



Evaluation of lead and cadmium concentrations in lipstick and eye pencil cosmetics

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Abstract

Background: The aim of this study was to determine the concentrations of lead (Pb) and cadmium (Cd) in lipstick and eye pencil cosmetics of different grades in the markets of Iran.

Methods: This descriptive study was conducted in Ahvaz city in 2018. Sixty different samples of lipstick and eye pencil of three common brands were selected and analyzed using the Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-OES) and the results were compared with standard values recommended by the Food and Drug Administration (FDA). The analysis of lipsticks was based on producer country and colors and producer country only for eye pencil.

Results: The mean concentrations of Pb and Cd were 41.86 and 53.42 µg/g, respectively. Concentrations of lead were higher than those of Cd in lipsticks, while for eye pencil, Cd showed higher concentrations. The overall results indicated that in all brands and colors of lipsticks, only 33% of the samples had Pb content less than the FDA limit, and among lipstick samples, 44% had Cd concentration less than the FDA limit of 3 µg/g, however, in 100% of the eye pencil samples, the concentration of Cd was higher than the recommended value of 3 µg/g.

Conclusion: Given the health risks of exposure to heavy metals and in order to increase community awareness about the harmful effects of cosmetics, it is necessary to monitor the concentration of these toxic elements in these products and encourage the manufactures to meet the FDA standards.

Keywords: Lead, Cadmium, Cosmetics, Environmental pollution

Citation: Feizi R, Jaafarzadeh N, Akbari H, Jorfi S. Evaluation of lead and cadmium concentrations in lipstick and eye pencil cosmetics. Environmental Health Engineering and Management Journal 2019; 6(4): 277–282. doi: 10.15171/EHEM.2019.31.

Article History:

Received: 10 August 2019

Accepted: 2 November 2019

ePublished: 6 December 2019

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Introduction

In recent years, the worldwide use of cosmetic products has had a big boost due to, their daily use for beauty, cleaning, improving or changing the skin (1,2). Cosmetic products are applied directly to human skin, and because of their components, their use can present risks to human health, causing possible reactions, such as hypersensitivity and irritant reactions (3,4). Recently, the occurrence of heavy metals pollution in cosmetics has attracted worldwide attention. Lead (Pb) and cadmium (Cd) are two potentially harmful heavy metals that cause considerable concerns (5,6). Pb contamination in cosmetics can originate from Pb solder, lead-based dyes in production material or from contaminated dust. Pb contributes to the preservation of paraffin and cosmetics on the skin. In rosin, the Pb-tin is used to stabilize the color and also to produce red color (7). Exposure to Pb could accumulate in the body organs

due to their long half-life, then, it would be absorbed by the red blood cells and circulated through the body. Symptoms may include abdominal pain, constipation, headaches, irritability, memory problems, inability to have children, and tingling in the hands and feet. In severe cases, anemia, seizures, coma, or death may occur (8-10). Cd is used in many cosmetic products according to its color properties as a colored pigment (11). Cd can accumulate in various organs and tissues, but mostly in kidney cortex. Cd exposure has been inconsistently associated with blood pressure. The symptoms of severe Cd ingestion are nausea, vomiting, abdominal cramps and pain, diarrhea, and tenseness (12-14). Cd also causes bone degradation because it affects calcium metabolism (15). Among cosmetic products, lipstick is one of the most commonly used one, which are produced from a range of chemicals and presented in a wide variety of dye. They are produced



by adding pigments that may contain heavy metals as impurities in the pigment formulation (16-18). Moreover, lipsticks, because of their direct oral ingestion have the higher risk, which can irritate the negative effects of their chemicals. Studies on the use of lipstick among women show that a woman inadvertently ingests 1.8 kg of lipstick during her life (19,20). Eye cosmetics could be another source of heavy metals exposure. Some cosmetics contain chemicals that can cause eye damage or heavy metals that can cause long-term health problems, such as Pb poisoning. Previous studies reported that various types of heavy metals, such as Pb, mercury, Cd, arsenic, nickel, and aluminium are detected in cosmetics, which pose health risks to consumers. Chronic exposure to these elements is associated with a variety of health problems, such as respiratory system cancer, skin disorders, Alzheimer, anemia, nervous system, reproductive disorders, cardiovascular problems, gastrointestinal disorders, impaired immunity, and even death (21-24). The world's largest producer of cosmetics products is divided into three categories: The European Union, the United States, and Japan. Iran has the seventh place in the world and is the third largest cosmetics importer and distributor in the Middle East (7,25). Due to the fact that many of these cosmetics imported into the country through illegal entry, due to being fake, they cause physical complications and skin lesions and diseases, such as skin allergies, skin ulcers, and even cancer (26). In recent years, the worldwide use of cosmetic products has rapidly increased due to their daily use for beauty, cleaning, improving and changing the skin. Because of the adverse effects of health regarding the presence of heavy metals, it is necessary to monitor the level of these elements in cosmetic products. Hence, the main aim of this study was to determine the concentrations of Pb and Cd in eye pencil and lipstick marketed in Ahwaz, Iran.

