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Heavy metals contamination in lipsticks and their associated health risks to lipstick consumers

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ABSTRACT

This study aimed to determine the heavy metals (lead, cadmium, and chromium) concentration in lipsticks of different price categories sold in the Malaysian market and evaluate the potential health risks due to daily ingestion of heavy metals in lipsticks. A total of 374 questionnaires were distributed to the female staff in a public university in Malaysia in order to obtain information such as brand and price of the lipsticks, body weight, and frequency and duration of wearing lipstick. This information was important for the calculation of hazard quotient (HQ) in health risk assessment. The samples were extracted using a microwave digester and analyzed using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). The concentrations of lead, cadmium, and chromium in lipsticks ranged from 0.77 to 15.44 mg kg^{-1}, 0.06–0.33 mg kg^{-1}, and 0.48–2.50 mg kg^{-1}, respectively. There was a significant difference of lead content in the lipsticks of different price categories. There was no significant non-carcinogenic health risk due to the exposure of these heavy metals through lipstick consumption for the prolonged exposure of 35 years (HQ < 1).

1. Introduction

Metal content in lipstick has been an international health concern. This is because lipstick is the basic daily product that is included in face makeup application, in addition to face powder, foundations, eye shadows, and blush (Piccinini et al., 2013). Naturally, lipstick is applied on the lips for the users to look more beautiful and attractive, but the price for these women to be beautiful is their exposure to heavy metals contained in the lipstick. Lipsticks are believed to contain heavy metals such as lead, nickel, aluminum, arsenic, cadmium, antimony, and chromium (Al-Saleh and Al-Enazi, 2011). Moreover, heavy metals can be released by the metallic devices used during the manufacturing of products (Volpe et al., 2012).

Lipstick consumers are exposed to heavy metals only in small amounts, but they expose themselves for a prolonged period of wearing time, which make it significant in developing chronic health risk. The application of lipstick on the lips might cause exposure to a minuscule amount of the lipsticks through ingestion when the consumers eat and drink.

Chronic health risk is an irreversible response characterized by a gradual onset of long duration, following a constant or continuous exposure period to a low toxicant dose. Chronic exposure to lead could cause neurological, teratogenic, and blood systemic effects. Ingesting large amounts of chromium can cause stomach upset and ulcers, convulsions, kidney and liver damage, and even death. Skin contact with certain chromium compounds can cause skin ulcers. For people who are extremely sensitive to chromium, allergic reactions consisting of severe redness and swelling of the skin have been observed (Gondal et al., 2010). Prolonged exposure to cadmium is closely linked with cardiovascular diseases, such as atherosclerosis and hypertension (Angeli et al., 2013). Other than the non-carcinogenic chronic health risks, exposure to heavy metals might also cause carcinogenic health risks to lipstick consumers. There is sufficient evidence of carcinogenicity of cadmium in rats and mice by inhalation and intramuscular and subcutaneous injection, but no evidence of carcinogenic response by ingestion (USEPA, 1991). The National Toxicology Program's Report on Carcinogens Review Committee has recommended that lead and lead compounds be considered “reasonably anticipated to be human carcinogens” (USEPA, 2004).

Extraction of heavy metals from cosmetics is usually based on microwave-assisted digestion (Al-Saleh and Al-Enazi, 2011;

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Piccinini et al., 2013; Volpe et al., 2012). The amount of heavy metals extracted depends significantly upon experimental conditions such as sample weight, combination of used acids, temperature, and decomposition procedure. Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) is often employed for the analysis of heavy metals in cosmetics (Piccinini et al., 2013; Volpe et al., 2012) due to their low limit of detection (LOD). Other techniques such as atomic absorption spectrophotometer (AAS) and laser-induced breakdown spectroscopy (LIBS) were also applied in the same field (Al-Saleh et al., 2009; Gondal et al., 2010). However, LIBS is often limited to application on solid samples.

Heavy metals in cosmetics may seem like a small proportion of sources that threaten human health in comparison to water, food, or air. However, their health toxicities should not be discounted, as cosmetics are worn for a prolonged period of time and are often applied over thin and sensitive areas of the skin such as the lips and eye contours. Upon application over the skin and absorption into the body, heavy metals are known to bio-accumulate, leading to toxic levels. The evaluations of potential health risk with respect to the daily consumption of lipstick for adult women are based on some insight into heavy metal content in lipsticks and serve as a basis for comparison to the standard of the *Integrated Risk Information System (IRIS) under the United States Environmental Protection Agency (*USEPA). Up until now, there has been no comprehensive research on the potential health risk of ingestion of heavy metals in lipstick. The objectives of this study were to (i) determine the selected heavy metals concentration in lipsticks of different price ranges in the Malaysian market and (ii) evaluate the possibility of potential health risk due to daily ingestion of heavy metals in lipsticks among lipstick consumers.

