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Beauty beware : Unmasking the hidden treats of heavy metals in Malaysia cosmetics

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ABSTRACT

Cosmetics have progressed into an essential part of daily routines due to their widespread use, commonly through topical application. However, many cosmetic products contain heavy metals which can accumulate and pose health risks over time. Concerns on product safety including ingredient monitoring have been raised as regular cosmetic use exposes consumers to potentially harmful chemicals. Understanding consumer perceptions is crucial for informed decision-making, yet research on user perception of cosmetics and heavy metal contents in the Malaysian market remains limited. This study focused on assessing heavy metal contents in face cream products from various brands as heavy metals pose a significant concern. The concentration of heavy metals in cosmetic products was analysed by using inductively coupled plasma-optical emission spectrometry (ICP-OES) and atomic absorption spectroscopy (AAS). The results indicate that 4440 ppm of mercury is present in Brand B, which is particularly alarming. These findings underscore the prevalence of unauthorised local products with higher-than-permissible levels of heavy metals, highlighting the need for stricter monitoring and regulation.

1. INTRODUCTION

Cosmetics are used for cleaning, beautifying, or changing the appearance of the human body, as well as boosting its attractive characteristics. Mascara, toothpaste, shampoo, hair conditioners, aftershave lotion, moisturisers, and lotions are all falls under cosmetics category (Abed et al., 2024). Cosmetic products include cream, which is commonly used in cosmetics, skincare, and skin therapy. The utilisation of fairness creams has risen significantly in recent years due to their ability to diminish melanin content, thereby enhancing the complexion and lightening the skin (Irfan et al., 2022). A cream is an emulsified mixture of oil and water with textures ranging from a thick liquid to partially solid. The cream includes an absorption phase, water, and oil. Other ingredients in the cream include emollients (5–25%), triglycerides (0–5%),

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mineral oil (5–70%), silicon oil (0–15%), humectant (0–5%), and preservatives. Cosmetic goods are made from thousands of elements. However, preservatives, antioxidants, waxes, hydroquinone, moisturisers, pigments, and heavy metals are often found as constituents in cosmetics (Munir et al., 2020). In fact, according to the study reported by Arputhanantham et al. (2024), most of the face cream samples are unfit for human use because they contain significant levels of heavy metals that exceed the permissible limit.

Heavy metals pose long-term risks to both human and environmental health as their accumulation can be toxic (Arputhanantham et al., 2024). Although heavy metals are toxic and can damage the kidneys, neurological system, and other organs, they are occasionally used as colouring agents or preservatives in cosmetics (Arshad et al., 2020, Mohammed et al., 2023) The topical application of cosmetics exposes consumers to the danger of interactions between heavy metals and large quantities of potentially dangerous compounds (Blanc et al., 1991). For instance, direct exposure to cadmium (Cd) may lead to low blood pressure in consumers. Additionally, the pattern in the accumulation of these metals in female bodies can change due to certain physiological modifications. Most metals interfere with the hormone system by acting as endocrine disrupters (Sani et al., 2016). Lead (Pb), arsenic (As), mercury (Hg), and cadmium (Cd) are among the numerous heavy metals that are considered lethal (Buksh et al., 2020).

Mercury (Hg) is one of the most frequently discovered heavy metals in cream products, which is present as an organic compound (e.g., methyl mercury) or an inorganic compound (e.g., mercury chloride, $HgCl_2$). Hg in the cream is cosmetically used for lightening skin tone through the inhibition of melanin synthesis (Giunta et al., 1983). The activity of tyrosinase on melanin synthesis can be restricted by Hg, which will decrease the production of melanin pigment (Junqueira et al., 2002). The accumulation of Hg can lead to the development of degenerative diseases in humans. Additionally, Hg can accumulate in the tubular kidney (Barr et al., 1973; Berlin, 1979; Bourgeois et al., 1986). Fig. 1 shows the dangerous consequences of the common heavy metals on the human body. Each heavy metal poses unique toxicological risks, but they all share the potential for bioaccumulation and chronic health effects, making their use in cosmetics highly concerning. In addition, Table 1 shows the toxicological effects of heavy metals commonly found in cosmetics, highlighting the associated health risks from exposure based on recent studies.

