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Heavy Metals Content in Selected Cream Marketed in Gusau Metropolis, Zamfara State, Nigeria, and Associated Health Risk

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ABSTRACT

In Nigeria, the use of beauty creams is a widespread practice. This research evaluates the levels of zinc (Zn), lead (Pb) and nickel (Ni) in five (5) different beauty cream brands commonly found in Gusau Metropolis, Zamfara State using Atomic Absorption Spectrophotometery (AAS). Estimated daily intake (EDI) as well as the health risk index (HRI) of these metals were also calculated to assess the dermal health risks associated with the use of the creams. The concentration of Ni (6.130±1.740 – 14.90±18.40 mg/kg) was notably higher, while Pb (2.833±1.457 – 34.80±48.80 mg/kg) was lower in all samples compared to permissible limits in cosmetics (Pb: 10 mg/kg; and Ni: 0.6 mg/kg), except for brand E, which had an excessively high Pb concentration. There are currently no established limits for Zn in cosmetics. Prolonged use of these creams may lead to health risks due to toxic metal exposure through dermal route indicated by an HRI greater than 1 for all metals. Therefore, it is recommended that relevant authority such as NAFDAC and SON intensify monitoring of these toxins in beauty cream products manufactured or imported into Nigeria to safeguard public health, particularly for vulnerable groups like children and women.

Keywords: Heavy Metals, Creams, Heath Risk Index, Estimated Daily Intake, Atomic Absorption Spectrophotometery.

1.0 INTRODUCTION

In recent years, cosmetics are constantly employed as a routine aspect of body care, particularly among the privileged classes worldwide. The term "cosmetics" refers to substances that are applied to the body, primarily the skin with a singular aim of enhancing appearance, cleansing, beautifying, masking body odour and maintaining skin condition (Health and Cosmetic Sciences Task-Force, 2022); Attard and Abstract, (2022). There is an increasing fervent for physical beauty leading to an increase use of personal care products (PCPs) like; lipsticks, powders, eye shadows and various moisturizing and lightening creams to mention but few.

Globally, women constitute approximately 4.1 billion of the world's population. With evolving beauty standards, increasing awareness, and access to skincare and cosmetic products, the global cosmetics market reached an estimated value of US$296 billion in 2023. This massive industry reflects not just economic growth, but also changing lifestyle patterns, especially among women.

In Nigeria, the cosmetics industry is experiencing rapid expansion. Projections from the Nigerian Bureau of Statistics (2024) estimate that the country will generate approximately US$1.88 billion in cosmetic industry revenue by 2025. In 2024 alone, around 237.5 million Nigerians were reported to be using cosmetic products, with about 118 million of them being women. According to estimates from the Federal Government and the World Health Organization, approximately 77% of Nigerian women use skin-lightening creams. In addition, a study by Akinyemi and Ilesanmi (2023) found that 70% to 80% of Nigerian women use other skincare or makeup products, highlighting widespread engagement with cosmetics beyond just skin-lightening.

Zooming in on Gusau, the capital of Zamfara State, around 262,000 women are reported to use skin-

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lightening creams. Interestingly, 70% of these women also use a range of other cosmetic or skincare products, indicating an overlap in product usage and a deep-rooted beauty culture. These figures not only point to growing consumer demand but also underscore the need for regulatory oversight, public health education, and industry innovation, particularly considering the health implications of some cosmetic ingredients of which consumers are often unaware of their presence and concentrations (Ferreira *et al.*, 2022; NBS, 2024.

Millions of individuals use multiple personal care products on a daily basis, which of course, exposes them to various chemicals via skin (dermal contact) particularly with prolonged use (IPCS, 2014; Gautam *et al.*, 2022). Many cosmetics contain heavy metals such as lead, cadmium, chromium, arsenic, mercury, cobalt, and nickel as ingredients or contaminants (Lara-Torres *et al.*, 2021). Recent researches have indicated that exposure to these metals can lead to health issues; including allergic contact dermatitis and other skin problems (Oh and Kim, 2025).

Dermal exposure to water-soluble toxic substances whether inform of element, compound or both is expected to be the primary route of exposure from cosmetic products, as most cosmetics, are applied directly to the skin, potentially posing health risks. Heavy metal absorbed through skin can be detected within 6 hours to 45 days in sweat, blood and urine (Salles *et al.*, 2023). Oral exposure can occur from cosmetics applied to the mouth or through hand-to-mouth contact after handling products containing heavy metal impurities. Inhalation of these metals is generally, considered negligible (Arshad *et al.*, 2020).

