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Metals Contamination in Face Powders and their Associated Health Risks to the Users in Mekelle, Ethiopia

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Abstract

The presence of heavy metals has been reported in cosmetics and their assessment in these products is of significantly important to protect the users. The objective of this study was to assess the levels of cadmium, lead and zinc in face powders and provide information on the risk associated with human exposure to these heavy metals in the products. The samples were pretreated using dry ashing technique and analyzed by flame atomic absorption spectrophotometer. The level of lead in face powders was below the detection limit while the concentrations of cadmium and zinc ranged from 0.13 to 0.215 mg/kg and not detected to 7.05 mg/kg, respectively. The systemic exposure dosage values for these metals in the products were below their respective provisional tolerable daily intake and/or recommended daily intake values. The margin of safety values were higher than 100 which exhibited that the concentrations of metals observed in these products do not cause substantial health risk to the users.

Keywords: Face powders; Margin of safety; Heavy metals; Systemic exposure dosage

Introduction

Heavy metals have been recorded in varying levels in different cosmetic products and some of these metals have been banned as intentional ingredients associated with their known or probable negative health consequences [1]. Some toxic heavy metals such as lead, and cadmium have been found in cosmetic powders [2-5]. Nevertheless, beauty consciousness of individuals has set the demand of cosmetic products in the market, and hence the associated side effects with these products have been a health issue [6,7]. The lack of global regulatory indications concerning the safety threshold of metals in cosmetics in Europe has raised many uncertainties within the cosmetic market. The European Union has not set any specific legal limits for ubiquitous traces of heavy metals in cosmetic ingredients [8]. However, the Federal Republic of Germany and Cosmetica Italia have set maximum amount of metals in cosmetic ingredients where the maximum limits for technically unavoidable traces are similar. Both authorities have recommended permissible limits for cadmium and lead at 5 mg/kg and 20 mg/kg, respectively [8,9] while the US FDA's limit lead as an impurity in colour additives used as ingredients in cosmetics is 20 mg/kg [10]. Later on, Health Canada's National Health Products Directorate has set these limits at lower values, 3 mg/kg and 10 mg/kg for cadmium and lead respectively, in cosmetic products to grant a high level of health protection to users [11].

In spite of conservative hypotheses, the findings investigated by using the most recent the Scientific Committee on Consumer Safety (SCCS) guidance do not illustrate a substantial risk to the users, following repeated exposure, even assuming that all the various products are utilized at the same time during a make-up session. However, heavy metal impurities in cosmetics are unavoidable due to the ubiquitous nature of these elements [8]. Even though many studies recorded a wide concentration range of elements in cosmetic products, only few paid attention to systemic exposure dosages and exposure risk evaluation of these metals. This study was conducted to determine the levels of heavy metals such as cadmium, lead and zinc in face powders marketed in Mekelle, Ethiopia and provide information on the human exposure risks to these metals in cosmetics.

Materials and Methods

Sample collection

Samples of various brands of commercially available face powder cosmetics were collected from supermarkets in Mekelle, Ethiopia in March, 2017. Samples were coded for ease of identification.

Sample digestion and analysis

Solid samples were dried in an oven at 105°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°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

All glassware and other containers were soaked in 10% nitric acid overnight and then rinsed with distilled deionized water thoroughly. Standard solutions were prepared from stock standard 1000 mg/L. Calibration curves were constructed from five series of working standard solutions (the correlation coefficients ranged from 0.9990 to 0.9997). Accuracy of the sample pretreatment method was tested by spiking standard solutions of metals to known amount of samples. Percentage recoveries ranged from 92.4% to 109%. Detection limits (LODs) were evaluated as the concentrations that give signals equal to three times the

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pooled standard deviations of the six blank measurements. LODs of Cd, Pb and Zn were 0.05, 0.02 and 0.07 mg/kg, respectively. Blank and samples were processed and measured in the same manner.

Statistical analysis

The data were analyzed using analysis of variance (ANOVA) and two-tailed T-test (for two data sets) to find differences between the means of metals levels in the samples at 95% confidence level. SPSS statistical package version 20.0 was used for statistical analysis.

Safety evaluation of face powder cosmetics

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) [12]:

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

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 [12].

$$SED(\mu g / kg\ bw / day) = \frac{C * AA * SSA * RF * BF}{BW} * 10^{-3} \quad (2)$$

Where C is the concentration of metal in the powder cosmetics; AA is the estimated amount of cosmetic powder applied per day (0.51 g); SSA (563 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) [12].

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:

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

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 4×10^{-3} for Pb [13], 1×10^{-3} for Cd and 3×10^{-1} for Zn [14,15]. The World Health Organization (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 [12]. In this study, SED and MoS were calcualted using mean levels of metals at 50% and 100% of the measured concentrations of metals in the samples.

Results and Discussion

Heavy metal levels in face powder samples

The mean levels (± SD) of metals in different brands of face powders are shown in Table 1. Lead was not detected in all brands of face powder products. The concentrations of both cadmium and zinc in the samples were within the range of 0.13 to 0.215 mg/kg and not detected to 7.05 mg/kg, respectively. There was no significant difference regarding the mean values of cadmium content in the samples while zinc levels in the brands of face powders were significantly different ($P<0.05$). Face powder P had higher concentration of zinc than other brands of the Face powders.

