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Spectrophotometric determination of aluminium in some antiperspirant and deodorant formulations marketed in Kano metropolitan

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Abstract

Aluminium (Al) concentrations in different brands of deodorants and antiperspirants were determined using UV-visible spectrophotometer. The mean percentage Al concentration in Antiperspirants and deodorants were 7.33 + 7.61% and 10.38 + 6.06% respectively. The observed levels in both deodorant and antiperspirant samples were within the maximum permissible limit of 0-25% as recommended by the United States Food and Drug Administration (FDA). Statistical computations using t-test revealed that there is no significant difference in concentration of Al in same brands of Antiperspirants and Deodorants purchased from Sabon Gari and Supermarkets. However, Analysis of variance (ANOVA) revealed that Al content in deodorants is significantly higher than that in Antiperspirants ($P<0.05$). The levels were of the order B> D>E>A>C>F=G and B>A>D>H>F>E>G>C>I in Antiperspirants and deodorants respectively.

Keywords: Antiperspirants; Deodorant; Aluminium; Kano and Concentration

Introduction

Aluminium (Al) has variety of uses because of its abundance and most of its derivatives exhibit low toxicity. The compounds of aluminium enjoy wide and sometimes large scale applications, such as sulfates used in water treatment, chlorides used in the production of synthetic rubber, polymers and also in antiperspirants (Helmboldt *et al.,* 2007). A deodorant is a substance applied to the body to prevent body odor caused by the bacterial breakdown of perspiration in armpits, feet, and other areas of the body. Antiperspirants are designed to control sweating and body odour (B.O.) in two ways: firstly by preventing sweat reaching the skin surface and secondly by reducing the bacteria that causes body odour via antimicrobial ingredients (Antiperspirantinfo.com, 2016).The standard percentage of aluminium salt allowed in antiperspirant is between 0-25% for Over-The-Counter (OTC) antiperspirant and 25-40% for prescription antiperspirant by U.S. Food and Drug Administration (FDA) (Kasim *et al.,* 2013). Many antiperspirants and deodorants contain Aluminum salts to reduce the flow of sweat from the skin. These salts

work by dissolving in sweat and temporarily inhibit the flow of sweat to the surface of the skin. This reduces the amount of sweat on the skin for a number of hours after the antiperspirant is applied. Aerosol and roll-on antiperspirants products typically contain ACH (Aluminum Chlorohydrate), whereas sticks, gels and other solid products are most likely to contain an Aluminum salt referred to as AZAG (Aluminum Zirconium Tetrachlorohydrex GLY). These Aluminum salts provide a safe and effective means of controlling sweat. In fact, Aluminum salts are the only active ingredients that are approved by the FDA for use in antiperspirants (Flarend *et al.,* 2001).

In very high doses, aluminium is associated with altered function of the blood-brain barrier (Banks *et al.,* 1989). A small percentage of people are allergic to aluminium and experience contact dermatitis, digestive disorders, vomiting or other symptoms upon contact or ingestion of products containing aluminium, such as antiperspirants and in antacids (Dolara, 2014).The effects of aluminium in antiperspirant have been examined over the course of decades with little evidence of skin irritation. Nonetheless, its occurrence in antiperspirants and food additives has caused concern (Ferreira *et al.,* 2008).

Aluminium increases estrogen-related gene expression in human breast cancer cells cultured in the laboratory. The estrogen-like effects of these salts have led to their classification as metalloestrogens (Darbre, 2006). There is little evidence that normal exposure to aluminium presents a risk to healthy adults (Gitlelman, 1988). Some studies point to risks associated with increased exposure to the metal, aluminium in food may be absorbed more than aluminium from water (Yokel *et al.,* 2008). Deodorants and Antiperspirants may contribute to breast cancer development, if aluminium-based compounds are applied frequently to skin near the breast (Darbre, 2003 & 2005). However, it is classified as a non-carcinogen by the US Department of Health and Human Services (Dolara, 2014).In case of suspected sudden intake of a large amount of aluminium, deferoxaminemesylate may be given to help eliminate it from the body by chelation (Igor, 2012).

Zen *et al.*(2009) detected the content of aluminium chlorohydrate in antiperspirant deodorants using screen-printed silver electrodes by one Drop analysis. The original detected values were 99.43 and 101.91 ppm. Determining Al using ICP-Mass spectrometry Mannello *et al.,* (2011) reported that the mean level of Al in nipple aspirate fluid was significantly higher in breast-cancer-affected women compared to healthy women. The reason for the high levels of Al remains unknown but possibility include exposure to Al based antiparspirants.

Partial least-squares regression for the simultaneous determination of Al and Be in geochemical samples using Xylenol orange was performed by Madrakian *et al.,* (2004). In the absence of surfactant, the complex colour development takes place at 2 hrs after mixing the reagents. Ahmed (2010) presented a simple ultra-trace and highly selective spectophotometric method for the rapid determination of Al at trace levels, using 2-hydroxynaphthaldehyde benzoylhdrazine in slightly acidic solution. The colour system obeys Beer's law and has high precision and accuracy.

This study is aimed at quantifying the amount of aluminium in antiperspirants and deodorants marketed in Kano Metropolis, Nigeria.