With numerous new products continuously entering the market, it is challenging to assess the safety of each one, especially since many lack labels indicating the presence or concentration of heavy metals (Faccio, 2020). Additionally, there are currently no stringent regulations in Nigeria governing heavy metal levels in consumer products, nor are there established national permissible limits. Therefore, it is essential to establish baseline data on heavy metal exposure in cream products in order to compare it to the existing studies.

1.1 Objectives of the Research

The objectives of this research are to:

i. evaluate the concentrations of zinc (Zn), lead (Pb), and Nickel (Ni) in five (5) different Beauty cream brands sold in Gusau metropolis, Zamfara state, and compare the concentrations to International standards and relevant studies.
ii. evaluates the human health risks associated with the use of these creams

2.0 MATERIALS AND METHODS

2.1 Sample collection

In July 2024, five different brands of beauty cream were randomly selected and purchased in triplicate from various retail shops, open markets, and cosmetic stores within Gusau Metropolis of Zamfara State. Products were chosen to reflect a range of popular brands and formulations (See Table. 1). To maintain anonymous, the samples were labeled with codes from A to E

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Table 1: Shows the Details about Collected Beauty Cream Samples

S/N	Sample Code	Name of cream	Date of Manufacture	Expiry Date
1	Brand A_1	Aloe Vera	12/23	11/26
2	Brand A_2	,,	01/24	01/24
3	Brand A_3	,,	12/23	03/27
4	Brand B_1	Carrotone	10/23	11/27
5	Brand B_2	,,	03/24	03/28
6	Brand B_3	,,	12/23	11/27
7	Brand C_1	Skin Light	08/22	09/27
8	Brand C_2	,,	11/23	03/27
9	Brand C_3	,,	12/23	04/27
10	Brand D_1	Caro White	09/22	04/26
11	Brand D_2	,,	11/23	03/27
12	Brand D_3	,,	11/22	04/26
13	Brand E_1	Carro Fresh	05/22	05/25
14	Brand E_2	,,	11/23	03/27
15	Brand E_3	,,	12/23	02/27

2.2 Sample Preparation and Analysis

1.0 g of each sample was weight and transferred into a 50cm^3 beaker, followed by the addition of 5.0c m^3 of concentrated mixture (HNO_3:$HClO_4$ in a 3:1 ratio). The beaker was placed on a hot plate in a fume cupboard and heated gently until a brown coloration appeared. Subsequently, an additional 3.0cm^3 of the acid mixture was added, and the mixture was left until a white coloration was observed. After cooling to room temperature, the sample was filtered through Whatman No. 1 filter paper into a clean 50cm^3 beaker.

The filtered samples were then quantitatively transferred into a 50cm^3 volumetric flask, diluted with deionized water, and shake thoroughly to ensure homogeneity. This procedure was repeated for three samples of each brand (triplicate) to prevent systematic bias (Kwanashie, and Umar, (2020); Akpe *et al.*, (2020).

Reagents blank determinations were used to calibrate the instrument readings. For validating the analytical procedure, the standard addition method was applied (Barthe *et al.*, 2021)

2.3 Heavy Metal Analysis

The analysis of Zinc (Zn), Nickel (Ni), and Lead (Pb) in the digested samples was performed using a T60 UV VIS spectrophotometer at the Department of Pure and Industrial Chemistry, Umaru Musa Yar'adua University, Kastina, Nigeria.

Each metal was analyzed at its respective maximum absorbance wavelengths (λ_{max}), 213

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nm for Zn, 232 nm for Ni, and 283 nm for Pb. A 1cm quartz cuvette was used as the optical pathlength for all measurement. Calibration curves for each metal were prepared using standard solutions of known concentrations, and absorbance values were used to determine metal concentrations in the samples based on Beer-Lambert's law. Detection limits for the spectrophotometer were approximately (Zn: 0.01 mg/L, Ni: 0.02 mg/L and Pb: 0.015mg/L).

2.4 Statistical Analysis

A one-way ANOVA test was conducted to assess the significant differences in the results from different samples using SPSS 21.0. Mean values were calculated to represent all cream samples for comparison with standard values.

The Coefficient of Variation (CV) was used to illustrate the distribution patterns of the heavy metals in the creams, calculated with the formula:

$$\boldsymbol{CV = SD \times 100/Mean} \quad \text{..... (1)}$$

where; SD is the standard deviation.

