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Research Article

LEVELS AND EXPOSURE RISKS OF METALS IN LIPSTICKS IN MEKELLE, ETHIOPIA

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ABSTRACT

This study aimed to determine the concentrations and human exposure risks of heavy metals (lead, cadmium and zinc) in lipsticks of different brands marketed in Mekelle, Ethiopia. The samples were dry-ashed in a muffle furnace and then digested with nitric acid, and analzed by flame atomic absorption spectrophotometer. The mean levels of metals in lipstick products ranged from 0.035 to 0.352 mg/kg cadmium and 6.398 to 17.638 mg/kg zinc while lead was not detected. The estimated systemic exposure dosage values for cadmium and zinc in lipsticks were below their respective provisional tolerable daily intake or recommended daily intake values. The margin of safety values were greater than 100 which showed that the metal levels found in these products do not pose significant health risk to the users.

Keywords: Lipsticks, Margin of safety, Metals, Systemic exposure dosage.

INTRODUCTION

Cosmetics products have been reported as a source of metal exposure to human being[1]. In spite of the fact that beauty awareness of individuals has set the demand of cosmetic products in market, the adverse effects associated with these products have been a health concern. Heavy metal contamination of the products is one of the critical explanations for adverse effects[2,3]. Many studies have investigated relatively high levels of heavy metals in various cosmetic products[3-6]. The common heavy metal contaminants of cosmetics are cadmium and lead[2,3]. Studies have reported different levels of heavy metals in lipstick products[7-11].

Possible sources of metals in cosmetic products are raw materials, water contaminated with metals and metal-coated apparatuses during cosmetics production. Intentional use of metals and their compounds, mainly as UV filters in face and body care products and pigments in coloured cosmetics, in the cosmetic industry contaminates the products with metals[12]. Hence monitoring the safety of cosmetic products, which would benefit the consumers, is crucial. The purpose of this study was to assess the levels and exposure risks of lead, cadmium and zinc in some brands of lipsticks available at local markets in Mekelle, Ethiopia.

MATERIALS AND METHODS

Sample collection

Three different brands of commercially available lipsticks were purchased from supermarkets in Mekelle, Ethiopia between February and March, 2017. Samples were coded for ease of identification.

Sample digestion and analysis

Solid samples were dried in an oven at 105^{o}C to constant weight and then stored in desiccators. About 3.5 g of each of the dried samples was weighed into a porcelain crucible and dry-ashed in a muffle furnace by stepwise increase of the temperature up to 550^{o}C for few hours. The ash samples then digested with a few ml of HNO_3, evaporated near to dryness on a hot plate in fuming hood, cooled and then filtered with whatman # 42 and diluted up to the mark (100 ml) into a calibrated flask. The resulting solution was then analyzed using Flame Atomic Absorption Spectrophotometer (AA240FS, Varian, Australia).

Quality assurance

Sample containers and all other glassware were cleaned with water, soaked in 10% nitric acid for 24 hours and then rinsed many times with distilled deionized water. Standard solutions were prepared from stock standard 1000 mg/L. Calibration curves were constructed from five series of working standard solutions. The correlation coefficients of the calibration curves ranged from 0.9990 to 0.9997 that showed there was a very good correlation between concentration and absorbance. Accuracy of the digestion method was examined by spiking standard solutions of metals to known amount of samples. Percentage recoveries ranged from 92.4% to 109%. Limits of detection (LODs) were evaluated as the concentrations that give signals equal to three times the pooled standard deviations of six runs of blank measurements. LODs of Cd, Pb and Zn were 0.0138, 0.0146 and 0.0151 mg/kg, respectively. Blank samples were also prepared using the same procedures as for the samples and analyzed simultaneously.

Statistical analysis

The data were analyzed using analysis of variance (ANOVA) and Tukey post hoc test to check differences between the mean levels of metals in the samples at 95% confidence level. SPSS statistical package version 20.0 was used for statistical analysis.