Materials and Methods

Materials

All the chemicals used in the study were analytical grade. Cosmetic products including eye pencils and lipsticks of different brands and colors were randomly purchased from the local markets in Ahwaz, Iran. Nitric acid (65%) and perchloric acid (70-72%) were purchased from Sigma Aldrich. Plastic bottles and glass wares were washed with detergents, rinsed with deionized water, and dried at room temperature before use. All samples were filtered by 0.45 µm filter paper. The concentrations of Pb and Cd were measured using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-OES, GBC, ICP- Australia OES Integra XL). The ICP-OES device was operated under a plasma power of 1400 W and plasma gas flow rate of 14.5 L/min.

Sample collection

This descriptive study was conducted in Ahvaz city in

2018. Three different brands of lipsticks with most popular colors (red, pink, and brown) and eye pencil were randomly collected from the local market in Ahvaz city, Iran. Samples were produced by China, France, Turkey, Germany, and Korea. The samples were taken to the laboratory and kept at room temperature for the subsequent preparation and analysis. Samples characteristics are presented in Table 1. Sample size was selected according to Eq. (1):

$$n = [(Z^2 \times S^2) / d^2] \quad (1)$$

where, z value for 95% confidence is 1.96, S is the standard deviation = 0.1, and d is the precision level = 0.05 obtained from a study in Sari, Mazandaran (Iran) (27).

Pb and Cd analysis

The samples were dried at 80°C for 12 hours in an oven until constant weight was achieved. Afterwards, 1 g of dried samples was digested with HNO₃, evaporated to near dryness on a hot plate, and then, cooled. The procedure was repeated with HClO₄. More HClO₄ were added until the evaporation of white fumes (marking the end of the digestion process) before heating to near dryness. The residual was diluted with deionized water, filtered through 0.45 µm Whatman filter, and made-up to mark in 50 cm³ volumetric flasks, transferred to sample plastic bottles, and kept at room temperature for subsequent analysis (28). The concentrations of Pb and Cd were measured using the ICP-OES device.

Statistical analysis

Statistical analysis was done using SPSS version 16 (SPSS Inc., Chicago, IL, USA) at $P < 0.05$. Descriptive statistical parameters, such as mean and standard error (SE) were used to describe the Cd and Pb concentrations in different cosmetic products. One-way analysis (ANOVA) was used to determine the significant difference between Cd and Pb concentrations in different types of cosmetics, brands, colors, and producer countries.

Table 1. Descriptive statistical analysis of quantitative monitoring of Cd and Pb in lipstick and eye pencil cosmetics products in Ahvaz, Iran

Types of Cosmetics	Brand	Country	Color	Replicates
Lipstick	1	China	Pink	6
			Brown	6
			Red	6
	2	France	Pink	6
			Brown	6
			Red	6
	3	Turkey	Pink	6
			Brown	6
			Red	6
Eye pencil	1	Germany	-	6
	2	Korea	-	6
	3	China	-	6
Total sample				72

Results

Pb and Cd concentrations

Descriptive statistics of the results for Pb and Cd concentrations in lipsticks and eye pencil based on the producer country, and cosmetics brands are presented in Table 2. The mean concentrations of Pb and Cd in all of the studied brands were 41.86 and 53.42 µg/g, respectively.

Quality according to producer country

The Pb content obtained according to the producer country for lipsticks revealed that the highest Pb concentration was found in lipsticks produced in China (Figure 1a). Statistical analysis revealed no significant difference in the Pb concentration between Turkish and French products ($P < 0.05$), whereas, there was a significant difference in the mean Pb content between Chinese, Turkish, and French lipsticks ($P < 0.001$). Comparison of the Pb content in eye pencil according to the producer country revealed that the maximum and minimum Pb concentrations were observed in the products of China (96.85 µg/g) and Korea (28.22 µg/g), respectively. There was a significant difference in the average Pb content between German and Korean, and Chinese eye pencils (Figure 1b). Comparison of the Cd content in lipsticks according to the producer country revealed that the highest Cd concentration was found in the lipsticks produced in China and the lowest one was found in French brand (Figure 1c). According to the results of one-way ANOVA, there was a significant difference in the mean Cd content between producer countries ($P < 0.001$). Comparison of the Cd content in eye pencil according to the producer country revealed that the maximum and minimum Pb concentrations were observed in the products by China (364.68 µg/g) and Korea (6.098 µg/g), respectively (Figure 1d).

