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Determination of heavy metals in Iranian food packaging plastic

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ABSTRACT: Dissemination of End-users to heavy metal is a salient issue where many researchers have been attentive on this subject for decades. These Metals can unfurl the Human Body via food contact consumption. So this research aims to investigate the content of heavy metals (lead, cadmium, chromium, iron, cobalt, copper, barium nickel, zinc, and arsenic has been determined in thirty-two different Iranian plastic food packaging containers by using Inductive-coupled plasma optical emission spectroscopy (ICP-OES) using Microwave digestion system. In Adding to that, The Investigated packed materials like which Includes Dairy Products, mayonnaises, and kinds of ketchup. The Results ended up claiming heavy metals ranges are Pb(0.018-1258 mg/kg), Cu(0.41-31.13 mg/kg), Ni(0.06-0.866 mg/kg), Zn(7.27-88.69 mg/kg), Fe(4.7-901.6 mg/kg), Cr(0.87-273.13 mg/kg), Cd(0.003-0243 mg/kg), Co (LDL - 0.358 mg/kg) and As(0.017-0.387 mg/kg). Lead (Pb) was detected at concentrations of 0.018-1258 mg/kg in eight of 32 packages. The highest concentrations were detected for Lead in the yellow and green-colored samples.

Keywords: Food Container Plastics, Heavy Metals, Microwave Digestion, And Inductive-Coupled Plasma Optical Emission Spectroscopy.

1. INTRODUCTION

A container that provides a means of marketing, saving, or product handling is referred to as the ‘‘package” word. In many countries, various plastic materials are used in food packaging, and one of the most important that plastic container parts are the lids (POP, Buculei, and Alexe, 2019)

Most food plastic containers are prepared with polystyrene, polypropylene, polyethylene (low and high density), etc. polymers. the plastics kind of food containers that produced from basic polymers requires adding some Additive to reach specific results (stabilizers, formability, coloring agents, plasticizers, antioxidants, curing agents, etc.) (Khan and Khan, 2015). Chemical contamination occurs in these packages.

This process of contamination occurs as a result of the direct or indirect contact between the food and therefore the packing, leading to the transfer of substances between the 2 components, a process called migration (UNGUREANU et al., 2020.) thus, lid and container made from virgin materials or recycled materials can be an important source of contamination of the environment with heavy metals, through heavy metal catalysts used for polymerization processes(Whitt et al., 2013), or through additives added to improve the properties of packaging materials, such as stabilizers, antioxidants, plasticizers, slipping agents(POP, Buculei and Alexe, 2019).

Heavy metals resulting from the migration process reach the body where they will affect the right functioning of biological systems by accumulating them within the body where they will promote the appearance of diseases, even at low concentrations(Sood and Sharma, 2019). The metabolization of heavy metals is difficult by the anatomy because it's 5 times additional denser than water.

Herein, as the concentration exceed the permissible limit, it becomes harmful and leads to toxic health hazards like disorders in the kidney, mental function, respiratory system, nervous system, and many other physiological activities of the body cells and other organs(Kaur, Sharma and Kaur, 2019)

Therefore, it can be accumulated in the body and when their concentration cross their permissible limit, can become harmful and causes toxic health hazards such as disorders in mental function, kidney, nervous system, respiratory system and many other physiological activities of the body cells and other organs(Kaur, Sharma and Kaur, 2019).

In this work, heavy metals and metalloids were determined different techniques and different instruments in the plastic container (UNGUREANU, MUSTĂȚEA and POPA, no date; Bakircioglu, Kurtulus and Ucar, 2011; Khan and Khan, 2015; Turner, 2016; Sood and Sharma, 2019) but this study its new for plastic lid container especially

The purpose of this research was to analyze heavy metals concentration (Pb, Cr, Cd, Co, Ni, Cu, Fe, Zn, Ba, and As) in different kinds of an Iranian food containers with the limits imposed by the rules in force.

2. MATERIALS AND METHODE

2.1 Sampling and preparation

Thirty-two plastic containers were collected from different types of Iranian food which are used for direct food packaging like (Drinks, Dairy products, Ketchup, Dough, and Milk) of the volume that ranged from 250 ml to 1.5 liters of different color at the Lox Agency company in Iraq.

