

# Determination of Some Heavy Metals in Cosmetic Products Collected from Benghazi-Libya Markets During 2016

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## Abstract

**Introduction:** Cosmetics have been utilized by most of the people irrespective of their race, gender, or age to beautify, modify, or improve the physical appearance. Many cosmetic products contain heavy metals as ingredients or impurities. Recent research has reported that these metals can cause many types of health and skin problems. **Aims:** The aim of this study is to detect the levels of heavy metals in some cosmetic products that are available in cosmetic shops around the city of Benghazi. **Materials and Methods:** Twenty-five of cheap facial cosmetic products that are widely in demand in cosmetic shops in Benghazi were collected in April 2016. The samples included eight kohl, seven eyeliners, and ten lipsticks. Metals including iron, copper, chromium, zinc, lead, and cadmium were analyzed in the selected samples using flame atomic absorption spectrophotometer after suitable digestion process. **Results:** Our results indicated that iron and copper were detected in all samples with concentration ranges varying from 0.5 to 124.5 mg/kg for iron and 1.8–51.4 mg/kg for copper. The concentration ranges of chromium, zinc, cadmium, and lead were varied from 0.0 to 7.25 mg/kg, 0.0 to 22.75, 0.0 to 125.0 mg/kg, and 0.0 to 20.25 mg/kg, respectively. **Conclusions:** The results showed that the selected metals were detected in most of the samples at varying concentrations. Kohl samples have the highest concentration of the analyzed metals. According to the maximum allowed limits recommended by the World Health Organization (WHO) for toxic metals in cosmetics, there was only one sample that had lead concentration higher than the maximum limit recommended by the WHO. In addition, there were twenty samples that had concentrations of cadmium above the WHO legislation limits.

**Keywords:** Benghazi, cosmetic products, eyeliner, heavy metals, kohl, lipstick

## INTRODUCTION

Cosmetics are defined as any substance or preparation intended to be placed in contact with the various external parts of the human body or applied to the teeth and the mucous membranes of the oral cavity. Cosmetics are mainly used for the purpose of cleaning, perfuming, protection, changing their appearance, correcting body odors, and keeping the surfaces in good condition.<sup>[1]</sup> Cosmetic products contain thousands of chemical substances; a group of these dangerous substances are heavy metals, such as lead, cadmium, nickel, arsenic and mercury, chromium, iron, copper, and cobalt.<sup>[2-4]</sup> Those metals and their compounds were used for different purposes in the cosmetic industry, mainly as ultraviolet filters in face and body care products and pigments in colored cosmetics.<sup>[2]</sup> The presence of heavy metals in cosmetic products cannot be forbidden. The cosmetic products may also be contaminated using metal-coated apparatuses during cosmetic production processes.<sup>[1,5]</sup> Owing

to the harmfulness of metals to human health, their presence in cosmetic products is restricted by several global health regulations such as World Health Organization (WHO)<sup>[6]</sup> and health legislations in various countries, including Germany,<sup>[6,7]</sup> Canada,<sup>[8]</sup> Jordan,<sup>[9]</sup> and European Union (EU) countries.<sup>[2,6]</sup> These regulations and their limits are based to provide a high level of protection to a consumer.

As a result of the health-related toxic effects of heavy metals, it is necessary to monitor commercially available cosmetics regarding the concentrations of metals, in order to recognize whether the concentrations are within the safe values ranges

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**How to cite this article:** Rahil SY, Elshara IA, Ahmida NH, Ahmida MH. Determination of some heavy metals in cosmetic products collected from Benghazi-Libya markets during 2016. *Libyan Int Med Univ J* 2019;4:10-7.

