DETERMINATION OF HEAVY METALS IN POWDER AND CREAM BLUSHERS FROM LOCAL COSMETIC BRANDS USING ATOMIC ABSORPTION SPECTROSCOPY (AAS)

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DETERMINATION OF HEAVY METALS IN POWDER AND CREAM BLUSHERS FROM LOCAL COSMETIC BRANDS USING ATOMIC ABSORPTION SPECTROSCOPY (AAS)

by

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Dissertation submitted in partial fulfilment of the requirements for the

Degree of Bachelor of Science (Honours) (Forensic Science)

January 2026

CERTIFICATE

This is to certify that the dissertation entitled **Determination of Heavy Metals in Powder and Cream Blushers from Local Cosmetic Brands Using Atomic Absorption Spectroscopy (AAS)** is a research work done by **Qistina Sara Binti Fazlin** from October 2025 to February 2026 under my supervision. I have read this dissertation and my opinion on it conforms to the acceptable standard of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted in partial fulfilment for the degree of Bachelor of Science in Forensic Science with Honours.

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DECLARATION BY STUDENT

I hereby declare that I conducted, completed and wrote the research entitled Determination of Heavy Metals in Powder and Cream Blushers from Local Cosmetic Brands Using Atomic Absorption Spectroscopy (AAS). I also declare that this dissertation is the result of my original work except as I cited and acknowledged in the dissertation. This thesis has not been previously submitted for any degree, diploma or other similar title to any other examining body or university.

……..

Qistina Sara Binti Fazlin

29 January 2026

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LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometry
ASEAN	Association of Southeast Asian Nations
Cd	Cadmium
Cr	Chromium
FDA	Food and Drug Organisation
g	Gram
HNO_3	Nitric acid
H_3PO_4	Perchloric Acid
kg	Kilogram
L	Litre
mL	Millilitre
µg	Microgram
µL	Microlitre
NPRA	National Pharmaceutical Regulatory Agency
Pb	Lead
Ppm	Parts per million
WHO	World Health Organisation

PENENTUAN LOGAM BERAT DI DALAM PEMERAH PIPI BERASASKAN SERBUK DAN KRIM DARIPADA JENAMA KOSMETK TEMPATAN MENGGUNAKAN SPEKTROMETER SERAPAN ATOM (AAS)

ABSTRAK

Logam berat telah digunapakai di dalam proses pembuatan kosmetik produk termasuk pemerah pipi sebagai pewarna. Malangnya, kandungan logam berat yang tinggi akan menyebabkan masalah kesihatan yang buruk kepada pengguna seperti kegagalan buah pinggang, organ hati yang tidak dapat berfungsi dengan baik dan masalah kerengsaan kulit, terutamanya jika terdedah untuk janga masa yang panjang. Penyelidikan ini bertujuan untuk menganalisis kepekatan logam berat, plumbum (Pb), cadmium (Cd) dan kromium (Cr) yang terdapat di dalam sampel pemerah pipi yang berasaskan serbuk dan pemerah pipi yang berasakan krim daripada jenama tempatan. Dengan itu, dua jenis formulasi yang berbeza daripada tiga jenama tempatan yang berbeza telah dipilih secara rawak dari pasaran tempatan bagi tujuan penyelidikan. Setiap sampel akan melalui proses homogenisasi dan penghadaman asid basah sebagai langkah penyediaan sampel. Sampel ini dianalisis menggunakan spektrofotometer serapan atom (AAS) bagi menentukan kepekatan logal berat di dalam sampel. Disebabkan ketidaktentuan perbezaan dalam kandungan logam berat diantara pemerah pipi berasaskan serbuk dan krim, perbezaan yang jelas tidak dapat dilakukan. Data yang diperoleh daripada penyelidikan ini akan dibandingkan dengan had kandungan logam berat yang telah dikeluarkan oleh Persatuan Negara-negara Asia Tenggara (ASEAN) dan Bahagian Regulatori Farmasi Negara (NPRA). Hasil penyelidikan mendapati bahawa sample A, B, C, Y dan Z menunujukkan kandungan Pb yang melebihi had yang dibenarkan (Pb ≤10 ppm). Cd yang melebihi had (Cd ≤1 ppm), didapati pada sampel C, X dan Z. Kandungan Cr yang tinggi dijumpai di dalam sampel A, B, X dan Z (Cr adalah dilarang). Kesimpulannya, pihak yang bertanggungjawab hendaklah memantau dengan rapi akan pengeluaran produk kosmetik tempatan kerana melebihi had maksimum kandungan logam berat yang dibenarkan akan menyebakan masalah kesihatan kepada pengguna dan boleh dikenakan tindakan undang-undang di bawah Akta Jualan Dadah 1952.