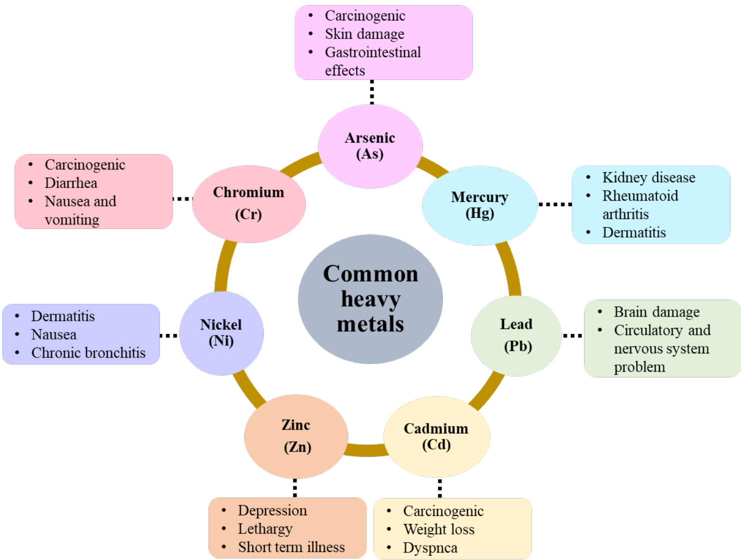

Fig. 1. Health risk caused by heavy metals

Source: Authors' illustration

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Table 1. Toxicological effects of heavy metals commonly found in cosmetics

Heavy metal	Toxicology effects
Lead	Hypertension, coronary heart disease, and other cardiovascular-related diseases (Obeng-Gyasi et al., 2018). neurotoxic effects especially towards children (Lewis, 2022).
Mercury	The use of products containing inorganic mercury can cause topical damage to the skin, kidneys, and nervous system. Long term exposure to inorganic mercury may also result in irritability, muscle weakness, memory loss and kidney failure (Rickets et al., 2020)
Cadmium	Neurodegenerative diseases Dysfunction of the prostate gland (changes in hormonal and secretory functions, impaired male fertility) Hypertension, atherosclerosis, and impaired heart function (Charkiewicz et al., 2024)

Source: Authors' illustration

Inductively coupled plasma-optical emission spectrometry (ICP-OES) and atomic absorption spectroscopy (AAS) are two of the most reliable methods for the detection and analytical control of heavy metals. The analytical techniques offer the benefits of automation, repeatability, and speed. Samples of cosmetic products must be pre-treated to liberate the heavy metals from the excipients and transform them into a high oxidizing state before analysing them via an appropriate analytical method. Consequently, certain processing procedures are created for the separation of heavy metals from cosmetic products before the spectroscopic examination. This process increases the solubility of metals in aqueous solutions for the measurement using atomic spectroscopy (AS).

The number of samples influences the effectiveness and reliability of the selected chemical analysis method. The homogeneity of the sample is also important, which necessitates the homogenisation of heterogeneous samples from cosmetic products, such as emulsions and micro-emulsions (lyophilic colloids), before the analysis. An appropriate amount of sample is solubilised after sampling or homogenisation, as necessary. The choice of solubilisation method depends on the type of the component of interest. Several methods are used to solubilise inorganic compounds (e.g., minerals and trace metals), including dry digestion, wet digestion, solid phase microextraction, and chelation solvent extraction (Selvaraju et al., 2020). The limit of the concentration of arsenic (As), lead (Pb), cadmium (Cd), and mercury (Hg) is shown in Table 2.

Table 2. Heavy metals limit

Heavy metals	Limit
Mercury	not more than 1 ppm
Arsenic	not more than 5 ppm
Cadmium	not more than 5ppm
Lead	not more than 20 ppm

Source: National Pharmaceutical Regulatory Agency (2022)

The purpose of this study was to analyse the perception of cosmetics users through a survey. This study was also conducted to evaluate the concentration of toxic metals, such as lead, cadmium, arsenic, and mercury in some fairness creams that are widely used by Malaysians and their impact on human health. The main reason for conducting this research is the growing use of cosmetic products among Malaysian consumers and the prevalence of heavy metals incorporation in these products which pose health risks to consumers.

