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Determination of Some Heavy Metals in Selected Cosmetic Products Sourced from Wambai Market, Kano

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Heavy metals have a negative impact on both the environment and living things. It is well recognized that heavy metals are non-biodegradable, persistent, and difficult to remove. Intentionally, some of these heavy metals are added to cosmetics as pigments, additionally, there are a number of unintended ways that heavy metals contaminate cosmetics; raw materials, additives, color minerals and untreated water. This study was carried out to determine the concentration of lead, cadmium, chromium, and nickel, in some cosmetic products from Wambai Market and then evaluate their potential health effects. Cosmetic samples were digested using a standard method. Approximately 1.0 g of each sample was digested, diluted, and analyzed using an Atomic Absorption Spectrophotometer (AAS). Calibration curve for each metal was constructed using standard solutions to determine metal concentrations in the samples. A cross-sectional survey was conducted among female students residing at the old campus hostels of Bayero University, Kano. A structured questionnaire assessed their knowledge, practices, and perceptions regarding heavy metal contamination in cosmetics. Data were collected and analyzed using descriptive statistics. The AAS analysis revealed that cadmium and nickel concentrations in all samples were within acceptable limits (0.005 mg/L and 0.02 mg/L, respectively). However, lead concentrations in all samples exceeded the safe limit (0.01 mg/L). Chromium concentrations were within acceptable limits (0.05 mg/L) for all samples except Sample ML (38.53% RSD). This study revealed significant lead contamination in cosmetic products from Wambai Market, posing potential health risks to consumers.

Keywords: Cosmetics, Heavy Metals, AAS, Wambai Marke.

1. Introduction

Heavy metals have a density higher than 5 g/cm³, and they are distinguished by their high toxicity, ductility, luster, thermal and electrical conductivity (Sharma et al., 2016). They can be ingested into the body through food, drink, or air and are naturally occurring elements found in the crust of the Earth. Although certain heavy metals are necessary for metabolism and overall health, consuming large amounts of them can be hazardous and cause related health issues (Wu et al., 2016).

To safeguard consumer health, regulatory bodies worldwide have set limitations for heavy metals in cosmetics. Examples of these organizations are the European Union's Cosmetics Regulation and the Food and Drug Administration (FDA) in the United States. The Federal Environmental Protection Agency, (FEPA), is in charge of regulating heavy metal contamination in Nigeria. Studies like Arshad et al. (2020) and Ullah et al. (2017) however, have demonstrated that some cosmetics still have heavy

metal concentrations over these thresholds, emphasizing the necessity for ongoing analysis and observation.

In order to evaluate the level of heavy metal contamination in cosmetics, different cosmetic products were sampled and analyzed to find out how much heavy metal is present. Due to their sensitivity and accuracy, analytical techniques like X-ray fluorescence (XRF), inductively coupled plasma mass Spectrometry (ICP-MS), and Atomic Absorption Spectroscopy (AAS) are frequently utilized for this purpose.

Despite legislative efforts to limit heavy metal pollution, worries about the possible health effects of exposure to these substances in cosmetics remain. Moreover, little is known about the level of heavy metal contamination in cosmetics that are imported from abroad and those locally made in Nigeria.

The numerous ways that heavy metals can contaminate cosmetics, during the production process, through the use of polluted raw materials, or by being present in color additives and preservatives exacerbate the issue. Morais et al. (2012) and (Sharma and Agrawal (2005) have expressed grave concerns about potential health disparities linked to heavy metal exposure in cosmetics, particularly for vulnerable groups like young children and pregnant women who may be more vulnerable to the negative effects of these metals. The general public's ignorance of the dangers of heavy metal poisoning from cosmetics also exacerbates the problem. In order to fill in these gaps, this study evaluates the presence of heavy metal in six distinct cosmetic items that are sold at Kano's Wambai Market.

2. Materials and Methods

2.1 Materials

The materials used are deionised water, two (2) different brands of powder whitening cream, lipstick, skin lighting cream, detergent, digestion tubes, hot plate 5% HNO₃, chemical reagent HNO₃, H₂SO₄, HClO₄, Atomic Absorption Spectrometer (pin AAcle 900H).

2.2 Method

2.2.1 Sample Collection

Two brands each of creams, lipsticks and powder were purchased from different cosmetics shops in various locations in Wambai market Kano State, Nigeria. The cream brands were coded GW and CW while the lipstick brands were coded ML, SL and the powder brand where coded IF and Ac.

2.2.2 Sample Preparation

Glassware and plastics were washed with detergent, rinsed with tap water, and soaked in a 5% HNO₃ solution for 24 hours, then rinsed with deionised water and dried at 80 °C for 48 h before use (Olmedo et al. 2010)

For each of the samples 1.0g was weighed using an analytical balance.

