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DETERMINATION OF SELECTED HEAVY METAL CONCENTRATIONS IN UNREGISTERED FACE WHITENING CREAMS SOLD IN JOHOR BAHRU, JOHOR, MALAYSIA BY USING INDUCTIVELY COUPLED PLASMA OPTICAL EMISSION SPECTROSCOPY AND THEIR HEALTH RISK ASSESSMENT

(Penentuan Kepekatan Logam Berat Terpilih dalam Krim Pemutih Muka yang Tidak Berdaftar Dijual di Johor Bahru, Johor, Malaysia dengan Menggunakan Spektrofotometer Pancaran Optik Plasma Gandingan Aruhan dan Penilaian Risiko Kesihatan)

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Abstract

This study determined the concentrations of arsenic (As), cadmium (Cd), mercury (Hg) and lead (Pb) in unregistered face whitening creams that are commonly accessible in Johor Bahru (Johor, Malaysia) local markets. Three separate brands (marked as Brand X, Brand Y and Brand Z) of unregistered face whitening creams were chosen. Each brand was purchased with five replicates. A total of 15 samples were purchased from five different locations. Microwave digestion process was used to digest the heavy metals out from the cream matrices, and later analysed by using inductively coupled plasma-optical emission spectroscopy (ICP-OES) method. Results showed slightly higher Hg concentrations in Brand X (6.5 ppm), whereas Pb concentration in the whitening creams were below the acceptable limit (ranged 0.1–0.4 ppm) as set by the Malaysia National Pharmaceutical Regulation Act (NPRA). Nevertheless, the Pb concentration exceeded the limit set by the World Health Organisation (WHO) for daily use, which is 0.05 ppm. Besides, As and Cd were not detected significantly in all brands. Health risk assessment for all samples identified with heavy metals, in consideration of the excessive mercury concentration and based on HRI results, could not ignore the fact that Brand X holds possible harmful effects on human health, following its use

Keywords: face whitening creams, heavy metals, mercury, microwave digestion, inductively coupled plasma-optical emission spectroscopy

Abstrak

Kajian ini menentukan kepekatan arsenik (As), kadmium (Cd), merkuri (Hg) dan plumbum (Pb) dalam krim pemutihan wajah yang tidak dikawal selia yang biasanya dapat diakses di pasaran tempatan wilayah Johor Bahru. Tiga jenama berasingan (bertanda X, Y dan Z) krim pemutihan wajah yang tidak didaftarkan telah dipilih. Setiap jenama dibeli dengan lima replikat. Sebanyak 15

sampel telah dibeli dari lima lokasi berbeza. Proses penghadaman gelombang mikro digunakan untuk mencerna logam berat dari matriks krim dan kemudian dianalisis menggunakan kaedah spektrofotometer pancaran optik plasma gandingan aruhan (ICP-OES). Hasil menunjukkan kepekatan merkuri pada jenama 'X' ialah sedikit lebih tinggi (6,5 ppm), manakala kepekatan plumbum dalam krim pemutihan berada di bawah had (berjulat 0.1–0.4 ppm) yang dapat diterima seperti yang ditetapkan oleh Akta Peraturan Farmasi Nasional (NPRA). Walau bagaimanapun, kepekatan Hg melebihi had yang ditetapkan oleh Pertubuhan Kesihatan Sedunia (WHO) untuk kegunaan harian iaitu 0.05 ppm. Selain itu, As dan Cd tidak dapat dikesan secara signifikan dalam ketiga-tiga jenama. Penilaian risiko kesihatan untuk semua sampel yang dikenal pasti dengan logam berat melalui penimbangan kepekatan merkuri berlebihan dan berdasarkan hasil HRI tidak dapat diabaikan hakikat bahawa Jenama 'X' mempunyai kemungkinan kesan berbahaya terhadap kesihatan manusia berikutan penggunaan produk tersebut.

