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Evaluation of Harmful Substances and Health Risk Assessment of Mercury and Arsenic in Cosmetic Brands in Nigeria

John Kanayochukwu Nduka[1], Isaac Omoche Odiba[2], Eruemrejovwo Inspector Aghoghome[3], Ngozi Lilian Umedum[1], Maduabuchi Joseph Nwosu[2]

[1]Environmental Chemistry and Toxicology Research Unit, Pure and Industrial Chemistry Department, NnamdiAzikiwe University, P.M.B. 5025, Awka, Anambra State, Nigeria

[2]Department of Chemistry, Alvan Ikoku Federal College of Education, P.M.B. 1033, Owerri, Imo State, Nigeria

[3]Chemistry Department, Delta State University, Abraka, Delta State, Nigeria

Correspondence: John Kanayochukwu Nduka,Environmental Chemistry and Toxicology Research Unit, Pure and Industrial Chemistry Department, Nnamdi Azikiwe University, P.M.B. 5025, Awka, Anambra State, Nigeria

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Abstract

Forty two different cosmetic samples consisting of 16 facial cosmetics, 6 soaps, 1 shower gel, 12 emulsions, 2 underarm cosmetics, 3 nail cosmetics and 2 perfumes were purchased from department stores and cosmetic shops within Onitsha Main Market and Eke-Awka in Anambra, Nigeria. Seven of these cosmetic (16.67%) were locally manufactured in Nigeria while thirty five (83.33%) were imported into Nigeria. The cosmetics were ashed before digestion and filtration. The filtrates were assayed for mercury and arsenic with AAS SearchTech AA320N. Hydroquinone presence was identified by chromatographic test while steroids, nitrite and N-nitrosamines were identified by colour test and together were assayed by UV-spectrophotometer (Spectrulab 21). The health risk assessment methods developed by the United States Environmental Protection Agency (US EPA) were employed to explore the potential human health risk of Mercury and Arsenic in cosmeticsamples.

Results showed that two (2) of the cosmetic samples contained mercury (0.003 ± 0.000mg/kg and 0.07 ± 0.00mg/kg) while three cosmetic samples contained arsenic (0.002 ± 0.000, 0.002 ± 0.000 and 0.005 ± 0.000 mg/kg). Hydroquinone concentration ranged from $1.14 \pm 0.00 - 1.83 \pm 0.03$ mg/kg (1.14E-02 – 1.83E-02 %).Steroid was found in only two samples with concentration of 16.70 ± 0.74 mg/kg and 17.63 ± 0.74 while N-nitrosamines and nitrite occurred in nine and eleven samples in the range of $4.66 \pm 0.09 - 43.52 \pm 0.47$ and $0.87 \pm 0.02 - 13.42 \pm 2.90$ respectively. The total cancer and non-cancer risk results indicated that although the chances of cancer risk and non-cancer risk resulting from the use of these cosmetic products were unlikely, build up of these heavy metals overtime on continuous usage could be detrimental.

Keywords: organic and inorganic substances, harmful substances, cosmetic products, risk assessment, Nigeria

1. Introduction

Cosmetic products are articles or preparations designed to be used on various parts of the human body for the purpose of cleaning, perfuming, protecting, beautifying, promoting attractiveness or altering appearance without changing the body's structure and operation (Adepoju-Bello et al., 2012; Oyedeji et al., 2011). Cosmetics are of diverse types and may include any material intended for use as a component of a cosmetic product; these include skin moisturizers, perfumes, lipsticks and lip glosses, finger nail polishes, eye and facial makeup preparations, shampoo, hair colours and deodorant. Certain chemicals that are a part of cosmetic formulations have been found to be harmful and use of cosmetic products containing such chemicals portends danger for human health. Notable examples of such chemicals, though not exhaustive, include heavy metals, hydroquinone, steroids and nitrosamines (Adepoju-Bello et al., 2012; SCCS,2012; WHO,2011; Oyedeji et al., 2011; Nnoruka and Okoye, 2006; Nnorom et al., 2005; Adebajo, 2002). It is unfortunate that despite regulations put in place to prevent/minimize the presence of such ingredients in cosmetics brands, heavy metals, organic and inorganic chemicals substances are still present in them. Some of the reasons advanced for their presence in cosmetic products include their existence as components of the major raw material used in cosmetic product manufacture (Adepoju-Bello et al., 2012) and their deliberate inclusion in cosmetic products (WHO, 2011). Cosmetic products and their ingredients are not subjected to clinical trials/laboratory testing(s) by regulatory bodies in Nigeria before pre-market approval. This is evident from Section C (2) of National Agency for Food and Drug

