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Original Article

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An investigation on the lead and cadmium content of cosmetics and sanitary products- a case study of toothbrush

Sanaz Pashapour[1], Zahra mousavi[1*], Noorolhoda Malakijoo[1], Nasim Yaghoubian[2]

[1] *Nutrition & Food Sciences Research Center, Pharmaceutical Sciences Branch, Islamic Azad University, Tehran-Iran (IAUPS)*

[2] *Department of Medicinal Chemistry, Faculty of Pharmacy, Pharmaceutical Sciences Branch, Islamic Azad University, Tehran - Iran (IAUPS)*

[3] *Department of Pharmacognosy, Faculty of Pharmacy, Pharmaceutical Sciences Branch, Islamic Azad University, Tehran - Iran (IAUPS)*

Abstract

Accordingly, this study was conducted to investigate the concentration of lead and cadmium of different toothbrush brands. For this purpose, a total number of 20 toothbrushes from different brands were taken randomly. The concentration of lead and cadmium in the toothbrushes was then specified using Graphite furnace atomic absorption spectroscopy (GFAAS), model AAS 6200. The samples were prepared based on the technique of acid digestion. According to the results, the average concentration of lead and cadmium in the toothbrushes were 0.13 μg g−1 and 0.02 μg g−1, respectively. The highest and lowest concentrations of lead in the samples were 0.44 μg g−1 and o.o1 μg g−1, respectively. The highest and lowest concentrations of cadmium were 0.15 μg g−1 and 0.01 μg g−1, respectively. In general, the concentration of lead and cadmium in all the toothbrushes was lower than the standard limit of 2002/94 / EC. There was observed a significant relationship between the concentration of lead and cadmium and the color of toothbrushes ($P<0.05$). The toothbrushes of red color contained the highest concentration of lead while the minimum content was found in the blue-color samples. The highest and lowest cadmium concentrations were found in the while and blue toothbrushes, respectively. Given the fact that even relatively low levels of exposure to heavy metals can lead to serious damage to human health, more comprehensive research is essential in the field of raw materials used in the manufacture of toothbrushes as widely used sanitary products in communities. It is also necessary to measure the concentration of heavy metals in the products in order to ensure the safe levels of harmful materials.

Keywords: cadmium, lead, heavy metals, cosmetics, toothbrush

******Corresponding author***: Zahra Mousavi, Department of Pharmacology & Toxicology, Faculty of Pharmacy, Pharmaceutical Sciences Branch, Islamic Azad University, Tehran - Iran.
Tel: +98-2122640051-5
E-mail address: mosavi50@yahoo.com

Introduction

Extensive media campaigns and increased public awareness towards beauty and health has increased the demand for hygienic and cosmetic products in modern societies so that the use of cosmetic products has recently become common among all upper, middle, and lower classes of society.(Mousavi, Ziarati, & Shariatdoost, 2013) With the increasing usage of cosmetics products, attention has been focused on the composition and ingredients of these products and side effects of their use. Cosmetic products on the market are often composed of complex and diverse materials. If these materials are inferior and substandard, it will leave irreparable risks on the consumers' health. Lead and cadmium are two toxic stuffs, mainly used as raw materials and pigments in the manufacture of cosmetics (Volpe, Nazzaro, Coppola, Rapuano, & Aquino, 2012; Ziarati, Moghimi, Arbabi-Bidgoli, & Qomi, 2012). These elements belong to the group of heavy metals and are common contaminants of cosmetics (Bocca, Pino, Alimonti, & Forte, 2014; Eghbali, Mousavi, & Ziarati, 2014) .