DETERMINATION OF HEAVY METALS IN POWDER AND CREAM BLUSHERS FROM LOCAL COSMETIC BRANDS USING ATOMIC ABSORPTION SPECTROSCOPY (AAS)

ABSTRACT

Heavy metals have been widely used in the manufacture of cosmetic products, including blusher, which mainly serve as colorants. However, higher concentrations of heavy metals could cause adverse health effects to the consumer such as kidney failure, liver dysfunction and skin irritation especially for long-term exposure. This study aims to analyse the concentration of heavy metals, lead (Pb), cadmium (Cd) and chromium (Cr) in the blusher samples which are powder-based blusher and cream-based blusher among the local brands products. Hence, two different types of formulations from three different local brands were randomly selected from local market. Each sample undergoes homogenisation and wet acid digestion process as the sample preparation procedure. The blusher samples were analysed using atomic absorption spectrophotometer (AAS) in order to determine the concentration of heavy metals in the sample. Due to inconsistency differences in concentration of heavy metals among powder and cream blusher, it prevents a clear comparison of the metal content. The data and results obtained from the study were compared to the established regulatory limit of heavy metals in cosmetic products as outlined by the Association of Southeast Asian Nations (ASEAN) and Malaysian National Pharmaceutical Regulatory Agency (NPRA). As the result, samples A, B, C, Y and Z displayed Pb concentration that above permissible limit, (Pb ≤10 ppm). Cd levels above the allowable limit (Cd ≤1 ppm) were observed among samples C, X and Z. Higher concentrations of Cr were observed in sample A, B, X and Z (Cr is banned). However, the authorities should closely monitor the manufacture of local cosmetic products as exceeding the standard permissible limit of heavy metals could cause adverse health effects to the consumers and may be charged under the Sale of Drugs Act 1952.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Cosmetic products could be considered as daily necessities as it commonly been used by all ages and genders to enhance personal appearance and self-care. Cosmetic has already been widely used and applied since in the early civilization especially in African, China and Greek however, the early cosmetic product was mainly based on natural element products (Raza-Naqvi et al., 2022). As the beauty industry grows, most cosmetic products, especially coloured beauty products including lipstick, blusher and eyeliner contain traces of heavy metals that have been added on purpose.

The heavy metal or mineral pigments have been a part of the cosmetic industry manufacture mainly to function as colorants especially in make-up products. It is because heavy metals in cosmetics may give various colorants by adding different metal pigments and minerals. Other than that, these mineral pigments may act as a preservation due to its characteristic anti-fungal properties (Arshad et al., 2020). This may help to prolong the product shelf life.

Blusher is one of the cosmetic products which comes in various colour including pink, red and yellow. Some blusher makeup also has a glitter effect on it which adds colour and creates a glowing appearance to the user. The various colour produced could possibly be due to the presence of heavy metal in the product (Raza-Naqvi et al., 2022).

Blusher products are available in different formulations in order to meet consumer preferences and skin type, commercially. This may include powder-based blusher and cream-based powder. Powder-based blusher is typically pressed into compact powder form. In contrast, cream-based blusher appears as smooth and creamy texture (Patel, 2025). This is because cream-based product produces in higher solvent content compared to powder-based (Akmal, 2023).

Heavy metal content also differs for both formulations which mainly due to manufacturing. As an example, a recent study shows a direct comparison of heavy metal presence in between cream and powder depilatory products which prove higher metal concentrations in powder-based products than cream-based products (Mohammadzadeh et al., 2021). Higher heavy metal content is often found in powder-based products in order to function as filler such as clay and talc, so the powder is more compact and not easily to crumble during the packaging process (FDA, 2019).

Blusher products are applied directly on the topical skin surface which is the cheek. This may lead to human facial exposure to heavy and toxic metal elements. The blusher makeup materials may penetrate to human blood vessels through layers of skin protective barrier. Absorption can occur via hair follicle and sweat gland (Akhtar et al., 2022).

Then, the product may bind to plasma protein and circulate in blood body system. Some metals elements could undergo phase I and phase II metabolism and excrete through urine (Arshad et al., 2020). Phase I and phase II metabolism is a sequential step in order to detoxify the foreign substances in the body. The phase I metabolism usually involve alteration of the molecule to become more soluble by undergoes oxidation, reduction and hydrolysis. Phase II metabolism involves conjugation process by binding the molecule substances with endogenous hydrophilic such as glucuronidation and acetylation (Almazroo et al., 2017). This allows to modify the molecule to become more water-soluble and easily excreted in urine.

However, some metal not able to go through metabolism process which results to accumulate in the human body. This may cause an adverse effect to the user including renal malfunction and skin disorder, especially if they are exposed to the source for a longer period of time. Hence, it is classified as a highly toxic metal (Collin et al., 2022).