Administration and Control (NAFDAC) Directorate of Registration and Regulatory Affairs' Guidelines for Registration of imported cosmetics in Nigeria which states that the requirement for cosmetic product registration is the attachment of a comprehensive certificate of analysis to the application for registration. Therefore, product safety and quality are monitored through post-market surveillance (PMS) activity. The implication is that the need for laboratory/clinical testing of cosmetics products by NAFDAC arises only when such products have been used by end-users and are discovered to be defective or have side effects on the consumers. Also in the same guideline, it is stated that mercury and its compounds as well as corticosteroids are not permitted in cosmetic products (Nigeria Nursing World, 2012). This is because mercury is reported to cause dermatitis and its cumulative toxicity causes damage to kidneys which could manifest as hypertension and fatal kidney failure. Prolonged use of cosmetics products containing corticosteroids on the skin causes recalcitrant acne, red striae, excessive hairiness, proneness to infections and absorption through skin which could manifest as severe hypertension, diabetes and cataract (Nigeria Nursing World, 2012). In addition, creams containing hydroquinone greater than two per cent (2%) are banned as they are reported to cause exogenous ochronosis which manifests as a dirty brown pigmentation on sun exposed areas and loss of skin elasticity (Nigeria Nursing World, 2012).

This study aims to evaluate some harmful organic and inorganic constituents and human health risk assessment of mercury and arsenic in cosmetic brands in Nigeria.

2. Materials and Methods

2.1Materials

The cosmetic samples used for this study were purchased from department stores and cosmetic shops in Onitsha Main Market and Eke-Awka in Anambra State, South-East Nigeria.

2.2Methods

The identification tests for hydroquinone was carried out on forty-two (42) cosmetic samples using the procedure of isolation and identification of drugs described by Clark(1975) while its thin-layer chromatographic determination and quantitative test were performed using the procedure described by Odumosu and Ekwe (2010).

The Liebermann-Burchard test was employed for the detection of steroid in which 0.5g of the test sample was dissolved in 10 cm^3 of analytical grade chloroform and mixed properly. To 2cm^3 of the sample solution, 6 drops of acetic anhydride was added gently in a test tube with gentle mixing. Then 0.5cm^3 of concentrated sulphuric acid was cautiously added down the side of the tube without mixing. The appearance of a blue-green colour indicates the presence of steroids. For quantitative determination, 1g of the test sample was dissolved in 10ml analytical grade methanol, mixed thoroughly and filtered with Whatman No. 41 filter paper, pre-washed with analytical grade methanol.To 2cm^3 of the sample solution in a 10cm^3 graduated test tube, 2cm^3 of 8M sulphuric acid was added followed by 2cm^3 of 0.5% w/v of Iron (III) Chloride and then 0.5cm^3 of 0.5% w/v potassium haxacyanoferrate (III) solution.

The mixture above was heated in a water bath maintained at 70^oC for 30 minutes with occasional shaking for colour to develop.This was then diluted to the mark with distilled water and absorbance was measured at 780nm against reagent blank.

A 1% solution (standard cholesterol in methanol) was prepared and serially diluted to give 10, 20, 30, 40 and 50 mg/mL solution whose absorbance were measured and together were used to prepare a calibration curve.Actual values of steroids present were extrapolated from the calibration curve.

Nitrosamine was determined using the spectrophotometric method as described in Okafor and Nwogbo (2005) while nitrite was determined by the spectrophotometric method described by Follet and Ratcliff (1963).

Samples were digested to determine mercury and arsenic were by the method described as follows: to a 1g of the sample 20cm^3 mixture of concentrated acid (Nitric acid, perchloric acid and hydrofluoric acid in 4:1:1 ratio) was added and heated in a fume cupboard till fumes stopped evolving. The hot beaker with its content was allowed to cool, then filtered into a 50 cm^3 measuring cylinder and made up to the 50 cm^3 with distilled deionised water. Mercury and arsenic were assayed using Search Tech AA320N Atomic Absorption Spectrometer.

2.3Risk Assessment Methods

The human health risk models including carcinogenic and non-carcinogenic ones established by the United States Environmental Protection Agency (US EPA) were adopted. These models and their threshold values were employed to assess the potential human health risks posed by arsenic and mercury. Human beings could be exposed to mercury and arsenic toxicity via dermal contact with cosmetic particles.

The calculations for the daily exposure dose of contaminants via dermal absorption pathway and the detailed explanation for all the parameters are shown below:

Table1.Formula for calculating dermal absorption

Exposure pathway	Calculation formula
Dermal Contact	$CDI_{dermal} = \frac{CS \times SA \times AF \times ABS \times EF \times ED}{BW \times AT} \times CF$

CDI = chronic daily intake; CS – exposure-point concentration: mg/kg(mg/L); EF – exposure frequency: 350 d/a; ED – exposure duration:30a; AT – averaging time for non-carcinogens: 365 X EDd; AT – averaging time for carcinogens:365 X 70d; BW – body weight : 70kg; SA – exposed skin area: 5700cm^2; AF – adherence factor: 0.07$mg.cm^{-2}$; ABS – dermal absorption fraction: 0.03(As) 0.001(other metals); CF – units conversion factor:10^{-6}kg mg^{-1}.