Kata kunci: krim pemutihan wajah yang tidak dikawal selia, penghadaman gelombang, logam berat, spektrofotometer pancaran optik plasma gandingan aruhan

Introduction

Cosmetics industry is one of Asia's fast-growing industries [1]. The Asia Pacific's market value improves to over USD 70 billion, making it the second highest after Western European market. Different beauty products are distributed in local market and believed to originate from China, the Philippines and Thailand. Excessive amounts of hazardous heavy metals, such as cadmium (Cd), chromium (Cr), lead (Pb) and arsenic (As) are found in these cosmetic products [2]. According to the World Health Organisation, of all potentially toxic elements, these four heavy metals have generated the most public health concern [3]. The heavy metals in cosmetic products that are applied to the skin (including face) can accumulate locally, and some metals such as Hg, Pb, Cd and Al can pass through the skin barrier and enter the blood vessels [3]. Complications such as extreme swelling, redness and thinning of the skin, ochronosis, dermatitis, severe kidney damage, anxiety, depression, psychosis and peripheral neuropathy were reported in patients. Skin whitening, which is one of the famous beauty products in Malaysia, are usually creams, gels or soaps [4]. The trend of using skin whitening products usually starts as a treatment for skin darkening caused by acne vulgaris, atopic dermatitis, eczema or even a condition that is being identified as darker skin due to social media stress [4]. Skin whitening products work by interfering with melanogenesis pathway, melanin transfer, or desquamation at any stage. The disruption of these processes will result in pigmentation reduction [4]. It is not surprising that toxic substance such as Hg is added into whitening creams, as it inactivates the enzyme responsible for melanin production [5].

Many aspects can cause skin pigmentation, the most common of which is ultraviolet (UV) radiation, which induces tanning reaction. The diverse kinetics of skin reaction towards UV radiation may result in skin tanning for several weeks [6]. Ultra-radiation is the most important factor in altering pigmentation of human skin. Instant skin darkening happens within minutes as a direct result of UV treatment (ultraviolet long wave (UVA)), followed by permanent skin darkening within a few hours, lasting for a few days [7]. On top of that, hormonal changes in the body can also stimulate pigmentation. Increases in oestrogens hormones that arise during pregnancy appear to have melanocyte inhibitory effects and contribute to hyperpigmentation. Darkening of skin is also clinically observed in response to inflammation [6].

Heavy metals can be defined as any chemical element that has at least five times a specified gravity than that of water [8]. Heavy metals turn out to be toxic when the body fails to digest them, and heavy metal accumulation occurs in the soft tissues. The most hazardous heavy metals to human health are As, Cd, Pb, Hg and tin (Sb) [9,10,11]. Increasing levels of Pb and Cd in the human body can cause skeletal muscle damage, cancer cell activation, reproductive deficiencies, brain impairment and kidney impairment. Hg is recognised as the most hazardous heavy metal that threatens the brain and central nervous system [12, 13, 14]. On the same note, As induces haematological disturbance, dermal

disruption, gastrointestinal disorder, respiratory changes, neurological abnormalities, cardiovascular weakness, genotoxic effects, reproductive abnormalities and cancer irregular differences in genetic material [15, 16, 17]. Long-term inhalation exposure to As is a leading cause of many serious conditions, such as skin disorders, central and peripheral nervous disorders, potential lung cancer risk and increased risk of gastrointestinal tract and urinary system cancer [18]. It was reported that Hg in skin whitening creams and other personal care products causes birth defects [19]. Abnormal placenta size leads to complications at birth as such, low cortisol levels, resulting in higher birth defect rates [19].