**Received:** 03-11-2018 **Accepted:** 06-03-2019 **Published:** 28-05-2019

### Access this article online

Quick Response Code:



Website:  
journal.lim.u.edu.ly

DOI:  
10.4103/LIUIJ.LIUIJ\_44\_18

for human health. Atomic absorption spectrometry (AAS) and inductively coupled plasma mass spectrometry are used to analyze the metal in cosmetic samples. In fact, prior to quantification of heavy metals, cosmetic sample should undergo a digestion process, to convert the components of matrix into simple chemical forms. Numerous methods, including wet-digestion and dry-ashing digestion methods, have been proposed to prepare cosmetic sample for elemental analysis.<sup>[10-13]</sup>

There are plenty of information about the detection of toxic metals in colored cosmetics, especially in Arab Countries.<sup>[14-19]</sup> However, no attempts have been done to investigate the presence of heavy metals in samples from cosmetic product shops in the city of Benghazi. Therefore, the purpose of this study was to identify the safety of some facial cosmetic products that are widely vended in stored around the city of Benghazi by determination of the heavy metals (including lead, cadmium, iron, copper, chromium, and zinc) using flame atomic absorption spectrophotometer (FAAS).

## MATERIALS AND METHODS

In this study, 25 of facial cosmetic products, including 8 kohl, 7 eyeliners, and 10 lipsticks, were purchased from cosmetic product shops in Benghazi, Libya. Most of these products are imported from countries that have weak regulatory inspection and screening as well as no standards for manufacturing. The prices of the selected cosmetic products ranged from 1 to 10 Libyan dinars. Codes are assigned to the products in place of their brand names as shown in Table 1. The information on the container labels and contents were carefully examined visually and noted for any defects or irregularities, such as cracks or leaks. Name of products, dates of manufacture and of expiry, preservative used, if any, as well as ingredient list on the labels of these products were noted and reported in Table 1.

### Chemicals and reagents

All chemicals and reagents that were used in the experimental work were of analytical grade. These chemicals included concentrated nitric acid (65%, Codex) and perchloric acid (70%, Merck). Hydrogen peroxide (30%) and sulfuric acid (98%) were obtained from Hopkin and Williams Chemical Ltd. Standard stock solutions (1000 ppm) of cadmium, chromium, copper, iron, zinc, and lead were purchased from Scharlau. These standards were used to prepare calibration solutions. Distilled deionized water was used for the preparation of all solutions.

Before the experiments were carried out, the glassware containers were soaked in water and soap and rinsed several times with tap water and then soaked them for 24 h in bath containing 10% nitric acid solution, to clear out any metal on the glassware surface. The containers were rinsed thoroughly with deionized water.<sup>[20,21]</sup>

### Procedure

The kohl and eyeliner samples were dried to constant weight in an oven at 80°C for 12 h. The dried samples were grounded

and homogenized in a mortar. About 0.1 g of sample was weighed in a clean test tube. The sample was digested with 5.0-ml nitric acid and 2.5-ml hydrogen peroxide using hot block digester (Grant QBT2 Digital Block Heater, England). The sample was heated at 60°C for 15 min. The heat was then increased to 130°C and digested for 1 h.<sup>[22,23]</sup>

Lipstick samples were first crushed in an agate mortar and then mixed well. About 0.25 g of each sample was weighed out in a test tube, and 2 ml of nitric acid, 2 ml of sulfuric acid, and 1 ml of perchloric acid were added.<sup>[1]</sup> Then, the digestion process was followed as mentioned for kohl and eyeliner samples.

After the digestion process, sample solutions were allowed to cool and then poured into 25-ml volumetric flask. The sample remaining in the tube was removed by rinsing several times with deionized water. The rinsing water was mixed with the previous sample in the flask and was used to make the solution up to the mark. The sample solution then was filtered using Whatman No. 41 filter paper. The absorbance of each sample solution was measured using FAAS (GBC model 932 Plus FAAS with GBC Avanta Software, version 1.33, GBC Scientific Equipment Ltd., Braeside, Victoria, Australia). The operating conditions adjusted in the spectrometer were carried out according to the standard guidelines of the manufacture. The concentrations of the elements in the sample solutions were determined from curves of absorbance versus concentration of the standard solutions. Blank solutions were prepared under identical conditions.<sup>[24]</sup>

### Statistical analysis

All the experiments of metal analysis were performed in duplicate, and the results were expressed as mean (mg/kg) ± standard deviation (mean ± SD). The analytical determination data were tested for normality distribution using the Shapiro–Wilk test.<sup>[25]</sup> When the data were normally distributed, the parametric statistical tests of mean comparison were applied. In this case, the comparisons between the different cosmetic products were performed by the one-dimensional variance analysis (one-way ANOVA) test, followed by the least significant difference test. For the data that did not follow a normal distribution, nonparametric Kruskal–Wallis test was performed.<sup>[26]</sup> All the statistical analysis and quality control tests were carried out using the Statistical Package for the Social Sciences (SPSS) (SPSS version 19.0; IBM, Chicago, Illinois, USA) Program, adopting the significance level of 5% ( $P < 0.05$ ).