The use of these metals, as ingredients in cosmetics, has attracted the attention of physicians and researchers in terms of their possible toxic effects (Gao et al., 2015; Liu, Hammond, & Rojas-Cheatham, 2013). The results of relevant studies show that increasing the amount of lead and cadmium in the human body can lead to serious health risks such as acute or chronic poisoning, pathological changes of organs, and cardiovascular diseases, failure of kidneys, bone damages, and liver disease. In addition, excessive accumulation of these elements in human body can also cause cancer (Koller, Brown, Spurgeon, & Levy, 2004). Researches also approve significant damage to internal organs such as liver, lungs, kidneys, central nervous system, and bones as a result of the accumulation of cadmium in human body (Afkhami, Ghaedi, Madrakian, & Rezaeivala, 2013; Khani, Ghiamati, Boroujerdi, Rezaeifard, & Zaryabi, 2016; Xiang et al., 2012). Epidemiological studies in human populations showed that cadmium increases the risk of breast, prostate and endometrial cancers (Ali, Damdimopoulou, Stenius, & Halldin, 2015; Julin et al., 2012; Khani et al., 2016). Lead is classified by the International Agency for Research on Cancer (IARC) in the category of possibly carcinogenic (Bocca et al., 2014; on the Evaluation, 2006). This hazardous substance can affect the reproductive, nervous, hematopoietic, hepatic and renal systems of humans and also cause low birth-weight as well as changes in pregnancy, lactation and menopause (Azeez et al., 2013). Lead effect on the fetus and central nervous system of children is also approved in some studies (Bellinger, 2008) .

In view of the negative effects of lead and cadmium, investigation of their concentration in cosmetic products is of utmost importance in order to control the quality of these products and ultimately improve the health of their consumers. According to the indiscriminate use of cosmetics, lack of attention to their standard, and unauthorized entry of counterfeit products to the countries, it is necessary to accurately check substances and ingredients of cosmetic products and prohibit their use in case of detecting dangerous elements in them, whereas the presence of these metals in the cosmetic products used by public can have irreversible effects on their health. One of the sanitary products used by the public is toothbrush. Due to the daily and extensive use of sanitary products, their evaluation in terms of heavy metal content is very important.

Given the importance of the issue and the role of toothbrush in public health, the present study, as the first comprehensive research of this type, was conducted to evaluate the lead and cadmium content of different brands of this sanitary product.

Material and methods

Preparation of the samples

The study population included 20 toothbrushes from different brand, which were selected randomly. In the first step, after removing the head of the toothbrushes, their weight was measured. Then, for incineration operation, each of the samples was placed in the oven for 5 hours at a temperature of 450 ° C. After cooling the ash at ambient temperature, it was filtered through the whatman paper. The ash powder was brought up to a volume with 0.1 molar nitric acid using Falcon tube 10 ml. In order to measure the amount of lead and cadmium, graphite furnace atomic absorption spectroscopy, AAS 6200 model manufactured by Shimadzu Co. in Japan was used.

Preparation of 10% nitric acid solution

Based on the m1v1=m2v2 equation, 1 liter of 10% nitric acid solution was prepared from 65% nitric acid reference solution. For this purpose, about 800 mL of deionized water was poured into a 1-liter breaker, and then, according to the above-mentioned equation, 154.8 m of 65% nitric acid was added to it. The solution was brought up to a volume with 10% nitric acid and homogenized by glass stirrer. All of the glass containers, used in the experiment, were placed in this breaker for 24 hours in order to be washed well with acid. Afterwards, they were washed with deionized water and thoroughly dried up by oven.

Measurement of lead and cadmium content of the samples

After heat adjustment of atomic absorption device, the prepared lead and cadmium standard solutions were measured from low to high concentration, respectively. The injected volume was the same in all of the standard solutions and the samples (about 3 cc). The concentration of standard solutions and the frequency of their read were recorded. After reading the standards, their calibration curves were plotted by the system and eventually lead and cadmium concentrations in the samples were measured in ppm.

Validation method

To determine the accuracy and precision of the experiment, recovery tests were conducted by spike and blank samples. For each of the heavy metals, spike samples were prepared at different concentrations. For each concentration, the samples were prepared in three consecutive days. The average recovery for cadmium and lead, respectively 93 and 89% with coefficients of variation were 6.6 and 5.2. Limit of detection (LOD) and limit of quantification (LOQ) was defined with the signal to noise ratio of 3 to 10 LOD and LOQ in the sample solution was measured as 0.004 μg kg-1 to 0.012 μg kg-1 for lead and 0.003 μg kg-1 to 0.01 μg kg-1 for cadmium.

Result and discussion

According to the results, average lead concentration in the samples was 0.13 μg g−1. Also, the average concentration of cadmium in the toothbrushes was 0.02 μg g−1. The highest and lowest lead concentration in the toothbrushes were 0.44 μg g−1 and 0.01 μg g−1, respectively (Figure 1). The highest and lowest concentrations of cadmium were reported as 0.15 μg g−1and 0.01 μg g−1(Figure 1).