2.2 Reagents and chemicals

Chemicals and reagents such as Nitric acid (65%), Hydrogen peroxide (30%) that are used in the study are supplied by Merck (Germany). An aliquot of an ICP multi-element standard solution (1000 mg/L Chem Lab CRM) containing the analyzed elements (Pb, Cr, Cd, Co, Cu, Fe, Ni, Zn, Ba, and As), was used in the preparation of calibration solutions.

2.3 Instrumentation

The measurement of concentrations was accomplished by using a Thermofisher (iCAP 7600 Dual / ICP-OES). In the table below, the operation conditions of the ICP-OES are shown. Microwave closed vessel microwave system (multiwave Go, Anton Paar, Graz, Austria) was used for microwave digestion.

Table 1 : The operating parameters of determination of elements by ICP-OES.

View Direction	Radial
UV Exposure Time	15
UV RF Power	1150
UV Neb Gas Flow	0.5
VIS Exposure Time	5
VIS RF Power	1150
VIS Neb Gas Flow	0.5
Cool Gas Flow Rate	12
Aux Gas Flow Rate	0.5

2.4 Sample preparation

For heavy metals determination, to a digestion vessel, 0.2 g of the sample is added followed by adding 9:1 nitric acid 65% and hydrogen peroxide 30% according to the program of instruments at 180 °C for 20 min and pressure 90%, sealed the vessel. Digestion was done in the microwave sample preparation system(Hineman, Purcel and Astill, 2010).

2.5 Calibration

For the preparation of calibration solution, An aliquot of an ICP multi-element standard solution (1000 mg/L Chem Lab CRM) containing the analyzed elements (Pb, Cd, Cr, Co, Cu, Fe, Ni, Zn, Ba, and As) was used. The solution of the working standard was prepared by dilution of the stock standard solutions to desired concentration in 1% HNO3. The calibration curves range selected by (5 points) for all the elements. All correlation coefficient r2 achieved was 0.9999. Measuring the detection limits (LOD) depended on the elemental concentrations that gave the standard deviation of a series of three blank solutions measurements.

2.6 Results And Discussion

In this study, ten heavy metals were determined for 32 food plastic containers that are commercially available in the markets. Heavy metals content According to European Directive 94/62/EC (Hänsch and Kinkel, 1995) (Packaging materials) and EU No.10/2011 (Food contact materials)(Union, 2011) on the packaging and packaging waste management to prevent their effects on the environment (consolidated version 2018),

The concentration limit of lead, mercury, hexavalent chromium, and cadmium present in packaging or packaging components have to be less than 100 mg/kg (94/62/EC.) and not exceed 60 mg/kg (EU No.10/2011). Table 2 show the results and it can be observed that:

Pb Concentrations

The monitoring of Pb concentration becomes essential because it is a widely distributed environmental poison and when used in the manufacture of packaging materials is a source of contamination for the food. According to the both mentioned directive and Iraqi standard, the Pb content of any plastic containers in direct contact with food may not

exceed 100 μg g^{-1}. The concentrations of Pb in this study were in the 0.018–1258 mg/Kg range for PL2 and PL27 samples. The 25% of the (8/32) investigated samples had values above the quality limit. While the samples (11,20, 26, 27, and 29) packaging for drinks and liquid products had five to twelve times higher values than the European Council quality limit.

It should be noticed that the migration of heavy metals from the equipment to food might be higher at a relative temperature compared to room temp(Bakircioglu, Kurtulus and Ucar, 2011). So the Iraqi summer weather is generally between 43-50 °C and it's very suitable for migration.

Cd Concentration

Cadmium is a toxic metal causing renal tubular dysfunction and bone toxicity at low exposure levels, such as in the general nonsmoking population. Furthermore, recent evidence suggests an association between elevated cadmium exposure and hormone-related cancers, e.g. breast cancer(Minh *et al.*, 2012) as well as effects on neurodevelopment (Ciesielski *et al.*, 2012)

The Cd contents of plastic food packaging samples analyzed in this study, the Cd content of all samples was below that limit. The values for Cd were in the 0.003–0.245 mg/Kg range.

