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Assessment of Carcinogenic and Non-Carcinogenic Health Risk of Some Marketed Herbal Oils in Port Harcourt, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The aim of this study was to assess the heavy metals, carcinogenic and non-carcinogenic health risk of three marketed herbal oils in Port Harcourt.
Study Design: A cross-sectional observational study.
Place and Duration of Study: This study was carried out at Anal Concept Limited located at 12 Poultry road, Odani Green City Elelenwo, Port Harcourt, Rivers State, Nigeria, between April 2020 and June 2020.
Methodology: The level of cadmium, lead, copper, arsenic and zinc was determined. While the carcinogenic (chronic daily intake and hazard quotient) and non-carcinogenic health risk (incremental lifetime cancer risk) were calculated. The three herbal oils were named sample A, B, and C. The oils were digested with concentrated HCL before quantification of cadmium, arsenic, lead, copper and zinc /using an atomic absorption spectrophotometer. Then the carcinogenic and non- carcinogenic health risk of each cosmetic were calculated.
Results: The results indicated that the concentrations of lead, cadmium and arsenic exceeded the maximum allowable concentrations, whereas zinc and copper is found below the acceptable limit

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set by WHO/EU in cosmetic A, B and C with sample A>C>B. The chronic daily intake (CDI) and hazard quotient were below the allowable limit for all three cosmetics. The incremental lifetime cancer risk was above the allowable limit of normal for all three cosmetics with cosmetic A > C > B. The results indicated that there are chances of cancer resulting from the use of these cosmetic products due to the build-up of the heavy metals contained in the products.

Conclusion: The result showed that all three different cosmetic brands had cadmium and arsenic levels above the acceptable limit for cosmetic products.

Keywords: Cadmium; lead; copper; arsenic; zinc; herbal oils.

1. INTRODUCTION

The assessment of the toxicological potential is a crucial step in the hazard evaluation of a cosmetic and it consists of a series of distinct toxicity studies [1]. Scientists have discovered that contamination due to poor manufacturing practices from biotoxin or corruption of the plant material with heavy metals are the reasons why herbal cosmetics are toxic [1]. Castro-Gonzalez and Mendez-Armeta stated that daily exposure to heavy metals from cosmetics when compared with other sources like food, water and air is negligible but due to the cumulative characteristics of heavy metals in the body during a human lifetime, cosmetic can be regarded as a substantial source of exposure in the body [2]. The degree of toxicity of heavy metals is directly related to their daily intake this is because once heavy metals enter the body, they tend to accumulate over time [3]. This accumulation increases its concentration thereby causing numerous adverse effects in the body. Mercury, cadmium, chromium, arsenic and lead are five heavy metals with the most potential for toxicity in humans and are widely distributed in the environment [3]. The distinguishing characteristics of heavy metals are the thiol group they contain which has a strong affinity for Sulphur. The thiol-SH bond formed uses up the active site of enzymes in reactions they catalyse. Thereby inhibiting the reaction rate, they were initially supposed to catalyse. This negatively alters the conventional physiologic system giving rise to adverse health effects. These undesirable effects, in some instances, can lead to death [3]. One of such unwanted effect is cancer while others could be non-carcinogenic. Examples include central nervous system damage due to exposure to lead or mercury and degenerative bone disease due to exposure to cadmium. Thus, the adverse effects from exposure to heavy metals can be carcinogenic or non-carcinogenic. Heavy metal contamination in herbal cosmetics is usually because of the absorption of these metals by plants, even if in minute quantities that lead to bioaccumulation of them in plant parts when such plants are used in the manufacturing of cosmetic products without removal. Although due to the high contamination of heavy metal in the environment because of natural causes or human activities. It is challenging to avoid heavy metal contamination in plants. It is, however, possible to remove such contaminant from the plant part before it is used in the manufacturing of cosmetic products. The risk associated with heavy metals present in cosmetics needs to be studied to raise awareness of the adverse effect on humans. So that although expensive, manufacturers must assure the safety of their products by removing them [4]. Cancer is a multiplicity of diseases, and while the understanding of certain types of cancer are increasing rapidly due to the molecular biological techniques that have been developed since 1980; there is still much to learn. However, cancer development is a multi-stage process, and critical genes are crucial to various types of cancer. Alterations in DNA in a number of these vital genes can cause increased susceptibility or cancerous lesions. Exposure to natural, synthetic, or physical agents are all contributory factors to somatic gene mutations. However, there are natural and synthetic substances and DNA repair processes which are also protective and maintain homeostasis. Genetics is an essential factor in cancer, an example can be found in genetic disease syndromes such xeroderma pigmentosum, where there is a lack of routine DNA repair, dramatically increase susceptibility to skin cancer from exposure to ultraviolet light from the sun [5]. Therefore, the aim of this study was to assess the heavy metals, carcinogenic and non-carcinogenic health risk of three marketed herbal oils in Port Harcourt.

2. MATERIALS AND METHODS

2.1 Procurement of Herbal Cosmetics

Three (3) types of commonly used herbal hair oils were purchased from a Supermarket in Port

Harcourt, Rivers state, Nigeria labelled, sample A, B and C, respectively and used for this study. Sample A is Allthingsnatural by Emi herbal oil, sample B Is Kakiva herbal oil and sample C Is Amal botanical herbal oil.