In addition, a woman with complication of erythema and itchy papulovesicular lesions on her face, neck, trunk sides and antecubital fossa prior (5h–6 h) was documented by using a skin whitening cream on her cheek and upper lip. The patient had a positive patch test for ammoniated mercury, thimerosal and metallic Hg [19]. Studies have reported many health effects related to Pb toxicity, including hypertension and renal failure [18], malformation of cognitive abilities and behaviour [20], Cd and its salts used in the manufacture of nickel-cadmium batteries, pigments and alloys are associated with emphysema, proximal renal tubular necrosis and deformities of the skeleton [20]. Latest studies show that Pb does not have a safe exposure level on its own, because even in trace amounts this element affects the foetus and causes abnormality to the central nervous system of children. [21, 22]. Considering the unfavourable adverse effects associated with high exposure of As, Cd, Hg and Pb to human health, many countries and organisations have prescribed specific maximum permissible limits for such heavy metals, covering the various types of personal care products. Face whitening creams are usually associated with Hg poisoning, whereby adverse reactions that range from dermatitis to exogenous ochronosis and steroidal acne can happen. Nephrotic syndrome is also associated with Hg and other elements such as corticosteroids and hydroquinone [23].

Considering the potential health issues that may arise when these chemicals are used, they are globally regulated by different regulatory bodies. For example, the National Pharmaceutical Control Bureau (NPCB) classifies all health and pharmaceutical nutrition products [24]. Under the Dangerous Drugs Act 1952, Control of Drugs and Cosmetics Regulations 1984, NPCB will determine whether the health or medicinal food products require registration [24]. Aligned with the need of a regulating amount of heavy metals in different matrices (including cosmetics), several organisations have set the acceptable amounts for As, Cd, Pb and Hg. For instance, the guidelines for control of cosmetic products in Malaysia (1st Revision) by the National Pharmaceutical Regulatory Agency (NPRA) set these limits based on factors such as in what amount should heavy metals be used in cosmetics; As ≤5.0 ppm, Cd ≤ 5.0 ppm, Pb ≤ 20.0 ppm and Hg ≤ 1.0 ppm [25]. The U.S. Food and Drug Administration (USFDA) has set the limit for heavy metals of As (≤ 3.0 ppm), Cd (≤ 4.0 ppm), Pb (≤ 10.0 ppm) and Hg (≤ 1.0 ppm) [26]. Furthermore, Malaysia's Food Act 1983 and Food Regulations 1985 have set the limits for As (≤ 1.0 ppm), Cd (≤ 1.0 ppm), Pb (≤ 2.0 ppm) and Hg (≤ 0.05 ppm) [26].

In Malaysia, there is no precise definition of counterfeit drugs in Malaysian law, but in The Sale of Drug Act (SODA) 1952 there are specific provisions under Regulation 7(1) (a), Regulation 7(1A) (a-g) Control of Drugs and Cosmetics Regulations (CDCR) 1984, which require all medical products to be licensed with the Ministry of Health (MOH) National Pharmaceutical Control Bureau (NPCB) before they reach the market. Moreover, they must meet a procedure which requires thorough review and final approval by the Drug Control Authorities (DCA) [27]. When the drugs go through all the criteria they are known as registered drugs or registered products [27]. Increase in market reports, cases and incidents is a bad sign for the public. They may consume health products which have been adulterated with poison or unsafe or unclean products because all unregistered drugs do not meet the requirements of Good Manufacturing Practices (GMP) [27].

Several studies were conducted to determine heavy metal concentrations in different personal care products,

including cosmetics [28, 9, 29]. Inductively coupled plasma-optical emission spectroscopy (ICP-OES) is a common technique to determine metal concentrations [30]. In 2015, impurities of heavy metals in lipsticks and their related risk of adverse impact to lipstick consumers were analysed by using ICP-OES [31]. Other included techniques used for such a determination by previous researchers were the atomic absorption spectrophotometer (AAS) [32, 33]. The use of solid-state techniques, such as laser-induced breakdown spectroscopy (LIBS) and X-ray fluorescence spectrometry (XRF), are other options for cosmetic analysis [33]. AAS, ICP-mass spectrometry (ICP-MS), ICP-atomic emission spectrometry (ICP-AES), and X-ray fluorescence spectroscopy (XFS) are the most widely used techniques for analysis of trace and heavy metals [34]. In Malaysia, the use of cosmetic products, particularly unregistered face whitening creams is increasingly in growth. The quantities of contaminants, including heavy metals, used in cosmetics as additives cannot be ignored as they pose health risks to consumers. In the future, this condition could lead to serious health effects on consumers as a hazardous chemical being accidentally introduced to consumers through the derma.

