

STUDY THE CONTAMINATION OF SOME CHEMICAL POLLUTANTS IN HOT FOODS STORED IN PLASTIC BAGS AND CONTAINERS

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ABSTRACT

Plastic food containers and bags are classified as the most dangerous food and water contaminants around the world, because of the possibility to transfer the chemicals from it to food as a result of heating. Therefore this study was aimed to estimate the chemical pollutants (heavy metals included lead, cadmium, arsenic, mercury and zinc) that transfer from plastic food containers and bags to food. Thirty food containers (15 packages and 15 bags) synthesized from Polyethylene Terephthalate (PET) were purchased from the local market in Baghdad. Cut each into small equal pieces (0.5×0.5) cm and placed in a thermo glass containers then submerged 3 food solution (D.W, 3%, acetic acid, and olive oil). Two thermal treatments were done on it; the first one was carried out by boiling on a hot plate surface for 10 and 15 minutes, and the second by heating in microwave for 5 and 10 minutes, heavy metals were estimated by using Atomic Absorption technique. The results showed the significant difference between the concentration of the elements at level ($p < 0.05$) in these treatment. Also transfer of heavy elements at zero time was very small percentage and insignificant, and the concentration of heavy metals in three solutions were increased as $C > B > A$ after treated with two thermal treatment. The concentration of all heavy elements in this solution after heating for 10 minutes and heating in microwave for 5 and 10 minutes. Were higher than the acceptable limits by the Food and Drug Administration (FDA) and European Commission (EU).

Key words: Food pollution, heavy metals, atomic absorption technique.

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دراسة التلوث ببعض الملوثات الكيميائية في الأطعمة الساخنة والمحفوظة بأكياس وعبوات بلاستيكية

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المستخلص

تصنف أواني وأغلفة حفظ الطعام البلاستيكية كأخطر ملوثات للغذاء والماء حول العالم، وتكمن خطورتها في احتمال حدوث انتقال للمواد الكيميائية منها إلى الغذاء نتيجة التسخين، لذا أجريت هذه الدراسة لتقدير الملوثات الكيميائية مثل العناصر الثقيلة (الرصاص والزرنيخ والكاديوم والزنك والانتيمون والزنك) المنتقلة من أواني وأغلفة الطعام البلاستيكية إلى الغذاء، تم شراء 30 حاوية غذاء (15 علبة و15 كيس) والمصنفة من مادة البولي اثيلين (Polyethylene Terephthalate (PET)) من الاسواق المحلية لمدينة بغداد. قطع كل منها إلى أجزاء صغيرة متساوية الحجم (0.5 × 0.5) سم ووضعت في أواني زجاجية حرارية ثم غمرت في ثلاث محاليل غذائية بصورة منفصلة شملت (ماء مقطر ، حامض الخليك بنسبة 3% ، زيت الزيتون). اجريت على القطع المغمورة معاملتين حراريتين شملت الاولى التسخين بالحرارة على سطح ساخن لمدة 10 و15 دقيقة، أما الثانية فكانت التسخين بالميكرويف لمدة 5 و10 دقائق وتم تقدير العناصر الثقيلة باستعمال تقنية الامتصاص الذري. بينت النتائج وجود فروق معنوية بين تراكيز العناصر عند مستوى دلالة ($P < 0.05$) في المعاملتين في حين لم يحدث انتقال للعناصر الثقيلة عند الوقت صفر إلا بنسب ضئيلة جداً وغير معنوية، كذلك بينت ان التسخين بالغلان لمدة 10 و15 دقيقة والتسخين بالميكرويف لمدة 5 و10 دقائق أدى إلى ارتفاع تراكيز العناصر الثقيلة في المحاليل الثلاث لتكون الهجرة $C > B > A$ إذ كانت تراكيز جميع العناصر الثقيلة في المحاليل بعد التسخين 10 والتسخين لمدة 5 و10 دقائق بالميكرويف أعلى من الحدود المقبولة التي وضعتها هيئة الغذاء والدواء (FDA) والتشريعات الاوروبية EU Commission.