2. Materials and methods

2.1. Study design

A cross-sectional study was carried out at the Universiti Putra Malaysia (UPM), a public university in Malaysia. A total of 374 questionnaires were distributed to the female staff in the university. The lipstick samples were purposely purchased based on the survey among the female staff that applies lipstick regularly. The respondents were required to provide information such as body weight, brand and price of the lipstick, and frequency and duration of wearing lipstick. The lipsticks were categorized according to their price: “cheap” (category I- < RM29.99), “intermediate” (category II- RM30-RM59.99), and “expensive” (category III- > RM60). The target samples were chosen based on the popularity among the respondents. Only the top 5 lipsticks in the list of each category were analyzed. The 15 lipstick samples were analyzed in triplicates that made up a total of 45 samples in this study.

2.2. Microwave digestion

Lipstick samples were extracted using a microwave digester according to the method of Piccinini et al. (2013). The digestion procedure was as follows: 0.4 g of lipstick was weighed into a microwave vessel liner. Subsequently, 6 mL of nitric acid (69%) purchased from Sigma–Aldrich (SA Steinheim, Germany) was added. The liners were placed in vessels, closed with a sealed cap, and put into the microwave oven Multiwave 3000 (Anton Paar, Graz, Austria). The samples were digested applying the following microwave program: 130 °C (ramp 15 min, hold 20 min), 200 °C (ramp 15 min, hold 20 min) and 50 °C (cold 10 min). The extracts were filtered to remove the wax and glitters from the lipsticks using filter paper and then diluted with ultrapure water (Millipore, Vimodrone (MI), Italy) to the final volume of 50 mL. There might be product loss in filtration of the glitters and waxes, since metals could still be bound to waxes. To overcome this limitation, the samples were analyzed in triplicates and the extraction recoveries were evaluated based on the analytical method as described in this study.

2.3. Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES)

Thermo Scientific iCAP 6000 Series ICP-OES was used to analyze the lipstick samples. Data collection and analysis were performed using iTEVA software from Thermo Scientific. The instrument was calibrated using a seven-point calibration curve (0.0005, 0.05, 0.1, 0.5, 1, 3, and 5 mg L^{-1}).

2.4. Quality control

For each batch of sample analysis, a method blank was carried throughout the entire sample preparation and analytical process (USEPA, 1996). These blanks are useful in determining if the samples are being contaminated. The limit of detection (LOD) and limit of quantification (LOQ) were calculated with three and ten times the standard deviation of the 10 individually prepared method blank solution (Khan et al., 2013). Extraction recovery was evaluated by spiking three replicates of blank matrix (organic lip balm) with heavy metals standard. The organic lip balm was divided into two groups: the first group (A1) was spiked with 0.25 ppm standard before the digestion, while the second group (A_2) was spiked with 0.25 ppm standard after the digestion but prior to ICP-OES injection. The percent of extraction recovery was calculated by comparing the concentration of heavy metals before the microwave digestion to its concentration spiked after digestion in the blank matrix using Eq. (1).

$$\text{Recovery}(\%) = \frac{A_1 - blank(ppm)}{A_2 - blank(ppm)} \times 100 \quad (1)$$

The instrument was calibrated with each element at a seven-point calibration curve. Linearity of each element was tested from 0.0005 to 5 mg L^{-1}. Linearity of the calibration curve for each element was evaluated by the coefficient determination (R^2). Identical samples were analyzed three times within one day's acquisition sequence. Each brand of lipstick was analyzed in triplicates in order to gain a more precise estimation of the data (USEPA, 1996). All sample containers were washed with detergents, acids, and ultrapure water. Acid wash was done on the microwave vessel liner to prevent any contamination from the previous sample digestion. The vessel liners were left overnight in 10% acid water to corrode any sample left or sticking on the vessel liner wall.

2.5. Health risk assessment

The major pathway of the heavy metals in lipstick entering the human body is ingestion. The dose received via ingestion was calculated using Eq. (2) (USEPA, 1997).

$$ADD_{ing} = \frac{C \times IR \times \times EF \times ED}{BW \times AT} \times CF \quad (2)$$

where ADD_{ing} is the average daily dose (ADD) of ingestion (mg kg^{-1} day^{-1}); C is concentration of the heavy metals in the lipstick to which the person is exposed (mg kg^{-1}); IR is the intake rate of the lipstick (40 mg day^{-1}) (SCCP, 2006); BW is the body weight of the exposed population (57.9 kg); EF is the exposure frequency (260 days $year^{-1}$); ED is exposure duration (35 years, based on the maximum duration of the exposed population); AT is