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2. METHODOLOGY

2.1 Conducting survey

The quantitative study was carried out by creating and distributing a well-structured questionnaire. The sample size for this survey was determined based on the target population of respondents from Universiti Teknologi MARA (UiTM), which includes staff and students. Given the scope of the study, it was important to capture perspectives from individuals who are representative of both the B40 and M40 income categories, as they make up a significant proportion of the UiTM population. While larger sample sizes can offer more statistically robust conclusions, the chosen sample size was deemed appropriate to achieve meaningful insights within the constraints of time and resources available for data collection. This study identified not only the factors that influence user perception of cosmetics purchases, but also answered the question of who uses such products by considering demographic variables, such as age, gender, and occupation. One key limitation of this survey is that it focuses exclusively on respondents from UiTM staff and students, which may limit the generalizability of the findings to other populations. This study also examined various factors that influence consumers while purchasing cosmetic products. The detail of the survey as follows:

(i) **Structure of survey:** Quantitative research was conducted to analyse the perception and behaviour of cosmetic product consumers, and to identify the most well-known local product that consumers have used.

(ii) **Sampling method:** The Voluntary Response Method was applied in the present research study point.

(iii) **Scale Used:** Not at all, rarely, sometimes, always—for the second part of the questionnaire.

Strongly agree, agree, neutral, disagree, strongly disagree—for the third part of the questionnaire

(iv) **Tools used:** The raw data was collected and computed into an Excel file. The data was plotted and analysed using bar graphs and percentages to determine the frequencies and trends.

2.2 Sample collection

Three samples of face cream obtained from the local market were selected for this study based on the survey (coded A, B, and C.)

2.3 Sample digestion and chemical analysis

The Thermo Scientific iCAP 6000 Series ICP Emission Spectrometer features a self-aligning Duo Enhanced Matrix Tolerance (EMT) torch that has an integral orientation lock to automatically establish reliable plasma gas connections. It is optimised to operate with nearly 20% less argon usage compared to typical ICPs. The iCAP boasts robust instrument optics, with plasma temperatures reaching as high as 10,000 °C. It requires only 1 L/min of purge gas in standby mode and an additional 2 L/min when in operation. With the highest standards of precision and the lowest detection limits currently available (detection limits for 66 elements at levels below 1 μg/L) this powerful full-frame technology is ideal for fingerprinting and retrospective analysis. The concentration of each metal in the samples was measured at distinct wavelengths, as detailed in Table 3.

Table 3. Wavelength for each metal

Heavy metals	Mercury (Hg)	Arsenic (As)	Cadmium (Cd)	Lead (Pb)
Wavelength (nm)	253.65	188.98	214.44	220.35

Source : Acharya et al. (2021)

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Determination of As, Pb, and Cd

Samples of whitening cream weighing 1.5 g each were transferred into a Teflon tube, and 10 mL of nitric acid (HNO_3) and two to three drops of hydrogen peroxide (H_2O_2) were added to each concentrated acid sample. Next, the samples were placed in a heat block at 90 °C for 1 hour and 30 minutes and the solution was allowed to cool to room temperature afterward. Each sample was added with distilled water to fill up to 20 mL before being filtered by Whatman No. 41 filter paper into the test tube. Then, 200 µL of a 2 ppm stock solution was added to each sample as a spike. The liquid extract was subsequently subjected to analysis using ICP-OES with the recommended instrument parameters for the determination of As, Pb, and Cd as illustrated in Fig. 2.