## RESULTS

The results of analysis of six heavy metals, including chromium, copper, iron, zinc, lead, and cadmium, using FAAS in cosmetic samples were shown in Tables 2 and 3.

Significant levels of iron have been found in all cosmetic samples ranging from 1.625 to 27.57 mg/kg in kohl, from 0.50 to 9.95 mg/kg in eyeliner, and from 0.6 to 124.5 mg/kg in lipstick. The highest concentration of iron was detected

**Table 1: List of cosmetics, their codes, and container label disclosures of the collected samples**

Cosmetic product	Sample code	Color	Country of manufacture	Manufacture and expiry dates	Other information
AL-SHERIFAIN (Kohl)	A1	Black	India (by Khojati Herbal Company)	Manufacture date: December 2013 Expiry date: Best before 3 years from Mfd.	Batch number: 1125 Free from lead Ingredients
HARMANIN'S SURMA (Kohl)	A2	Black	Pakistan	-	Most useful for eye troubles
AL REEHANA (black Arabic kohl)	A3	Black	-	-	-
AL HASHEEMI (kohl)	A4	Black	Karachi, Pakistan	Manufacture date: March 2015 Expiry date: March 2020	-
HARMAIN'S SURMA (kohl)	A5	Black	Pakistan	-	Most useful for eye troubles
ALBAYLESEN (kohl)	A6	Black	-	-	Pure Arabic kohl consists of natural stone powder
ATHMED ( <i>ALMAKHALA ALNABAWIAH</i> ) (kohl) Zam Zam and Rose Water	A7	Black	Al-Madinah, Saudi Arabia	Manufacture date: January 2013 Expiry date: January 2016	Original quality 100% pure
AL-ASMAD (AL-HARMAIN) (kohl) Zam Zam and Rose Water	A8	Black	Al-Madinah, Saudi Arabia	-	Original quality 100% pure
Flormar Waterproof eyeliner	E1	Black (number 101)	EU	-	Ingredients*
Flormar Ultra black eyeliner	E2	Black (number 02AG)	Langenfeld, Germany	-	Ingredients*
The Colossal Kajal (eyeliner)	E3	Black	Pakistan	-	-
Flormar Waterproof eyeliner	E4	Blue (number 109)	EU	-	Ingredients*
EVER BEAUTY Sword pencil 24 h (eyeliner) Waterproof and long staining	E5	Green (number 027)	China	Manufacture date: April 2013 Expiry date: April 2018	Ingredients* -
Flormar Waterproof eyeliner Kohl pencil (eyeliner)	E6	Black (number 101)	Czech Republic	-	Ingredients*
Flormar (eyeliner) (DIPLINER)	E7	Black	Black	Manufacture date: July 19, 2016 Expiry date: July 19, 2021	-
LOREAL (lipstick)	L1	Red (number 296)	Paris, France	-	-
LOREAL (lipstick)	L2	Brown (number 236)	Paris, France	-	-
LOREAL (lipstick)	L3	Brown dark (number 214)	Paris, France	-	-
FARMASI (Maxi Rouge Lipstick)	L4	Pink (number 06)	Turkey	Manufacture date: January 2012 Expiry date: January 2016	Batch number: 0689
Beauty (lipstick)	L5	Light-Shiny brown	-	-	-
Beauty (lipstick)	L6	Reddish brown	-	-	-
Beauty (lipstick)	L7	Dark brown	-	-	-
Final Touch (lipstick)	L8	Red (number 107)	China	-	-
Final Touch (lipstick)	L9	Pink (number 116)	China	-	-
Final Touch (lipstick)	L10	Orange (number 120)	China	-	-

