Comparative Analysis of the Heavy Metals Content in Selected Colored Cosmetic Products at Saudi Market

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Abstract

Heavy metal impurities in cosmetics are common due to their natural abundance. However, they should be kept to a minimum wherever technically feasible. Although human external contact with a substance rarely results in a significant systemic exposure, local exposure to cosmetics may pose a risk of heavy metal contamination. In this study, we sought to investigate the heavy metal concentration present in various cosmetic products from different brands and qualities that are available in the Saudi Market, also to analyze and compare the determined values relative to the reported permissible levels according to international standards. In this study, we have selected several facial cosmetics from the Saudi market and classified their quality into three main classifications based on their price. This was followed by an analysis and reporting of heavy metal content using an inductively coupled plasma–mass spectrometer. We found that three metals were below the permissible limits (Pb, As, and Cd) for cosmetics according to the Saudi Food and Drug Administration and Canadian Standards, besides (Cr) which was also below the limit of the United States Food and Drug Administration. The level of (Ni) exceeded the recommended range in the three-class classifications. On contrary, Pb, Cr, As, and Cd have all exceeded the acceptable levels based on European standards. Further assessment and careful selection of heavy metals content in cosmetics are urgently needed, as there are fluctuations in values between different international standards which might pose a potential harmful effect to human health from the daily use of cosmetics containing heavy metals impurities.

Key words: Health effect, international standards, maximum permissible limit, toxicity

INTRODUCTION

The high content levels of heavy metals in cosmetics have significant implications as these metals can penetrate the skin and be systemically absorbed. Excessive exposure to metals that impure some cosmetic products can lead to accumulation in the body and dysfunctions in vital organs.[1] Most of the countries have banned the excessive use of metals as an active ingredient in cosmetic products and have provided permissible limits that should not be exceeded; however, metal impurities indeed still occur.[2] The adsorption of heavy metals to the skin may increase due to the frequent use of cosmetics, unintentional swallowing of lipstick, or sweating skin covered with cosmetics.[3]

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Therefore, this study aims to determine the heavy metal concentrations present in various cosmetic products that were selected from different brands (qualities) and available in the Saudi Market, also to analyze and compare the determined HM values relative to the reported permissible levels according to European Union (EU), World Health Organization (WHO), Canada, Germany, United States Food and Drug Administration (USFDA), and Saudi Food and Drug Administration (SFDA) Standards [summarized in Table 1].

MATERIALS AND METHODS

The method followed in this project is shown in Figure 1.

Sample collection

Thirty-five colored cosmetic samples were selected from local stores in the city of Riyadh, KSA, that were imported and locally manufactured. The samples prices were ranging from SAR 1.00 to SRA 250 per container. The samples were classified according to the price: lower class (SAR 1–SAR 35), middle class (SAR 36–SAR 85), and higher class (SAR 96–SAR 250).

Chemicals and reagents

For the sample preparation, we utilized analytical grade nitric acid (65%, Sigma Aldrich) and perchloric acid (70%–72%, Sigma Aldrich) and the mixture was prepared in a 4:1 ratio of nitric acid and perchloric acid using a hot plate inside fuming hood. To ensure dryness, the temperature was slowly increasing for 2–3 h due to exothermic nature of the oily compounds that would burn with a flame. The procedure was repeated until the evolution of white fumes suggesting the end of the digestion process and dryness. After that, solutions were allowed to cool and filtered into a calibrated flask (100 mL) using Whatman no. 42 and diluted up to the mark.

Table 1: Heavy metals analysis according to the European Union, World Health Organization, Canada, Germany, United States Food and Drug Administration, and Saudi Food and Drug Administration Standards

International standards (PPM)	Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn	AS
EU[4]	P	P	P	ND	ND	P	P	10000	P
WHO[5-7]*	1	ND	ND	ND	ND	ND	0.2	ND	0.01
Canada[8]	3	ND	ND	ND	ND	ND	10	ND	3
Germany[9,10]	0.1	ND	ND	ND	ND	10	2	ND	0.5
USFDA[11]	ND	ND	50	ND	ND	ND	10	ND	3
SFDA[12]	3	P	P	ND	ND	P	10	10000	3

*For food additives. P: Prohibited, ND: Not determined, PPM: Part per millions, EU: European Union, WHO: World Health Organization, USFDA: United States food and drug administration, SFDA: Saudi Food and Drug Administration, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Ni: Nickel, Pb: Lead, Zn: Zinc, AS: Arsenic