In this work, the risk effect is made up of carcinogenic risk assessment for arsenic and mercury through dermal exposure pathway. Cancer risk can be evaluated from:

$$\text{cancer risk} = CDI \times SF$$

Where cancer risk represents the probability of an individual lifetime health risks from carcinogens; CDI is the chronic daily intake of carcinogens (mg kg^{-1} d^{-1}); SF is the Slope factor of hazardous substances (mg kg^{-1} d^{-1}), Slope factor was calculated using the formula – slope factor = 1/6 (ED_{10}) (US EPA, 2011).

The cumulative cancer risk can be calculated from:

$$\text{total cancer risk} = \sum_{K=1}^{n} CDI_k SF_k$$

Where CDI_k is the chronic daily intake (mg kg^{-1} d^{-1}) of substance k (i.e. in a given cosmetic), SF_k is the slope factor for substance k (kg d^{-1} mg^{-1}) (i.e. the sum of the calculated slope factor for the heavy metals detected in a given cosmetic). The acceptable or tolerable risk for regulatory purposes is within the range of 10^{-6} – 10^{-4}.

The non-carcinogenic risk from individual heavy metal can be expressed as the hazard quotient:

$$HQ = CDI/RFD$$

Where the non-cancer hazard quotient (HQ) is the ratio of exposure to hazardous substances and RFD is the chronic reference dose of the toxicant (mg kg^{-1} d^{-1}).

$$\text{Chronic hazard index} = \sum_{K=1}^{n} CDI_k / RFD_k$$

Where the chronic hazard index (HI) is the sum of more than one hazard quotient for multiple substances, CDI_k is the daily intake of heavy metal (k) and RFD_k is the chronic reference dose for the heavy metal k. HI values > 1 shows that there is the chance that non-carcinogenic risk may occur and when HI < 1 the reverse applies (Liu et al., 2013).

3. Results

Table 2.Shows the sample coding and data introduction of cosmetics products manufactured in Nigeria including manufacturing and expiry date, batch number and regulatory authorities (NAFDAC) number where available.

Table 2. Sample Coding of Cosmetic Products Manufactured in Nigeria

Sample Code	Name of Product	Name of Manufacturer	Country of Manufacture	Date of Manufacture	Expiry Date	Serial/Batch Number	NAFDAC No.
1	Beauty Fair Complexion Lotion	Beauty fair Laboratories Ltd.	Nigeria	NA	NA	2	NA
2	Royal Gold Cortex Remover	Golden Cross Ind. Ltd	Nigeria	NA	NA	20091608	NA
3	Beauty Fair Multiactive Toning Cream	Skin Care Solutions	Nigeria	6/1/2011	6/1/2012	NA	NA
4	Classic White Whitening Cream	Kings Body Care Cosmetics	Nigeria	NA	NA	NA	NA
5	Royal Acrylic Nail Remover	Golden Cross Ind. Ltd	Nigeria	NA	NA	OO32213	NA
6	Tura Medication Soap	Tura Intl Ltd	Nigeria	11/20/2009	11/19/2012	2-168	02-3585
7	Balllin Glycerin Oil	Emjaph& J Ind. Ltd.	Nigeria	NA	NA	NA	NA

[Key:NA – Not Available, NAFDAC – National Agency for Food and Drug Administration and Control**]**

Table 3.Shows the sample coding and data information of cosmetics products manufactured outside Nigeria including manufactures, country of manufacture, date of manufacture and expiration, batch number and regulatory authority's (NAFDAC) number, if any.

Table 3.Sample Coding of Cosmetic Products Manufactured Outside Nigeria.

