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Original Article

Assessment of Toxic Elements and Peroxide Value in Lipsticks Collected From Karaj, Iran

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Abstract
The present study aimed to evaluate the levels of lead (Pb), arsenic (As), and mercury (Hg), as well as peroxide values in 52 samples of lipstick in Karaj, Iran. The Varian Spectra AA-220 atomic absorption spectrometer was utilized to determine the concentration of metals. The average levels of the analyzed metals were in good accordance with the standard levels set by the Institute of Standards and Industrial Research of Iran (ISIRI 14622). The obtained results illustrated that the mean (±SE) levels of Pb, As, and Hg were 3.029±0.787, 0.546±0.090, and 0.044±0.002 µg/g, respectively. Moreover, the mean peroxide value (2.173±0.314 mEq/kg) was lower than the maximum amount set by ISIRI 14622)10 mEq/kg). Therefore, a continuous monitoring program to ensure acceptable quality of these products along with an enhancement in the consumers' awareness of the potential hazards of the regular use of cosmetic products is highly recommended.
Keywords: Lipstick, Lead, Arsenic, Mercury, Toxic elements, Peroxide

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1. Introduction

The use of cosmetics is as old as the human civilization. There is a great tendency towards different types of cosmetics and their use is increasing day by day. Despite the great interest of consumers in these products, the presence of toxic elements in them has raised concerns (1). These elements have a toxic, persistent, and aggregative nature which can lead to their accumulation in human skin and consequently their further migration to blood vessels, which can lead to subsequent problems (2). High concentrations of toxic elements in the body can cause their accumulation in many parts of the human body, giving rise to hepatotoxicity, nephrotoxicity, and neurotoxicity (3, 4). Trace concentrations of toxic elements can be either intentionally inserted into cosmetics or supplied as impurities (e.g., synthetic dyes) in the raw materials (5, 6). Cosmetic products are regularly used by numerous individuals globally. They have been identified as significant contributors to the release of harmful substances into the environment, posing potential risks to human health and the ecosystem. The toxic components of these products can ultimately contaminate surface water and agricultural soils through wastewater, potentially entering the human food chain (7). Consequently, contamination of marine organisms with various toxic substances, particularly methylmercury, which is linked to neurodevelopmental disorders in children, is increasing. This component is also a teratogen (8). Among cosmetic products, lipsticks are particularly popular. Lipsticks are believed to contain toxic elements such as chromium (Cr) (6), nickel (Ni), lead (Pb), arsenic (As), aluminum (Al), cadmium (Cd), and antimony (5, 6, 9). In October 2007, a team of researchers conducted a study to determine the lead content in 33 different lipstick brands, utilizing tests aimed at assessing the health implications of cosmetics. The study findings revealed that a significant number of samples (20 samples, 61%) exhibited elevated levels of Pb (10). Nnorom et al (11), Khalid et al (12), and Tsankov et al (13) reported that Pb concentrations in various brands of lipsticks were 41.1 µg/g, 87–123 µg/g, and 0.286–6.234 µg/g, respectively.

Naturally, small amounts of lipsticks are ingested every time they are used. Although small amounts of toxic elements exist in lipsticks, the prolonged and regular use of these products plays a significant role in developing chronic diseases, particularly skin cancer (1, 14). Lately, concerns have been raised about the health impacts of toxic elements, especially Pb, in cosmetic products like lipsticks (15, 16).

Recent research has shown that there is no safe limit for Pb, due to its neurotoxic nature (17). Pb has an important role in increasing the blood pressure and risk of cardiovascular diseases in adults, decreasing cognitive ability, and the formation of renal tumors (18, 19). Additionally, it can also induce multiple adverse effects on human health, including peripheral vascular diseases, elevated blood pressure, melanosis, cancer, gangrene, and skin lesions (20). Furthermore, mercury (Hg) is another well-known neurotoxin which can also cause cutaneous diseases; therefore, its use in skin products was banned in 1973 by the US Food and Drug Administration (21).

The prolonged exposure to these toxic metals would lead to the occurrence of oxidative stress or oxidative deterioration of lipids, proteins, and DNA in the body due to their ability to trigger the production of free radicals (i.e., peroxides, reactive oxygen molecules, etc.), which is the main cause of acute and chronic diseases, such as different types of cancers, atherosclerosis, and so on (22, 23). Moreover, regarding cosmetic products, there is a possibility of lipid oxidation and consequently complete spoilage of the product via the production of peroxide molecules which are highly toxic and invasive, thereby being harmful to human health. Peroxide value is the amount of peroxide or active oxygen produced per one kilogram of a sample of oil or fat, which is expressed in milliequivalents per kilogram of oil or fat (mEq/kg) (24, 25). The major cosmetic oils used in these products for achieving the desired viscosity and melting point are categorized as follows: (*i*) mineral oils, (*ii*) natural oils, and (*iii*) synthetic oils. Mineral oils are insoluble in water and alcohol and are used as emollients. Natural oils are obtained from the seeds of vegetable oils. Except for jojoba, they are all triglycerides. Synthetic oils are esters of fatty acids with alcohols. Isopropyl myristate is one of the most important synthetic oils (24-26).

