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Original article

Heavy Metal Content in Cosmetic Products and their Health Risk Assessment in the Libyan Market

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Abstract
This study aimed to determine the concentrations of selected heavy metals (Pb, Cd, and Zn) in cosmetic products available on the Libyan market due to their potential health risks associated with prolonged exposure. Ten cosmetic samples, including face creams and lipsticks, were analyzed using atomic absorption spectrometry (AAS). Zinc was detected in all samples at concentrations ranging from 0.06 to 2.69 ppm and was the most abundant metal, likely attributable to its intentional use as an ingredient in cosmetic formulations. Lead concentrations ranged from <0.01 to 2.51 ppm, with the highest levels observed in lipstick samples, raising concerns regarding possible absorption through repeated application. Cadmium levels were consistently low in all samples (<0.1 ppm), indicating minimal contamination. All detected heavy metal concentrations were within internationally permissible limits. Moreover, health risk assessment revealed that the Target Hazard Quotient (THQ) and Hazard Index (HI) values for all samples were below unity, suggesting no significant non-carcinogenic health risk associated with the topical use of these cosmetic products. However, the presence of heavy metals, although remaining within acceptable limits, reinforces the need for stricter regulatory oversight.
Keywords. Heavy Metals, Health Risk Assessment, THQ, Facial Cream, Lipsticks.

Introduction

Cosmetic products have become an important part of the daily routine for many people in recent years, and the demand for them has increased significantly as they are used to improve appearance and care for the skin and hair [1-3]. With the increasing popularity of these products, growing health concerns have emerged regarding the presence of undesirable or harmful ingredients, especially heavy metals such as lead, cadmium, and zinc, which can accumulate in the body with continuous use and lead to negative effects on overall health [4,5]. Mercury, lead, cadmium, zinc, chromium, arsenic, cobalt, and nickel are common heavy metals found in cosmetics [6]. They may be present in some raw materials or as a result of contamination during manufacturing or storage processes.

Numerous studies worldwide have shown that these heavy metals can be found in various types of cosmetics, such as lipstick, face powder, foundation, and eyeshadow, in varying proportions, and sometimes exceeding the legal limits in some countries [7-9]. For example, an analytical study of cosmetics in Tanzania revealed that zinc levels were the highest among other heavy metals, followed by lead and then cadmium, with some exceeding internationally accepted limits. Another report indicated the need for regular monitoring and evaluation of these metals to ensure product safety and minimize health risks to users [7,10]. As a result, some regulatory bodies place limits on the presence of certain metals in cosmetics. For example, a panel of experts established by the U.S. Food and Drug Administration (FDA) set limits for arsenic (5 ppm), lead (5 ppm), and other heavy metals (20 ppm) [11]. The World Health Organization (WHO) has also set limits for lead (10 ppm), cadmium (0.3 ppm), and mercury (1 ppm). For the European Union, the limits for lead, cadmium, and chromium are 0.5, 0.5, and 1.0 ppm, respectively, while Canadian authorities have set limits for lead (10 ppm), cadmium (3 ppm), and mercury (3 ppm) [12]. However, there are often discrepancies between different regulatory bodies regarding the types of metals and their limits. Numerous previous studies have demonstrated the presence of heavy metals in cosmetics at varying levels. Significant concentrations of mercury were recorded in skin-whitening creams in Iraq, with clear variations between samples [5]. Other studies using advanced analytical techniques such as AES-ICP and ICP-MS revealed the presence of toxic elements like lead, cadmium, and mercury in face creams and other cosmetic products. In some cases, the concentrations exceeded internationally permitted limits [13,14]. Research in Pakistan has shown that the source of raw materials, manufacturing methods, storage, and transportation are major contributors to increased heavy metal levels [15].

Analyses of hair dyes and lipsticks have also revealed varying concentrations of lead and other heavy elements. Some products were within safe limits, while others contained alarming levels, with a clear difference in metallic and bacterial contamination between high-priced and low-priced products [16-18]. These findings underscore the need for enhanced health monitoring of cosmetic products to minimize their potential negative impacts on public health. This research takes on a unique character when conducted in the Libyan market, where cosmetic products are sourced from both local and imported manufacturers, and quality control standards and requirements may vary. Therefore, this research aims to measure the concentration levels of heavy metals, such as lead, cadmium, and zinc, in samples of cosmetic products

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available in the Libyan market and compare them to internationally recognized standards. Furthermore, the Target Hazard Quotient (THQ) and the Overall Hazard Index (HI) will be calculated.