Samples preparation and analysis

The glasswares utilized were washed three times with DDD and rinsed with 5% HNO_3 solution before use for the analysis [Figure 2]. The samples were kept at 130°C for 30 min, then it raised to 200°C for 30 min, then the temperature of the muffle furnace was raised at 600°C for 6 h. After cooling, the samples were digested in aqua regia solution on a hotplate. The samples were filtered through Whatman filter paper No. 42 and transferred to a volumetric flask (100 mL) and completed up to the mark with deionized water, as shown in Figure 2. All the samples were analyzed by inductively coupled plasma–optical emission spectrometry (Perkin Elmer-Optima 7300DV). The method for the analysis of heavy metals has been optimized for a suitable analysis. The parameters were set as power, 1550 W; plasma gas, 15 L/min; auxiliary gas, 0.2 L/min; nebulizer, 0.8 L/min; and sampling rate, 0.3 mL/min. Results were analyzed for statistical significance, which is shown in tabulated form as mean ± standard devitation, and ND indicating "not detectable."

Standard metal solutions

For each heavy metal, the calibration standards were prepared from the certified standard metals stock solution (1000 ppm-manufactured under ISO 9001 Quality Assurance System-Perkin Elmer) using a range from 0.5 to 10 ppm and prepared in double-distilled water (DDD).

Statistical analysis

The data were analyzed using Prism statistical package software, version 9 (GraphPad Software, Inc., San Diego, CA) and experiments were conducted in triplicate. Values were summarized in table format and represented as mean ± standard error of mean with ND as not detectable. The below equations were used to obtain the amount of each specific metal in part per millions (PPM).

$$\text{Content mg / kg} = \frac{\left(\text{concentration}\,\frac{\text{mg}}{\text{L}}\right) \text{X} \times \text{Volume mL}}{\text{sample weight G}}$$

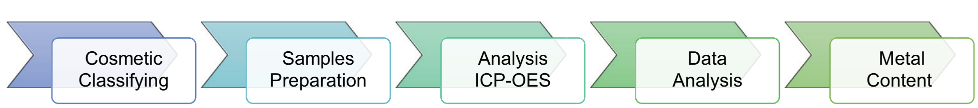

Figure 1: Study design

$$PPM = \frac{\left(\text{concentration}\frac{mg}{L}\right) X \times 100\ mL}{\text{sample weight } G}$$

RESULTS AND DISCUSSION

Heavy metals analysis

The heavy metal contents for the selected metals which are Cd, Co, Cr, Cu, Fe, Ni, Pb, Zn, and As were measured and compared between cosmetics classes. The results are summarized in Tables 2 and 3 and Figure 3 and discussed in the below sections.

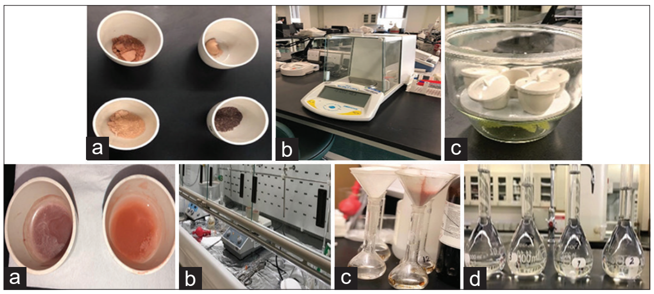

Figure 2: Samples preparations: (a) Addition of HNO3 and H2O2, (b) application of heat, (c) samples filtration, and (d) samples are wetted

Cadmium (Cd)

Cd has been used as natural color in cosmetics; however, it may possess serious risks to human health such as kidney stones, pneumonitis, and loss of bone density.[4,5] Our results showed that all the samples tested were free of Cd, which fit the limits of all international standards.

Cobalt (Co)

Co could have some benefits for humans, as it is considered to be a part of Vitamin B12. However, high exposure to Co has serious adverse health effects, including asthma, skin allergies, and dermatitis.[6] Our results demonstrated that the content of cobalt in all the examined cosmetics was <3 PPM.

Chromium (Cr)

Exposure to cosmetics containing significant amounts of chromium may increase the risk of developing skin redness, swelling, allergy, and ulcer.[7] All samples tested were below the USFDA limit.