The lipsticks and powder samples, were crushed in a porcelain mortar before being weighed.

2.2.3 Digestion of Samples

The collected samples were digested using acids mixture (65 % HNO₃, 98% H₂SO₄ and 70% HClO₄ in ratio of 1:1:1). For each sample 1.0 g was weighed and transferred to a digestion tube followed by the addition of 5 mL of HNO₃ (65%) and the mixture was kept overnight at room temperature. Subsequently, the contents were heated on a hot plate by slowly increasing the temperature up to 90 °C and after appearance of brown fumes, the mixture was allowed to cool. Then H₂SO₄ (5 mL, 98%) were added and heated again for 30–60 min followed by cooling to room temperature. Finally, then 5 mL of 70 % HClO₄ were added and the

contents were digested until clear solution was obtained (Saeed et al., 2011, Ayenimo et al., 2010). The samples were cooled to room temperature and filtered through Whatman filter paper and the final volume (50ml) was adjusted with deionised water. The clear solution was used for metal quantification

2.2.4 Calibration and Chemical Analysis

The Atomic Absorption Spectrophotometer (AAS) (pin AAcle 900H) was set up and calibrated according to the manufacturer's instruction. Prior to sample analysis, standard solutions of lead, cadmium, lead and nickel were prepared from a 1000 ppm Standard Stock Solution of GFS Fishers' AAS Reference Standard. These standards were then serially diluted to generate a range of known concentrations spanning the expected concentrations of these metals in the samples. The calibration curve was constructed for each heavy metal by measuring the absorbance of each standard solution and plotting it against its concentration. Equations for these curves were obtained. For lead determination from each sample, the absorbance obtained from each sample was used to calculate the corresponding concentration using the formula $Y = Mx + C$ (Y = concentration, M = a constant, x = absorbance and C = a constant). For Lead, $Y = 0.022x + 0.242$ with $R^2 = 0.982$. curve was used to determine the concentration of the metal in the samples based on their respective absorbance values.

The same procedure was followed for Chromium, Nickel and Cadmium from the equations obtained from each element.

2.2.5 Chemical Analysis

The digested samples were filtered to remove any remaining solid particles. Each sample solution was aspirated into the flame of the AAS instrument. The instrument was programmed to sequentially aspirate the samples, starting from the lowest concentration standard to the highest. This ensured that the instrument was properly calibrated and that the readings were within the linear range of the instrument's detector. The absorbance of each sample at the characteristic wavelength of the metal was recorded. The concentration of each metal in the sample was calculated based on the absorbance value and the calibration curve. The concentration of heavy metals in each sample was compared with established safety limits to determine the potential risk of toxicity.

2.2.6 Survey Study

This study employed a cross-sectional survey design to assess the knowledge, practices, and perceptions regarding heavy metal content in cosmetic products among the female students at old Campus of Bayero University (BUK) from Wambai market Kano.

2.2.7 The perception of survey outcomes

The study participants predominantly consisted of final year students (57.1%) from various academic levels, with the majority falling within the 21-26 age range (71.4%). Most participants were single females (81.0%). This demographic profile suggests that the study captured a young, predominantly unmarried female population, likely with a higher level of education, which could influence their perceptions and behaviour regarding cosmetic product use and awareness of heavy metal contamination.

2.2.8 Data Collection Instrument

A structured questionnaire was developed and administered to the participants. The questionnaire consisted of four sections: demographic information, cosmetic use, adverse effects of cosmetic use, and knowledge and awareness of heavy metal contamination in cosmetic products.

Data were collected over a period of 2 months. Trained research assistants were responsible for administering the questionnaires and collecting the data. Participants were assured of the confidentiality of their responses, and informed consent was obtained prior to data collection.

2.2.9 Data Analysis

Quantitative data were analyzed using descriptive statistics such as frequencies and percentages. The data were entered into a statistical software package for analysis. Chi-square tests or Fisher's exact tests were used to examine associations between categorical variables. A p-value of less than 0.05 was considered statistically significant.