الكلمات المفتاحية: تلوث اغذية، عناصر ثقيلة، تقنية الامتصاص الذري.

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INTRODUCTION

Food safety from different toxins is a major source of concern for food manufacturers, regulators, consumers and consumers around the world, food contamination refers to the presence of toxic chemicals or microbial pathogens that can have adverse health effects on humans (5, 18), the effect of chemicals on consumer health is often apparent after long exposure and at low levels, usually, chemical pollutants present in foods are not affected by the temperature used in cooking, but they remain in them and do not break down because they are often resistant to high temperatures (7). The packaging process protects packaged food from damage by external factors such as pests, unwanted odors, microorganisms, light and oxygen, so, food packaging factories seeks to produce and develop high quality, multilayer carton, mineral and polymer packaging systems which are supposed to be non-perishable, decomposing, interaction and interfering with food to allow the marketing of pre-cooked foods while retaining most of its desirable characteristics to the consumer, such as prolonging life of the product, while keeping it as fresh as possible, preserving the taste, flavor, color and smell desired and characteristic of that food, it provides a appropriate mechanism for serving the consumer in a single meal that can be prepared in a few minutes either by immersing and boiling the food bag in water or heating in the normal oven or microwave (3, 12, 20). Food and beverage products may be highly reactive with the substances they touch, they are good as many solvents used in chemistry lab, for example, food acids can cause corrosion of metals, and can decompose fats, oils and the plastic material leakage, reacts with it, drinks can break up paper and unprotected cardboard, in practice, there are no fully functional nutrients, so their chemical components may migrate to packaged food, glass, ceramics, plastics, rubber and paper can release accurate amounts of their chemical components when they touch certain foods (2,7). The transmission of chemical contaminants from food contact materials is called migration, a source of significant contamination of food, the transfer of chemical pollutants from the packaging to the food depends on various

factors such as the physiochemical characteristics of the transfer process, the type of packaging material and the type of food (fat, acidic, salt, etc.), temperature, storage time, and the size of the package is proportional to the size of the food stored in it, and the types of chemical pollutants that can be transported from the package to food are very numerous and varied [19,8]. The chemical contaminants that move from the packaging to the food are divided into two categories, the first category includes polymeric and chemical materials that are intentionally added to the plastic packaging's in operation to ensure certain characteristics are required in the package, These include antiperspirants, antioxidants, UV stabilizers, paints, printing inks, etc. which can migrate or migrate from the packaging to food, in addition, residues of the polymeric materials from which the packaging is made may be transported mainly to food, the target category also includes intentionally added chemicals such as food additives for flavor, taste, bleach, antioxidants, etc., added to food when manufactured, the second category could come from unintentional chemical pollutants during production, processing, packaging, transport and storage operations (9, 18). Food packaging materials are sources of pollution with heavy metals that can migrate from the packaging to the food product, these heavy metal elements and metal compounds may be hazardous to human health such as arsenic, barium, cadmium, lead, mercury and other elements, that may be present in small concentrations, but some of them very dangerous to health even those concentrations (22), these heavy metal may exist in the food within the permissible limits, but because of their ability to accumulate in the human body occur diseases and symptoms of serious damage to the nervous system and problems in the process of digestion and representation of food and is a factor in the incidence of tumors and cancers, may disrupt metabolic functions inside the human body in two ways, either accumulate in organs such as the heart, brain, liver, kidneys and bones and thus disrupt the function of those members, or substituting useful biological food minerals, thus inhibiting or chelating them in their biological function

in metabolism of nutrients within the body (4). Due to the multiplicity and spread of packaging materials from various local and foreign producers in the Iraqi markets and their use in packing various kinds of foodstuffs, and because of the lack of health culture by most owners of packaged and ready-made food factories, restaurant owners and consumers the great risks caused by misuse of these materials during the process of heating food or save and sell it is hot in plastic packaging, or through the use of some plastic containers in the preservation of acidic and fatty foods, the aim of this study was to investigate chemical contamination of heavy metal elements that may be transferred from

plastic containers and packages to food and hot beverages.