Effect of color

Comparison of the Pb content according to lipstick color revealed that the highest concentration of Pb was found

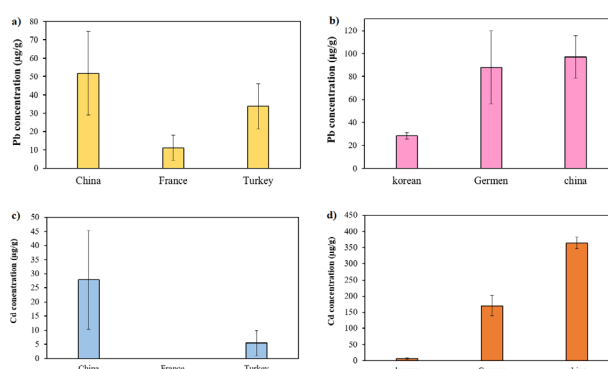


Figure 1. Comparison of the mean Pb level in lipsticks (a), eye pencil according to the producer country (b), Comparison of the mean Cd level in lipsticks (c), and eye pencil according to the producer country (d).

for red lipsticks and the lowest one was found for pink ones (Figure 2a). Statistical analysis revealed a significant difference between Pb concentration and color of lipstick samples ($P < 0.001$). Comparison of the Cd content according to lipstick color showed that the highest concentration of Cd was found in lipsticks produced by China in red color, while the lowest one was found in lipsticks produced by France in all colors and Turkey in pink color (Figure 2b).

Comparison according to FDA

According to the results reported by the Food and Drug Administration (FDA) on the Pb content in lipsticks in 2011, the limit value for Pb as a color additive in cosmetics is 20 µg/g (6,29). It was found that only 33% of all brands and colors of lipsticks had Pb content less than the FDA limit that was related to French brand. In contrast, all Turkish and Chinese products had Pb concentrations higher than the permitted limit (Figure 3a). As well, 44% of all lipstick samples had Cd content less than the FDA limit of 3 µg/g, that was related to French and Turkish lipsticks with pink color (Figure 3b). Moreover, Pb levels

Table 2. Descriptive statistical analysis of quantitative monitoring of Cd and Pb in lipstick and eye pencil cosmetics products in Ahvaz, Iran

Types of Cosmetics	Brand	Country	Color	Mean ± SE	
				Pb (µg/g)	Cd (µg/g)
Lipstick	1	China	Red	81.15±7.20	51.11±1.67
			Brown	41.63±0.91	16.23±1.13
			Pink	32.38±1.23	16.27±1.19
	2	France	Red	18.86±0.55	0
			Brown	11.19±0.51	0
			Pink	2.91±0.05	0
	3	Turkey	Red	49.05±0.45	6.07±0.52
			Brown	31.09±0.52	10.26±0.48
			Pink	21.10±0.52	0
Eye pencil	1	China	-	96.85±18.57	364.68±47.96
	2	Germany	-	87.96±31.97	170.41±14.70
	3	Korea	-	28.22±2.84	6.09±0.92

SE: standard error, Pb: lead, Cd: cadmium.

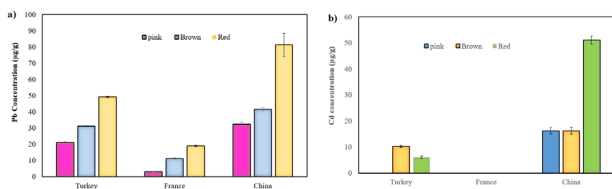


Figure 2. (a) Comparison of the Pb content according to lipstick color and (b) Comparison of the Cd content according to lipstick color.

in eye pencil was above the permitted limit in all samples tested (Figure 3c). However, 100% of eye pencil samples had Cd content above the recommended value of 3 µg/g. In this study, the concentrations of Pb and Cd in the most cosmetics were higher than the recommended value by the FDA.

Discussion

In this study, samples were randomly collected from three different brands of lipsticks with most popular colors (red, pink, and brown) and eye pencil from the local market in Ahvaz, Iran. Samples were produced by China, France, Turkey, Germany, and Korea. The concentrations of Pb and Cd were measured in the cosmetic products. According to the results, the concentrations of Pb and Cd in all brands of lipsticks and eye pencils studied were 41.86 µg/g and 53.42 µg/g, respectively. This result showed that the concentrations of Pb were higher than Cd levels found in lipsticks samples. While for eye pencil, Cd concentrations were higher than Pb levels (Table 2).

The results obtained in terms of producer country are consistent with the results reported by Gunduz and Akman (30), which demonstrated high levels of Pb in Chinese and Taiwanese cosmetics and low levels in the cosmetics produced by the USA and France (25). The findings of this study on Cd content in eye pencil according to the producer country are consistent with the results of studies by Al-Saleh et al and Gondal et al, according which the high levels of Cd and Pb in cheap products are related to Chinese and Indian companies (15,31).