Therefore, this paper presents the output found when Hg, As, Pb and Cd concentrations were determined in several unregistered face whitening cream samples sold in Johor Bahru, Johor, Malaysia. ICP-OES was used and the most harmful brand whitening cream was classified by using statistical comparative method. Health risk assessment was also presented.

Materials and Methods

Chemicals and instrumentation

The chemical analyses were conducted in a government-certified (MS ISO/IEC 17025:2017) commercial laboratory in Johor Bahru. The methodology employed for this study was adapted from the respective commercial laboratory in-house method, which were based on AOAC 999.11, 20th Edition (for Pb and Cd) and AOAC 971.21, 20th Edition (for Hg and As). Nitric acid, hydrochloric acid, hydrogen peroxide 30% v/v, 1.1% w/v stannous chloride in 3%v/v hydrochloric acid or 0.2% w/v sodium borohydride in 0.05% sodium hydroxide, 50% w/v magnesium nitrate and deionised water were used for sample preparation. All glassware was soaked with sulphuric acid (H_2SO_4) 5-10%. Later, these apparatuses were deeply cleaned with detergents and then rinsed with deionised water and air dried before use. Sample digestion was conducted by using analytical grade nitric acid (Sigma Aldrich, Malaysia) and perchloric acid (70%, Sigma Aldrich, Malaysia). Custom calibration solutions for As, Cd, Pb, and Hg were prepared from a common stock solution of 1000 mg/L. All solutions were prepared by using deionised water.

The stock solutions were diluted in series to provide the desired concentrations of 0 mg/L, 0.05 mg/L, 0.10 mg/L and 0.20 mg/L for As, Cd and Hg, and 0 mg/L, 0.1 mg/L, 0.5 mg/L and 1.2 mg/L for Pb, with regard to the calibration curves. When needed, the face whitening cream samples with concentrated metals were diluted appropriately to fit the linearity of the calibration curves. The dilution factor was then then factored in during final calculation. For this study, inductively coupled plasma-optical emission spectrometer (Thermo Scientific ICAP 600 SERIES) was used for the heavy metal's determination. The calibration curves were constructed by using the absorbance values versus the analyte concentrations applied, with the determination coefficient (R^2) which exceeded 0.995. Wavelengths used to identify targeted heavy metals were as follows; Hg (185.0 nm), As (193.8 nm), Pb (220.4 nm) and Cd (226.5 nm).

Sampling and sample preparation

In March 2018, three different brands of face whitening creams (Brand X, Brand Y, and Brand Z) were collected from five different shops in Johor Bahru, Johor, Malaysia. Each brand had five respective replicates (marked as X_1, X_2, X_3, X_4, X_5, Y_1, Y_2, Y_3, Y_4, Y_5, Z_1, Z_2, Z_3, Z_4 and Z_5). The cream samples were uniformly combined by using a sterile stirrer. Samples of whitening cream (1.5 g) were weighed into a 20 mL Teflon tube and added to each concentrated acid samples of 6 mL nitric acid (HNO_3, 65%), 3 mL hydrochloric acid (HCl, 37%) and 0.25 mL hydrogen

peroxide (H_2O_2). Samples were then placed for 30 minutes in an ETHOS 900 microwave digester, and the solution was allowed to cool to room temperature. Approximately 5 mL of distilled water was applied to each sample and then filtered into 20 mL Teflon tube through a funnel with a Whatman No. 41 filter paper. By using distilled water, the solution was then filtered to 20 mL. The liquid extract was then used under the recommended instrument parameters for the determination of As, Pb, Cd and Hg by using ICP-OES.