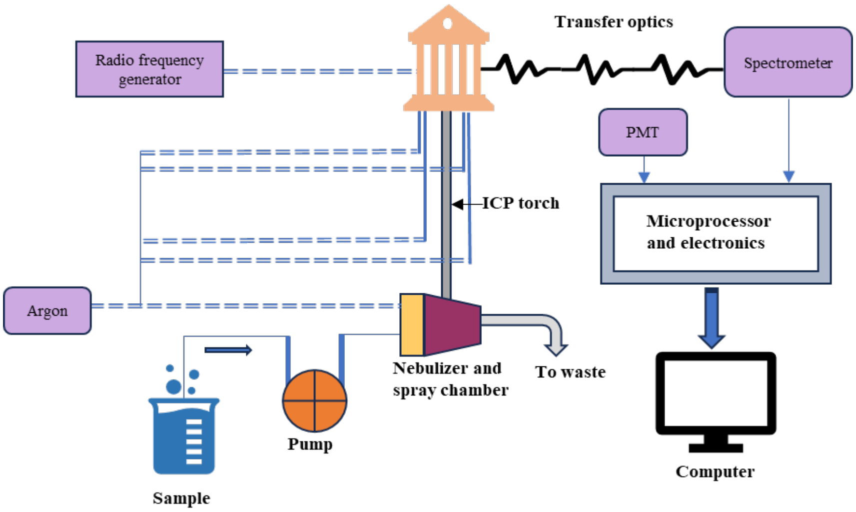

Fig 2. Experimental setup for ICP-OES

Source : Authors' illustration

Determination of Hg

A Teflon tube containing 1.5 g of face cream samples was weighed, and then 1 mL of distilled water, 1 mL of hydrochloric acid (HCl), 10 mL of nitric acid (HNO_3) (65%), and 1 mL of sulphuric acid (H_2SO_4) were added. Next, samples were heated at 90 °C for 30 minutes in a heat block as demonstrated in Fig. 3(a), and the solution was allowed to cool to room temperature afterwards. Each sample was added with distilled water to fill up to 50 mL before being filtered by Whatman No. 41 filter paper into a test tube as shown in Fig. 3(b). Then, each sample was spiked with 250 µL of Hg. The liquid extract was subsequently subjected to AAS determination of Hg using the recommended instrument parameters as shown in Fig. 4. This method has been widely used by earlier study which used the AAS method to assess mercury levels in whitening cream (Rohaya et al., 2017)

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(a) (b)

Fig. 3. (a) Heat block heating process and (b) filtration process

Source : Authors' illustration

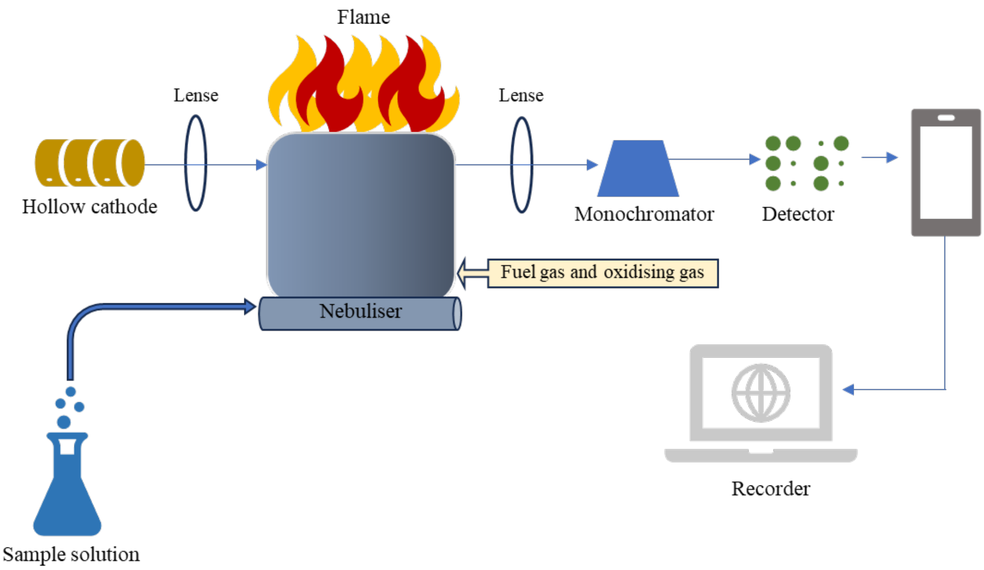

Fig. 4. Experimental setup for AAS

Source: Authors' illustration

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3. RESULT AND DISCUSSION

3.1 Survey result

Fig. 5 shows the top three brands with the highest votes among the seven brands selected through the previous survey conducted. Based on the findings, three products had gained a high popularity, which are product A (72%), Product C (32%) and Product B (30%), respectively. This result leads to the selection of product to be investigated and analysed as a sample in this study. Additionally, all the selected samples are from the face cream category, indicating that most cosmetics consumers consider face cream as an essential part of their daily routine.