\*Active ingredients of A1 sample contain: Sankh 42.5%, Sufoof-E- Syah 42.5, BhimseniKafoor 15%. Other products mainly contain triglycerides, hydrogenated vegetable oil, caprylic/capric triglycerides, rhusucceaneacera, talc powder, toco pherol, ascorbial palmitate, multi vitamins..etc.

at 124.50 mg/kg in sample L8. There is no available internationally acceptable maximum limit for iron in cosmetic products.<sup>[5,27]</sup>

Copper was also detected in all cosmetic samples, with concentrations ranging from 0.95 to 51.40 mg/kg [Table 2]. The highest concentration was detected in lipstick (sample

**Table 2: Descriptive statistic summary of some essential metal concentrations in different cosmetic products in mg/kg**

Cosmetic product	Sample code	Concentration of metals (mg/kg) <sup>a</sup>			
		Fe	Cu	Cr	Zn
Kohl	A1	27.75±0.354	15.15±0.566	2.50±0.354	ND
	A2	24.62±0.177	31.0±0.707	3.50±0.00	ND
	A3	19.88±0.177	29.50±0.354	ND	11.62±0.177
	A4	15.62±0.884	22.12±0.177	ND	16.88±0.530
	A5	2.75±0.354	12.25±0.354	1.62±0.177	3.50±0.354
	A6	10.62±0.884	9.25±0.707	ND	ND
	A7	1.62±0.177	27.62±0.177	ND	ND
	A8	16.88±0.530	24.75±0.354	7.25±0.707	22.75±0.707
	Mean±SD (n=8)	14.97±9.490	21.46±8.269	1.86±2.565	6.84±9.064
Range	1.62-27.75	9.25-31.0	ND-7.25	ND-22.75	
Eyeliner	E1	0.80±0.00	1.95±0.212	ND	ND
	E2	2.30±0.141	16.15±0.212	ND	0.75±0.0707
	E3	8.00±0.424	6.85±0.212	0.65±0.212	7.70±0.283
	E4	1.40±0.00	20.20±0.424	1.70±0.141	2.20±0.141
	E5	3.45±0.212	0.95±0.0707	ND	ND
	E6	0.50±0.00	5.45±0.0707	ND	ND
	E7	9.95±0.212	23.85±0.354	1.20±0.283	0.25±0.354
	Mean±SD (n=7)	3.77±3.70	10.77±9.191	0.507±0.701	1.557±2.822
	Range	0.50-9.95	0.95-23.85	ND-1.70	ND-7.70
Lipstick	L1	8.45±0.636	39.05±1.485	1.50±0.566	ND
	L2	3.45±0.778	14.50±1.838	1.80±0.566	ND
	L3	15.75±0.212	7.85±0.071	ND	5.05±0.0707
	L4	0.60±0.141	20.15±0.212	ND	0.95±0.212
	L5	10.30±0.424	1.80±0.00	ND	1.45±0.0707
	L6	94.15±0.495	51.40±0.283	ND	ND
	L7	1.85±0.212	32.35±0.354	ND	ND
	L8	124.50±1.556	11.20±0.141	0.65±0.0707	ND
	L9	4.05±0.778	10.55±0.919	0.30±0.424	0.45±0.636
	L10	70.45±0.636	3.90±0.283	0.95±0.0707	ND
Mean±SD (n=10)	33.355±45.53	19.275±16.36	0.52±0.683	0.79±1.580	
Range	0.60-124.50	1.80-51.40	ND-1.80	ND-5.05	
Test for normality <sup>b</sup>		Parametric	Parametric	Nonparametric	Nonparametric
<i>P</i> <sup>c</sup>		0.139 (NS)	0.240 (NS)	0.598 (NS)	0.591 (NS)

ND: Not detected, NS: Nonsignificant differences between metal content in kohl, eyeliner, and lipstick. <sup>a</sup>Each value is the average of two separated determinations, <sup>b</sup>Normal distribution is detected by Shapiro-Wilk test value, <sup>c</sup>One-way ANOVA test is used for parametric distribution, and Kruskal-Wallis test is used for nonparametric. SD: Standard deviation

L6), whereas the lowest concentration was detected in eyeliner (sample E5).