Table 1. Summary of AAS results

Metal	Sample	Mean (mg/kg)	SD (mg/kg)	%RSD	Acceptable Limits mg/kg	Inference
Cadmium	Sample ML	0.058	0.0008	1.32	0.005	WAL
Cadmium	Sample AC	0.064	0.0010	1.58	0.005	WAL
Cadmium	Sample SL	0.064	0.0004	0.69	0.005	WAL
Cadmium	Sample GW	0.064	0.0005	0.84	0.005	WAL
Cadmium	Sample If	0.065	0.0017	2.68	0.005	WAL
Cadmium	Sample Cw	0.055	0.0007	1.35	0.005	WAL
Nickel	Sample ML	0.329	0.0040	1.22	0.02	WAL
Nickel	Sample AC	0.447	0.0054	1.21	0.02	WAL
Nickel	Sample SL	0.378	0.0081	2.13	0.02	WAL
Nickel	Sample GW	0.351	0.0049	1.38	0.02	WAL
Nickel	Sample If	0.456	0.0025	0.54	0.02	WAI
Nickel	Sample Cw	0.314	0.0010	0.31	0.02	WAL
Lead	Sample ML	0.287	0.0249	8.67	0.01	AAI
Lead	Sample AC	0.359	0.0237	6.59	0.01	AAL
Lead	Sample SL	0.261	0.0293	11.23	0.01	AAL
Lead	Sample GW	0.255	0.0214	8.41	0.01	AAI
Lead	Sample If	0.305	0.0128	4.18	0.01	AAL
Lead	Sample Cw	0.261	0.0183	6.99	0.01	AAL

3. Results and Discussion

3.1 Results

Table 1 provides the results of the AAS analysis for Cadmium, Nickel, Lead and Chromium in the study samples.

Cadmium: All samples are within the acceptable limits (0.005 mg/kg), indicating that the concentration of Cadmium in these samples is within safe levels.

Nickel: Similar to Cadmium, all Nickel samples are within the acceptable limits (0.02 mg/kg), indicating that the Nickel concentration in these samples is also within safe levels.

Lead: None of the Lead samples are within the acceptable limits (0.01 mg/kg), suggesting that the concentration of Lead in these samples exceeds the safe levels.

Chromium: Except for Sample ML, all Chromium samples are within the acceptable limits (0.05 mg/kg), indicating that the Chromium concentration in these samples is within safe levels. However, Sample ML has a high % RSD (38.53%), indicating a high variability in the data for this sample, which might require further investigation. These results are in line with the results presented (Sukandar et al., 2012).

Chromium	Sample ML	0.062	0.0237	38.53	0.05	AAI
Chromium	Sample AC	2.660	0.0174	0.65	0.05	WAL
Chromium	Sample SL	1.193	0.0102	0.86	0.05	WAL
Chromium	Sample GW	0.073	0.0399	54.68	0.05	WAL
Chromium	Sample If	3.089	0.0283	0.92	0.05	WAL
Chromium	Sample Cw	0.075	0.0198	26.54	0.05	WAL

Key: SD = Standard deviation, RSD = Relative Standard Deviation,
AAL= Above acceptable limit ,WAL= within acceptable limits

Table 2: Demographics of the 21 study participants

S/N	Variable	Options	Frequency	Percentage (%)
1	Academic level	200 level	1	4.8
		400 level	8	38.1
		500 level	12	57.1
		Total	21	100.0
2	Age range	15-20 years	2	9.5
		21-26 years	15	71.4
		Above 26 years	4	19.0
		Total	21	100.0
3	Marital status	Married	4	19.0
		Single	17	81.0
		Total	21	100.0
4	Gender	Male	0	0.0
		Female	21	100.0
		Total	21	100.0

Table 3: Use of cosmetics by the participants

S/N	Variable	Options	Frequency	Percentage (%)
1	Frequency of cosmetic use	About once a week	1	4.8
		More than once a day	2	9.5
		Never	1	4.8
		Once a day	10	47.6
		Rarely	7	33.3
		Total	21	100.0
2	Types of cosmetic products	Cream	14	66.67
		Lipstick	13	61.9
		Lip gloss	1	4.76
		Powder	8	38.1
		Total	21	100.0
3	Skin irritation or allergic reactions from using cosmetic products	No	11	52.4
		Yes	10	47.6
		Total	21	100.0

Table 4: Knowledge and awareness of the study participants

S/N	Variable	Options	Frequency	Percentage (%)
	Participants who have heard of "Heavy metal contamination"	No	4	19.0
		Yes	17	81.0
		Total	21	100.0
	Awareness of the potential	No	3	14.3

health risks associated with heavy metal contamination in cosmetic products	Yes	18	85.7
	Total	21	100.0
Awareness of regulations or standards governing the use of heavy metals in cosmetic products?	No	16	76.2
	Yes	5	23.8
	Total	21	100.0
Sources of information about the safety and quality of cosmetic products?	Internet/online	6	28.57
	Friends	1	4.76
	Leaflets in the package	1	4.76
	News	2	9.52
	Books	1	4.76
	Media	1	4.76

3.1.1 Cosmetic usage and experience

Cosmetic Usage and Experience: Table 3 provides an overview of participants' cosmetic usage habits. The results show that almost half (47.6%) of the participants use cosmetics daily, while 9.5% use them more than once a day. The most commonly used products are creams (66.67%) and lipsticks (61.9%), followed by other products like lip gloss and powder, which are less popular. Notably, 47.6% of participants reported experiencing skin irritation or allergic reactions to cosmetic products, highlighting a significant concern among the study population regarding cosmetic safety and efficacy.