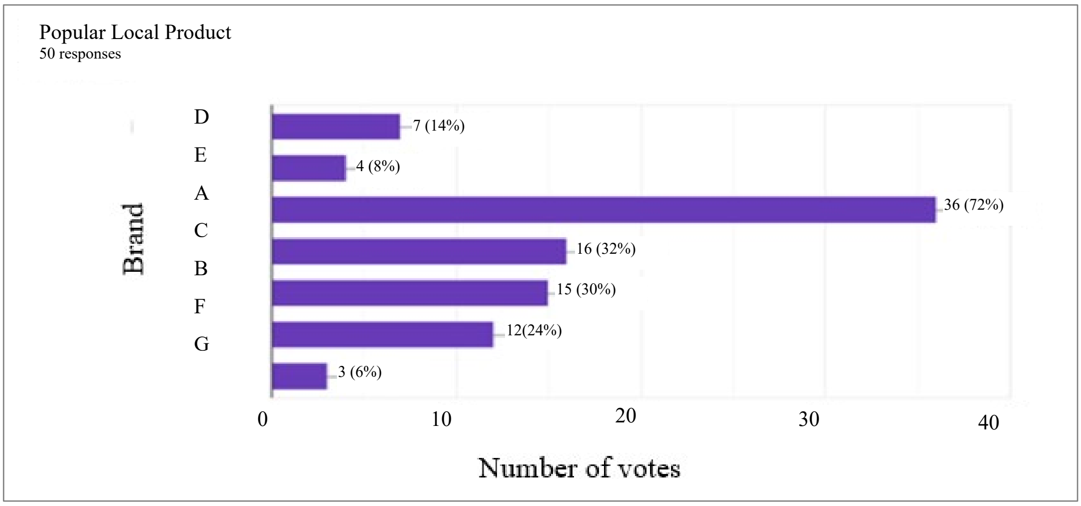

Fig. 5. List of popular local products

Source: Authors' own data

Furthermore, this study also presented the factors that influence consumers in selecting a cosmetic product. Based on the conducted survey shown in Fig. 6, the respondents were mostly influenced by advertisements (48%) of any brands of cosmetic products, followed by habits (20%) of regular use of cosmetic products and peer groups (24%) who frequently use cosmetic products. The findings show that customers are often easily drawn to and interested in trying new products that are well-advertised or frequently featured in advertisements. Their strong curiosity will drive them to acquire the product and experience it for themselves.

Fig. 7 illustrates that half of the respondents collected the information before making a cosmetics purchase. However, the remaining half only sometimes or rarely collected the information, while the rest did not do so at all. The results imply the reason for slightly poor awareness among many individuals about the importance of gathering information on the products they use. Consequently, many consumers are potentially exposed to hazardous products

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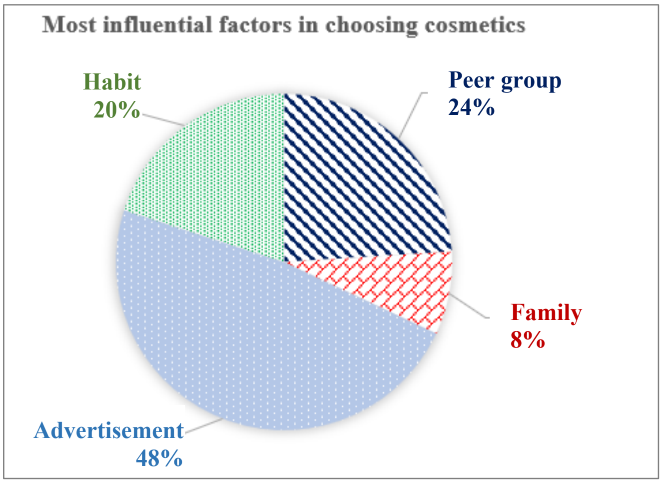