The total concentration of chromium in the cosmetic samples ranged from 0.30 to 7.25 mg/kg, Table 2. The highest concentration (7.25 mg/kg) was obtained in sample A8, whereas the lowest concentration of 0.30 mg/kg was found in sample L9.

The concentration of zinc ranged from 0 (not detected [ND]) to 22.75 mg/kg. The highest concentration was detected in sample A8. The eyeliner and lipstick samples had a maximum concentration of zinc recorded at 7.70 mg/kg (sample E3) and 5.05 mg/kg (sample L3), respectively.

The statistical analysis of the results in Table 2 showed that no statistically significant differences between kohl, eyeliners,

and lipsticks, were observed for the content of iron, chromium, copper, and zinc.

The toxic metals such as lead and cadmium were also analyzed in the cosmetic samples. Lead was detected in all types of investigated cosmetic samples, mostly present in kohl samples, with concentration ranging from ND to 20.25 mg/kg, while the concentration of cadmium ranged from ND to 125.0 mg/kg. The highest concentration detected was in sample A1 [Table 3].

The statistical analysis of the toxic metals in cosmetic samples gave *P* value corresponding to 0.599 and 0.029 for analysis results of lead and cadmium, respectively [Table 3]. These values indicated that there were no significant differences for lead concentrations in the types of cosmetic products, whereas significant differences were observed for cadmium

**Table 3: Descriptive statistic summary of toxic heavy metal concentrations in different cosmetic products in mg/kg**

Cosmetic product	Sample code	Concentration of metals (mg/kg) <sup>a</sup>	
		Pb	Cd
Kohl	A1	ND	125.0±4.243
	A2	1.75±0.354	25.25±2.121
	A3	20.25±0.707	82.875±2.298
	A4	3.88±0.177	ND
	A5	ND	29.625±0.884
	A6	ND	ND
	A7	2.25±0.000	56.375±3.712
	E8	ND	1.90±0.141
	Mean±SD (n=8)	3.52±7.085	40.48±45.210
Eyeliner	Range	ND-20.25	ND-125.0
	E1	1.20±0.141	4.95±0.0707
	E2	1.95±0.0707	ND
	E3	2.60±0.141	0.90±0.141
	E4	ND	6.35±0.495
	E5	8.70±0.424	10.60±0.980
	E6	2.90±0.141	ND
	E7	ND	ND
	Mean±SD (n=7)	2.48±2.975	3.257±4.158
Lipstick	Range	ND-8.70	ND-10.60
	L1	5.05±1.626	21.25±1.768
	L2	0.55±0.778	10.05±0.354
	L3	1.90±0.141	18.45±0.778
	L4	ND	5.70±0.707
	L5	ND	12.65±0.0707
	L6	ND	8.70±0
	L7	1.75±0.0707	23.85±0.778
	L8	ND	13.80±0.424
	L9	7.95±2.7577	9.55±0.636
	L10	ND	10.25±0.354
Mean±SD (n=10)	1.72±2.710	13.43±5.910	
Test for normality <sup>b</sup>		Nonparametric	Parametric
	P <sup>c</sup>	0.599 (NS)	0.029 (S)

<sup>a</sup>Each value is the average of two-separated determinations, <sup>b</sup>Normal distribution is detected by Shapiro-Wilk test value, <sup>c</sup>One-way ANOVA test is used for parametric distribution, and Kruskal-Wallis test is used for nonparametric. ND: Not detected, NS: Nonsignificant, S: Significant differences between metal contents in kohl, eyeliner, and lipstick

concentrations in cosmetic products ( $P < 0.05$ ). The results indicated that the concentrations of cadmium in kohl samples were significantly difference from eyeliner and lipstick samples.