Methods

The chemicals used in this study were concentrated nitric acid, sulfuric acid, and hydrogen peroxide. The equipment used included a drying oven, desiccator, hot plate, sensitive balance, and an atomic absorption spectrometer (AAS). Ten samples (Table 1) were randomly collected from several local markets in Tripoli, representing various international brands of cosmetic products, including face creams and lipsticks, after verifying that they were not expired.

Table 1. Cosmetic product names

Sample Number	Sample name	Product type
A1	Boujois	Face cream
A2	Note	Face cream
A3	Mac	Face cream
A4	BB	Face cream
A5	Deborah	Face cream
A6	Lareen	Lipstick
A7	VIP	Lipstick
A8	Romantic bird	Lipstick
A9	Fashon matte	Lipstick
A10	Deborah Lip	Lipstick

To prepare the samples,1 gram of each sample is placed in a 50 ml conical flask with 5 ml of concentrated nitric acid. The mixture is left to stand at room temperature for 24 hours for initial digestion. After this time, the mixture is gradually heated on a hot plate at 90°C until the remaining nitric acid disappears as brown vapor, and then allowed to cool. Next, 5 ml of concentrated sulfuric acid is added, and the mixture is reheated for 30–50 minutes. Following this, 5 ml of hydrogen peroxide is added, and the mixture is allowed to cool. Finally, the mixture is filtered into a 50 ml standard flask and filled to the mark with distilled water. The mixture is then ready for measurement using an atomic absorption spectrometer. These steps are repeated three times for each sample, and the average of the readings is then calculated. To determine the extent of the risk these elements in cosmetic products pose to human health, the Target Hazard Quotient (THQ) and Hazard Index (HI) were calculated [19,20,21], which should be less than one, according to the following equations (1,2, 3).

$$THQ = \frac{CxIRxEFxED}{RfDxBWxAT} \quad \text{(1)}$$

$$\frac{EFxED}{AT} = 1 \quad \text{(2)}$$

$$THQ = \frac{CxIR}{RfDxBW} \quad \text{(3)}$$

EF = Exposure Frequency, ED = Exposure Duration, IR = Ingestion Rate mg/day, AT = Averaging Time C=Concentration (mg/kg), RfD =Reference Dose (mg/kg/day), BW=Body Weight (kg)

Assumptions and accepted parameters (based on topical cosmetic studies): IR= 20 mg/day for face Cream and 10 mg/day for Lipstick, EF= 365 days/year, ED= 30 years, BW= 60 kg, AT= EDx365= 10950.

The reference dose (RfD) values for heavy metals were adopted as stated in [19,21,22], where they amounted to Pd = 0.0035 (mg/kg/day), Cd = 0.001 (mg/kg/day), Zn = 0.3 (mg/kg/day)

HI is calculated as in the following equations (4):

$$HI = \sum THQ_{Pd} + THQ_{Cd} + THQ_{zn} \quad \text{(4)}$$

Results and Discussion

The results of the sample analysis showed that the studied cosmetic products contained varying concentrations of lead, cadmium, and zinc as follows (Table 2):

Table 2. Concentration of heavy metals (ppm) in face cream and lipstick

Sample Number	Product type	Sample name	Concentration (ppm)		
			Pb	Cd	Zn
A1	face cream	Boujois	0.33	< 0.1	2.69
A2	face cream	Note	0.39	< 0.1	0.89
A3	face cream	Mac	0.22	< 0.1	2.38
A4	face cream	BB	0.07	< 0.1	0.07
A5	face cream	Deborah	< 0.01	< 0.1	2.17
A6	Lipstick	Lareen	0.39	< 0.1	0.08
A7	Lipstick	VIP	2.51	< 0.1	2.69

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A8	Lipstick	Romantic bird	< 0.01	< 0.1	0.06
A9	Lipstick	Fashon matte	0.26	< 0.1	0.10
A10	Lipstick	Deborah Lip	0.24	< 0.1	0.06

Lead

The concentration of lead in the studied cosmetic products ranged from <0.01 to 2.51 ppm, with the highest level detected in VIP lipstick. Face creams generally contained lower Pb levels, ranging from 0.07 to 0.39 ppm, while lipsticks ranged from <0.01 to 2.51 ppm. The average Pb concentration was 0.20 ppm for face creams and 0.68 ppm for lipsticks, indicating that lipsticks tend to contain higher lead levels than creams. Although these values are well below the international limit of 10 ppm for cosmetics [17,23,24,25], the presence of Pb warrants attention due to potential health risks with prolonged exposure, particularly for children and pregnant women. Based on the calculated Target Hazard Quotient (THQ) values, even the highest Pb concentration corresponds to a THQ < 1, indicating no significant non-carcinogenic risk from daily topical use of these products.