Detection and quantification of heavy metal presence in makeup, such as blusher could be conducted as part of safety regulation initiatives, especially for unregistered products including products that are not being approved by the Ministry of Health (KKM). Referring to guidelines for control of cosmetic products in Malaysia by National Pharmaceutical Regulatory Agency (NPRA), some metals are allowed to be used in manufacture of cosmetic products but must be within the permissible and safety limit (NPRA, 2022). Products with exceeded permissible limit could be classified as unsafe for consumer to use. This may also lead to facing regulatory actions such fines and suspension of product license.

1.2 Problem Statement

Cosmetic product including blusher make-up are widely used by any gender, age and race. The blusher type make-up commonly used to enhance glowing effect and more colour on the face. As the product suspected to contains certain concentration of heavy metal and toxic elements, it may cause harmful to the consumer. A consumer that used the product as daily necessities are potentially exposed at a greater risk of effect due to longer exposure period to the particular make-up (Sylvia et al., 2021).

The mineral element or heavy metal are intentionally being added into the cosmetic product during the manufacturing process. Hence, different brand product might contain different concentration level of heavy metal depending on their formula. Thus, the concentration of metal presence must be within permissible limit that already been set by regulatory organisations.

This is because, higher exposure to the toxic metals may accumulate in consumer's body especially in their kidney and liver. Some brand products add higher heavy metal content which over than the permissible limit into cosmetic products including blusher. This might cause skin irritation and allergic reaction to the consumer as the material added consider as unsafe to the skin (Raza-Naqvi et al., 2022). One case reported on 2016, where the selling cosmetic product contains higher concentration of toxic heavy metal including mercury, cadmium, chromium, lead and arsenic which the product will been banned for use in cosmetic purposes (Naz,2016).

However, this study only focusing on analysis of three different types of heavy metals which are lead (Pb), cadmium (Cd) and chromium (Cr). This is because most previous study which involving blusher cosmetic products focusing on the three heavy metals mentioned (Pb, Cd and Cr). This could be referred to a journal from Slyvia et al. (2021) and Intisar A. F. El Sharaa et al. (2025) where both journals involve the analysis of blusher sample with heavy metals of Pb, Cd and Cr.

In this study, several blusher sample from different local brands with similar shades will be used to quantify the concentration of heavy metals that are present in the blusher product. This study aims to compare the concentration of heavy metals of Pb, Cd and Cr that presence between powder-based blusher and cream-based blusher in order to determine which formulation may pose higher risk exposure to the consumer.

Qualitative and quantitative analyses could be conducted using atomic absorption spectrophotometry (AAS). This analytical technique can help to detect and quantify the presence of heavy metals in the blusher product samples. AAS used the atomisation concept to function as it measures the specific wavelength of light of the metal present that being absorbed. Higher intensity of light absorbed could indicate a greater amount of atom metal presence in the sample (Agilent, 2022).

The result of heavy metal concentration will be compared to the permissible limit that been set by regulatory bodies such as Association Southeast Asian Nations (ASEAN) and Malaysian National Pharmaceutical Regulatory Agency (NPRA) as the formal guidelines for a safe level of exposure. Exceeding the recommended level may potentially to pose health risk to the consumer.

1.3 Objectives

1.3.1 General Objectives

To detect the presence of heavy metals (Pb, Cd and Cr) in blusher and quantify the metals using analytical techniques, atomic absorption spectrophotometry (AAS).

1.3.2 Specific Objectives

i) To determine the concentration of heavy metals between different types of blushers, which are cream and powder of the same brand.
ii) To compare the result against the permissible limit of the cosmetic safety regulations.

1.4 Hypothesis

1.4. 1 Alternative Hypothesis (H_a)

The concentration of heavy metals (Pb, Cd and Cr) measured in powder and cream blushers from local cosmetic brands are within the permissible limit.

1.4.2 Null Hypothesis (H_o)

The concentration of heavy metals (Pb, Cd and Cr) measured in powder and cream blushers from local cosmetic brands are exceeding the permissible limit.

1.5 Research Question

i) What are the concentrations of each heavy metal (Pb, Cd and Cr) contained in different blusher cosmetic products?
ii) Is there a difference in the concentrations of heavy metals between different types of blushers within the same local cosmetic brand?
iii) Are the concentrations of heavy metals detected within the permissible safety limits established by standard regulatory authorities?

1.6 Significance of Study

This study is greatly significant as it to determine the concentration traces of heavy metals (Pb, Cd and Cr) between two different types of blushers which are powder-based blusher and cream-based blusher. This may help in terms to determine in which formulations of products could pose a higher risk to the consumer as the study involve in comparison between powder-based blushers and cream-based blushers.