Safety evaluation of lipsticks

Margin of safety (MoS) is used to assess the risk of human exposure to metals in cosmetic products. The MoS is calculated by dividing the no observed adverse effect level (NOAEL) value of the cosmetic substance under study by its estimated systemic exposure dosage (SED)[13]:

$$MoS = \frac{NOAEL}{SED} \quad (1)$$

The systemic exposure dosage is investigated based on the amount of the finished product applied to the skin per day, the concentration of metals in the cosmetic product under study, the dermal absorption of the metal and a human body weight value[13].

$$SED(\mu g / kg\, bw / day) = \frac{C * AA * SSA * RF * BF}{BW} * 10^{-3}$$

Where C is the concentration of metal in the lipsticks; AA is the estimated amount of lipstick applied per day (0.057g); SSA (4.8 cm^2) is skin surface area expected to be treated with the finished cosmetic product; RF is retention factor (1 for leave on cosmetic products); BF is the bioavailability factor; 10^{-3} is the unit conversion factor; and BW is a default body weight of 60 kg was used. The values of AA, SSA and RF used in the present study were the standard values established by the Scientific Committee on Consumer Safety (SCCS)[13].

NOAEL is the highest dose or exposure level where no adverse treatment-related findings are observed. NOAEL values were calculated from the oral reference doses (RFDs) as follows:

$$NOAEL = RFD * UF * MF \quad \textbf{(3)}$$

Where UF is uncertainty factor and MF is modifying factor. In this case the default values of UF and MF were 100 and 1. The RFDs (mg/kg/day) used were $4x10^{-3}$ for Pb[14], $1x10^{-3}$ for Cd and $3x10^{-1}$ for Zn[15,16].

The WHO proposes a minimum value of 100, and it is generally accepted that the MoS should at least be 100 to conclude that a substance is safe for use. The SCCS acknowledges the fact that in many conventional calculations of the MoS, the oral bioavailability of a substance is assumed to be 100% if oral absorption data are unavailable. However, it is considered appropriate to assume that not more than 50% of an orally administered dose is systemically available[13]. In the present study, SED and MoS were obtained using mean concentrations of metals at 50% and 100% of the measured levels of metals in the lipsticks.

RESULTS AND DISCUSSION

Heavy metal levels in lipstick samples

The mean concentrations (± SD) of metals in different brands of lipsticks are given in Table 1. Lead was not detected in all brands of lipstick products. The levels of cadmium and zinc in the samples were within the range of 0.035 to 0.352 mg/kg and 6.398 to 17.638 mg/kg, respectively. The mean values of both cadmium and zinc content in the different brands of lipsticks were significantly different ($P<0.05$). The cadmium content in Lipsticks C was significantly higher than other brands of lipsticks though it had much lower zinc content.

The safe reasonable cutoff points of heavy metals in cosmetic products vary from country to country. Health Canada has set that the maximum permissible limit for cadmium in cosmetics is 3 mg/kg while in Germany this value is recommended at 5 mg/kg[17,18]. The

mean levels of cadmium in lipstick products in this study were below the limits specified by the Canadian and Germany Authorities. However, many studies in different origins of the world reported higher concentration of cadmium content in lipsticks. Nourmoradi et al. (2013) reported the level of cadmium in the most commonly used lipsticks in Iran within the range of 4.08–60.20 mg/kg[19] while the study conducted in Nigeria shows the mean concentration 8.4 mg/kg of cadmium content in lipsticks[7]. On the other hand, Zakaria and Ho reported the concentration of cadmium in lipsticks taken from the Malaysian market in the range of 0.06–0.33 mg/kg, which is consistent with the present study[8]. Other studies also reported similar findings in Nigeria[9,10] and Pakistan[11].

Even though lead was not detected in these cosmetics in the present study, many studies in various countries investigated a wide concentration range of lead content in lipstick samples[7-11,19]. The level of lead content in lipsticks was reported from undetectable value to as high as 3.76 g/kg[2].