Fig. 6. Factors that influence respondents while choosing their cosmetic product

Source: Authors' own data

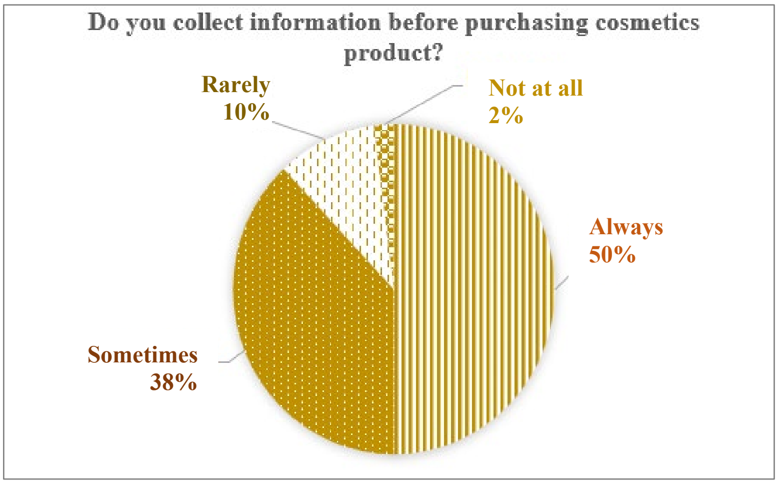

Fig. 7. Percentage of respondents that collect information before purchasing cosmetic product

Source: Authors' own data

3.2 ICP-OES method validation

Table 4 shows the linear range, R^2 coefficient of determination, the limit of detection (LOD), and the limit of quantification (LOQ) for each of the four heavy metals. The R^2 varied from 0.9996 to 0.9999, and the three-point calibration curve exhibited excellent linearity over the concentration range of 0.01 ppm to 0.1 ppm. Considering the compliance of every calibration curve obtained with the standards, it is reasonable to assume that the responses were linear. Therefore, the detection of these analytes in all samples is deemed acceptable.

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Table 4. The method validation data for the ICP-OES of As, Cd, Pb, and Hg

Heavy metals	Linear range (ppm)	Calibration curve		
		R^2	LOD (μg/L)	LOQ (μg/L)
As	0.01–0.1	0.9997	0.026	0.092
Cd	0.01–0.1	0.9996	0.016	0.056
Pb	0.01–0.1	0.9999	0.024	0.084
Hg	0.01–0.02	0.9998	0.021	0.076

Source: Authors' own data

Solutions containing known concentrations of each element were measured to calibrate an ICP-OES. A calibration curve was generated using these data. The calibration curve in Fig. 8 shows the relationship between the amount of an element present in the solution and the intensity of light emitted at a certain wavelength

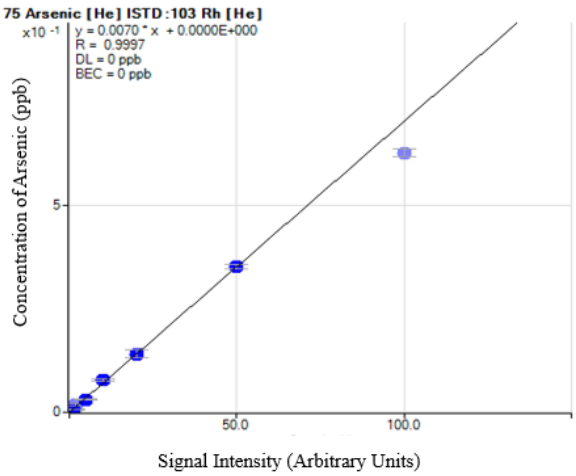

Fig. 8. Calibration curve of arsenic

Source: Authors' own data

3.3 Heavy metal concentration

When used topically, ingredients of cosmetics may first penetrate sweat glands before entering blood capillaries, depending on their intended use. Despite the slow process of raptness through the skin, prolonged use of cosmetics leads to the accumulation of the ingredients. Additionally, adding heavy metals to the mixture of contaminants speeds up the process and leads to toxicity that can cause various diseases. This research mainly focused on identifying four heavy metals namely, As, Cd, Hg, and Pb, which are frequently linked to negative health impacts, in local face cream products.