2.2 Determination of Heavy Metals in the Oils Using Atomic Absorption Spectrophotometer

The heavy metal analysis was carried out at Anal Concept Limited located at 12 Poultry road, Odani Green City Elelenwo, Port Harcourt, Rivers State, Nigeria. For the determination of the various heavy metals the oils were first digested using the 3031 method. This involved 0.5 g of sample A, B and C to be measured and mixed with 0.5g of finely ground potassium permanganate, respectively. Then 1.0 ml of concentrated sulfuric acid was added to each sample mixture while stirring the sample. A strong exothermic reaction occurs. The samples were then treated with 2 ml concentrated nitric acid. 10 ml of concentrated HCL was added and then then heated until the reaction was complete and then filtered. The filter was washed with hot concentrated HCL. The filter paper was then transferred to a digestion flask, treated with 5ml of concentrated HCL. The individual samples were brought to volume and the concentration of cadmium, arsenic, lead, copper, and zinc were analyzed using the atomic absorption spectrophotometer GBC Avanta Ver 1.33.

2.3 Calculation of Carcinogenic and Non-Carcinogenic Health Risk

To calculate the non-carcinogenic health risk (chronic daily intake (CDI) and hazard quotient (HQ)) and the carcinogenic health risk (incremental lifetime cancer risk (ILCR)) of the various heavy metals the EPA guidelines for health risk assessment was used [6].

The chronic daily intake, hazard quotient, hazard index and incremental lifetime cancer risk of each cosmetic was calculated.

Chronic daily intake (CDI) = $\frac{\text{CWSAKP.ABS.ET.EP.CF}}{\text{BW.AT}}$

Hazard Quotient (HQ) = $\frac{\text{CDI}}{\text{RFD}}$

Incremental lifetime cancer risk (ILCR) = CDI.CSF

Where

CW =concentration of heavy metal in the product
SA = skin surface area
KP = permeability coefficient
ABS = dermal absorption factor
ET =exposure time
EP = exposure period
CF = unit of conversion
BW= body weight
AT =average time
CSF = cancer slope

3. RESULTS AND DISCUSSION

Heavy metal contamination in food, water and skincare products poses a serious threat to human life because of their toxicity, bio-accumulative nature, and persistence in the environment [7]. Heavy metals have a strong affinity for sulfur, in the human body. They usually bind, via thiol groups (–SH), to enzymes responsible for controlling the speed of metabolic reactions. The resulting sulphur-metal bonds inhibit the proper functioning of the enzymes involved leading to deteriorating human health and sometimes death [4]. Heavy metal analysis of all three cosmetics detected heavy metals above the WHO and US EPA acceptable limits of cadmium, lead, arsenic and copper while zinc is within the acceptable limit (Table 1).

Table 1. Concentration of heavy metals in the herbal oil samples

S/N	Hair samples	Cadmiun (mg/kg)	Lead (mg/kg)	Arsenic (mg/kg)	Copper (mg/kg)	Zinc (mg/kg)
1	A	2.370	18.060	45.660	1.700	5.910
2	B	1.580	11.38	21.090	1.080	5.760
3	C	2.260	13.390	30.088	1.190	5.110
USEPA Limit		0.5	0.5	2.5	0.5	18
WHO Limit		0.3	10	10	1	20

Key: Sample A = Allthingsnatural By Emi Herbal Oil , Sample B = Kakiva Herbal Oil, Sample C= Amal Botanical Herbal Oil

The WHO acceptable limit of cadmium is less than 0.3 mg/kg, for lead is less than 10 mg/kg, for arsenic is less than 10 mg/kg, for copper is less than 1 mg/kg and zinc is less than 20 mg/kg [8]. The US EPA acceptable limit of cadmium is less than 0.5 mg/kg, for lead is less than 0.5 mg/kg, for arsenic is less than 2.5 mg/kg, for copper is less than 0.5 mg/kg and zinc is less than 18 mg/kg [9]. This result agrees with [9] that some cosmetics used in Nigeria seem to be laced with lead and cadmium of worrisome public health levels. Heavy metals contamination of herbal preparations in other reports also [10]. The heavy metals contamination may occur due to polluted environment in which the herbal plants grow; [10] the polluted conditions in which the plants are dried and processed, the storage conditions and even adulterated purposefully by the manufacturer of the products in the final dosage form [10].