Sample Code	Name of Product	Name of Manufacturer	Country of Manufacture	Date of Manufacture	Expiry Date	Serial/Batch Number	NAFDAC No.
8	Femtight Antiseptic Vaginal Wash Soap	Oro Laboratories	Phillipines	NA	NA	48003Cf 35824687	NA
9	Face to Face Facial Mask	DK Laboratories (m) Bhd	Malaysia	8/1/2010	8/1/2012	10100872	NA
10	St. Ives Apricot Facial Scrub	St. Ives Laboratories Inc. Los Angeles	U.S.A	NA	NA	4001703	NA
11	Palmer's Cocoa Butter Body Cream	E.T. Brown Drug Co., Inc., Englewords Cliff, NJ 07632, U.S.A. www.palmers.com	U.S.A	NA	NA	R0202A	NA
12	Cucumber Extract Facial toner	Splash Research Institute	Phillipines	5/1/2010	5/1/2012	100403 AL1	NA
13	Fantasy Body Spray (Rapsberry)	Perfumes de Coeur	U.S.A	NA	NA	261690 74171	NA
14	Chris Adams Active Woman Perfume	Chris Adams	UAE	NA	NA	6211001 70098	NA
15	Veet Hair Removing Cream	Reckitt Benckister	India	8/1/2010	8/1/2012	890139635 4406	NA
16	Sleek concealer Powder	Sleek Makeup	England	NA	NA	LKNE T54	NA
17	Black Opal Crème Stick Foundation	Bio Cosmetic Research Institute	U.S.A	NA	NA	278110 1882	NA
18	Fruity Lip Balm (Strawberry)	Quianxin Cosmetics	China	NA	NA	694383180 0026	NA
19	Baolish Eyeliner	NA	China	NA	NA	NA	NA
20	Mary Kay Cream to Powder	Mary Kay Inc.	U.S.A	NA	NA	14698	NA
21	Far Away Body Shimmering Powder	AVON	U.S.A	NA	NA	F3257	NA
22	Island Beauty Lipstick	Island Beauty Cosmetics	NA	NA	NA	NA	NA
23	St. Ives Body Cream	St. Ives Laboratories Inc.	U.S.A	NA	NA	NA	NA
24	Vovi Milk Complex Cream	Vovi Products Company	U.S.A	NA	2/1/2013	NA	NA
25	Empire Fade Cream Lotion	Aquimpex Spa Divisine Cosmetics	Italy	6/1/2009	6/1/2014	B926D6	NA
26	Fair and white Exfoliating Soap	Labo Derma	Paris	NA	NA	C11AO5M	NA
27	Clear Essence Maxitone	Bluefield Associates	U.S.A	12/1/2010	12/1/2012	1012011	02.1055
28	Ushas Eye Shadow	ZhejrangUshas Cosmetics Ltd	China	2/1/2011	2/1/2014	A11/02A	NA
29	Bouquet Roll-on Deodorant	Gerva Corporation sd, Bhn	Malaysia	3/1/2010	3/1/2012	955009 11045	NA
30	Sally Hansen Nail Colour	Del Laboratories Inc	U.S.A	NA	NA	NA	NA
31	Jordana Loose Powder	Eugenco International Ltd.	U.S.A	NA	NA	NA	NA
32	Pop Facial Cream	NA	Thailand	15/10/2008	14/10/2013	QC901	NA
33	Jennifer Lopez Secret	Isabel Cosmetic Int'l	U.S.A	NA	NA	0280014 02340	NA
34	Eden Apricot Scrub Soap	Dynamix Int. Ltd.	EU	1/1/2010	11/2015	100017	NA
35	Crusader Medicated Soap	Elliot Irving Ltd	United Kingdom	NA	NA	NA	NA
36	Lentheric antiperspirant Roll on	Lentheric	South Africa	5/1/2009	5/1/2012	111697	NA
37	Swiss Luxury Bath Shower Gel	Nature Care Cosmetics	United Kingdom	3/1/2010	3/1/2014	14	02-3329
38	Dove Body Fairness Lotion	Unilever	United Kingdom	NA	NA	62234 B30102	NA
39	Mac Waterproof Mascara	Mac Cosmetics	Canada	NA	NA	FILB48211	NA
40	Dark and Lovely Compact Powder	Ebony Cosmetics	London	NA	NA	6181100	02-1771
41	Bioclaire Body Lightening Lotion	N.P Gandcurci	Cote d'ivoire	NA	NA	60720 3491002	NA
42	Absolute Juicy Lip Shimmer	Nicka K Cosmetics	China	NA	NA	60720 3491002	NA

[Key:NA – Not Available, NAFDAC – National Agency for Food and Drug Administration and Control]

Table 4.Shows that all the cosmetic products manufactured in Nigeria had no detectable mercury by the method employed while only Royal Gold Cortex Remover®, of products made in Nigeria had 0.002mg/kg of arsenic. 1.83 ±0.03mg/kg and 1.33 ± 0.03mg/kg of hydroquinone were contained in classic White Whitening Cream® and Royal Acrylic Nail Remover. Steroids were not detected in any of the locally made products.8.38 ± 0.04 and 8.47 ±0.01mg/kg (mg/l) of nitrosamine and nitrites were determined in Beauty Fair Multiactive Toning Cream.

Table 4.Levels of Hazardous Substances in Cosmetic Products Manufactured in Nigeria.