Higher CV values, indicate greater variability in the distribution of the measured parameters (Adekunle *et al*., 2014).

2.5 Risk Assessment

The potential adverse health effects of the metals in the creams were evaluated using two primary risk assessment methods:

2.5.1 Estimated Daily Intake (EDI)

The EDI for the metals was calculated using the formula: $\boldsymbol{EDI = C \times \frac{D}{W}}$ ……. (2)

where C is the mean concentration of the metals obtained in this study, W is the average adult body weight (70 kg) as reported by Akpe *et al.*, (2020), and D, is the daily amount of cream used (2.05g/kg/day) (Loretz *et al.*, 2005).

2.5.2 Health Risk Index (HRI)

The human health risks associated with heavy metal exposure in creams were estimated using the Health Risk Index (HRI), calculated by dividing the EDI, by the dermal reference doses for each metal:

HRI = Calculated EDI / Dermal reference dose for each metal …….(3)

The dermal reference doses for Zn, Ni, and Pb are 6×10^{-2}, 5.4×10^{-3}, and 5.25×10^{-4} mg/kg/day, respectively.

An HRI value below 1 indicate no significant health risks, while value exceeding 1 suggest potential health concerns related to overexposure (Cerulli *et al.*, (2022); Adekunle *et al*., (2014), and Navaro *et al.*, (2024).

3.0 RESULTS AND DISCUSSION

3.1 Results

3.1.1 Heavy Metals

Table 2: Shows the Mean and Standard Deviation of the Triplicate Measurement of Heavy Metals and the Standards in the Cream Sample (mg/kg)

S/N	Sample Code	Zn (mg/kg)	Ni (mg/kg)	Pb (mg/kg)
1	Brand A	2.225±0.90^{c}	6.410±4.290^{b}	6.750±4.650^{b}
2	Brand B	3.696±1.678^{ab}	6.550±3.290^{b}	6.170±2.180^{b}
3	Brand C	4.480±1.850^{b}	6.130±1.740^{b}	3.140±2.740^{c}
4	Brand D	5.740±4.460^{a}	14.50±19.30^{a}	2.833±1.457^{bc}
5	Brand E	4.260±1.900^{b}	14.90±18.40^{a}	34.80±48.80^{a}

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6	EU/WHO	-----	0.6/0.3	10

- Data are mean ± the standard deviation of three replicate results
- Values within the same column with different subscript are significantly different at $p<0.05$.

3.1.1.1 Zinc (Zn)

The zinc levels measured in the creams ranged from 2.225±0.908 mg/kg to 5.740±4.460 mg/kg. The highest concentration, 5.740±4.460 mg/kg, was found in Brand ***D***, while the lowest, 2.225±0.908 mg/kg, was in Brand ***A***. Significant differences exist between the different brands of the creams.

3.1.1.2 Nickel (Ni)

Nickel levels in the creams ranged from 6.130±1.740 to 14.90±18.40 mg/kg, with Brand ***E*** showing the highest concentration and Brand ***C*** the lowest. All brands are well above the regulatory limits of 0.6 and 0.3 ppm set by EU and WHO respectively (Table 2). Brand ***D*** and ***E*** shows the highest level with no significant difference between them while, Brand ***A***, ***B*** and ***C*** have similar moderate levels.

3.1.1.3 Lead (Pb)

The concentrations of lead in the samples varied from 2.833±1.457 to 34.80±48.80 mg/kg, with Brand ***E*** showing the highest level at 34.80±48.80 mg/kg and Brand ***D*** the lowest at 2.833±1.457. Only Brand ***E*** significantly exceeds the WHO and EU limit. Brand ***A***, ***B***, ***C***, and ***D*** are below the limit, but still contain notable level.