Quantifying the concentration level of heavy metal Pb, Cd and Cr may ensure the safety product to be used by the consumer. This also allows all the brand products to follow the regulatory guidelines that already established by the regulatory, as an example National Pharmaceutical Regulatory Agency (NPRA) and Association of Southeast Asian Nations (ASEAN) which are responsible for monitoring and taking any actions against products that exceed the permissible limit.

Furthermore, higher concentration and exposure of heavy metals could cause adverse health effects which include skin irritation, skin allergic reaction and kidney failure (Raza-Naqvi et al., 2022). This is because most make-up products including blusher applied directly onto the skin which makes the absorption of toxic elements much easier. Hence, it will cause harm to the consumer as it increases the potential health risk to the consumer.

CHAPTER 2

LITERATURE REVIEW

2.1 Cosmetic Product

Cosmetic products could refer to beauty products that been applied on human body mainly for cleansing, promote attractiveness and altering someone's appearance (Parbin Iraqui et al., 2022). The human body mentions could refer to nail, hair, skin and legs. Cosmetic may also be widely known as make-up which including foundation, loose powder, lipstick, eyeliner, eyeshadow and blusher. This will result in a temporary and artificial beauty transformation (Bakshi et al., 2022). Thus, beauty products are being used by most people without exception in terms of age, gender and race.

However, some past study show that some toxic heavy metals are being added into the cosmetic product intentionally during the manufacturing process. As an example, a study shown traces of lead (Pb), cadmium (Cd), nickel, (Ni), mercury (Hg) and arsenic (As) in several cosmetic product including lipsticks, eyeshadow, eyebrow, mascara, foundation and face cream (Attard et al., 2022).

Another study also analyses heavy metals in several lipstick samples of cosmetic products, where some samples exceed the permissible limit of heavy metal content such as Pb and Cr in which could lead to skin irritation and allergic especially for a long-term exposure (Saah et al., 2024). This study is classified under environmental toxicology as it involves in relations of environmental and consumer health. However, lack of information regarding heavy metals in blusher beauty products.

2.2 Blusher

Blusher is classified as coloured facial cosmetic due to commercially produced in various colours such as pink, brown, red and orange. It primarily applied on facial skin, specifically cheek to enhance glowing and beauty effect by adding the colour to the facial area. However, the various colour produces could be due to the addition of certain heavy metals in the cosmetic product. Difference metal added could produce different colour of blusher product (Raza-Nazqi et al., 2022).

Besides, blusher also commercially produce in different types of formulations including powder-based blusher and cream-based blusher. Hence, both formulations will undergo different manufacturing processes, in which heavy metal content could be variant in both formulations among similar colour shades.

Less research studies that involve direct comparison of heavy metal content between different formulations of blusher. However similar study has conducted in 2025 by the University of Benghazi, Libya where it reported that powder blusher and face powder generally show higher Pb and Cd compared to liquid foundation products (Intisar A. F. Sharaa et al., 2025). Thus, long-term use of blusher on cheeks leads to a greater risk of heavy metal exposure.

2.2.1 Powder-based Blusher

Powder-based blusher is typically manufactured by pressing into a compact (Patel, 2025). The powdered blusher is mainly composed of powdered pigments or fillers such as clay, talc and mica (FDA, 2019). Other than that, powder blusher is commonly applied dry on the cheek, hence there is a higher chance of inhalation exposure of the loose powder particles in addition of dermal exposure. This will increase the consumer's risk of exposure to heavy metals, especially for repeated and prolonged use.

2.2.2 Cream-based Blusher

Creams-based blusher product which also refer as semi-solid is one of the type formulations of blusher cosmetics products (Rejakumar et al., 2022). Cream-based blusher appears as smooth and creamy texture (Patel, 2025). This is because cream-based product produces in higher solvent content compared to powder-based (Akmal, 2023). These formulations are designed to enhance adherence to the skin to provide a longer cosmetic effect. As the result, it will prolong the skin contact and contribute to higher risk of dermal exposure to traces of heavy metal content in cosmetic products.

2.3 Heavy Metal

Heavy metal may refer to minerals or metals in which some of the metals have various biochemical and physiological functions, however it may cause pollution in the environment and health risk to public (Chaudhery Mustansar Hussain, 2020). Despite the risk, heavy metals have still continuously been added in beauty and cosmetic product during the manufacturing process. This mainly to be served as colorant. Some metal also to function as antifungal and antibacterial agents which help to prolong the shelf life of the product (Arshad et al., 2020).

Referring to NPRA, several heavy metals are allowed to be added for such purposes in cosmetic manufacturing industry but in certain permissible limits. It is because, any concentration heavy metal higher than the limit may pose adverse health effect especially to the consumer.