3.1.2 Knowledge of the participants

Table 4 presents the knowledge and awareness of the study participants regarding heavy metal contamination in cosmetic products. The majority (81.0%) of participants had heard of heavy metal contamination, and most (85.7%) were aware of the potential health risks associated with it. However, a significant portion (76.2%) were unaware of regulations or standards governing the use of heavy metals in cosmetics. Regarding sources of information about the safety and quality of cosmetic products, the internet/online sources were the most common (28.57%), followed by news and other less frequent sources like friends, leaflets, books, and media.

3.2 Discussion

The results showed that Cadmium and Nickel concentrations were within acceptable limits in all samples, indicating their levels were safe. Therefore, the problem associated with Nickel is avoided. Because exposure to an extremely high level of nickel by inhalation can lead to severe damage to the lungs and kidneys. (Agency for Toxic Substances and Disease Registry 1997). Similarly, exposure to Cd and especially chronic exposure can cause renal dysfunction, cadmium metabolism disorders also increased incidence of some forms of cancer (Selinus and Alloway, 2005). However, Lead

concentrations exceeded the safe limits in all samples, suggesting potential health risks associated with Lead exposure. This has negative influence on both children and adults. For children, Pb reduces physical growth and mental growth (Simeonov *et al.*, 2010). The intelligence of children is diminished and symptoms of irritability and fatigue could be observed. Pregnant women exposed to Pb have higher rates of infertility, miscarriage, and stillbirths (Ediin *et al.*, 2000). Chronic exposure to Pb can affect physical growth and can cause anaemia, kidney damage, headache, hearing problems, speaking problems, fatigue, or irritable mood (Simeonov *et al.*, 2010). The toxicity of Pb is multiple biochemical effects. It can inactivate enzymes, compete with calcium for incorporation into bones and interfere with nerve transmission and brain development (Ediin *et al.*, 2000). Chromium concentrations were mostly within safe limits, except for one sample (ML) which exhibited high variability, warranting further investigation.

The findings concerning Cadmium and Nickel are reassuring, suggesting that the sources or production processes associated with these metals are not significantly contaminating the samples. This could be attributed to stringent regulations and control measures in place for these metals. However, the consistently high levels of Lead across all samples are concerning and indicate a more widespread issue that requires attention.

The presence of Lead in the samples could be attributed to various factors, including environmental pollution, industrial activities, or the use of Lead-containing materials in the production cosmetics (Ediin *et al.*, 2000). The high variability in Chromium concentration in sample ML raises questions about this particular brand.

The survey results offered knowledge, practices and perceptions of consumers from Wambai Market, Kano, Nigeria, regarding heavy metal content in cosmetic products. The high representation of individuals is in the 500 level students, suggests a relatively educated group, which could influence

their understanding of product safety and chemical risks.

Participants reported using cosmetics regularly, with a significant portion using them daily. This frequency of usage could potentially increase the risk of exposure to heavy metals if present in these products, emphasizing the importance of monitoring and regulation. The most commonly used cosmetic products were creams and lipsticks, aligning with typical consumer preferences. However, a noteworthy finding was the high percentage of participants reporting skin irritation or allergic reactions from using cosmetics, indicating a potential issue with product safety or ingredient quality.

Regarding knowledge and awareness, the majority of participants had heard of heavy metal contamination, indicating a basic awareness of this issue. However, awareness of regulations or standards governing heavy metal use in cosmetics was low, suggesting a gap in consumer knowledge that could impact their ability to make informed choices. Overall, the study findings underscore the importance of regular monitoring and stringent control measures to minimize heavy metal contamination and protect public health.

4. Conclusion

The AAS analysis of the samples showed that the amounts of heavy metals varied. Cadmium and Nickel fall within acceptable bounds, Lead surpassing safe limits in every sample and Chromium displaying significant variability in just one sample. These findings highlight how crucial it is to keep an eye on the amounts of heavy metals in consumer goods, especially cosmetics, to make sure strict adherence to safety regulations to reduce health hazards.

Conflict of Interest

The authors declare no conflict of interest.

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