MATERIALS AND METHODS

The transfer of heavy metal elements from bags and plastic containers to the foods stored there was studied based on recommendations adopted by the US Food and Drug Administration and the European Food Commission (11, 13) Which classified foods depending on their type, grade of fat content, sugar and alcohol content, Accordingly, the liquids in the food to be studied were divided into groups to simulate natural food solutions, which could measure the extent of migration between food and packaging materials based on a study (6) as in Table 1.

Table 1. FDA and EU recommended for alternative food simulants:

simulants	alternative food simulants
Simulant A	Water for aqueous foods
Simulant B	3% w/v acetic acid for acidic foods
Simulant C	Rectified olive oil for fatty/oily foods

Samples collection

Disposable plastic bags and containers that purchased from the local markets of Baghdad from polyethylene terephthalate (PET), were transferred to the laboratories of the Market Research and Consumer Protection Center / University of Baghdad, after stored in clean containers until laboratory tests

Experience design

The experiment of this study was designed according to a study (17) with some modification; three experimental solutions were prepared (D.W. only, D.W. + 3% acetic acid, olive oil). The plastic bags and packages

were cut into regular pieces (0.5 cm x 0.5 cm) each type were placed separately in tight closed thermocouple containers of suitable size, then added 15 ml of each experimental solution to each type of plastic (bag and package), the last separately samples of some samples were treated with heat by hotplate surface until boiling for 10 and 15 minutes, the others treated by putting inside the microwave oven and heat for 5 and 10 minutes separately as shown in (Table 2). All samples were left to cool and analyze to estimate the transfer of chemical contaminants from packaging to food.

Table 2. Design of the experiment in terms of types of plastic polymers, types of food simulants solutions and standard thermal transactions

package-food	food simulants	zero time	Boiling for 10 min.	Boiling for 15 min.	Microwave for 5 min.	Microwave for 10 min.
polyethylene terephthalate (PET)	Distilled	some	some	some	some	some
	Water	samples	samples	samples	samples	samples
	3% w/v acetic acid					
	Rectified olive oil					

Samples preparation

One to two ml of cooled solutions were transferred to a glass bottle and sealed with a silicone seal, placed in the helium vaporizer at room temperature.

Preparation of solutions and glass

All the standard solutions were prepared for the experiment, deionized water used for dilutions; HClO₄ acid was supplied by E.Merck, Germany, and dilution 10% with deionized water. All glass tools and bottles were cleaned with nitric acid (10%) then

washed with non-ionic water twice and dried well.

Calibration standards preparation

Standard calibration solutions for heavy metals (lead, cadmium, arsenic, mercury and zinc) were prepared at the same time it was prepared with 5% nitrates at concentrations 0, 0.1, 0.2, 0.4, 0.6, 0.8, 1 mg / dcm³.

Determination of heavy elements in samples

Heavy metal elements lead Pb, cadmium Cd, arsenic As, mercury Hg and zinc Zn were estimated filtration the samples using Shimadzu AA-6200 supplied with ASC 6100 auto sampler atomic absorption spectrometer provided according to the method mentioned (16) and by using acetylene gas then compared

with standard solutions. The concentrations of mg / dcm³ were converted to mg / kg.

Statistical analysis

The Statistical Analysis System- SAS (2012) program was used to explain the effect of difference factors in study parameters. Least significant difference –LSD test were used to significant comparing between means in this study (24).

RESULTS AND DISCUSSION

The results shows in Table (3) that amount of heavy metal elements in the PET plastic samples were treated with the simulant solution (water only), There were significant differences between the levels of the elements in the treatments at the level of significance ($P < 0.05$).