Cadmium, chromium and lead are proven to presence in most cosmetic product including blusher (Intisar A. F. El Sharaa et al., 2025). This statement also could be supported by a study in 2021 by College of Pharmacy where it is involving analysis blusher product using AAS. Based on the study, it shows metal Cd, Cr and Pb are found in most blusher cosmetic products (Sylvia et al., 2021). In which greater exposure will cause adverse health effects to the consumer.

2.3.1 Lead

Lead contamination in blusher cosmetics products is typically functions as colour additives but in a low concentration. According to NPRA, lead should contain not more than 20ppm. However, continuous exposure of lead could damage the kidney and liver. It is because, free radicals from lead could imbalance the reactive oxygen species and antioxidants in the body that causing oxidative stress (Raza-Naqvi et al., 2022). This will damage the skin cells and tissue.

Additionally, lead is classified as neurotoxic, nephrotoxic and hepatotoxic whenever contact to internal organs specifically the vital organs (Attard et al., 2022). Neurotoxic may refer to substances or metal that cause damage on nervous system. Long-term exposure could affect the cognitive impairments and neurological disorders of the individuals (Olusola et al., 2024).

On the other hand, nephrotoxic is a term that describes substances or metal which cause damage to the kidney. Common disease that associated with kidney damage including acute kidney injury, tubular necrosis and crystal nephropathy (Cleveland Clinic, 2025). This could be fatal to the individuals especially in high amount exposure with prolonged exposure.

Hepatotoxic defined as substances or metals including Pb that may cause harm to the liver. Detoxification process mainly occurs in kidney, hence higher exposure of harmful substances may cause severe damage to the liver and may lead to kidney failure (Rusyn et al., 2021).

2.3.2 Cadmium

Cadmium which classified as toxic heavy metal due to its harmful effects even in low amounts of exposure (Witkowska et al., 2021). Referring to NPRA, the permissible limit is not more than 5ppm. Cadmium is used as a colour pigment in cosmetics. Cadmium could accumulate in the liver for a short-term exposure however, in long-term exposure cases, it could bind to small proteins, be transported, and accumulate in the kidney. This will lead to renal malfunction (Raza-Naqvi et al., 2022).

Furthermore, Cd released slowly to the general circulation in order to excrete in the form of urine. This causes a concern as metal Cd could accumulate in the body for a longer period of time and lead to toxicity. Cd also tends to accumulate and bind to specifically to the keratin which may affect skeletal. This could contribute the risk of osteoporosis and skin aging (Attard et al., 2022).

2.3.3 Chromium

One of the heavy metals found in most blusher cosmetic products is chromium (Sylvia et al., 2021). Chromium heavy metal been used as a colour additive in products. Prolonged exposure of chromium metal may cause adverse health effects including kidney failure and allergic to contact skin especially in case where chromium accumulates in the stratum corneum (Raza-Naqvi et al., 2022).

The National Pharmaceutical Regulatory Agency Malaysia (NPRA) is the government organisation that regulates the cosmetic products in Malaysia, where the department closely follow the guidelines from ASEAN. Based on both standards, no numerical values which set the limit for Cr metal. It is because ASEAN generally prohibits the use of Cr as the ingredients in cosmetics as stated in ASEAN Cosmetic Directive (Annex II).

2.4 Adverse Health Effects

Standard regulatory organisations including NPRA, ASEAN and WHO have established the permissible limit of heavy metals in cosmetic products (Raza-Naqvi et al., 2022). Hence, exceeding the limits might contribute to a higher risk of adverse effects to the consumer which may lead to heavy metal poisoning. Heavy metal poisoning is an effect due to greater exposure of heavy metals which can damage internal organs including kidney and liver. This effect is considered life-threatening and irreversible (Cleveland Clinic, 2022).

2.4.1 Route of entry

Heavy metals could easily enter human body through various routes of exposure. However, dermal absorption considers as the most common and significant routes for exposure heavy metals from cosmetic products such as blusher. It is because blusher mostly applied directly on the cheek skin surface. Heavy metals could penetrate easily especially through sweat glands, hair follicles and corneum stratum (Akhtar et al., 2022). Even though rate of dermal absorption considers as low compared to other routes, repeated exposure to the sources could increase the cumulative risks (Gad, 1994).

There are several factors which could increase the rate of penetration of heavy metals through dermal. One of the factors is the skin condition. A damage corneum stratum due to physical damage, chemicals damage or environmental factors could affect the protective barrier of the skin which make the skin more permeable to any exposure substances. Other than that, a well hydrating skin could also enhance the solubility and diffusion of heavy metals substances into the skin barrier which increase the rate of dermal absorption (Anderson et al., 2014).