Zinc

Zinc concentrations in the studied cosmetic products ranged from 0.06 to 2.69 ppm, with the highest levels detected in Boujois face cream and VIP lipstick. Face creams generally contained higher Zn concentrations compared to lipsticks, with average values of 1.64 ppm and 0.59 ppm, respectively. Zinc is an essential element commonly used in cosmetic formulations, including as an active ingredient in sunscreens. However, elevated concentrations may indicate contamination or the use of raw materials containing higher Zn levels. These findings are consistent with previous studies reporting that zinc is often present at higher levels than other heavy metals in cosmetics [7,18].

Cadmium

Cadmium concentrations in all studied cosmetic products were below the detection limit (<0.1 ppm), indicating good adherence to manufacturing practices and reflecting positively on consumer safety, given the high toxicity of Cd even at low concentrations. These results are consistent with previous studies reporting low or absent cadmium levels in commercial cosmetics compared to other heavy metals [14,23,24]. General observations revealed that lipsticks contained higher levels of lead compared to face creams, consistent with previous studies showing that lip products are more likely to accumulate heavy metals due to the coloring agents used. Overall, most samples exhibited metal concentrations within permissible limits, suggesting that several manufacturers adhere to international safety standards. However, variations between brands highlight the need for enhanced local regulatory oversight of the Libyan cosmetic market.

Target Hazard Quotient (THQ) and Hazard Index (HI) of Heavy Metals. The potential non-carcinogenic health risks of the studied cosmetic products were assessed using the Target Hazard Quotient (THQ) and the cumulative Hazard Index (HI). The THQ for each metal was calculated using the standard methodology, and for cadmium, concentrations below the detection limit (LOD) were substituted as C = LOD/2, in accordance with established scientific practices.

An illustrative example of sample A1 (Boujois face cream) is shown below:

$$THQ_{Pb} = 0.33 \times 0.00002/60 \times 0.0035 = 0.0000314$$

$$THQ_{Cd} = 0.05 \times 0.00002/60 \times 0.001 = 0.0000167$$

$$THQ_{Zn} = 2.69 \times 0.00002/60 \times 0.3 = 0.00000298$$

$$HI = 0.0000314 + 0.0000167 + 0.00000298 = 0.0000510$$

The results of calculating the remaining samples are shown in (Table 3 and Figure 1).

Table 3. THQ and HI calculation

Sample Number	Product type	Target Hazard Quotient (THQ)			Hazard index (HI)
		Pb	*Cd	Zn	
A1	face cream	3.14×10^{-5}	1.67×10^{-5}	2.98×10^{-6}	5.10×10^{-5}
A2	face cream	3.71×10^{-5}	1.67×10^{-5}	9.88×10^{-7}	5.47×10^{-5}
A3	face cream	2.10×10^{-5}	1.67×10^{-5}	2.64×10^{-6}	4.03×10^{-5}
A4	face cream	6.66×10^{-6}	1.67×10^{-5}	7.70×10^{-8}	2.34×10^{-5}
A5	face cream	4.76×10^{-7}	1.67×10^{-5}	2.41×10^{-6}	1.95×10^{-5}
A6	Lipstick	1.85×10^{-5}	8.33×10^{-6}	4.40×10^{-8}	2.68×10^{-5}
A7	Lipstick	1.19×10^{-4}	8.33×10^{-6}	1.49×10^{-6}	1.28×10^{-4}
A8	Lipstick	2.38×10^{-7}	8.33×10^{-6}	3.30×10^{-8}	8.61×10^{-6}
A9	Lipstick	1.23×10^{-5}	8.33×10^{-6}	5.50×10^{-8}	2.06×10^{-5}
A10	Lipstick	1.14×10^{-5}	8.33×10^{-6}	3.30×10^{-8}	1.97×10^{-5}

** Since the cadmium results were below the Limit of Detection (LOD), they were calculated according to the established scientific methodology: C=LOD/2*