Sample Code	Metal Content (mg/L), (mg/Kg)		Hydroquinone (mg/L), (mg/Kg)	Steroids (mg/L), (mg/Kg)	Nitrosamines (mg/L), (mg/Kg)	Nitrite (mg/L) (mg/Kg)
	Hg	As				
1	ND	ND	ND	ND	ND	ND
2	ND	0.002± 0.000	ND	ND	ND	ND
3	ND	ND	ND	ND	8.38± 0.04	8.47± 0.01
4	ND	ND	1.83± 0.03	ND	ND	ND
5	ND	ND	1.33± 0.03	ND	ND	ND
6	ND	ND	ND	ND	ND	ND
7	ND	ND	ND	ND	ND	ND

[Key: ND – Not detected by method employed]

Table 5. Shows that 0.07 ± 0.00 and 0.07 ± 0.00 mg/kg (mg/l) of mercury were contained in Crusader Medicated Soap® and LenthericAntipersperant Roll On®, Arsenic occurred in St. Ives Body Cream® and Bioclaire Body Lightening Lotion® with 0.002 ± 0.00 and 0.005 ±0.00 mg/l levels. Hydroquinone levels (mg/kg or mg/l) of 24.00 ± 0.001, 1.39 ± 0.002, 1.41 ± 0.01, .36 ± 0.006, 1.59 ± 0.35, 1.66 ± 0.006, 1.59 ± 0.35, 1.66 ± 0.006, 1.16 ± 0.03 and 1.17 ± 0.00 were contained in face to face Facial Mask, Cucumber Extract Facial Tones, Veet Hair Removing Cream, Black Opal Cream, Stick Foundation, Vovi Milk Complex Cream®, Empire Fade Cream Lotion, Fair and White Exfoliating Soap®Lentheric Antiperspirant Roll-On® and Swiss LuxuryBath Shower Gel®. In all imported cosmetics, only 17.63 ±0.74mg/kg and 16.70 ± 0.74mg/kg of steroids were reported in Jordana Loose Powder and Eden Apricot Scrub Soap®. Nitrosamine levels in mg/kg or mg/l were reported in Femtight Antiseptic Vaginal Wash Soap® (15.16 ± 0.03), St. Ives Apricot Facial Scrub (8.10 ±0.29) Cucumber Extract Facial Toner®(13.73±0.35), Black Opal Cream Stick Foundation (4.66 ± 0.09), St. Ives Body Cream (43.05 ± 0.35), Vovi Milk Complex Cream® (43.05 ± 0.23), Empire Fade Cream Lotion® (43.52 ±0.47) and Fair and White Exfoliating Soap®(11.72 ± 0.25). Nitrite levels (mg/kg or mg/l) of imported cosmetics occurred as follows: Femtight Antiseptic Vaginal Wash soap® (4.15 ± 0.01), St. Ives Apricot Facial Scrub (10.32 ±0.02), Cucumber Extract Facial Toner (3.20 ± 0.01), Black Opal Cream Stick Foundation (2.88 ± 0.01), St. Ives Body Cream (11.62 ± 0.01), Vovi Milk Complex Cream (12.43 ± 0.01), Empire Fade Cream Lotion (0.87 ± 0.01), Fair and White Exfoliating Soap (13.42±2.90), Jordana Loose Powder (7.83 ± 0.06) and LenthericAntiperspirant Roll-On® (6.05 ± 0.02) .

Table 5.Levels of Hazardous Substances in Cosmetic Products Manufactured Outside Nigeria.