Estimation of daily intake of toxic metals and health risk index assessment

An adult's daily absorption rate for As, Cd, Hg and Pb was calculated by consumption of the unregistered face whitening cream following an Equation 1 suggested by Omenka et al. [35].

$$EDI = (C \times D) \div W \quad (1)$$

where, estimated daily intake (EDI) is the estimated daily intake, C is the concentration of the metals obtained in this study, D is the estimated daily amount of whitening cream being used in g/kg/day (1.54g) and W is the average body weight of an adult [35]. Body weight of an adult was reported in the Malaysian Adult Nutrition Survey as 63 kg as the average weight [35]. The potential health risks to consumers due to heavy metal exposure through the unregistered face whitening creams in this study were estimated by using the Health Risk Index (HRI), obtained by dividing the estimated daily intake by the metal dermal reference doses (Equation 2). Dermal reference dose for As is 3×10^{-4}, Cd is 2.5×10^{-3}, Hg is 1.6×10^{-4} and Pb is 1.4×10^{-4}.

$$HRI = Calulated\ EDI \div dermal\ reference\ dose\ for\ each\ metal \quad (2)$$

The hazard index collected must be less than 1 so that there are no health risks. If the hazard index values surpass 1, there could be worries about the correlation amongst possible health risks over exposure.

Statistical analysis

Data analyses were carried out in this research by using the IBM SPSS Version 22.0, and the normality of the data was checked by using the Kolmogorov-Smirnov and Shapiro-Wilk tests prior to the hypothesis test. It was given that the small number of samples used in this research, and the indication provided by the Shapiro-Wilk test prevailed over the Kolmogorov-Smirnov. Therefore, when the Shapiro-Wilk test values were found to be less than 0.05 ($p<0.05$), the data could be interpreted as not normally distributed. The analysed details included quantities of As, Cd, Pb and Hg within the three different brands. Based on the analysis, it was found that the data breached the assumption of normality. Statistical inference was used to compare the median between groups by using the non-parametric Mann-Whitney U test. The level of significance (*) was set at 0.05 for inferring the importance of the result [36].

Results and Discussion

ICP-OES method validation

For all the four heavy metals, linear range, coefficient of determination (R^2), limit of detection (LOD) and limit of quantification (LOQ) are shown in Table 1. The three-point calibration curve shows excellent linearity over the concentration range from 0.01 ppm to 0.25 ppm, whereby R^2 ranged from 0.9996 to 1.000. Given that all the calibration curves obtained followed the standard requirements, it could be explained that the responses were linear. Therefore, the detection of these analytes in all samples proved to be acceptable. LOD was the lowest analyte concentration reported with a signal-to-noise ratio (S/N) of at least 3:1, while LOQ corresponded to the lowest analyte concentration in a calibration curve with an S/N of at least 10:1. The LODs and LOQs for Pb, Cd, Cu and Hg were determined with the aid of the data from the calibration curves.

Concentration of heavy metals in face whitening creams

This work focused mainly on the determination of four heavy metals, namely As, Cd, Hg, and Pb in unregistered face whitening products, which are often associated with side effects to human health. The Guidelines for Control of Cosmetic Products in Malaysia (1st Revision) published by the NPRA, Ministry of Health Malaysia [20] stated that the limits for As, Cd, Pb and methyl-Hg are 5 ppm, 5 ppm, 20 ppm, 1 ppm, respectively. The concentrations of heavy metals determined in all 15 samples are tabulated in Table 2.

No Cd was detected for all brands (Brand X, Brand Y and Brand Z). As was detected in samples of Brand Y, which was 0.2 ppm for two out of five replicates. According to the *Guidelines for Control of Cosmetic Products in Malaysia* (1st Revision) released by NPRA, the volume of As found in both samples was within the permitted range [20]. However, As was not found in the other three samples of Brand Y, which might be because they belong to separate processing batches. Even though the determined concentration of As in Brand Y was within the permitted limit, repeated use of this product may lead to critical skin disease and chronic effects on health [37]. As enters the body through inhalation, ingestion, and skin penetration. Hyperpigmentation, palmar and solar keratosis, diarrhoea and vomiting, skin changes and neuropathy, ischemic heart disease, confusion and memory loss, respiratory disease and a higher risk of diabetes are other symptoms that are associated with As poisoning [38].