In addition of dermal absorption, heavy metals in blusher cosmetics products could enter the human body through inhalation. As an example, powder-based blusher may generate fine dust that contains traces of heavy metals during the application, which could be subconsciously inhaled and enter the body through the respiratory tract (Jaishankar et al., 2014). It is significant to know the routes of entry as it could have different absorption efficiencies and toxicokinetic of the heavy metals. Hence, a higher rate of absorption may lead to a higher risk of bioaccumulating metals in the body.

2.4.2 Bioaccumulation

Bioaccumulation is a process where the chemicals including heavy metals accumulate in living organism greater than rate of elimination for a long period of time (Kumar et al., 2022). The heavy metals may penetrate the body and diffuse into the blood vessels. This allows the traces of heavy metals to distribute throughout the body and binding with small proteins including albumin and erythrocyte membranes (Akhtar et al., 2022). Thus, it can transport to others internal organ and accumulate.

Kidney is reported with higher risks of accumulate area as it is where the filtration of glomerular tubules and reabsorption in proximal tubule takes place (Barbier et al., 2005). Hence, most heavy metal poisoning including metals lead, cadmium and chromium may cause kidney failure to the consumer.

Other than that, liver also at risk of heavy metal accumulation where the main detoxification site of the foreign substances in body to occur (Kim et al., 2021). Heavy metal such as cadmium will accumulate at bone as their target organ. This may contribute to risk of osteoporosis. Osteoporosis is referred to low bone mass which cause the bone more fragile and risk to fractures (Akhtar et al., 2022).

Application of cosmetic products specifically blusher on the cheek skin surface may contribute to the risk of bioaccumulation of heavy metals in the body. Greater risk could be grouped especially for a daily and frequent use of blusher product as it increases the continuous exposure to the heavy metals content in the products. Although, blusher product mostly applied in small quantity, however the repeated and long-term usage may increase the heavy metals exposure level. This case may be more severe if the individual is diagnosed with skin disorder such as eczema and dermatitis.

2.5 Atomic Absorption Spectroscopy (AAS)

AAS is an analytical technique that could be used to detect and quantify the presence of specific heavy metals contained in blusher cosmetic products. AAS applied the concept of atomisation where the analyte in blusher sample will convert into free atoms by flame. Then, atoms will absorb the light at an element-specific wavelength (Hill & Fisher, 2017). The amount of absorbance is directly proportional to the concentration of metal present in the sample.

AAS considered as a good method to detect the presence of heavy metals as it offers a good level of sensitivity and cost-effective. It is capable of detecting traces of heavy metals despite in lower concentration of the sample. This allow the results to compare with regulatory limits which are established by WHO, FDA, NPRA and ASEAN. Furthermore, numerous previous studies regarding blusher cosmetic products including study by Sylvia et al. (2021). successfully detect heavy metals lead, cadmium and chromium using AAS as the analytical technique.

CHAPTER 3

METHODOLOGY

3.1 Chemicals and Reagents

The list of chemicals that have been used throughout the research study are provided in Table 3.1.

Table 3.1: List of chemicals and reagents

Chemicals/ Reagents	**Brand/ Supplier**
Lead (Pb) Standard Solutions	PerkinElmer Pure
Cadmium (Cd) Standard Solutions	PerkinElmer Pure
Chromium (Cr) Standard Solutions	Merck KGaA, Darmstadt, Germany
Perchloric Acid 70-72%	Merck KGaA, Darmstadt, Germany
Nitric Acid 65%	Merck KGaA, Darmstadt, Germany

3.2 Equipment and Instrument

The instruments used can be referred as in Table 3.2 along with the brand and model for each instrument.

Table 3.2: List of equipment and instruments

Instrument/ Equipment	**Brand**	**Model**
Analytical balance	AND (A&D Company Limited)	HR-251AZ
Atomic Absorption Spectrophotometer (AAS)	PerkinElmer	PinAAcle 900F
Deionised water	Sartorius (arium pro)	H2DPRD-DI-T
Hotplate	Stuart	UC152D
Micropipette 20-100 µL, 100-1000 µL	Chermopharm Sdn Bhd	P1000
Thermometer	G H ZEAL LTD	

3.3 Sample Collection

In this study, two different types of blushers, powder-based blusher and cream-based blusher were chosen from three different local brands that are available from the local market. The two different types of formulations which are powder-based blusher and cream-based blusher were selected with similar colour shades among them to minimize the potential of bias.

The powder-based blushers were labelled as sample A, sample B and sample C while the cream-based blushers were labelled as sample X, sample Y and sample Z. The study was repeated three times for each blusher sample. Hence, a total 18 sample was used to analyse the presence of heavy metals of lead (Pb), cadmium (Cd) and chromium (Cr) in each blusher sample. The physical appearance and characteristics of each sample were also observed and recorded.