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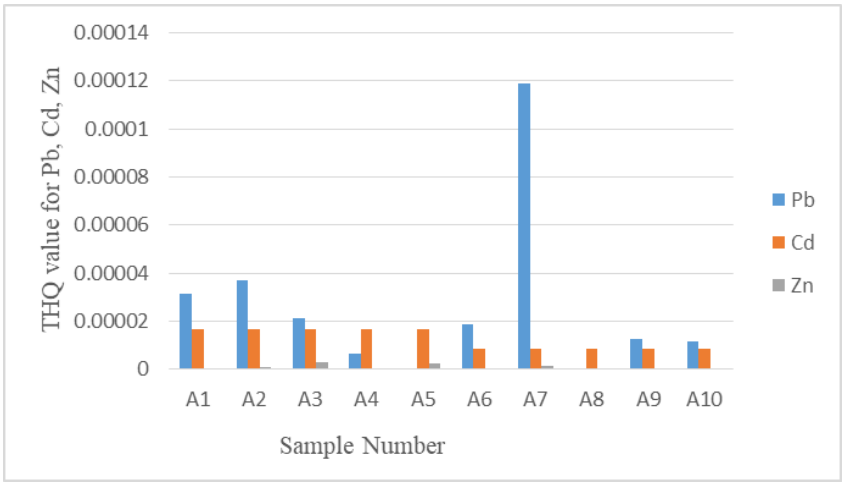

Figure 1. THQ value for Pb, Cd, Zn

The non-carcinogenic health risk assessment of the studied heavy metals in cosmetic products available in the Libyan market was conducted using the Target Hazard Quotient (THQ) and the Total Hazard Index (HI). All face cream and lipstick samples showed THQ values for lead, cadmium, and zinc below 1 (THQ < 1), and the cumulative HI values were very low, well below 1, indicating no potential non-carcinogenic health risks from normal, long-term use. These findings are consistent with previous studies [18,26,27]. Among the samples, lipstick A7 (VIP) exhibited the highest HI due to relatively higher concentrations of lead and zinc; however, this value remains well within safe limits. In contrast, face cream A5 and lipstick A8 showed the lowest HI values, reflecting lower heavy metal contents (Figure 2).
Overall, lipsticks tend to have slightly higher HI values compared to face creams, consistent with their higher lead content. The contribution of Pb was dominant in HI, while Cd and Zn contributed minimally. Therefore, daily use of these cosmetic products, according to standard approved values, poses no non-carcinogenic health risk to consumers, and all calculated HI values fall within internationally acceptable limits.

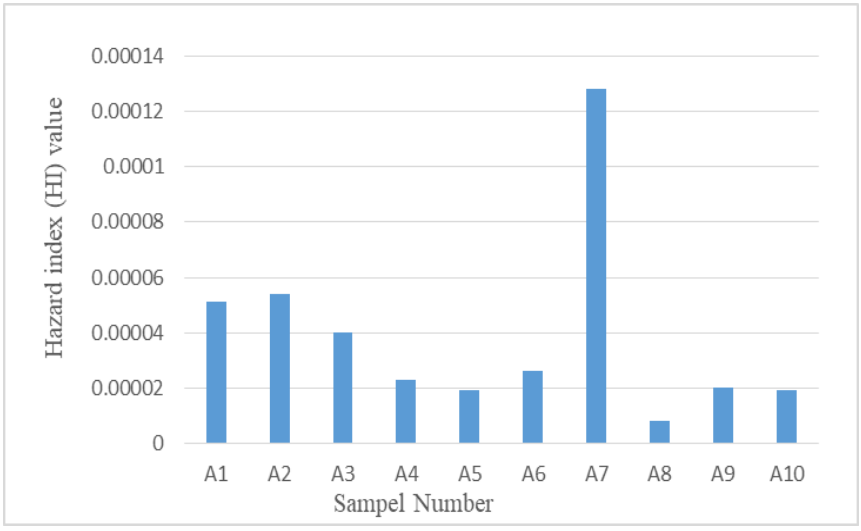

Figure 2. Hazard index (HI) value

Conclusion

This study demonstrated that cosmetic products available in the Libyan market contain varying levels of heavy metals, including lead (Pb), cadmium (Cd), and zinc (Zn). Zinc was the most prevalent element, while lead and cadmium were present at lower concentrations. Although prolonged continuous use of cosmetics containing heavy metals can pose health risks in general, the calculated Target Hazard Quotient (THQ) and overall, Hazard Index (HI) for all studied products were well below 1, indicating no significant non-carcinogenic health risk for consumers under normal usage conditions. Although the results show safe levels within approved exposure limits, they underscore the need to establish a permanent monitoring system and strengthen regulatory frameworks to ensure continued compliance with safety standards in the Libyan market.

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Conflicts of Interest
The authors declare that there are no conflicts of interest regarding the publication of this paper.

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