The analysis results showed that the concentrations of these two dangerous elements in the toothbrushes are lower than the limit set by the EC/94/2002 standard. This is in line with the results of other studies in which lead and cadmium concentrations of the cosmetic products have been reported much lower than the EC/94/2002 standard. As such, in a study by Nourmoradi et al. (2013), the lead and cadmium concentrations in 50 samples of lipstick and eye-shadow were reported below

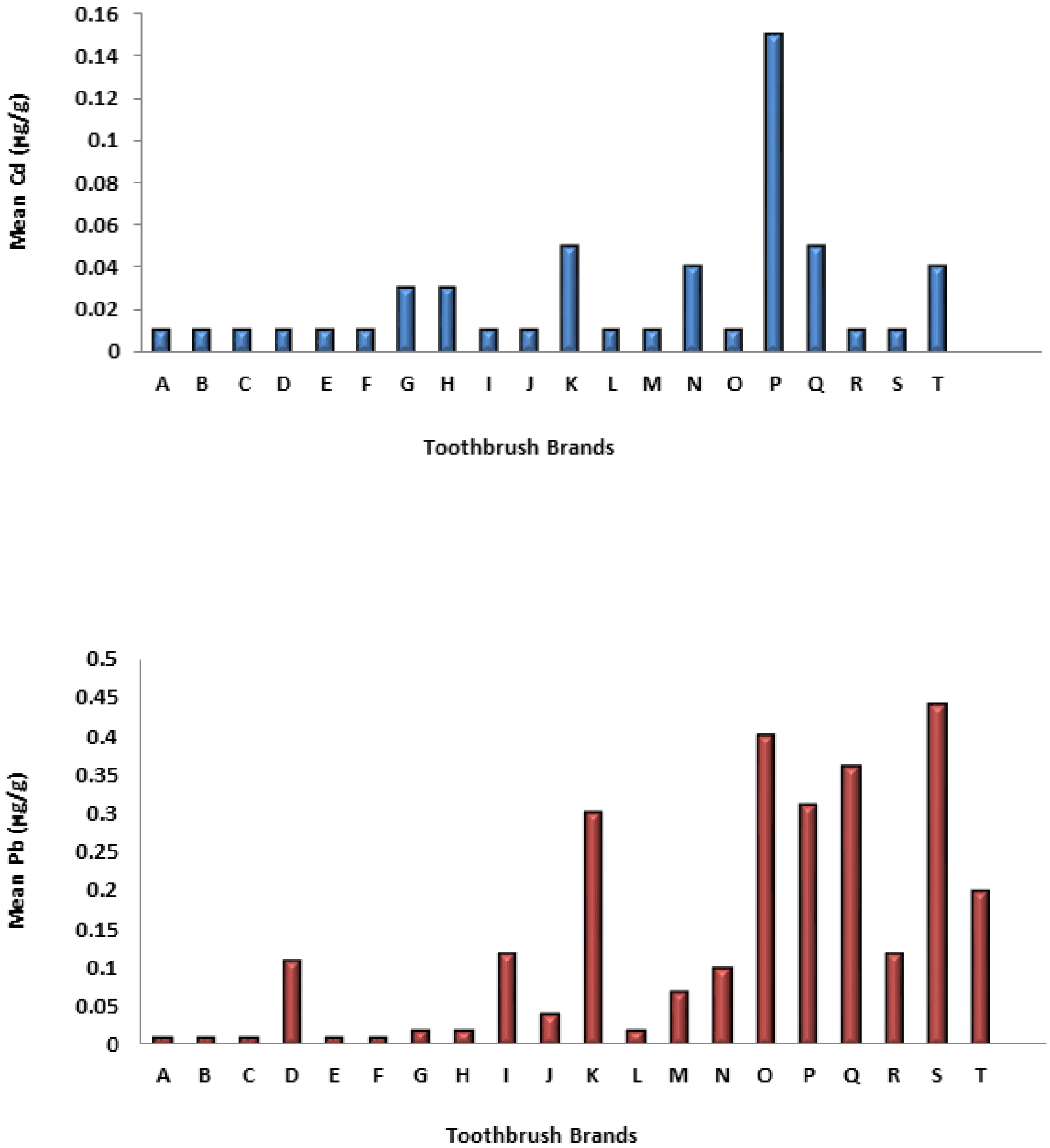

Figure 1: Comparison of Lead and Cadmium concentrations in different Toothbrush Brands samples