3.4 Sample Preparation

All apparatus and glassware that used were washed with liquid soap and rinsed with tap water. Each glassware used was soaked in a container filled with 10% of nitric acid (HNO_3) for overnight to reduce the risk of contamination from the previous sample. The glassware were then soaked in the deionised water overnight. The laboratory glassware were hung and allowed to air-dry completely.

Each blusher sample undergoes homogenisation process to ensure the analysed collected samples can represent the whole sample. The powder-based blusher was homogenised using a mortar pestle while the cream-based blusher homogenised by stirring the sample using glass rod. Difference technique was applied due to contrast formulation of blusher. Then, all samples undergoes wet acid digestion for sample digestion as refers to an established journal written by Sylvia et al. (2020).

The samples were weighed to 0.5 g with ± 0.0015 (n=6) g using the analytical balance and placed into 100 mL conical flask for powder-based blusher and into 100 mL beaker for cream-based blusher. Each sample was specifically labelled. Specific measurement of mass for each sample could refer to Table 3.3.

Table 3.3: Mass (g) of each sample

Type of Blusher	Sample	Trial number	Mass (g)	Average Mass(g)
Powdered blusher	Sample A	1	0.5042	0.5048
		2	0.5061	
		3	0.5040	
	Sample B	1	0.5021	0.5031
		2	0.5046	
		3	0.5025	
	Sample C	1	0.5018	0.5033
		2	0.5011	
		3	0.5070	
Cream blusher	Sample X	1	0.5073	0.5067
		2	0.5041	
		3	0.5087	
	Sample Y	1	0.5022	0.5025
		2	0.5041	
		3	0.5011	
	Sample Z	1	0.5036	0.5039
		2	0.5045	
		3	0.5037	

A volume of 25 mL of 65% nitric acid (HNO_3) was added to each conical and beaker containing the blusher sample. The samples were allowed to stand overnight. Subsequently, the samples were boiled slowly on a hotplate for 35 minutes at 83 °C, followed by a cool-down period of several minutes. A volume of 10 mL of 72% perchloric acid ($HCIO_4$) was added to the mixture solution. The mixture solution was further heated slowly on the hotplate until a pale or colourless solution was observed.

Subsequently, the mixture was boiled slowly using the hot plate until colourless. The mixture was allowed to cool down for several minutes and followed by the addition of 25 mL of deionised water. The heating process was continued for several minutes until nitrogen dioxide gas (NO_2) was completely gone.

The solution was then filtered and placed into a 100 mL volumetric flask. The filter paper was rinsed with deionised water to reduce the possibility of loss of analyte during the transfer process. The solution was added with deionised water until the calibration mark was reached. Method blank were treating the same without adding blusher sample.

Standard calibration solution for Pb, Cd and Cr were prepared after sample preparation. Then, the standard calibration solutions followed by blusher samples were analysed using AAS.

Furthermore, the parameters such as coefficient of determination (R^2), percent recovery, limit of detection (LOD) and limit of quantification (LOQ) were calculated. The readings concentration of each sample which is below the LOD and LOQ values were spiked with a known concentration of Pb, Cd and Cr.

3.5 Standard Stock Solution

The concentration of standard solutions of metals lead (Pb), cadmium (Cd) and chromium (Cr) were prepared within 0.625 mg/L to 10 mg/L for Pb metal, 0.0625 mg/L to 1.0 mg/L for Cd metal and 0.3125 mg/L to 5 mg/L for Cr metal.

The preparation was prepared based on a dilution formula, $M_1V_1 = M_2V_2$ in order to obtain the desired concentration, where M is the concentration of solution and V is the volume of the solution. Hence, five calibration standard points with different concentrations were used for the calibration curve on Atomic Absorption Spectrophotometry (AAS).

3.6 Heavy Metal Analysis

The atomic absorption spectrometer (AAS) was used in this study to determine the concentrations of heavy metals including Pb, Cd and Cr in each blusher sample. Accordingly, only three hollow-cathode lamps that correspond in detecting metals Pb, Cd and Cr were switched during the operation.

The five standard calibration solutions for each metal were analysed using AAS. Standard solutions were analysed sequentially from the lowest concentration to the highest concentration. Subsequently, each blusher sample was analysed using the AAS. The deionised water which functions as a blank solution was also analysed before the analysis of the standard solution.