Sample Code	Metal Content (mg/L), (mg/Kg) Hg	As	Hydroquinone (mg/L), (mg/Kg)	Steroids (mg/L), (mg/Kg)	Nitrosamines (mg/L), (mg/Kg)	Nitrite (mg/L) (mg/Kg)
8	ND	ND	ND	ND	15.16± 0.03	4.15± 0.01
9	ND	ND	1.24± 0.01	ND	ND	ND
10	ND	ND	ND	ND	8.10± 0.29	10.32± 0.02
11	ND	ND	ND	ND	ND	ND
12	ND	ND	1.39	ND	13.73± 0.35	3.20± 0.01
13	ND	ND	ND	ND	ND	ND
14	ND	ND	ND	ND	ND	ND
15	ND	ND	1.41± 0.01	ND	ND	ND
16	ND	ND	ND	ND	ND	ND
17	ND	ND	1.36± 0.06	ND	4.66± 0.09	2.88± 0.01
18	ND	ND	ND	ND	ND	ND
19	ND	ND	ND	ND	ND	ND
20	ND	ND	ND	ND	ND	ND
21	ND	ND	ND	ND	ND	ND
22	ND	ND	ND	ND	ND	ND
23	ND	0.002± 0.000	ND	ND	13.73± 0.35	11.62± 0.01
24	ND	ND	1.59± 0.35	ND	43.05± 0.23	12.43± 0.01
25	ND	ND	1.14± 0.00	ND	43.52± 0.47	0.87± 0.01
26	ND	ND	1.66± 0.06	ND	11.72± 0.25	13.42± 2.90
27	ND	ND	ND	ND	ND	ND
28	ND	ND	ND	ND	ND	ND
29	ND	ND	ND	ND	ND	ND
30	ND	ND	ND	ND	ND	ND
31	ND	ND	ND	17.63± 0.74	ND	7.83± 0.06
32	ND	ND	ND	ND	ND	ND
33	ND	ND	ND	ND	ND	ND
34	ND	ND	ND	16.70± 0.74	ND	ND
35	0.07± 0.00	ND	ND	ND	ND	ND
36	0.003± 0.000	ND	1.16± 0.03	ND	ND	6.05± 0.02
37	ND	ND	1.17± 0.00	ND	ND	ND
38	ND	ND	ND	ND	ND	ND
39	ND	ND	ND	ND	ND	ND
40	ND	ND	ND	ND	ND	ND
41	ND	0.005± 0.000	ND	ND	ND	ND
42	ND	ND	ND	ND	ND	ND

[Key: ND – Not detected by method employed,]

Table 6.Shows that Royal Gold Cortex of all locally made cosmetics does not pose non-cancer and carcinogenic risks arsenic's hazard quotient of 1.56E-08 is less than one(1), so non cancer risk is unlikely while cancer risk of 2.59E-14 is a minimal value.

Table 6.Non-carcinogenic Risk (Hazard Quotient [HQ]) and Cancer Risk for Individual Mercury and Arsenic Detected in Cosmetic Products Manufactured in Nigeria.

Sample Code	Non-carcinogenic Risk (Hazard Quotient [HQ])	Cancer Risk
	Hg	As	As
2		1.56E-08	2.59E-14

Table 7.Indicates that hazard quotient of imported cosmetics were in order; Crusadfer Medicated Soap (Hg-1.28E-07) and Lentheric Antiperspirant Roll-On® (Hg-5.47E-09), St. Ives Body Cream® (As-4.68E-07) and Bioclaire Body lightening Lotion (As-1.17E-06), whereas the cancer risk were St. Ives Body cream®(As-7.81E-13) and Bioclaire Body lightening Lotion® (As-1.95E-12)

Table 7.Non-carcinogenic Risk (Hazard Quotient [HQ]) and Cancer Risk for Individual Heavy Metal Detected in Cosmetic Products Manufactured outside Nigeria.

Sample Code	Non-carcinogenic Risk (Hazard Quotient [HQ])		Cancer Risk
	Hg	As	As
23		4.68E-07	7.81E-13
35	1.28E-07		
36	5.47E-09		
41		1.17E -06	1.95E-12

4. Statistical Analysis

Student's t-test was used for the comparison while f-test/ levene's test for equality of variances evaluates the basic assumption of the t-test that the variance of the two groups are approximately equal; $t(12) = 0.893$, $p = 0.390$. All differences were considered significant at 5% level, therefore, a p-value ≤ 0.05 was considered statistically significant. Since p-value for the comparison of Nigerian-made cosmetics with imported cosmetics is greater than 0.05 ($p = 0.390$), it can be concluded that the place of production has no significant effect on the standard (in terms of safety) of cosmetic products sold in Nigeria. Therefore, preference for imported cosmetics is just as a result of mere perception.

Descriptive statistics were calculated using the Statistics for Social Sciences (SPSS) software version 16. The data was displayed using the parameter of the mean value.

5. Discussion

No mercury was discovered in any of the cosmetic samples (0 %) manufactured in Nigeria. Royal Gold Cortex Remover® had an arsenic content of 0.002mg/L (2µg/L), which is below the 0.01mg/L (10µg/L) drinking water standard set by World Health Organization (WHO, 2010). Increased levels of skin cancer have been associated with arsenic exposure, even at levels below the 10 part per billion (10µg/L) drinking water standards (Knobeloch et. al., 2006).

Two samples (28.57 %) of the cosmetics manufactured in Nigeria, namely, Royal Gold Cortex Remover® and Classic White Whitening Cream®, had hydroquinone content of 1.33mg/L(1.33E-04%) and 1.83mg/L(1.83E-04%) respectively, which is below the Maximum Acceptable Limit (MAL) of two per cent (2%) set by NAFDAC (Nigeria Nursing World, 2012). This is indicative that the hydroquinone in these cosmetics may have been used as an antioxidant rather than for skin lightening purposes (Oyedeji et. al., 2011).