## DISCUSSION

In this study, 25 individual cosmetic products were tested to determine the concentration of some heavy metals. The products were sold by a distinct seven companies, such as

Beauty, Final Touch, Loreal, Ever Beauty, Flormar, Flormasi, Khojati Herbal Company, as shown in Table 1. These products represented the common cosmetics sold in local markets in Benghazi. Table 1 presents the container label disclosures for the brands of selected samples. In this study, only six products disclosed the manufacture and expiry dates of their production. Those dates are very important and must be determined to provide guides of the time frame that can be reasonably guaranteed. Three of the seven manufactures gave indications of the ingredients, and with regard to batch numbers of products, only one company ( Khojati Herbal Company, India) gave the batch number of the product. Nondisclosure of batch number, meaning that in the event of a defective product being accidentally released into the market, recalls would be extremely difficult to effect.<sup>[28]</sup>

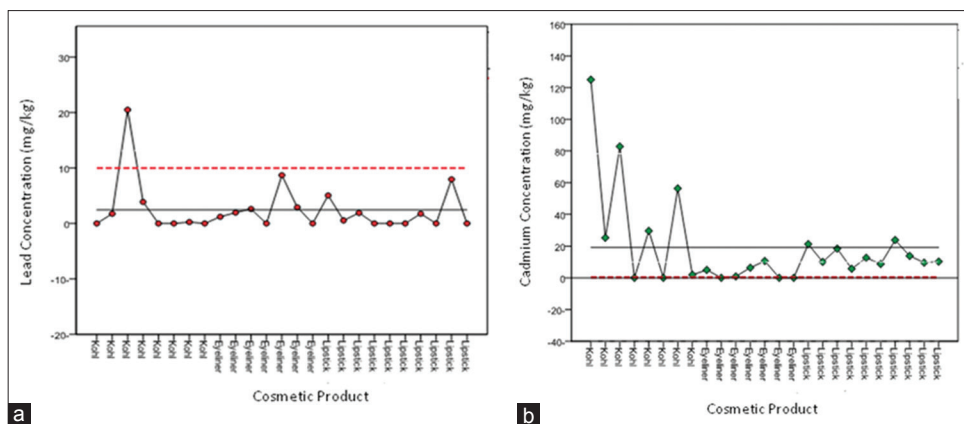
Iron and copper metals were detected in all cosmetic samples, whereas chromium and zinc were detected in 48% of the samples. Although some metals such as chromium, copper, iron, and zinc, in trace amounts, play important biochemical roles in many organisms, the toxic effects are observed at high concentrations. All those metals can lead to damaged or reduced central nervous system functions and damage to blood composition, lungs, kidney, liver, and other vital organs. Long-term exposure may result in slowly progressive physical, muscular, and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy, and multiple sclerosis.<sup>[29]</sup>

Although EU regulation has suggested that the concentration of some heavy metals, such as chromium, in color additive cosmetics should be  $<1.0$  mg/kg,<sup>[2]</sup> there were eight samples with chromium concentration higher than EU standard in cosmetic products. The presence of chromium in the body facilitates the entry of glucose into cell.<sup>[30]</sup> However, exposure to high levels of chromium has been linked to kidney and lung damage and other cancers. Chromium is also linked to skin effects such as eczema and other inflammations of the skin.<sup>[7]</sup>

Zinc was detected in 12 samples. Mahmood *et al.* reported that zinc oxide was probably used in kohl because of its powerful natural sunblock property.<sup>[31]</sup> Furthermore, zinc is necessary for oxygen metabolism and mitochondrial function.<sup>[4,32]</sup>

The toxic metals, such as lead and cadmium, were detected in some samples. However, the WHO sets maximum limits at 10.0 and 0.3 mg/kg, for lead and cadmium in cosmetic products, respectively.<sup>[6,7]</sup> Figure 1a and b shows the comparison of the levels of lead and cadmium that were detected in the investigated samples with the maximum allowed limits of these metals recommended by the WHO in cosmetics. Figure 1a shows that there was only one cosmetic sample that had a content of lead much higher than the maximum level recommended by the WHO. In fact, sample A3 contained lead metal at concentration of 20.0 mg/kg. Figure 1b shows that the contents of cadmium in 20 samples were above the allowed maximum limit, recommended by the WHO for cadmium in





**Figure 1:** (a and b) The comparison of the levels of lead and cadmium that were detected in the investigated samples with the maximum allowed limits of these metals recommended by the World Health Organization in cosmetics (dotted red line)

cosmetics. These toxic metals may get into the products when poor quality raw materials were used.