Copper (Cu)

Chronic and sustained exposure to copper can results in liver and kidney damage, anemia, and immune toxicity. Green hair discoloration is also a well-known effect of excessive exposure to copper.[8] There are no significant

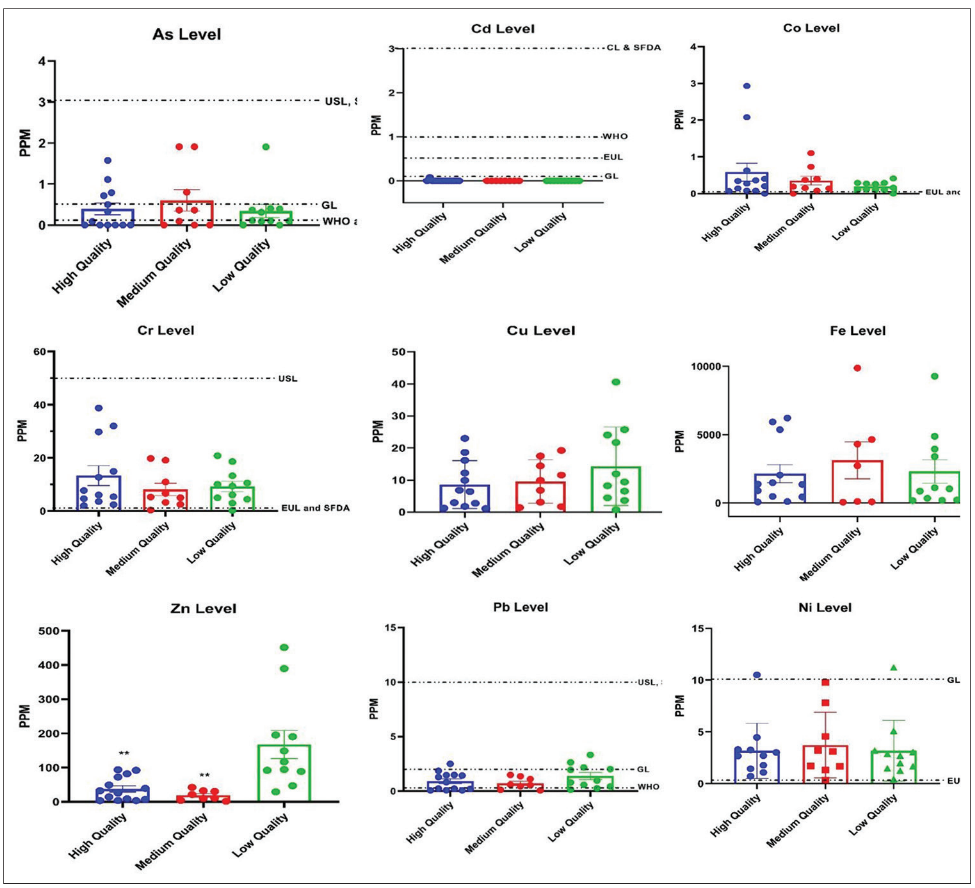

Figure 3: Heavy Metal contents of Cd, Co, Cr, Cu, Fe, Ni, Pb, Zn, and, As in Three Different Cosmetic categories products. Where, CL: Canadian limit, SFDA: Saudi FDA limit, WHO: World Health Organization limit, EUL: European limit, GL: German limit, USL: US limit

Table 2: Heavy metals analysis obtained values from inductively coupled plasma mass spectrometer in part per millions