The mean concentration of zinc in this study was 13.573 mg/kg, which is in agreement with the findings of the study done in Nigeria where the zinc level in lipsticks ranged from 12.1 to 16.4 mg/kg[9]. Iwegbue et al. (2016) reported the concentration of zinc content, 18.2 mg/kg, in lipstick products in southern part of Nigeria[7]. Nevertheless, the study conducted in Pakistan reveals lower level of zinc, 0.696–1.61 mg/kg, in the lipstick samples[11].

The variation of metal levels in lipstick samples in different origins related to the ingredients, manufacturing process or the containers[6,20]. For instance, the high level of zinc in some of the products are because of the use of some natural or inorganic pigments such iron oxides, carmine, mica, titanium dioxide, aluminium powder and manganese violet[2,20].

Health risk assessment

The calculated systemic exposure dosage (µg/kg bw/day) and MoS of heavy metals from the lipstick products are shown in Table 2. The SED of cadmium from the samples ranged from $7.98x10^{-8}$ to $1.61x10^{-6}$ µg/kg bw/day for 50% and 100% bioaccessibility scenarios. The provisional tolerable daily intake (PTDI) of cadmium is set at 1 µg/kg bw/day; however, the European Food Safety Authority (EFSA) set the provisional tolerable weekly intake (PTWI) of cadmium as 2.5 µg/kg bw/week[21]. The estimated SED values of cadmium from the use of these lipsticks by far lower than its provisional tolerable intake. The study done in southern part of Nigeria indicates the systemic exposure dosage of cadmium in lipstick samples in the range of $1.96x10^{-5}$ to $3.92x10^{-5}$ µg/kg bw/day at both 50% and 100% bioaccessibility[7]. The SED of zinc in the product samples ranged from $1.46x10^{-5}$ to $8.04x10^{-5}$ µg/kg bw/day at both bioaccessibility scenarios. The recommended dietary allowance value for zinc is 12 mg per day[22]. The estimated systemic exposure dosages of zinc from the application of lipsticks are below its recommended daily intake value. The calculated margins of safety for both cadmium and zinc in lipstick samples were higher than the minimum value of 100 proposed by the WHO.

CONCLUSION

This study investigated that cadmium and zinc were found in lipstick products at levels below permissible limits. The margin of safety estimated for each metal in the samples was greater than the proposed value of 100 set by the WHO to conclude that a substance is safe for use though consistent use of the products may build up these metals in the human body for a prolonged period of time to unsafe levels. The establishment of the maximum permissible limits of heavy metals in cosmetic products and regular monitoring system are recommended to prevent human health risks associated with the use of cosmetics.

Table1: Metal levels (mg/Kg) in lipsticks in Mekelle, Ethiopia

Lipsticks code	Cd	Pb	Zn
A	0.044±0.025	ND*	16.682±0.261
B	0.035±0.036	ND	17.638±0.747
C	0.352±0.030	ND	6.398±0.306
Overall mean	0.144±0.03	-	13.573±0.438

* ND – Not detected

Table 2: Systemic exposure dosage and margin of safety of Cd and Zn in lipsticks at 50% and 100% bioaccessibility

Lipsticks code	At 50% bioaccessibility		At 100% bioaccessibility	
	Cd	Zn	Cd	Zn
Systemic exposure dosage				
A	$1.0x10^{-7}$	$3.8x10^{-5}$	$2.01x10^{-7}$	$7.6x10^{-5}$
B	$7.98x10^{-8}$	$4.02x10^{-5}$	$1.6x10^{-7}$	$8.04x10^{-5}$
C	$8.03x10^{-7}$	$1.46x10^{-5}$	$1.61x10^{-6}$	$2.92x10^{-5}$
Margin of safety				
A	$9.97x10^{8}$	$2.63x10^{6}$	$4.98x10^{8}$	$1.31x10^{6}$
B	$1.25x10^{9}$	$2.49x10^{6}$	$6.27x10^{8}$	$1.24x10^{6}$
C	$1.25x10^{8}$	$6.86x10^{6}$	$6.23x10^{7}$	$3.43x10^{6}$

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