	26.7
cadmium	<0.01	0.02	0.011 $\pm$ 0.003	0.05	15	100	0	0.0

**NB:**

For cadmium, mean (<0.01) was calculated as 0.01 in statistical analysis.

Accepted limits were determined according to the Egyptian Standard (ES No 7136/2010)

Table (2): Levels of lead migration from different cooking pots to the examined beef samples (n=3 sample for each cooking pot)

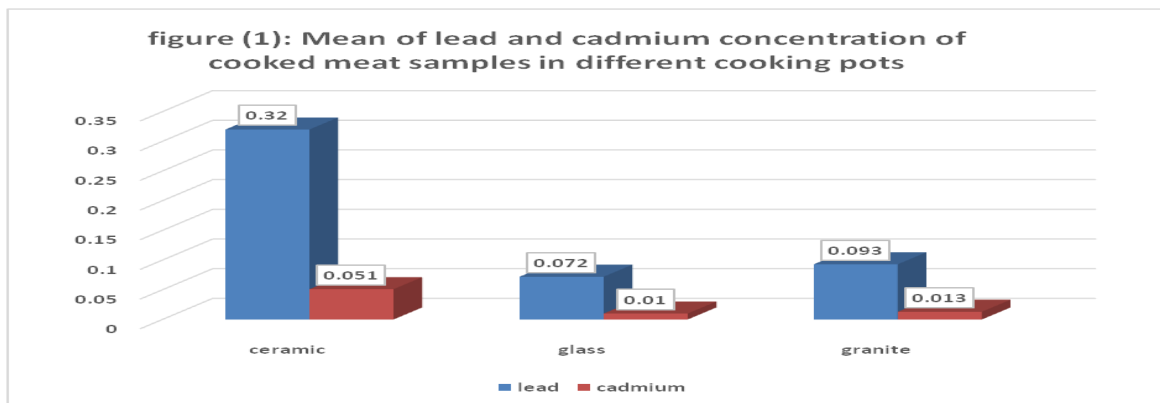
pots	Min	Max	Mean $\pm$ SD		Permissible limit mg/kg	Accepted		Non accepted	
			Concentration	%		No	%	No	%
ceramic	0.09	0.5	0.32 $\pm$ 0.21 <sup>a</sup>	78.13	0.1	1	33.3	2	66.7
glass	0.06	0.09	0.072 $\pm$ 0.005 <sup>b</sup>	2.7	0.1	3	100	0	0.0
granite	0.08	0.11	0.093 $\pm$ 0.01 <sup>ab</sup>	24.7	0.1	2	66.7	1	33.3

There were significant differences ( $p<0.05$ ) between means having different letters.

Table (3): Levels of cadmium migration from different cooking pots to the examined beef samples (n=3 samples for each cooking pot).

pots	Min	Max	Mean $\pm$ SD		Permissible limit	Accepted		Non accepted	
			Concentration	%		No	%	No	%
ceramic	0.03	0.07	0.051 $\pm$ 0.02 <sup>a</sup>	78.4	0.05	2	66.7	1	33.3
glass	<0.01	<0.01	0.01 $\pm$ 0.0 <sup>b</sup>	9.1	0.05	3	100	0	0.0
granite	0.01	0.02	0.013 $\pm$ 0.01 <sup>ab</sup>	15.3	0.05	3	100	0	0.0

There were significant differences ( $p < 0.05$ ) between means having different letters.



## DISCUSSION:

Both of lead and cadmium are chemicals which are toxic, persistent, not metabolized and are able to accumulate in human and animal tissues causing carcinogenic, nephrological and immunological disorders (Mc Dowell, 2003 and Zukowska et al. 2008).

Table (1) showed that 11 of examined raw beef meat samples (73.6%) before cooking were accepted for lead and 4 samples (26.4%) were not accepted according to the Egyptian Standers (ES No7136/2010) with maximum of (0.2), minimum of (0.06) and mean of  $0.07 \pm 0.047$ , While 100% of the samples were accepted for cadmium with maximum of (0.02), minimum of (<0.01) with mean of  $0.011 \pm 0.003$ . In this respect, Gonzalez et al. 2006 noticed that concentrations of Pb and Cd were  $0.002 \text{ mg/kg}$  for both elements which were lower than the current results. While the obtained results by Abdelaziz, 2012 revealed that lead recorded a mean value of  $3.75 \text{ ppm}$  while cadmium was estimated by  $1.57 \text{ ppm}$  and they were higher than the obtained results in the current study.