Sample number	Sample weight (g)	Obtained value from instruments (I)	(I) X 100	Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn	AS
1	1.1935	0.001	0.1	0.1	2.9	197.3	1.8	900.4	105.0	0.3	3.5	2.3
2	1.392	ND	ND	ND	0.1	4.7	79.3	1357.5	0.7	2.5	93.8	0.8
3	1.392	ND	ND	ND	0.0	3.6	23.0	10822.6	1.4	1.4	81.9	0.7
4	1.20265	0.002	0.2	0.2	2.1	29.8	2.7	1380.2	72.1	1.5	39.2	1.6
5	1.1183	ND	ND	ND	0.3	32.0	3.0	1484.3	4.5	1.9	8.8	0.1
6	1.2335	ND	ND	ND	0.1	2.0	1.2	103.0	1.8	0.2	3.8	ND
7	0.295	ND	ND	ND	0.3	14.9	40.3	482.4	10.5	3.7	25.8	ND
8	1.1	ND	ND	ND	ND	0.3	0.7	194.7	0.5	0.3	46.6	ND
9	1.49	0.019	1.9	1.3	ND	0.4	1.4	57.4	0.3	7.0	1.5	ND
10	1	ND	ND	ND	0.4	5.3	9.9	4310.0	7.8	1.5	30.2	0.8
11	1.036	ND	ND	ND	0.3	3.0	24.0	4879.3	1.3	1.0	451.1	0.4
12	1.0953	ND	ND	ND	1.1	11.0	14.4	30505.1	3.2	1.4	42.1	0.4
13	1.3605	ND	ND	ND	0.4	19.1	1.7	9873.4	9.8	0.6	4.0	1.9
14	1.0521	ND	ND	ND	0.3	20.8	3.6	868.4	11.2	3.3	389.4	0.1
15	1.8177	ND	ND	ND	0.1	10.1	8.2	1036.9	1.5	0.4	195.1	0.1
16	1.125	ND	ND	ND	0.3	4.4	11.9	3944.0	1.7	2.0	148.7	0.1
17	1.0013	ND	ND	ND	0.1	5.0	9.4	173.4	2.0	0.8	29.2	0.1
18	0.6066	ND	ND	ND	9.2	140.1	16.2	96564.0	43.5	1.5	92.2	0.3
19	1.2486	0.001	0.1	0.1	0.2	9.4	21.7	3396.8	3.2	0.2	92.2	0.4
20	1.3375	ND	ND	ND	0.1	19.8	6.8	4650.3	4.6	0.4	21.5	0.4
21	1.5278	ND	ND	ND	0.3	6.1	25.7	1116.8	2.9	2.0	89.0	1.9
22	1.3482	ND	ND	ND	0.1	6.1	18.6	448.3	3.3	0.8	72.2	1.1
24	1	ND	ND	ND	0.2	5.4	12.2	2039.0	3.3	1.3	14.4	0.5
25	1.0924	ND	ND	ND	0.7	5.0	19.2	41785.6	3.1	0.5	7166.2	0.4
26	0.9616	ND	ND	ND	0.1	13.3	40.6	345.6	2.7	2.2	190.2	1.9
27	1.0713	ND	ND	ND	0.2	2.5	3.1	2730.0	1.7	1.1	10.5	0.1
28	0.9811	ND	ND	ND	0.4	18.7	4.5	9281.7	5.1	2.7	94.5	0.3
29	1.2	ND	ND	ND	0.1	7.8	1.1	5366.0	2.7	0.1	3.6	ND
30	0.96	ND	ND	ND	0.6	38.8	9.9	5931.1	3.0	0.2	32.1	ND
31	0.7	ND	ND	ND	0.1	3.3	11.6	82.3	1.7	0.1	32.1	ND
32	1.1	ND	ND	ND	0.4	2.5	6.8	66.8	1.1	0.1	49.3	ND
33	1.2	ND	ND	ND	0.1	6.7	17.5	110.3	1.3	0.1	9.8	ND
34	1.043	ND	ND	ND	0.1	10.5	6.5	218.1	3.1	0.6	116.9	ND
35	1.26	ND	ND	ND	0.4	12.7	6.4	6221.6	2.7	0.1	7.1	ND

Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Ni: Nickel, Pb: Lead, Zn: Zinc, AS: Arsenic, ND: Not determined

Table 3: Standard deviations of the cosmetics products categories

Metal	High price	Medium price	Low price
Fe	2148±667	3116±1355	2314±861
Ni	3.2±0.8	3.7±1.0	3.2±0.8
Pb	0.9±0.2	0.7±0.2	1.4±0.3
Zn	37.7±9.2	18.9±5.2	167.5±40.9
Cu	8.5±2.1	9.5±2.2	14.2±3.6
Cr	13.3±3.7	8.1±2.3	9.2±1.9
Co	0.5±0.2	0.3±0.1	0.2±0.0
As	0.4±0.1	0.6±0.2	0.3±0.1
Cd	0	0	0

(*n*=8-12) and SEM. SEM: Standard error of mean, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Ni: Nickel, Pb: Lead, Zn: Zinc, AS: Arsenic

differences in the content of Cu between various cosmetic classes, all of which contained Cu in <30 PPM, except for one low-quality product which reached 40 PPM.