The study by Castro-Gonzalez and Mendez-Armeta stated that daily exposure from cosmetics when compared with other sources like food, water and air is negligible but due to the cumulative characteristics of heavy metals in the body during a human lifetime, cosmetic can be regarded as a substantial source of the materials [2]. The degree of toxicity of heavy metals is directly related to their daily intake. In this study ingestion and dermal absorption was considered. The non-carcinogenic health risk analysis the chronic daily intake (CDI) was calculated for cadmium, arsenic, lead, copper and zinc in the three herbal cosmetics it was discovered the CDI for copper, lead and arsenic was highest in the order sample A> C > B, while for cadmium was sample C >A > B and for zinc was sample A >B >C (Table 2). All the studied heavy metals in the three cosmetics had hazard quotient below 1. The levels are below the acceptable level of non-carcinogenic harmful health risk in all three cosmetics. To estimate the total potential non-carcinogenic health risk induced by more than one metal, the hazard index which is a sum of all the hazard quotient of each metal in the cosmetic. The hazard index of the three herbal oil is below the acceptable limit of <1, thus low non-carcinogenic health risk (Table 3). Though the risk is in the order of Sample A> C >B. Heavy metals are known carcinogens [11], so the carcinogenic health risk was also estimated in the research work. The incremental lifetime cancer risk of the heavy metal's cadmium, arsenic and lead in the three herbal oil were above the maximum tolerable limit which is from $1X10^{-6}$ to $1X10^{-4}$. Levels above $1X10^{-4}$ is considered harmful and a cancer risk [6].

Table 2. Chronic daily intake (CDI) for heavy metals in the oil samples through different pathways

Metals	**CDI_{ing} (10^{-7})**	**CDI_{der} (10^{-5})**	**CDI_{Total} (10^{-5})**
Copper (Cu)			
Sample A	1.0	5.3	5.4
Sample B	0.7	3.4	3.5
Sample C	0.7	3.7	3.8
Lead (Pb)			
Sample A	11.0	5.7	5.8
Sample B	6.9	3.6	3.7
Sample C	82.0	4.2	5.0
Cadmium (Cd)			
Sample A	13.9	71.0	71.1
Sample B	9.9	4.9	5.0
Sample C	14.5	74.5	74.6
Arsenic (As)			
Sample A	28.0	143.5	143.8
Sample B	18.4	94.6	94.7
Sample C	12.9	66.3	66.4
Zinc (Zn)			
Sample A	21.7	18.5	18.8
Sample B	21.2	18.1	18.3
Sample C	18.9	16.1	16.3

Key: Sample A= Allthingsnatural By Emi Herbal Oil, Sample B = Kakiva Herbal Oil, Sample C= Amal Botanical Herbal Oil

Table 3. Mean values of non-carcinogenic risks posed by heavy metals in the oil samples through different pathways

Metals	HQ_{ing}	HQder	HQTotal
Copper (Cu)	**$X10^{-7}$**	**$X10^{-8}$**	**$X10^{-7}$**
Sample A	13.3	8.4	14.1
Sample B	8.5	5.6	9.1
Sample C	9.3	6.0	9.9
Lead (Pb)	**$X10^{-3}$**	**$X10^{-7}$**	**$X10^{-3}$**
Sample A	1.4	2.6	1.1
Sample B	1.7	1.7	1.7
Sample C	1.0	19.6	1.0
Cadmium (Cd)	**$X10^{-3}$**	**$X10^{-5}$**	**$X10^{-3}$**
Sample A	149.0	2.9	149.0
Sample B	9.8	1.9	9.8
Sample C	142.0	2.8	142.0
Arsenic (As)	**$X10^{-2}$**	**$X10^{-4}$**	**$X10^{-2}$**
Sample A	9.3	18.0	9.4
Sample B	6.1	12.0	6.2
Sample C	4.3	8.3	4.4
Zinc (Zn)	**$X10^{-7}$**	**$X10^{-7}$**	**$X10^{-7}$**
Sample A	7.2	3.6	10.8
Sample B	6.0	3.5	9.5
Sample C	6.3	3.1	9.4

Key: Sample A= Allthingsnatural By Emi Herbal Oil, Sample B = Kakiva Herbal Oil, Sample C= Amal Botanical Herbal Oil

Table 4. The incremental life- time cancer risk (ILCR) of carcinogenic health risks via total exposure (ingestion and dermal contact) to the oils of the study samples for adults

Heavy metals	ILCR mean
Lead (Pb)	
Sample A	$9.6\ X10^{-3}$
Sample B	$1.4\ X10^{-3}$
Sample C	$1.1\ X10^{-3}$
Cadmium (Cd)	
Sample A	$8.7\ X10^{-1}$
Sample B	6.0 X10-^{2}
Sample C	$9.1\ X10^{-2}$
Arsenic (As)	
Sample A	$2.2\ X\ 10^{-3}$
Sample B	$1.4\ X\ 10^{-3}$
Sample C	$1.0\ X\ 10^{-3}$

Key: Sample A= Allthingsnatural By Emi Herbal Oil ,Sample B = Kakiva Herbal Oil, Sample C= Amal Botanical Herbal Oil

Among the herbal oils studied sample group A had the highest ILCR level for cadmium, arsenic and lead followed by sample C. Sample B had the least amount of ILCR (Table 4).

4. CONCLUSION

The result showed that all three different cosmetic brands had cadmium and arsenic levels above the acceptable limit for cosmetic products. The continued use of these products contaminated by these heavy metals will release them slowly into the body of recipients with Allthingsnatural by Emi having the highest carcinogenic and non-carcinogenic risk, followed by Kakiva herbal oil. Amal botanical oil has the least carcinogenic and non-carcinogenic risk of all three brands.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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