Table 3: Shows the Coefficient of Variation (CV) of Heavy Metals in the Different Products

S/N	Sample Code	Zn (n=3)	Ni (n=3)	Pb (n=3)
		Coefficient of Variation (%)		
1	Brand A	40.50	66.93	68.89
2	Brand B	45.40	50.23	35.33
3	Brand C	41.29	28.38	87.26
4	Brand D	77.70	133.10	51.43
5	Brand E	44.60	123.49	140.23

Table 4: Shows the Estimated Daily Intake of Heavy Metals via Dermal Exposure from Cream Commonly Used in Gusau Zamfara State

S/N	Sample Code	Zn (mg/day)	Ni (mg/day)	Pb (mg/day)
1	Brand A	6.50×10^{-2}	1.9×10^{-1}	1.98×10^{-1}
2	Brand B	1.08×10^{-1}	1.91×10^{-1}	1.81×10^{-1}
3	Brand C	1.31×10^{-1}	1.79×10^{-1}	9.20×10^{-2}
4	Brand D	1.68×10^{-1}	4.25×10^{-1}	8.30×10^{-2}
5	Brand E	1.25×10^{-1}	4.36×10^{-1}	1.019

Table 5: Shows the Health Risk Index (HRI) of Heavy Metals in Creams Commonly Used in Gusau Zamfara State

S/N	Sample Code	Zn	Ni	Pb
1	Brand A	1.086	3.48×10^{1}	3.76×10^{2}

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2	Brand B	1.804	3.55×10^{1}	3.44×10^{2}
3	Brand C	2.187	3.32×10^{1}	1.75×10^{2}
4	Brand D	2.801	7.86×10^{1}	1.58×10^{2}
5	Brand E	2.079	8.08×10^{1}	1.941×10^{3}

4.0 DISCUSSION

The results of heavy metal in the cream samples analyzed are discussed below.

4.1 Zinc (Zn)

Currently, there are no national or international guidelines specifying acceptable zinc levels in cosmetics, making it challenging to assess potential health risks to consumers. In Nigeria however, the regulatory body NAFDAC only mandates that zinc compounds be clearly listed using their INCI (International Nomenclature of Cosmetic Ingredients) names and that the product remains safe for use under normal conditions (Kwanashie & Umar, 2020).

The zinc concentrations found in this study were lower than the range values of (17.82-138.06 mg/kg), (1.99-47.81 mg/kg), and (0.15±0.006-20.62±0.35 mg/kg) reported by Chedik and Moreno, (2022); Zhang *et al.*, (2024), and Mgbemena *et al.*, (2024) but higher than the range value of 0.000 – 0.736 mg/kg obtained by Kwanashie, and Umar (2020) in a similar studies. Stewart *et al.*, (2024) noted that prolonged zinc accumulation could negatively affect oxygen and calcium transport, nerve transmission in the brain, and could leads to reduced IQ, learning difficulties, premature birth, and low birth weight. Excessive zinc exposure may also pose risk to unborn and newborn babies via maternal blood or milk, potentially resulting in severe outcomes.

Furthermore, Estimated Daily Intake (EDI) of zinc in this study was between 6.50×10^{-2} - 1.68×10^{-1} mg/day, with the ranking of brands from highest to lowest being Brand ***D*** > Brand ***C*** > Brand ***E*** > Brand ***B*** > Brand ***A.*** The Hazard Indices ranged from 1.086 to 2.079, indicating potential health risks associated with excessive exposure (HRI > 1). (Qu *et al*., 2012).

4.2 Nickel (Ni)

Absorption of nickel through skin is generally low, but individual with nickel sensitivity, can react even to minute levels, and that is why Eu mandates labeling for nickel-containing products if they exceed certain thresholds (EU, 2020). The nickel concentrations found in this study were higher than the 0.000 ± 2.720 mg/kg, and 0.054-3.908 mg/kg reported by Kwanashie, and Umar (2020); in some selected personal care products in Ahmadu Bello University Zaria; and Ukonaku *et al.*, (2020), in similar study respectively, but far below 228.40 mg/kg reported by Stewart *et al.*, (2024) in cosmetics products sold in Ghana.

The Estimated Daily Intake (EDI) for Nickel was between 1.79×10^{-1} - 4.36×10^{-1} mg/day, with Hazard risk indices (HRI) ranging from 3.32×10^{1} - 8.08×10^{1}, indicating a significant health risk from dermal exposure. Nevertheless, nickel as a naturally occurring element that may be essential for humans is a primary cause of contact dermatitis, where even minimal exposure to other toxic metals can exacerbate allergies. Nickel dermatitis can result in erythema, eczema, and skin thickening in areas of contact (EU, 2020).

4.3 Lead (Pb)

The lead concentrations found in this studies were higher than those reported by Akpe *et al.* (2020), Ukonaku *et al.*, (2020), and Mgbemena *et al.*, (2024) in a similar studies, which ranged from

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0.00- to 0.23 mg/kg. However, they were lower than the 78.00 – 325.20 mg/kg range and 19.46±0.32 mg/kg reported by Nnorom *et al.* (2005) and Usman *et al.*, (2021) respectively.