Pots often used to cook different food are

made of various materials, the migration of heavy metals specially lead and cadmium is affected by the pot material used in its manufacturing and the type of food throughout the process of cooking. Studies on Pb and Cd migration throughout the cooking process are lacking and large scale of the previous studies used the food stimulants to investigate the effect of the cooking process on lead and cadmium transfer to cooked food like using of acetic acid (for acidic food), ethanol (for alcoholic food and distilled water (for water-based food) (Zhou et al. 2017).

Commonly, cooked food samples had higher content of lead and cadmium compared to control samples confirming that they can be leached from the cooking pots into food throughout the cooking process depending on the materials which pots made of, also the pitting surface of ancient pots helps in leaching of more lead and cadmium than new ones (Onyeka and Ibeawuchi, 2018).

Table (2) and figure (1) revealed that the highest content of lead noticed in ceramic pots with mean of  $0.32 \pm 0.21 \text{ mg/kg}$ , followed by granite pots which recorded  $0.093 \pm 0.01 \text{ mg/kg}$

and lastly the glass pots with mean of  $0.072 \pm 0.005$  mg/kg after cooking. 33.3% of beef samples which cooked in ceramic pots were accepted and 66.7 % were not accepted (above permissible limit 0.1mg/kg). Meanwhile, all examined samples in glass pots were 100% accepted (below permissible limit 0.1 mg/kg), and 66.7 % of examined samples were accepted while 33.3 were not for granite pots. The percent of leaching for lead were 78.13, 2.7, and 24.7 from ceramic, glass and granite pots, respectively. ceramic pots were significantly higher than glass, meanwhile there was no significant difference between glass and granite pots.

**Table (3) and figure (1)** showed the mean of cadmium concentrations for different cooking pots were  $0.051 \pm 0.02$  mg/kg with a minimum of 0.03 and a maximum of 0.07 for ceramic pots, while for glass pots recorded a mean of  $0.01 \pm 0.0$  mg/kg with a minimum and a maximum of  $< 0.01$  mg/kg, and granite pots mean estimation was  $0.013 \pm 0.01$  mg/kg with a minimum of 0.01 and a maximum of 0.02 mg/kg. 66.7% of meat samples which cooked in ceramic pots were accepted and 33.3 % were not accepted otherwise found to be above permissible limit (0.05mg/kg). Mean while, all examined samples in both glass and granite pots were 100% accepted below permissible limit (0.05 mg/kg), the percent of leaching of cadmium were 78.4, 9.1 and 15.3 from ceramic, glass and granite pots, respectively.

Ceramic pots were significantly higher than glass one while there was no significant difference between glass and granite pots.

When ceramic pots were processed with acetic acid concentration 4%, pb and Cd were released and their amounts increased with cooking time, also the higher the acidity, the increased leached amount of pb and Cd (**Zhou et al. 2017**). Processed ceramic articles with acetic acid 4% at 35°C for 24 hours constituted a lead content of 0.017 mg/kg and 0.015 mg/kg respectively, which increased to 0.022mg/kg and 0.023mg/kg when the temperature was raised to 45°C as mentioned by **Ahmad et al. (2018)**, which were lower than that of the current results. Meanwhile, **Taiwa et al. (2017)**, estimated the migration level which ranged

from 0.1-0.9 mg/l and 0.3 to 4.19 mg/l by using leaching test with acetic acid 4% in ceramic articles for lead and cadmium, respectively. In this regard, **Monika et al. (2018)**, recorded 0.87 mg/l and 0.15 mg/l for pb and Cd in ceramic articles respectively, which were higher than the obtained results of the current study, they added that none of the glass articles transferred pb or Cd (below permissible limit) which oppose with the ongoing study.

The results in the current study considered one of the rare studies dealt with detection of heavy metals (pb and Cd) migration from different cooking pots (ceramic, granite and glass) to food during cooking process.

### CONCLUSION:

In this study, it was obvious that ceramic pots were the most leachable of lead and cadmium followed by granite and lastly glass pots. Migration of such metals from cooking pots within food throughout cooking process depending on the used materials in manufacturing of the cooking pots. Using of pots of low-grade materials and old pitted surface pots should avoided to be used in cooking of food. The present study also suggested that nutritional exposure to lead and cadmium should be minimized as metal exposure has harmful effect on human's health.

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