Taken together, the presence of toxic elements and the high concentration of peroxide in cosmetics can create health problems, which require constant monitoring to ensure consumers' safety. To our knowledge, there are limited studies that report the heavy metal contamination of lipsticks and there is no report on the peroxide value of them at the national level. Therefore, the purpose of the present study was to investigate the concentrations of Pb, As, and Hg elements in solid lipsticks purchased in Karaj, Iran, and compare them with their standard levels. Moreover, the amount of lipid peroxidation in lipstick samples, in terms of peroxide value, was measured.

2. Materials and Methods

2.1. Sampling and Sample Preparation

A total of 52 solid lipstick samples authorized by the Food and Drug Administration of Iran were randomly purchased from local markets in Karaj, Iran. The specimens underwent acid digestion utilizing a mixture of 65% nitric acid (HNO_3) and 75% perchloric acid ($HClO_4$). Initially, 10 mL of nitric acid was mixed with 10 g of specimens and maintained at 95 °C for 3 hours. Subsequently, 10 mL of perchloric acid was added to the specimens. Following centrifugation at 7000 rpm for 10 minutes, the specimens were filtered and subjected to digestion on a sand bath. The volume was then increased to 25 mL with distilled water. Under these conditions, the specimen was prepared for injection into the machine (27, 28). All chemicals in this research were of analytical grade (Merck KGaA, Darmstadt, Germany).

2.1. Measurement of Heavy Metals and Peroxide Number

The Varian spectra AA-220 furnace atomic absorption spectrometer (FAAS) was used to measure the levels of Pb and As ions at wavelengths of 283.3 nm and 193.3 nm, respectively. It was equipped with a deuterium lamp for background correction and a GTA-96 graphite furnace atomizer. Mercury levels were measured using a hydride generation atomic absorption spectrometer (HG-AAS, Varian, USA) employing the cold vapor technique. A mercury hollow cathode lamp was used as the light source at the wavelength of 253.652 nm. Stock standard solutions were prepared at three distinct concentrations (100, 500, and 1000 ppm). Daily working standard solutions were prepared by adding stock solutions to the blank samples (10 mL). Next, the standard metal solutions and control samples were utilized to establish the calibration curve. Ultimately, the absorbance readings obtained were converted into concentrations (10).

Lipid peroxidation was assessed in terms of peroxide number, according to the standard method defined by the Institute of Standards and Industrial Research of Iran (ISIRI 14622). The peroxide number was calculated with the following equation:

$$A = \frac{V \times M \times 1000}{m} \quad (1)$$

Where V is the volume of the consumed sodium thiosulfate (mL), M is the concentration of the consumed sodium thiosulfate (mol/L), and m is the weight of the sample (g).

2.2. Statistical Analysis

SPSS version 16.0 (SPSS Chicago, IL) was used for statistical analysis. The results were displayed as mean ± standard error of the mean. Differences between the mean levels of toxic elements and their standard levels were tested for significance using the one-sample t test at a significance level of $P \leq 0.001$.

3. Results and Discussion

Based on our results, the mean levels of Pb, As, and Hg in 52 samples were 3.029 ± 0.787, 0.546 ± 0.090, and 0.044 ± 0.002 ug/g, respectively. Pb had the highest mean concentration, while Hg had the lowest mean concentration. The obtained results illustrated that the mean levels of the analyzed metals were in good compliance with their Iranian standard levels (10 µg/g for pb and 3 µg/g for As) (INSO 14622) ($P < 0.001$). None of the tested samples exceeded the acceptable limits, except for 3 samples of lipsticks. In other words, the concentration of Pb was higher than 10 µg/g in 3 samples (27.00, 24.57, and 15.36 µg/g). The concentrations of the tested toxic elements in the 52 samples of lipstick and their standard limits are shown in Table 1.