The estimated daily intake (EDI) of lead in the present study, ranged from 8.3 x 10^{-2} - 1.019 mg/day, while the Hazard risk indices (HRI) varied from 1.58 x 10^{2} - 1.94 x 10^{3}, significantly exceeding those of zinc and nickel. This highlights urgent concerns regarding lead exposure through dermal contact and other routes (FDA, 2022; Ferreira *et al.*, 2022).

Lu *et al.*, (2017) noted that less than 1% of lead is absorbed through the skin via sweat gland ducts, and due to its low affinity for red blood cells, is mostly distributed in intercellular fluid. Research has shown that lead has a strong affinity for proteins, binding to hemoglobin and plasma proteins, which can inhibit red blood cells production and reduce oxygen supply to vital organs. As lead binds more proteins, its likelihood of passing through the bone marrow increases, potentially leading to reproductive issues, renal impairment, liver damage, and central nervous system encephalopathy. Low lead exposure poses risks for pregnant women, as it can disrupt retinal development in the first trimester, resulting in possible visual system defects (Ahmadi and Ziarati, 2015).

Young children are particularly vulnerable to lead poisoning due to their hand-to mouth activity and high gastrointestinal absorption rate (Arhad *et al.*, 2020). While humans can eliminate about 50% of lead within two to six weeks after immediate exposure, it can take 25 to 30 years to remove halve of the lead that has accumulated over time (Nriagu *et al*., 1996).

5.0 Results of Statistical Analysis

The coefficient of variation (CV) was employed to assess the distribution patterns of heavy metals in five commonly used beauty cream brands in Gusau, Zamfara State. According to Adekunle *et al*., (2014), higher CV values indicate grater variability in the distributions of the analyzed parameters. The CV for heavy metals in the creams ranged from 40.5 to 77.70 for zinc, 28.38 to 133.10 for nickel, and 35.33 to 140.23 for lead (Table 3), following the order: **Pb > Ni > Zn**. This indicates an uneven distribution of metals in the creams. Additionally, the One-way ANOVA results showed a significant difference ($p<0.05$) in the concentrations of these metals across the analyzed brands (Table 2) with a few exceptions. This suggests a lack of guidelines or stringent regulations regarding the raw materials used in these products or possible contamination.

Zinc compounds (like zinc oxide or zinc pyrithione) are often intentionally added for their skin-protective, antimicrobial, and UV-blocking properties. In lower-quality formulations, zinc may also appear as an unintended contaminant in raw materials. Nickel on the other hand, is often a contaminant in pigment like iron oxides and titanium dioxide which serves as a colorant in this creams. It may also result from contact with nickel-containing containers or machinery during production. While, Lead can be present in trace amounts in natural minerals or pigment used in cosmetics (e.g., iron oxide, clays), manufacturing equipment that isn't properly maintained may leach lead into products and could also originate from improper manufacturing practices, especially from unregulated or poorly regulated sources (Health and Cosmetic Sciences Task-Force, 2022; Gautam *et al.*, 2022: FDA, 2022) and that is why in a developed countries like the US. FDA only permits trace level of lead in cosmetics (typically < 10ppm).

6.0 CONCLUSION

This study examined the levels of heavy metals such as zinc, nickel and lead in various cream brands commonly used in Gusau, Zamfara State Nigeria. The metal levels in all samples were below WHO/EU permissible limits, except for Ni and Pb in Brand ***E,*** which exceeded standard values. Zn levels, though unregulated, also showed significant variation across products. The concentrations hierarchy was Pb > Ni and Zn.

Furthermore, this research highlighted that human exposure to heavy metals can occur not only through common sources like food, water,

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and mining but also from personal care products such as cream, likely from contaminated raw materials or poor manufacturing practices.

Health risk assessments using Estimated Daily Intake (EDI) and Health Risk Index (HRI) revealed that all creams pose potential health risks, particularly due to elevated lead and nickel levels, with HRI values far above 1.

Statistical analysis confirmed significant inter-brand variability ($p < 0.05$), suggesting inconsistent manufacturing quality.

The study highlights the urgent need for stricter regulatory enforcement by the relevant authorities (NAFDAC, SON), to prioritize regular product monitoring, and public awareness to reduce health risks from cosmetic use particularly among vulnerable groups like children and women in Nigeria

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