Cr Concentrations

The recommended daily intake of Cr by the National Research Council, Food and Nutrition Board is 50–200 μg (Bratakos, Lazos and Bratakos, 2002). The Cr levels found in the materials used for this study ranged from 0.87–273.13 mg/Kg, with a mean value of 137 mg/kg. These values are also higher than the surface guideline limits of 100 mg/kg provided by the Council of Europe.

Ni Concentrations

The Ni concentrations in the samples were in the 0.06-0.866 mg/kg range. There is no information available in the literature for maximum allowable nickel levels in plastic. However, the WHO (World Health Organization) recommends a maximum daily intake of 100–300 μg Ni (Meeting, 1994). Thus, the nickel levels found in the samples can be considered as not being a health risk.

Fe Concentrations

Exposure to excess Fe can lead to numerous pathological consequences such as colorectal cancer and heart disease (Nordberg, Fowler and Nordberg, 2014). The Fe is no suggested concentration limit for plastic containers. The average Fe content of the studied samples was 4.7- 901.6 mg/kg. The heavy metal intake limit set by FAO/WHO based on body weight. For an average adult (60 kg body weight), the provisional tolerable daily intake (PTDI) is 214 μg Pb, 48 mg Fe, 3 mg Cu, and 60 mg Zn, respectively(Joint, Additives and Organization, 1999).

Co Concentrations

In the literature, no information is available for safe cobalt levels in food packaging plastic. The maximum concentration of Co for the cheese packaging material tested in this study was 0.358 mg/kg, indicating that there are no health safety concerns from its cobalt content.

Ba Concentration

The toxic outcomes of barium compounds include cardiac and/ or renal failure, pulmonary edema, respiratory paralysis, and gastric as well as intestinal hemorrhages, Barium sulfate and barium hydroxide play a role in plastic and papermaking(Sood and Sharma, 2019). The maximum allowed limits barium migration according to Regulation (EU) no. 10/2011are 1.0 mg/kg. However, the barium value in this work was found in the 0.04-159.5 mg/kg range for plastic containers respectively. In this study the mean value of barium was 79.8 mg/kg almost eighty times higher than the migration range

Cu Concentration

Copper is known to be important and toxic for many biological systems. It may migrate from soil to food materials through mineralization by crops, environmental contamination, or food processing.

The average daily dietary requirement for copper in the adult human has been estimated at 3 mg(Joint, Additives and Organization, 1999). The copper values in this work were found 31.13 for PL24 plastic containers respectively. The mean value for copper in this study was 14.68 almost higher than The average daily dietary requirement for Cu in the adult human has been estimated to be 3 mg (Joint, Additives and Organization, 1999).

Zinc Concentration

Zinc is a nutritionally essential metal, and a deficiency results in severe health consequences, the consequences of Zinc deficiency in a huge spectrum of clinical effects depending on age, stage of development, and deficiencies of associated metals. At the other extreme, excessive exposure to zinc is relatively uncommon and occurs only at very high levels (Bakircioglu, Kurtulus and Ucar, 2011). The zinc content of substances in contact with galvanized copper or plastic pipes may be increased. The maximum tolerable daily intake of zinc is 60 mg (Joint, Additives and

Organization, 1999). In this experiment, the values of zinc for plastic container samples are 88.69 mg/kg range generally higher than the WHO's values (Table 2).