### CONCLUSIONS

The results of elemental analysis showed that iron and copper metals were detected in all cosmetic samples, whereas chromium and zinc were detected in 48% of the samples. The concentration of the analyzed essential metals in the investigated facial cosmetic samples was in order kohl >lipstick >eyeliner. The analyzed essential metal concentrations in the facial cosmetic samples were sometimes higher than reported studies. Some of these essential metals are used as colorants in some cosmetics.

The concentrations of cadmium and lead in some cosmetic samples were above the maximum allowed limits set by the WHO. In fact, cosmetics are not safe products, but they have a high demand to use. Therefore, the public should be educated about the hazard of prolonged use of cosmetic products that contain toxic elements. Extensive and continue use of these cosmetic products could release the heavy metals slowly and cause harm to users of these products.

National standard legislations should be available for cosmetic products to monitor the safety of these products before their importing and reaching consumers. However, further studies are needed to evaluate the concentrations of metals in different types of cosmetics and body care products in order to protect consumer health.

### Financial support and sponsorship

University of Benghazi (All the laboratory work has done in the analytical chemistry laboratory, Department of Environmental Health, Faculty of Public Health, Benghazi University. Furthermore, the Standards of metals and the FAAS were provided by the Nutrition Department, Faculty of Public Health, Benghazi University).

### Conflicts of interest

There are no conflicts of interest.

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## ملخص المقال باللغة العربية

تعيين محتوى بعض المعادن في مستحضرات التجميل المجمعّة من أسواق مدينة بنغازي خلال عام 2016

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**مقدمة:** يستخدم الناس على اختلاف أعراقهم وأجناسهم وأعمارهم مستحضرات التجميل لغرض التجميل وتحسين المظهر الخارجي. وقد وجد إن العديد من مستحضرات التجميل تحتوي على معادن ثقيلة إما كأحد المكونات الأساسية للمستحضر، وإما بسبب التلوث. وأظهرت العديد من هذه الدراسات إن هذه المعادن تسببت في مشاكل للجسم البشري والجلد.

**الأهداف:** إن هدف هذه الدراسة تحديد مستوى بعض المعادن الثقيلة في عدد من مستحضرات التجميل المتوفرة في أسواق مدينة بنغازي.

**المواد والطرق:** جُمعت 25 عينة من مستحضرات الخاصة بتجميل الوجه والتي كانت الأكثر طلبًا في محلات بيع مستحضرات التجميل في مدينة بنغازي خلال شهر أبريل 2016. واشتملت العينة على 8 كحل و7 محدد للعين و10 أحمر شفاه. وقد تم تعيين تركيز كلاً من معدن الحديد والكروم والنحاس والزنك والكاديوم والرصاص في جميع العينات باستخدام مطافية الامتصاص الذري اللهبّي، بعد عملية تهضيم مناسبة لكل عينة.

**النتائج:** دلت النتائج على احتواء جميع العينات على عنصري الحديد والنحاس بمدي تركيز يتراوح من 0.5-124.5 ملجم/كجم للحديد و1.8-51.4 ملجم/كجم للنحاس. وتراوحت تراكيز كل من الكروم والزنك والكاديوم والرصاص من 0-7.25 ملجم/كجم، 0-22.75 ملجم/كجم، 0-125 ملجم/كجم، 0-20.25 ملجم/كجم، على التوالي.

**الاستنتاج:** أظهرت النتائج وجود المعادن المختارة في معظم العينات بتركيزات مختلفة. وأن عينات الكحل احتوت على أعلى تركيز لمعظم المعادن التي تم تحليلها. ووفقاً للحد الأقصى المسموح به من قبل منظمة الصحة العالمية للمعادن السامة في مستحضرات التجميل، لم يكن هناك سوى عينة واحدة لديها تركيز للرصاص أعلى من الحد الأقصى الذي أوصت به منظمة الصحة العالمية. كما وجد أن 20 عينة من مستحضرات التجميل تحتوي على تركيزات من الكاديوم فوق الحد الأقصى المسموح به من قبل نفس المنظمة.

**الكلمات المفتاحية:** مستحضرات التجميل، الكحل، أحمر الشفاه، محدد العين، المعادن الثقيلة، بنغازي.