None of the locally manufactured cosmetic sample contained steroid. This may suggest compliance with the National Agency for Food and Drug Administration and Control's (NAFDAC) total prohibition of corticosteroid usage in cosmetic products (Nigeria Nursing World, 2012). Only one sample (14.29 %), Beauty Fair Multi Active Toning Cream®, had Nitrosamines content of 8.37mg/L. A proper classification and identification of the type of nitrosamine compound present in this cosmetic product becomes necessary as studies show that animal species tested with N-nitroso compounds were not resistant to their carcinogenic effect, irrespective of the mode of application. N-nitroso compounds are known to have similar metabolic effect in humans as they have in animals, hence may be carcinogenic to humans as well (Scientific Committee on Consumer Safety, 2012). Furthermore, available epidemiological evidence from case studies on nitrite and nitrosamine supports a positive association with gastric cancer while other evidence supports a positive association between nitrite and nitrosamine intake and oesophageal cancer (Jacksyn and Gonzalez, 2006).

Thirty three foreign cosmetic samples (94.29 %) did not contain mercury. However, two samples (5.71%) namely: Crusader Medicated Soap® and LenthergicAntiperpirant Roll-on®, had, mercury contents of 0.07mg/kg and 0.003mg/L respectively. The use of these two cosmetics calls for caution as case studies have shown effects such as tremors, impaired cognitive skills and sleep disturbance in workers with chronic exposure to mercury vapour even at low concentrations in the range 0.7 - 42µg/m^3 (equivalent of 7.0×10^{-10} mg/L(kg) – 4.2×10^{-8} mg/L(kg)) (Ngim et. al., 1992; Liang et. al., 1993). Also, Nigeria's National Agency for Food and Drug Administration and Control (NAFDAC)

prohibits inclusion of mercury as ingredients in cosmetics (Nigeria Nursing World, 2012). Only two samples (5.71 %), 23 and 34, by name St. Ives Apricot Facial Scrub® and Bioclaire Body Lightening Lotion® have arsenic content of 0.002 mg/L and 0.005 mg/L respectively (Table 5).Twenty seven samples (77.14 %) have no hydroquinone content while the remaining 8 samples (22.86 %) have hydroquinone content in the range of 1.14 – 1.66 mg/L (kg) (1.44E-02 – 1.66E-02%) which is less than the 2% Maximum Permissible Level (MPL) set by NAFDAC. Thirty three samples (94.29 %) have no steroids content while only samples 31 and 34 (5.71 %) by name Jordana Loose Powder® and Eden Apricot Scrub® have steroids content of 17.63±0.74 mg/kg and 16.70±0.74 mg/kg respectively(Table 5). A variety of steroid medications from anti-allergy nasal sprays, topical skin creams,eye drops , to prednisone have been implicated in the development of Central Serous Retinopathy (CSR) (Carvalho-Recchia et. al., 2002). Also, twenty seven samples (77.14 %) have no nitrosamines while 8 samples (22.86 %) contained nitrosamine and these include: Black Opal Crème Stick Foundation® (4.65mg/L(kg)), St. Ives Apricot Facial Scrub® (8.09 mg/L (kg)), Fair and White Exfoliating Soap® (11.71 mg/L (kg)), Cucumber Extract Facial Toner® (13.71 mg/L (kg)), St. Ives Body Cream® (14.13 mg/L (kg)), FemtightAnteseptic Vaginal Wash Soap® (15.16 mg/kg (L)), Vovi Milk Complex Cream® (42.99 mg/L (kg) and Empire Fade Cream Lotion® (43.37 mg/kg (L) (Table 5). It is suggested that one of the ways by which humans can protect themselves from any negative effect of nitrosamines and its co-chemicals such as secondary amines and nitrite in cosmetics is to ensure that they are not used in the formulation (Lautenschläger, 2006).Only Beauty Fair Multiactive Toning Cream® (14.29 %) out of the seven locally manufactured cosmetic sample contained nitrite with a concentration of 8.47 mg/kg which is above the WHO's recommended daily intake (ADI) value of 5.00mg/kg body weight(Table 5). Ten (28.57 %) of the imported cosmetic samples contained nitrite with Empire Fade Cream Lotion® having the least nitrite concentration of 0.87mg/kg while Fair and White Exfoliating Soap® had the highest nitrite concentration of 12.43 mg/kg. Only four out of the ten imported cosmetic samples containing nitrite, namely Femtight Antiseptic Vaginal Wash®, Cucumber Extract Facial Toner®, Black Opal Crème Stick Foundation® and Empire Fade Crème Lotion® having concentrations of 4.15 mg/kg, 3.20mg/L, 2.88 mg/kg and 0.87mg/L respectively; had nitrite content below the WHO's recommended daily intake (ADI) value of 5 mg/kg (Table 5). Nitrite is approximately ten (10) times more toxic than nitrate (Schneider, 2012) and when nitrite enters the blood stream; it interacts with the haemoglobin and forms methaemoglobin, a compound which reduces the blood's oxygen carrying capacity (Lenntech, 2014; Okafor and Nwogbo, 2005).