According to the Guidelines for Control of Cosmetic Products in Malaysia published by the National Pharmaceutical Regulatory Agency (NPRA), Ministry of Health Malaysia, the limits for As, Cd, Pb, and Hg are 5 ppm, 5 ppm, 20 ppm, and 1 ppm, respectively. Table 5 shows the concentration of heavy metals found in the three samples.

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Table 5. Concentrations of As, Cd, Hg, and Pb in face cream samples

Source	Concentration (ppm)			
	As	**Cd**	**Pb**	**Hg**
A	0.089	ND	0.26	ND
B	ND	ND	0.082	4440
C	0.184	ND	0.490	ND

*ND= not detected

Source: Author's own data

These results demonstrate that no Cd was found in all tested brands (Brand A, Brand B, and Brand C). As was found in samples of Brand A and Brand C at a concentration of 0.089 ppm and 0.184 ppm, respectively. The amount of As detected in both samples was within the permissible range, as per the Guidelines for Control of Cosmetic Products in Malaysia published by NPRA. Notably, As was not detected in Brand B. Despite the low level of As present in Brands A and C, prolonged use of these products may cause serious skin issues and other long-term health problems. As enters the body through skin penetration, ingestion, and breathing. The signs and symptoms of As poisoning include hyperpigmentation, palmar, solar keratosis, diarrhoea, vomiting, skin changes, neuropathy, ischemic heart disease, memory loss, respiratory disease, and an increased risk of diabetes (Mohammed et al., 2017).

Pb was found in samples of all tested brands: Brand A (0.26 ppm), Brand B (0.082 ppm), and Brand C (0.49 ppm). These concentrations are within the permitted limit of Malaysian standards. Due to its tendency to attach to proteins, the organic form of Pb is more easily absorbed by the skin barrier than its inorganic form. According to Sun et al. (2017), sweat gland ducts absorb lead more frequently than epidermis. Furthermore, Pb is disseminated to almost the entire intercellular fluid once enters the body through skin penetration due to its low attraction toward red blood cells.

Pb also has a strong affinity for protein, which causes it to gravitate toward haemoglobin and plasma proteins in blood cells. Such interactions stop the production of red blood cells, depleting the supply of oxygen to vital organs in the body. Additionally, the probability of passing through the bone marrow may grow as the capacity bonding of Pb and protein increases. Such intoxication can harm sexual organs, the liver, kidneys, and the central nervous system and create encephalopathy (Sun et al., 2017).

Hg was found in Brand B at a concentration of 4440 ppm, which is higher than the permissible limit according to the Malaysian standard. Hg is typically present in either organic or inorganic cosmetics. While inorganic mercury is frequently used to whiten skin, organic mercury is used as a preservative in cosmetics. The most common forms of mercury (II) in skin creams are ammoniated mercury (II) and mercury (II) chloride. Small amounts of Hg and its derivatives are deemed as cumulative toxins that can be harmful to human health. Following a single application of a product containing 10,000 ppm of mercury, adult skin could absorb up to 450 µg of mercury (Dórea, 2016).

Fig. 9 compares the concentration of heavy metals concentration found in all tested brands. The presence of heavy metals was determined in three popular local face cream brands obtained from the Malaysian market. While Cd was not found in any of the brands, Brand B contained a relatively high concentration of Hg. Due to its high Hg concentration (4440 ppm), which exceeds the NPRA limit, Brand B may be deemed as the most dangerous face cream compared with the other two brands.