Pb was detected in two brands, which were three samples of Brand Y (range 0.1-0.4 ppm) and five samples of Brand Z (range 0.2-0.4 ppm). The concentrations were found within the allowed Malaysian standard range. Pb in the form of organic compounds is very much easily absorbed by skin barrier as compared to its inorganic form because of its tendency to bind to proteins [39]. It was reported that, the absorption of lead took place more through the sweat gland ducts as compared to through epidermis. Furthermore, because of the poor affinity for red blood cells, Pb which has penetrated through the skin would be distributed almost completely in the intercellular fluid [39]. Due to its high affinity for protein, lead tended to attach itself to haemoglobin and plasma protein of blood cell. These prevented the production of red blood cells, and thus caused inadequate supply of oxygen to vital organs. Moreover, as the capacity bonding of Pb and protein increased, the tendency to pass through the bone marrow may increase as well. Such intoxication can cause damage to sexual organs, renal impairment, liver damage and encephalopathy in the central nervous system [39].

The amount of Hg detected for Brand X (ranged from 4.3-6.5 ppm) and Y (ranged from 0-0.05 ppm), in which the detected Hg concentrations were higher than the permitted level set by the Malaysian standard for Brand X. Typically, Hg is found in two forms of cosmetics, which is organic or inorganic. Organic mercury is used in cosmetic preservatives, while inorganic mercury is commonly used as an agent for skin whitening. Inorganic compounds are generally a combination of Hg with chlorine, sulphur and oxygen. Meanwhile mercury (II) chloride and ammonised mercury (II) are most common in skin creams [38]. Small amounts of Hg and its compounds are dangerous to human health, and these are cumulative toxins. An adult skin could consume up to 450 µg Hg from a single treatment of a product, carrying 10,000 ppm of mercury [40, 41].

Table 1. The method validation data for the ICP-OES of As, Cd, Pb and Hg

Heavy Metals	Linear Range (ppm)	Calibration Curve		
		R^2	LOD (ppm)	LOQ (ppm)
As	0.01 - 0.25	1.0000	0.03	0.1
Cd	0.01 - 0.25	0.9990	0.03	0.1
Hg	0.01 - 0.25	0.9996	0.003	0.01
Pb	0.01 - 1.2	0.9996	0.03	0.1

Table 2. Concentrations of As, Cd, Hg and Pb in face whitening cream samples

Unregistered Whitening Products Analyzed	Heavy Metals Concentration (ppm)			
	As	Cd	Hg	Pb
X_1	N.D	N.D	4.7	N.D
X_2	N.D	N.D	6.5	N.D
X_3	N.D	N.D	4.3	N.D
X_4	N.D	N.D	4.6	N.D
X_5	N.D	N.D	5.8	N.D
Y_1	N.D	N.D	0.05	N.D
Y_2	N.D	N.D	0.05	N.D
Y_3	N.D	N.D	0.03	0.1
Y_4	0.2	N.D	N.D	0.4
Y_5	0.2	N.D	N.D	0.4
Z_1	N.D	N.D	N.D	0.4
Z_2	N.D	N.D	N.D	0.4
Z_3	N.D	N.D	N.D	0.4
Z_4	N.D	N.D	N.D	0.4
Z_5	N.D	N.D	0.02	0.2

N.D = Not Detected

Table 3. Range of As, Cd, Hg and Pb detected in whitening cream samples

Heavy Metals	Unregistered Face Whitening Products Analyzed		
	Brand X Median (Range)	Brand Y Median (Range)	Brand Z Median (Range)
As	0.2 (N.D-0.2)	N.D	N.D
Cd	N.D	N.D	N.D
Pb	N.D	0.1(0.1-0.4)	0.4 (0.2-0.4)*
Hg	5.8 (4.3-6.5)*	0.03 (0-0.05)	N.D

N.D = Not Detected

Table 4. Estimated daily intake and health risk index of As, Hg and Pb *via* dermal exposure from whitening creams commonly found in local market of Johor Bahru