Iron (Fe)

High levels of ferrous (Fe2+) are associated with damage to vital body organs such as the liver and kidneys. Our results showed considerable variations in the amount of iron in different cosmetic classes. All cosmetic samples did not exceed 10000 ppm.

Nickel (Ni)

One of the harmful adverse effects of nickel is allergic reactions that primarily affect skin rash at the reaction site.[9]

Ni was present in most of the samples with a relatively high amount, only two samples of the high and low classes exceeded the German limit (10 PPM), while all products of medium class did not exceed that threshold.

Lead (Pb)

Lead has a severe toxicological profile, it affects neurological, cardiological, and renal functions, since it is widely distributed throughout the body and affects every cell.[10] All cosmetics contain lead below 4 PPM, which is consistent with the guidelines of SFDA, USFDA, and Canada. However, only one high and few low-quality products exceeded the German limit (2 PPM).

Zinc (Zn)

In general, zinc is not considered to be harmful; thus, there are no international regulations that restrict the amount of zinc in cosmetics. The low-quality cosmetics showed the highest content of zinc; however, all samples demonstrated <500 PPM of zinc, which is acceptable as it is within the recommended range of EU and SFDA.

Arsenic (As)

Oral and inhalation exposure to arsenic can cause serious internal effects such as altered myocardial depolarization and cardiac arrhythmia.[11] All the tested samples contained arsenic in an amount lower than the standards of SFDA, USFDA, and Canada. In addition, most of the low-quality cosmetics were below the German limit (0.5 PPM). The WHO recommends that arsenic should not exceed 0.01 PPM as a food additive.[12] In cosmetics, the USFDA, SFDA, and Canada have allowed a higher limit (3 PPM).

CONCLUSIONS

In summary, the present study was designed to determine the contents of heavy metals in selected colored cosmetic products at the Saudi Market and compare the results with the available international standards. The study findings showed that low-quality products were containing a high amount of lead, copper, iron, and zinc, while the products of the high class were containing high amount of cobalt, chromium, and arsenic. Nickel and cadmium were found to be high in all colored cosmetic classes. Together these results provide important insights into the insignificant effect of the price on the content of heavy metals in cosmetics. Even though the most analyzed samples in this study were European brands, some of the products did not appear to comply with European standards while it follows American and Canadian regulations. Therefore, it may be necessary to reconsider the limits of heavy metals impurities in cosmetics.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Saadatzadeh A, Afzalan S, Zadehdabagh R, Tishezan L, Najafi N, Seyedtabib M, *et al*. Determination of heavy metals (lead, cadmium, arsenic, and mercury) in authorized and unauthorized cosmetics. Cutan Ocul Toxicol 2019;38:207-11.
2. Iwegbue CM, Bassey FI, Obi G, Tesi GO, Martincigh BS. Concentrations and exposure risks of some metals in facial cosmetics in Nigeria. Toxicol Rep 2016;3:464-72.
3. Ghaderpoori M, Kamarehie B, Jafari A, Alinejad AA, Hashempour Y, Saghi MH, *et al*. Health risk assessment of heavy metals in cosmetic products sold in Iran: The Monte Carlo simulation. Environ Sci Pollut Res Int 2020;27:7588-95.
4. Godt J, Scheidig F, Grosse-Siestrup C, Esche V, Brandenburg P, Reich A, *et al*. The toxicity of cadmium and resulting hazards for human health. J Occup Med Toxicol 2006;1:22.
5. WHO. Guidelines for Drinking Water Quality. Vol. 1. Geneva, Switzerland: Recommendations, World Health Organization; 2004.
6. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for cobalt. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service; 2004.
7. Mills GC, Alperin JB, Trimmer KB. Studies on variant glucose-6-phosphate dehydrogenases: G6PD Fort Worth. Biochem Med 1975;13:264-75.
8. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Copper. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service; 2004.
9. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Nickel. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service; 2005.
10. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Lead. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service; 2020.
11. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Arsenic. United States: Agency for Toxic Substances and Disease Registry; 2007.
12. Joint FAO. World Health Organization, and WHO Expert Committee on Food Additives. Evaluation of certain contaminants in food: seventy-second [72nd] report of the Joint FAO/WHO Expert Committee on Food Additives. World Health Organization, 2011.