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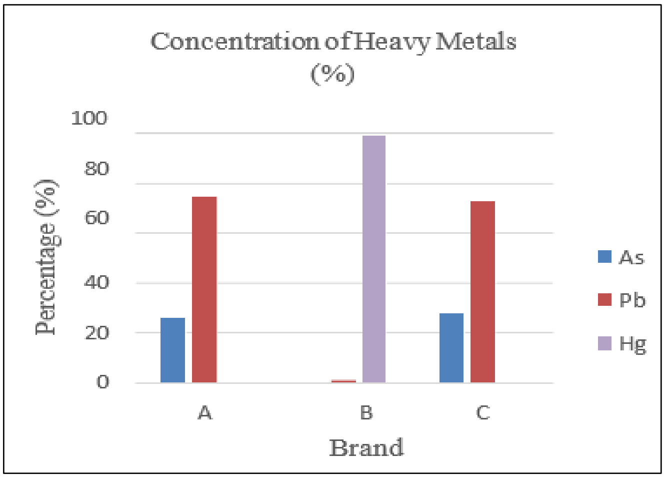

Fig. 9. Comparison of heavy metals concentration (%) for each brand

Source: Authors' own data

As was found in trace amounts in Brands A and C. In contrast, a significant amount of Pb was detected in all tested brands. The results of the risk assessment indicate the possible risk to human health with continuous use of these brands, despite the concentrations not exceeding the limit. The use of these chemicals over an extended period may negatively affect public health, suggesting the potentially significant harmful effects of these brands on human health.

As a result, it is imperative to educate consumers about the potentially dangerous substances found in cosmetics, especially those that were not properly regulated during production or have not been legally registered. When buying cosmetics, consumers should also exercise caution by making sure the products are registered with the relevant health authorities and by looking for valid certifications or registration numbers on the container. It is crucial to steer clear of purchasing cosmetics from dubious sources, such as untrusted internet retailers or street sellers, and to exercise caution when purchasing items that omit ingredient lists.

In addition, it is the duty of producers to ensure that allergies and contaminants are regularly tested for independently and to utilise safe chemicals instead of ones that are known to be dangerous. Along with educating customers about these issues, a top goal should be maintaining ingredient safety and transparency in product development. Long-term customer trust will be fostered by investing in sustainable practices, such as eco-friendly, safer formulas and ethical sourcing, in addition to improving safety.

Regulators, after all, are crucial in this regard since they enforce pre-market safety studies and have more stringent registration requirements for cosmetics. Products should be randomly tested and regularly monitored in order to preserve market integrity, particularly those sold in black markets or online. Companies found to be selling dangerous or unlicensed items should face harsher penalties. When combined, these actions can greatly lower the health hazards connected to unregulated and dangerous cosmetics.

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4. CONCLUSION

The study concludes that the presence of heavy metals, especially mercury, in cosmetic items poses serious health hazards, with some unlicensed brands having levels that surpass permissible limits. The finding that Brand B contained 4440 parts per million of mercury highlights the critical need for more stringent regulation and enforcement in the cosmetics sector. The results have wider ramifications for consumer safety since they highlight the possible long-term health effects of using unregulated cosmetics and the vital role that regulatory organisations play in safeguarding the general public's health. To address these issues, several actionable recommendations are proposed such as customers should make it a priority to buy cosmetics from reliable suppliers, make sure the items are registered with the appropriate authorities, and learn to read labels for potentially dangerous components. Manufacturers need to pledge to conduct more thorough testing on their products, get rid of dangerous substances from their recipes, and be open and honest about their labelling and marketing strategies. Regulatory organisations need to adopt more thorough surveillance of cosmetic items, especially unlicensed local brands, and create clearer guidelines for heavy metal limitations in cosmetics. To stop the sale and use of dangerous items, public education campaigns, stricter enforcement of laws, and regular product testing are required. Adopting these steps can greatly lower the dangers to consumer health and increase confidence in the cosmetics sector.

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CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Syahirah Adila Abdul Latif: Conceptualisation, methodology, formal analysis, investigation, and writing-original draft; **Farah Hanim Ab Hamid**: Project administration, conceptualisation, supervision, validation, writing-reviewing and editing, **Harumi Veny**: Conceptualisation, methodology, and validation, **Rozana Azrina Sazali**: Conceptualisation, methodology, supervision, and validation

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