The maximum permissible limits of heavy metals in cosmetic products vary among countries across the globe. Health Canada has set that the maximum permissible limit for cadmium in cosmetics is 3 mg/kg while in Germany and Italy this value is recommended at 5 mg/kg [8,9,11]. The present study investigated that the mean concentrations of cadmium in the samples were below the limits set by both Canadian and Germany Authorities. A comparison of metals levels in cosmetic powders found in this study with the concentrations reported in the literature is given in Table 2. Faruruwa and Bartholomew reported the level of cadmium in cosmetic powders within the range of 0.1-0.5 mg/kg, which is consistent with the present study [16]. Other studies also reported similar findings in Nigeria [3] and Pakistan [4]. However, other surveys recorded higher concentrations of cadmium in face powder cosmetics [2,17].

Even though lead was not detected in these cosmetics in this survey which is in agreement with the findings of other work [16], many studies in various countries investigated a wide concentration range of lead in cosmetic powder samples [2-5,18]. The levels of zinc content in these samples in this work were lower than the values obtained in other surveys. Faruruwa and Bartholomew recorded 15.9-53.5 mg/kg concentrations of zinc in powder cosmetics [16] while Issa et al. reported 46.12 to 54.01 mg/kg in facial powders collected from the Arabian Market [5]. Other studies investigated higher concentrations of zinc in face powder samples ranging from less than 10 mg/kg to 1067,3300 and 25398 mg/kg in Pakistan [4], Nigeria [2] and Palestine [18], respectively. The variation of heavy metals contamination in powder cosmetics related to the origin of ingredients, production process and/or the containers [19,20]. For example, few natural or inorganic pigments are considered as sources of high concentration of zinc content in some of the cosmetic products [6,20].

Health risk assessment

The estimated systemic exposure dosages (µg/kg bw/day) and margins of safety of metals from the powder products are indicated in Table 3. The systemic exposure dosages of cadmium from the samples ranged from 8.9×10^{-4} to 1.03×10^{-3} µg/kg bw/day at half and 100% bioaccessibility. The provisional tolerable daily intake (PTDI) of cadmium is set at 1 µg/kg bw/day; however, the European Food Safety

Face powder code	Cd	Pb	Zn
S	0.215 ± 0.130	ND*	ND
M	0.130 ± 0.065	ND	0.258 ± 0.045
P	0.186 ± 0.147	ND	7.050 ± 1.237

Table 1: Concentrations of metals (mg/Kg) in face powder samples.

Origin/market site	Cd	Pb	Zn	Ref.
Ethiopia	0.13-0.215	ND	ND-7.05	This study
Nigeria	2.1-5.0	5.9-3399.9	8.0-3300.0	[2]
Nigeria	0.31-1.1	5.93-22.57	-	[3]
Pakistan	0.258-0.36	2.325-3.975	1.818-1067	[4]
Egypt/Saudi Arabia	0.725- 0.792	6.75-11.3	46.12-54.1	[5]
Nigeria	0.1-0.5	ND	15.9-53.5	[16]
Nigeria	ND-8.1	0.4-41	-	[17]
Palestine	ND-0.93	ND-9.38	1.676-25398	[18]

Table 2: Comparative values (mg/kg) of metals in face powders in this work with reported data in the literature.

Face powder code	At 50% bioaccessibility		At 100% bioaccessibility	
	Cd	Zn	Cd	Zn
Systemic exposure dosage				
S	5.14×10^{-4}	-	1.03×10^{-3}	-
M	3.11×10^{-4}	6.17×10^{-4}	6.22×10^{-4}	1.23×10^{-3}
P	4.45×10^{-4}	1.69×10^{-2}	8.9×10^{-4}	3.37×10^{-2}
Margin of safety				
S	1.94×10^{5}	-	9.72×10^{4}	-
M	3.21×10^{5}	1.62×105	1.61×10^{5}	8.1×10^{4}
P	2.25×10^{5}	5.96×10^{3}	1.12×105	5.1×10^{3}

Table 3: Systemic exposure dosage and margin of safety of Cd and Zn in face powders at 50% and 100% bio accessibility.

Authority (EFSA) set the provisional tolerable weekly intake (PTWI) of cadmium as 2.5 µg/kg bw/week [21]. The systemic exposure dosages of cadmium in face powders in south Nigeria were 1.96×10^{-2} to 3.92×10^{-2} µg/kg bw/day for 50% and 100% bioaccessibility scenarios [2]. The calculated systemic exposure dosages of zinc in this survey ranged from 6.17×10^{-4} to 3.37×10^{-2} µg/kg bw/day while Iwegbue et al. recorded 1.48×10^{-2} and 2.96×10^{-2} µg/kg bw/day systemic exposure dosages of zinc in face powders for 50% and 100% bioaccessibility scenarios, respectively [2]. The recommended daily intake of zinc is set at 12 mg per day [22]. The systemic exposure dosages of zinc from the application of cosmetic face powders were below its recommended dietary allowance value. The estimated margins of safety for cadmium and zinc in the samples were greater than the minimum value of 100 proposed by the World Health Organization.

Conclusion

This study revealed lower concentrations of cadmium and zinc in face powders compared to their respective maximum permissible limits. The margins of safety estimated for both heavy metals were greater than the proposed value of 100 set by the WHO to conclude that a substance is safe for use. However, prolonged use of the products may increases the amount of these metals in the human body overtime. The establishment of the permissible limits of heavy metals in cosmetic products and regular monitoring system are recommended to prevent metals associated health risks.

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