Sample	Heavy Metals (g/kg/day)			Heavy Metals (HRI)		
	As	Hg	Pb	As	Hg	Pb
X_1		0.1149			3.8296	
X_2		0.1589			52.9630	
X_3		0.1051			35.0370	
X_4		0.1124			37.4815	
X_5		0.1418			47.2593	
Y_1						
Y_2						
Y_3			0.0024			17.4603
Y_4	0.0005	0.0012	0.0098	0.1630	0.4074	69.8413
Y_5	0.0005	0.0012	0.0098	0.1630	0.4074	69.8413
Z_1			0.0098			69.8413
Z_2			0.0098			69.8413
Z_3			0.0098			69.8413
Z_4			0.0098			69.8413
Z_5			0.0049			34.9206

Statistical analysis

Statistical analysis was carried out on the study data to determine which of the selected whitening cream brands is the most hazardous to health. To determine the normality of data distribution, Kolmogorov–Smirnov and Shapiro-Wilk tests were used.

The cross-sectional sampling of products took place on March 2018, and here the values were expressed as median (range). Considering that the results violated normality assumption, the Mann-Whitney U test was used to compare the median between classes. Significance level of 0.05 was used to determine the significant differences between groups.

Symbol (*) represents the significantly higher concentration of an analyte in a group as compared to another ($p < 0.05$). Comparison by using Mann Whitney U test with a significance level of 0.05 was used to determine the significant concentration differences between brands (Table 3). The data are presented as a median ± interquartile range. Mann Whitney U test was performed for concentrations of Brand X and Brand Y for Hg, and concentrations of Brand Y and Brand Z for Pb. The concentration of Hg in Brand X was statistically higher than in Brand Y. The concentration of Pb in Brand Z was higher than in Brand Y, but statistically it was not significant. As compared to the other two products, Brand Y was comparatively safer, but repeated use of this product may result in Hg and Pb accumulation and ultimately acquired the side effects of the respective heavy metals.

Estimation of daily intake of toxic metals and health risk assessment

Table 4 provides the estimated daily intake (EDI) of metals (As, Hg, and Pb) from the use of unregistered face whitening creams which were included in this work. Cd was not counted for EDI because Cd was not observed in the samples. The EDI obtained were 0.00049 mg/day for As, 0.0012 mg/day to 0.16 mg/day for Hg, and 0.0024 mg/day to 0.0098 mg/day for Pb. The EDI order of metals in unregistered face whitening creams was Hg>Pb>As. The hazard risk indices (HRI) were determined by using the EDI and the values are also shown in Table 4. The HRI value must be less than 1 to avoid any health hazards to consumers. If the gained HRI values were more than 1, there may be concerns about the potential health risk [42]. HRI obtained for As was 0.1629 while for Hg the values ranged from 0.4074 to 52.69, and Pb was ranged from 17.64 to 69.84 respectively. Since the HRI values obtained for Hg and Pb were greater than 1, this means that such products will no longer be safe for use and may have side effects to consumers' health.

Conclusion

Three different brands of unregistered face whitening creams obtained from local markets in Johor Bahru had been analysed for heavy metals concentrations. Cd was not detected in all brands while very high concentration of Hg was found in Brand X. From direct comparison, Brand X could be categorised as the most harmful face whitening cream relative to the other two brands because it contained the highest Hg concentration, which was 6.5 ppm; higher than the NPBC limit set. Small amount of Pb was detected in Brand Y and Brand Z with variation of Pb concentration in Brand Y. There was no substantial concentration of As detected for Brand Y and Brand Z, but some amount of Hg and Pb were detected. Meanwhile the amount of As and Pb were below the limit for Brand Y and Brand Z, the results of the risk assessment suggested that the brands could cause a risk to human health upon prolonged use. The HRI values obtained for Hg and Pb in Brand X and Brand Z were > 1. Therefore, it could be concluded that these brands have high potential to be harmful to humans and the long-term use of these substances could cause a public health issue.

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