6. Human Health Risk Assessment

The non-carcinogenic risk and cancer risk values of the elements present in each cosmetic product were determined (Tables 6 and 7). The results showed that for cosmetic products manufactured in Nigeria, only arsenic in Royal Gold Cortex® with calculated non carcinogenic risk value of 1.56E-08 constituted a non-cancer risk while arsenic in St. Ives Body Cream® (non-cancer risk value =4.68E-07), Bioclaire Body Lightening Lotion® (non-cancer risk value =1.17E-06) and mercury in Crusader Medicated Soap® (non-cancer risk value =5.47E-09) constituted non-cancer risks for cosmetic products manufactured outside Nigeria. Only arsenic is carcinogenic among the two elements examined (Liu et al., 2013), although the US EPA has determined mercuric chloride and methyl mercury as possible human carcinogen (Das et al., 2011). For cosmetic products manufactured in Nigeria, its calculated cancer risk value in Royal Gold Cortex® (cancer risk =2.59E-14) constituted the only cancer risk while for cosmetic products manufactured outside Nigeria, its cancer risk value in St. Ives Body Cream (cancer risk =7.18E-18) and Bioclaire Body Lightening Lotion® (cancer risk =1.95E-12) constituted the cancer risks. These values also translated into the total non-cancer risk values (Hazard Indices [HI]) and cancer risk values for each product. The values fell below the non-cancer risk (Hazard Index) and cancer risk threshold values of one (1) and 10^{-6} – 10^{-4} respectively set by USEPA (Liu et al., 2013; US EPA 2001). These imply that the chance of non-cancer and cancer risk resulting from exposure to these metals at these concentrations is unlikely; however, heavy metals are cumulative in nature due to their long half lives and therefore build up of these elements on continuous usage of these cosmetic products could be detrimental. Mercury is also associated with kidney damage (Scragg, 2006). The US EPA has determined that mercuric chloride and methyl mercury are possible human carcinogens. The nervous system is very sensitive to all forms of mercury. Exposure to high levels can permanently damage the brain, kidneys, and developing foetuses. Effects on brain functioning may result in irritability, shyness, tremors, changes in vision or hearing and memory problems (Das et al., 2011). Inorganic arsenic is a known carcinogen and can cause cancer of the skin, lungs, liver and bladder. Ingestion of very high levels can possibly result in death. Long term low level exposure to arsenic can cause a darkening of the skin and the appearance of small "corn" or "warts" on the palms and soles (Das et al., 2011). Some major clinical effects of mercury and arsenic include tremor, gingivostomatitis, peripheral neuropathy, acrodynia, acute tubular necrosis, gastroenteritis, CNS effects and birth effects (Das et al., 2011). Despite the awareness of health hazards associated with organic and inorganic chemical compounds as well as heavy metal exposures, medical diagnosis of patients who may be suffering from heavy metal poisoning are highly reported in Nigeria hospitals. Although serious evidence that non communicable diseases (NCDs) such as cardiovascular diseases, diabetes mellitus, cancer and respiratory diseases which may be associated

with heavy metal exposures and which were, before now, the major causes of morbidity and mortality in the developed world are now emerging as an important component of the disease burden in developing countries like Nigeria (Gill, 1999). In their work, Unachukwu et al., (2008), showed that out of 3294 total medical admissions at the University of Port-Harcourt Teaching Hospital (UPTH) Nigeria, from June, 2000 to June, 2004, 56.2% (1853) were cases of various non-communicable diseases. The breakdown showed that diseases of the cardiovascular, endocrine and renal systems occurred most accounting for 35.7% (662), 18.5% (342), and 18.6% (311) respectively. Others were neurological 14.5% (269), gastrointestinal 5.0% (93), haematological 4.9% (911), respiratory problems 2.4% (44), musculoskeletal 1.82% (33) while dermatological diseases accounted for 0.4% (7) of non-communicable admissions (Unachukwu et al., 2008), hypertension, diabetes mellitus and chronic renal failure were the most common cardiovascular, endocrine and renal disorders respectively. Various heavy metals have been implicated in most of these non-communicable diseases.

7. Conclusion

The existence of these hazardous substances in most of these cosmetic products examined calls for caution in their use by consumers as these cosmetic products may constitute significant route of exposure (most especially via the dermis) to these hazardous substances thereby constituting health concerns over extensive use.

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