Table 2: the concentration of the heavy metals in (mg/Kg)

Sample	Cr	Cd	Co	Cu	Fe	Ni	Zn	Ba	Pb	As
PL1	9.645	0.03	0.049	29.372	13.659	0.241	63.564	3.894	41.593	0.221
PL2	2.204	0.017	0.107	1.355	7.524	0.36	67.636	0.761	0.018	0.09
PL3	2.299	0.021	0.049	0.925	19.983	0.098	61.812	1.472	0.965	0.066
PL4	1.942	LDL	0.03	0.507	17.707	0.294	58.991	74.653	0.035	0.223
PL5	1.831	0.083	0.125	13.226	20.236	0.06	88.695	1.005	11.93	0.122
PL6	42.394	0.004	0.059	20.311	9.176	0.662	63.959	16.119	186.615	0.042
PL7	1.833	0.006	0.061	1.504	5.993	0.254	54.496	1.23	0.012	0.165
PL8	1.714	0.003	0.059	1.515	6.136	0.158	51.268	0.219	0.084	0.185
PL9	1.74	0.013	0.095	1.611	12.921	0.275	58.472	0.689	0.023	0.165
PL10	2.188	0.009	0.058	0.799	25.963	0.672	77.633	3.298	1.02	0.099
PL11	107.999	0.01	0.024	0.808	5.03	0.252	59.514	58.74	499.845	0.049
PL12	1.922	0.02	0.056	16.851	15.259	0.219	60.85	4.07	0.052	0.098
PL13	1.654	0.014	0.01	0.532	13.46	0.209	50.698	1.404	0.024	0.112
PL14	0.87	0.01	0.073	26.631	13.347	0.307	57.222	2.59	0.121	0.024
PL15	1.858	0.002	0.126	19.319	6.846	0.263	76.568	0.09	0.162	0.248
PL16	1.876	0.023	0.106	18.938	16.925	0.255	57.112	159.578	0.014	0.115
PL17	1.882	0.024	0.025	0.883	15.891	0.265	51.598	0.863	0.093	0.017
PL18	25.649	0.008	0.073	1.763	9.952	0.276	60.063	9	113.557	0.121
PL19	1.876	0.012	0.021	0.437	17.037	0.276	57.101	70.936	0.089	0.033
PL20	239.999	0.008	0.075	0.554	6.111	0.866	7.27	83.047	1,192.32	0.355
PL21	2.655	0.01	0.069	26.051	15.161	0.739	18.858	1.092	0.518	0.235
PL22	5.232	0.024	0.076	2.018	901.591	0.756	91	0.616	0.469	0.224
PL23	4.387	0.01	0.358	0.364	370.65	0.56	76.385	1.895	5.217	0.387
PL24	47.252	0.026	0.048	31.135	12.026	0.479	78.129	18.562	231.19	0.017
PL25	2.935	0.011	0.082	23.214	10.171	0.491	76.793	2.419	0.338	0.289
PL26	207.244	0.005	0.04	0.593	5.987	0.518	14.567	58.735	898.413	0.281
PL27	273.13	0.245	0.079	1.597	7.8	0.696	15.342	2.756	1,258.60	0.173
PL28	7.861	0.013	0.038	0.638	5.836	0.553	21.118	5.964	26.664	0.252
PL29	205.621	0.016	0.084	0.489	4.755	0.767	15.418	0.048	1,045.80	0.059
PL30	2.756	0.033	0.06	0.41	5.385	0.571	12.542	0.342	0.38	0.384
PL31	3.322	0.006	0.073	5.646	11.998	0.633	46.727	0.332	2.751	0.232
PL32	2.691	0.005	0.064	6.836	6.83	0.361	81.952	0.787	0.498	0.273

3. Conclusion

Today most food packaging is plastic-type. The food factory and scientists are faced with great difficulties in the attempt to control toxic elements leaching into foods from their respective packaging materials. Only limited data are currently available for permissible maximum levels of toxic metals. Restriction limits have been established for cadmium, lead, and nickel by the Council of Europe. Iran hasn't regulation for the lead content of food packaging. The determination of metals in the samples has been estimated successfully using ICP-OES. Herein, using of microwave digestion for plastic sample made the preparation procedure faster, most effective, simpler, and less contaminated

In conclusion, the samples in this study show below maximum legal concentrations of Fe, Co, Ni, Ba, Cd, Cr, and Cu, except for Pb that found in the 8 samples PL6, PL11, PL18, PL20, PL24, PL26, PL27 and PL29, most of the samples

are a container of liquid food and have more risk for health. And most of this lead comes from the pigments and additives used during plastic preparation.

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