Table 3. Concentration of heavy metals in plastic samples treated with a distilled water solution (Simulant A), estimated at mg / kg

package-food	food simulants	zero time	Boiling for 10 min.	Boiling for 15 min.	Microwave for 5 min.	Microwave for 10 min.
polyethylene terephthalate (PET)	Distilled Water 3% w/v acetic acid Rectified olive oil	some samples	some samples	some samples	some samples	some samples

The results in Table 3 show that concentrations of all heavy metals at zero time before the treatment were very small and almost insignificant, but after heating for 10 minutes it seems that the migration of heavy elements became slightly higher concentrations while within the acceptable limits approved by the legislative organizations (15,25), arsenic, mercury and lead concentrations were 0.0011, 0.0010 and 0.0011 mg / kg, respectively, this corresponds to the findings of (23,28) which indicated that migration is virtually zero at zero time of thermal treatment, however, concentrations of heavy elements soon begin to increase with heat treatment in boiling and in microwave after treatment for 10 minutes. At boiling point for 15 min it became clear that concentrations of most elements exceeded the acceptable limits to 0.0212, 0.0067, 0.0054, 0.1023 and 0.3102 mg / kg respectively except of cadmium, which did not exceed the acceptable limit, with a concentration of 0.0438 mg/ kg, this was confirmed by (21) when they mention

that the transfer of mineral pollutants from plastic food containers to food during cooking with water only, and they find that the concentrations of lead and cadmium reached 0.8790 and 0.6751 mg / kg, respectively. After 15 minutes of cooking, all heavy element concentrations were significantly increased. After 10 minutes of microwave treatment the results were similar to (7) when they heated plastic cans in distilled water, and found the concentrations of lead, mercury, cadmium and antimony compounds were reached to 0.1213, 1.1042, 1.7211 and 2.4532 mg / kg, respectively, while (23) indicated a significant increase in heavy metals concentrations due to migration during microwave heating for 15 minutes to 0.7630, 4.7612 and 6.8761 mg / kg for elements of mercury, cadmium and antimony, respectively. Table 4. shows the concentration of heavy metal elements in plastic samples treated with 3% acetic acid (Simulant B). Significant differences between element levels were observed at ($P < 0.05$).

Table 4. Concentration of heavy metals in plastic samples (PET) treated with 3% acetic acid (Simulant B), estimated at mg / kg

Heavy Metals	Control Zero time	Boiling for 10 min	Boiling for 15 min.	Microwave for 5 min.	Microwave for 10 min.	LSD value	Permissible limits
Pb	0.0121	0.1324	2.3412	2.9723	4.1023	0.739 *	0.01
As	0.0042	0.0251	0.1087	0.1304	0.2122	0.074 *	0.005
Cd	0.0113	1.1072	3.1365	3.4265	4.1145	0.825 *	0.1
Hg	0.0057	0.0341	0.1272	0.2001	0.7612	0.306 *	0.005
Sb	0.0134	2.3153	3.9823	3.3892	4.1037	0.655 *	0.025
Zn	0.0612	1.1724	3.5420	4.1022	5.9832	0.609 *	0.2

* (P<0.05).

At time zero before treatment, the levels of the elements were very small and insignificant except for the antimony and zinc, which appeared at 0.0134 and 0.0612 mg / kg, although there are within acceptable limits, but it indicates the sensitivity of this element to acid solutions, which causes the migration of packaging materials to food, this is confirmed by (26) when they mention to sensitivity of this element in the plastic bottles of beverages and juices. The concentrations of migratory heavy metals from the food packages and containers treated with the Simulant B solution increased after 10 minutes of boiling, all of which exceeded the acceptable limits, especially in cadmium 1.1072 mg / kg , antimony 2.3153 mg / kg and zinc 1.1724 mg / kg, these results were similar to those of (9,21) when found that the transmission of these elements was 2.5431, 2.9754 and 2.0891 mg / kg respectively in the first study, and 2.1102, 1.9231 and 1.6754 mg / kg for the same elements in the second study, also after the boiling for 15 minutes, the concentration of all elements increased significantly, that indicating the significant effect of boiling for