the standard limits. According to their results, lead and cadmium concentrations were within the range of 0.08-5.2 μg g−1 and 0.08-60.20 μg g−1, respectively. Lead and cadmium concentrations in the eye shadow fell within the range of 0.85-6.90 μg g−1 and 1.54-55.59 μg g−1, respectively. The concentrations of lead and cadmium in 24 different types of eye shadow studied by Omolaoye et al (2010) were respectively within the ranges of 5.00±0.00-55.00±11.67 μg g−1 and 0.00±0.00-8.89±1.92 μg g−1, which were below the standard limit.

In a study by Lwegbue et al. (2016), the concentration of cadmium and lead was investigated in 9 cosmetic products; including lip gloss, lip large, eye pencil, eyeliner, eye shadow, mascara, blush, and powder. Their results showed that the average concentration of cadmium was much lower than present study and the EC/94/2002 standard. However, unlike the results of the present study, the maximum concentration of lead in the cosmetic products was beyond the standard limit. The average concentrations of cadmium and lead in the study by Lwegbue et al. (2016) were in the ranges of 3.1-8.4 μg g−1 and 12-240 μg g−1. In a study by Ullah et al. (2013), the average concentration of lead and cadmium in 15 cosmetic-sanitary products were 141.6±0.016 μg g−1 and 0.238±0.001 μg g−1. As their results show, the mean concentration of cadmium was less than the standard limit and the average lead concentration was greater than the limit, which is similar to the findings by Lwegbue et al. (2016). In research by Norom et al. (2005), the geometric mean values of lead in cosmetics, including eye pencil, eyeliner, and lipstick were in the range of 87.3 μg g−1 to 132.2 μg g−1 and cadmium concentration in all of the samples was lower than 1.0 μg g−1. These values were below the standard limit. Given the fact that even relatively low levels of exposure to heavy metals can lead to serious damage to human health, it is necessary to prevent illegal entry and smuggling of toothbrushes, as the most widely used sanitary product, to countries and measure the concentration of heavy metals in the products in order to ensure the safe levels of harmful materials. This study also found a significant relationship between lead and cadmium concentrations and different colors of toothbrush ($P<0.05$). The highest level of lead was measured in the red toothbrushes while the blue toothbrushes contained the lowest level of lead. The highest amount of cadmium also belonged to the toothbrushes with white paint and the lowest was seen in blue toothbrushes. Ziarati et al (2012) also reported a significant difference between the concentration of lead and cadmium and different colors of lipstick ($P<0.05$). They studied 120 lipsticks from 19 different brands. According to their findings, the highest and lowest amounts of lead were measured in pink and purple lipsticks while the highest and lowest levels of cadmium were reported from brown and orange lipsticks. The results of these studies confirm the use of heavy metals as impurities in the color additives. According to the foregoing, due to the widespread use of toothbrush and toxicity of their heavy metal content, it is recommended to take sufficient precaution in the manufacture of raw materials and attempts should made to use high quality and standard input materials in the cosmetic and sanitary products.

Conclusion

Heavy metals, such as lead and cadmium, are among the pollutants that are normally used for retention of materials in the cosmetic and sanitary products, including toothbrushes. The use of heavy metals, as ingredients of these products, is carcinogenic to humans and can be very dangerous. Therefore, due to the increased use of cosmetic products in modern societies and the entry of counterfeit products to the market, it is required to accurately check the quality of these products and their ingredients. Therefore, in this study, toothbrushes, as one of the most important and widely used sanitary products, were examined in terms of their lead and cadmium content. The results showed that the concentration of lead and cadmium in none of the toothbrushes was beyond the permissible limit set by the EC/94/2002 standard. Given the small number of the samples examined in this study, it is suggested to do more comprehensive and detailed studies in this field with greater sample size. Due to the widespread use of cosmetics in communities and metal toxicity of heavy metals, it is also necessary to examine the concentration of these metals in other cosmetic products.

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