Cosmetic products are consumed daily by countless consumers around the world. They can release toxic elements into the environment, posing great hazards to human health and also the environment. The toxic elements of these products will ultimately end up in surface water and agricultural soils through wastewater and subsequently get into the human food chain. Accordingly, contamination of marine animals with different toxic elements, especially Hg, in the form of methylmercury which is associated with neurodevelopmental disorders in children, is on the rise (29). Lipsticks are among the most commonly used cosmetic products (30). Studies have demonstrated that different ingredients that are usually used in lipstick formulas are responsible for their contamination with heavy metals (5, 30). In this respect, color additives like synthetic dyes, which serve as cosmetics compartments, are usually contaminated with metallic impurities (5, 29, 30). Despite the prohibited use of toxic elements as ingredients in cosmetic products, the metallic impurities of these products seem to be unavoidable even under good manufacturing practices, due to the high overload of toxic elements in the surrounding environment as a result of either anthropogenic or lithogenic activities (5, 30, 31). Pb, Hg, and As are highly toxic non-essential elements that tend to accumulate in body organs and have long-lasting toxic effects (31). Therefore, chronic exposure to these elements can lead to serious health disorders including different types of cancer (31, 32). Chronic exposure to Hg and Pb may lead to neurological damage, weight loss, anemia, and intelligence quotient reduction in children. In addition, As is a carcinogenic metalloid that can cause renal and hepatic disorders (3, 31). Therefore, many authorized regulatory organizations, including the FDA, have determined the maximum permissible levels for toxic elements in cosmetic products (30, 31).

Our findings are comparable to the findings of a recent survey performed in Saudi Arabia on 28 samples of lipstick, where Pb was found at concentrations ranging from 0.30 to 2.4 µg/g, with a mean of 0.7 ± 0.4 µg/g. Contrary to our result, they have concluded that the levels of Pb in all samples were in good accordance with their standard level (5). In 2007, the Campaign for Safe Cosmetics (CSC) declared that 61% of 33 samples of lipsticks contained Pb, with a maximum Pb amount of 0.65 µg/g, which was much lower than our result (9). In different studies, the concentration of Pb in lipstick samples was reported to range from 0.77 to 15.44 mg/kg (14) and 0.290 to 6.780 mg/kg (32), which were lower than our findings. In addition, the United States Food and Drug Administration examined 400 lipstick samples and noticed a maximum Pb level of 7.19 µg/g (33). A recent study performed in Sanandaj province of Iran displayed that the mean concentration of Pb was far lower (0.083 µg/g) compared to the current study (34).

In line with our results, the mean concentration of As in the 28 lipstick samples was 0.5 ± 1.2 µg/g (5). Consistent with our results, another study concluded that the median As concentration was 0.21 mg/kg (35). In addition, our findings showed that all concentrations of Hg in our survey were lower than 1 µg/g. This is in line with the results of a recent study reporting that the average concentrations of Hg in the 28 samples of lipsticks were 0.004 ± 0.003 µg/g, with the highest value of 0.02 µg/g (5). Furthermore, a previous study showed that the median value for Hg was lower than the detection limits of the methods (35).

Moreover, the mean peroxide value (2.173 ± 0.314 mEq/kg) was lower than the maximum limit set by ISIRI 14622 10(mEq/kg). Peroxide value is an indicator of lipid peroxidation level. Lipid peroxidation leads to deterioration of the lipid content of the cosmetic product and subsequently ends up with lipstick spoilage. Therefore, using oils with high stability towards rancidity is of great importance. It has been demonstrated that Jojoba oil serves as a standard oil-phase base in the cosmetic industry because of its stability towards rancidity. The peroxide value of jojoba oil is low which means minimum oxidation would occur (36).

4. Conclusion

Given our results, the concentration of the toxic elements (i.e., Pb, Hg, and As) in the analyzed lipstick samples was

Table 1. The Mean Concentrations of Toxic Elements Along With the Peroxide Values (mEq/kg) in Lipsticks

	No. of Samples	Minimum	Maximum	Mean ± SE	MPLs (ISIRI 14622)	*P* value
Pb	52	0.001 (µg/g)	27.00 (µg/g)	3.029 ± 0.787 (µg/g)	≤ 10 (µg/g)	0.001[a]
As	52	0.001 (µg/g)	2.800 (µg/g)	0.546 ± 0.090 (µg/g)	≤ 3 (µg/g)	0.001[a]
Hg	52	0.017 (µg/g)	0.100 (µg/g)	0.044 ± 0.002 (µg/g)	≤ 1 (µg/g)	0.001[a]
PV	52	0.000 (mEq/kg)	9.010 (mEq/kg)	2.173 ± 0.314 (mEq/kg)	≤ 10 (mEq/kg)	0.001[a]

Abbreviations: SE, standard error; MPLs: maximum permissible levels; Pb, lead; As, arsenic; Hg, Mercury; PV, Peroxide value.
[a] The difference between the mean concentration level and the standard level was significant (*P* value ≤ 0.001).

in the safe range and did not raise any safety concerns in consumers, as their levels were lower in comparison with the acceptable limits set by the Iranian standard organization, except for 3 samples of lipstick that had a pb content greater than 10 µg/g. Despite the low concentrations of toxic elements found in this survey, which ensure us that the tested lipsticks would not pose immediate health problems for their consumers, we should not neglect the synergistic interactions of these elements as well as their aggregating properties over a long period. Therefore, a continuous monitoring program to ensure acceptable quality of these products along with an enhancement in the consumers' awareness of the potential hazards of the regular use of cosmetic products is highly recommended.

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The authors declare no conflict of interests.

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