medium period on the transport of heavy elements from the covers to the acidic fluids, this was confirmed by (21) when obtain the concentrations of lead, mercury, and antimony compounds were 2.6541, 0.6511 and 3.5422 mg / kg in cooking plastic containers in acidic medium for 15 minutes. The concentrations of heavy metals migrated from food packages to the acid solution by heated in microwave oven for 5 and 10 minutes record of the high levels in lead elements 2.9723, 4.1023 mg / kg, cadmium 3.4265, 4.1145 mg / kg, antimony 3.3892, 4.1037 mg / kg, zinc 4.1022 and 5.9832 mg / kg, respectively. The studies of (1, 27) indicated a significant increase in the concentrations of lead, mercury and antimony elements from the acceptable limits when treated with a 10-minute acidic acid solution to 5.1233, 1,0123 and 4.7651 mg / kg respectively in the first study and 4.9102, 1.3661, and 5.0982 mg / kg respectively in the second study. Therefore the results indicated that great effect of transfer or migration of heavy element from packing materials to food when heating by microwave.

Table 5. Concentration of heavy metals in plastic samples treated with olive oil (Simulant C), estimated at mg / kg

Heavy Metals	Control Zero time	Boiling for 10 min	Boiling for 15 min.	Microwave for 5 min.	Microwave for 10 min.	LSD value	Permissible limits
Pb	0.0118	0.2611	2.9811	3.6532	5.0137	0.508 *	0.01
As	0.0014	0.0392	0.5355	0.4021	0.7666	0.259 *	0.005
Cd	0.0143	1.8326	4.0921	4.9065	6.1092	1.019 *	0.1
Hg	0.0048	0.1078	0.6343	0.5657	0.7344	0.357 *	0.005
Sb	0.0154	1.6521	4.0212	5.0133	7.2092	0.926 *	0.025
Zn	0.0723	1.8722	2.8872	4.9323	7.3102	1.192 *	0.2

* (P<0.05).

Table 5 shows the concentration of heavy metals in the plastic samples (PET) treated with olive oil (Simulant C). The results showed significant differences between the levels of elements at the level of significance

(P <0.05) in treatment, the concentrations at zero time before thermal treatment were very small and almost insignificant in most treatments except lead (0.0118 mg / kg), which was clearly affected by the oil solution, that

mean it was on the edge of the acceptable limits of 0.01mg / kg, while after 10 minutes of boiling, the concentrations of all heavy metals increased from acceptable limits to 0.0392, 1.8326, 1.6521, 0.1078 and 1.8722 mg / kg in arsenic, cadmium, antimony mercury and zinc, respectively. And after 15-minute of boiling a stronger effect than its predecessor on heavy element concentrations, these results were consistent with (9) when they study the treatment of plastic containers at boiling temperature in an oil medium for 10 to 20 minutes, the heavy metals migration recorded high levels of 3.7621, 1.0032, 5.7102 and 1.0923 mg / kg for lead, arsenic, antimony and zinc respectively, Kigozi, et al. (17) pointed out that the migration of heavy metal elements from plastic to food at boiling temperatures in oil solution for 20 minutes was 6.0924 and 2.9871 mg / kg for the antimony and lead elements, respectively. The concentration of heavy metals transported from the plastic containers to the oil medium recorded very high levels when heated with microwaves for 5 and 10 minutes. The concentration of lead was 3.6532 and 5.0137 mg / kg, cadmium 4.9065, 6.1092 mg / kg, and antimony 5.0133 and 7.2092 mg / kg Respectively, zinc 4.9323 and 7.3102 mg / kg respectively, and the concentrations of all elements were well above the acceptable limits established by the legislative organizations concerned with food contamination (11,27), while Galotto and Guarda (14) reported the removal of heavy metals and high concentration of plastic containers into fatty solutions of foods when treated with high temperatures such as boiling and heating with microwaves for 25 minutes, the concentrations of lead, mercury and antimony compounds reach to 6.9102, 1.9821 and 8.7234 mg / kg, respectively.

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