The data from the atomic absorption spectrophotometry (AAS) was used to calibrate the calibration curve for each metal. The samples in this study were originally measured by mass (g), hence a conversion unit from mg/L to mg/kg was required in order to determine the actual concentration of heavy metals in the samples. Therefore, the conversion unit was based on the formula as below.

$$\text{Concentration of heavy metals (mg/kg)} = \frac{\text{concentration of heavy metals (mg/L) X volume of sample (mL)}}{\text{Mass of sample (kg) X 1000}}$$

CHAPTER 4

RESULT AND DISCUSSION

4.1 Sample Collection

The study involves the collection of two different types of red blushers which are powder-based blusher and cream-based blusher. Three different local brands were chosen based on their availability in the local market. The observation of the sample was recorded as in Table 4.1.

Table 4.1: Types of blushers

Local brands	Types of Blushers	
	Powder-based blusher	Cream-based blusher
Brand J	(Sample A)	(Sample X)
Brand K	(Sample B)	(Sample Y)
Brand L	(Sample C)	(Sample Z)

Based on Table 4.1, powder-based blusher appeared as a dry and solid while in contrast, cream-based blusher could be described as creamy. Other than that, powder-based blusher in sample A, sample B and sample C exhibit shiny appearance but these characteristics were not observed on cream-based blusher samples.

The cream-based blusher of sample X, sample Y and sample Z also seems to be slightly adhesive to the surface compared to the powder-blusher sample. In terms of texture, the powder-based blusher could be described as non-greasy.

The cream-based blusher may describe as smooth and moist texture. This might be due to higher solvent content in this cream type of products (Akmal, 2023). The cream formulations usually consist of water, oils and waxes which caused the cream product to be appeared as viscous emulsion (Khare et al., 2021).

4.2 Sample Preparation

The act of cleaning the apparatus consider as a basic procedure before using the glassware. It is to ensure the accuracy and precision of the analysis by removing any residues and contaminants from the previous experiment, which could alter the results.

Besides, all glassware were soaked with 10% of nitric acid followed by rinsing with deionized water as it is the standard procedure in laboratories (Wickham, 2018). This step allows to decontaminant and ensures no trace of residue remains in the glassware. This because nitric acid able to remove free metal ions and other contaminants due to its oxidizing properties (Lab Alley, 2022). Hence, it will minimize the risk of contamination while providing reliable data for this study.

The procedure of sample preparation was conducted with reference to a previously established journal by Sylvia et al, 2020. The procedure could be adapted into this study, as the previous study also involved the analysis of blusher samples using atomic absorption spectrophotometry (AAS) as the analytical instrument.

Homogenous step was included as the sample preparation procedure to ensure uniformity of datasets analysis by reducing the variability of the sample. This is because the analysed sample could be represented from the whole sample (Pawliszyn, 2012). Hence more consistent data be produced.

In this study, the blushers were originally in solid and semi-solid form. However, AAS requires the sample in a homogenous liquid solution to be analysed in order to provide a clear measurement of AAS (Mohan, 2025). Thus, acid wet digestion method was applied in order to digest the complex solid sample into an aqueous solution (Mustafa Soylak, 2025).

The acid wet digestion technique was used to break down complex blusher matrices into solution by applying heat and strong acids such as nitric acid (HNO_3) and perchloric acid ($HCIO_4$). Hence, the digestion method allows for the removal of any interference of organic matter (Mustafa Soylak, 2025). Higher interference compounds could possibly to disrupt AAS reading by producing false absorbance measurements.

All blusher sample including powder-based and cream-based were spiked with known metal concentrations. The spiked concentration for Pb is 1.667 ppm, 0.167 ppm for Cd metal and 0.833 ppm for Cr.

It is because the data from AAS show that unaltered blusher samples displayed a low concentration of heavy metals. This causes the data to be plotted out from linear range of calibration curve due to concentration of metal detected in each sample below the lowest standard calibration points of the metals (Pb, Cd and Cr).

This result has a higher possibility of the data obtained to be unreliable as no linear relationship display on the area where the data points fall. Therefore, each blusher samples including sample A, B, C, X, Y and Z were spiked to overcome the problems. This procedure ensures the data obtained to be higher than LOD and LOQ values thus, hence the data could be more reliable.

4.4 Standard Calibration Curve

Lead (Pb), cadmium (Cd) and chromium (Cr) were the heavy metals that has been focused on this study. Hence, a linear calibration curve for each metal was plotted based on the data obtained from AAS.

The blank sample displayed 0.00 mg/L as the concentration of metals in each AAS analysis. This used for correcting the data reading in AAS by removing the background interference or noise. Hence, the data obtained may be highly reliable and precise.

Figure 4.1 shows the linear calibration curve and R^2 for each metal. Coefficient of determination (R^2) used to describe the data variability in the calibration curve. The maximum and minimum range of R^2 is within 0 and 1, in which a higher value of R^2 indicate the strong relationship between concentration of metal and absorbance value (Rahman et al., 2023).