The results demonstrated that the highest concentration of Pb was found in red color lipstick and the lowest one was observed in pink lipsticks. This finding can be attributed to the presence of impurity in the dye used for the production of these cosmetic products. The statistical analysis also revealed that the highest Cd concentration was found in red color lipstick made in China, while the lowest one was observed in lipstick made in France in all colors studied. Moreover, pink color lipsticks made in Turkey showed very low concentrations of Cd. These differences may be attributed to the quality of raw materials used in these cosmetic products. The primary ingredients found in lipstick are oil, alcohol, and dye. Pb might be actual as impurities in the color additives (15). Therefore, high concentrations of Pb in lipstick are due to adding dyes, such as pink, brown, and red dyes to

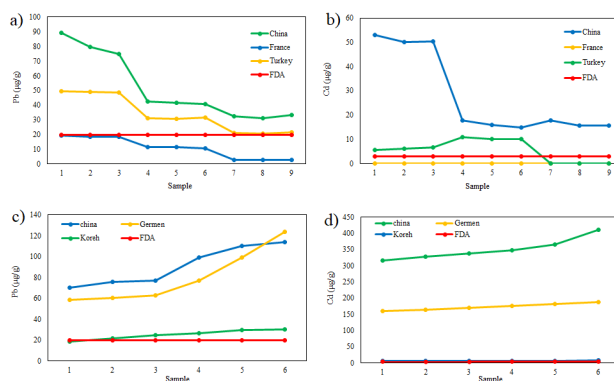


Figure 3. (a) Comparison of the mean Pb level in lipsticks with the FDA limit, (b) Comparison of the mean Cd level in lipsticks with the FDA limit, (c) Comparison of the mean Pb level in eye pencil with the FDA limit, and d) Comparison of the mean Cd level in eye pencil with the FDA limit.

these products. The most commonly used Cd compound in cosmetic products are Cd sulfide and Cd selenide for making different colors, such as yellow, orange, and black. Similarly, Nourmoradi et al also reported that the levels of Pb and Cd in dark colors were higher than those in light colors (32). Six replicates of reagent blanks fortified with low level standards were analyzed for each element. The LOD, calculated as three times of the standard deviations, and LOQ, calculated as 10 times of the standard deviations, are shown in Table 3. Comparing with the FDA guidelines, as can be seen in Table 4, similar results demonstrated that the lowest level of Pb was found in cosmetic products produced in France and the highest one was found in cosmetic products produced in China and Taiwan (30). Therefore, in order to prevent the adverse and harmful health effects of the cosmetic products on human, and to increase the community awareness on hidden dangers of cosmetics to promote health, the preparation and use of these products must be done according to the FDA standards.

Conclusion

In this study, 60 samples of lipstick and eye pencil of different brands were selected and analyzed by the ICP-OES. Mean concentrations of Pb and Cd in all the brands studied were 41.86 and 53.42 µg/g, respectively. The concentrations of Pb were higher than Cd levels found in

Table 3. Limits of detection and quantitation in the analytical portion

	Cadmium	Lead
LOD	00.4876	0.05486
LOQ	0.01057	0.13798

Table 4. Levels of lead and chromium in lipstick according to the FDA

Element	FDA
Pb (ppm)	10
Cd (ppm)	3, 6+

the lipstick samples. While Cd levels were higher than Pb levels found in eye pencil samples. The results showed that in all lipstick samples, the metals concentration in lipsticks with pink color was lower than that of red color solid base lipsticks. The overall results showed that in all brands and colors of lipsticks, only 33% had Pb content less than the FDA limit, and among lipstick samples, 44% of all samples had Cd content less than the FDA limit of 3 µg/g; however, in eye pencil samples, 100% of samples had Cd content above the recommended value of 3 µg/g. Therefore, in order to prevent the adverse and harmful effects of the cosmetic products on human health, and to increase the community awareness on hidden dangers of cosmetics to promote health, the preparation and use of these products must be done according to the FDA standards.

Acknowledgements

The authors would like to thank Ahvaz Jundishapur University of Medical Sciences for financial support of this research. The research project was financially supported by the Student Research Committee of Ahvaz Jundishapur University of Medical Sciences (Grant No. 96S11).

Ethical issues

The authors declare that all data collected during the experiments are presented as expressed in the manuscript and no data from the study has been or will be published separately elsewhere.

Competing interests

The authors declare that they have no conflict of interests.

Authors' contributions

All authors have contributed in designing, collection, analysis, and interpretation of data. All authors have studied and approved the final manuscript.

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