Materials and methods

Sampling

Eighteen brands of deodorants and fourteen brands of antiperspirants marketed in Kano were randomly sampled and purchased from Sabon Gari Market and some supermarkets in Kano metropolis, Nigeria as described in tables 1 and 2

Sample Preparation

2 ml of each brand was digested using 10 ml conc. Aqua regia (combination of Nitric Acid and Hydrochloric Acid in the ratio 1:3). The mixture was evaporated on a hot plate in a fume cupboard until the brown fumes disappeared leaving white fumes (Kassim *et al.,* 2013). The digest was allowed to cool and made up to the mark in a 50ml volumetric flask.

Sample Analysis

This was carried out according to the method reported by Mohammad et al, 2013. 2 ml of each digested sample and 1 ml of xylenol orange were transferred into a 25ml volumetric flask and diluted using potassium hydrogen phthalate (KHP) buffer. The mixture was then transferred into a beaker and kept in a water-bath at 700C for about 8 minutes which was then allowed to cool at room temperature.

Instrumentation

UV-visible spectrophotometer (Jenway model UV-6705) was used. The samples were analyzed for aluminium at a λ max 550 nm.

The concentration of Aluminium in both the deodorants and antiperspirants were obtained from the calibration curve by interpolation.

Table 1: Sample of various brands of deodorants purchased from commercial stores and Sabon Gari market.

S/N	SAMPLE	COM	DOM	DOE	DOP
1.	A	NIGERIA	06-16	06-18	25-08-16
2.	A	NIGERIA	04-16	04-18	26
3.	B	INDONESIA	06-16	06-18	25-08-16
4.	B	INDONESIA	04.16	04-18	
5.	C	NIL	12.15	12-17	25-08-16
6.	C	NIL	08.16	08-18	
7.	D	S/AFRICA	06-15	06-17	25-08-16
8.	D		05-15	05-17	
9.	E	NIL	06-12-15	06-12-17	25-08-16
10.	E		12-15	12-17	
11.	F	NIL	14-12-16	14-12-18	25-08-16
12.	F		14-12-16	14-12-18	
13.	G	CHINA	06-15	06-17	25-08-16
14.	G		06-16	06-18	
15.	H	POLAND	20-4-2016	19-4-2019	30-08-16
16.	H				31-08-16
17.	I	NIGERIA	04-16	04-2018	25-08-16
18.	I		12-16	12/2018	26

Table 2: Samples of various brands of antiperspirants purchased from commercial stores and Sabon Gari Market.

S/N	SAMPLE	COM	DOM	DOE	DOP
1.	A	NIL	02-16	02 - 18	26-08-16
2.	A		03-16	03 - 18	
3.	B	S/AFRICA	01 - 16	01 – 18	26-08-16
4.	B		01 – 06	01 – 18	
5.	C	GERMANY	04 – 16	04 – 18	26-08-16
6.	C		04 – 16	04 – 18	
7.	D	CHINA	02 – 16	02 – 19	26-08-16
8.	D		04 – 16	04 – 19	
9.	E	GHANA	12 – 15	12 – 17	26-08-16
10.	E		08 – 16	08 – 18	
11.	F	UAE	02 – 15	02 – 17	26-08-16
12.	F		02 – 15	02 – 17	
13.	G	S/AFRICA	04 – 16	04 – 18	26-08-16
14.	G		06 – 16	06 - 18	

Country Of Manufacture (COM), Date of Manufacture (DOM), Date Of Expiration (DOE), Date Of Purchase (DOP).

Statistical analysis

Statistical computations were carried out using Microsoft Excel Spread Sheets. The t-test and analysis of variance (ANOVA) were carried out according to procedures described by O'Mahony, 1986.

Results and discussion

Aluminium content in different brands of Antiperspirants and Deodorants were determined using uv-visible spectrophotometer.

Table 3 and 4 shows the concentration of Al in Antiperspirants and deodorants samples obtained from Sabon Gari Market and Supermarkets.

Table 3:
Mean concentration of aluminium (%) + standard deviation (sd) and percentage in antiperspirants samples

S/N	Samples	1ST (Sabon Gari)	2nd (Supermarket)
1.	A	1.089	0.109
2.	B	18.165	1.817
3.	C	0.455	0.046
4.	D	16.343	1.634
5.	E	15.230	1.523
6.	F	0.00	0.00
7.	G	0.00	0.00
		=7.326 + 7.609	

Table 4:
Mean concentration of aluminium (%) + standard deviation (sd) and percentage in deodorants samples

S/N	Samples	1ST (Sabon Gari)	2nd (Supermarket)
1.	A	17.01	1.70
2.	B	18.18	1.88
3.	C	01.43	0.143
4.	D	16.34	1.635
5.	E	10.60	1.06
6.	F	12.04	1.204
7.	G	03.41	1.341
8.	H	03.74	1.37
9.	I	0	0
		=10.38 + 6.06	

The frequency distribution pattern of Al in antiperspirant samples is as shown in Fig. 1. It is bio-modal and skewed towards high frequency at lower concentration with a mean and standard deviation of 7.33 + 7.61%. The observed Al level covers the range of 0 – 18.20%. While Fig. 2 represents the frequency distribution pattern of Al in deodorants. The distribution is also bimodal and is skewed towards high frequency at higher concentration with a mean and standard deviation of 10.38 + 6.06%.

The observed Al percentage level covers the range of 0–1.88% in Deodorant respectively.
Even though Al content appear higher in some brands, but all were within the acceptable value of 0 – 25% as recommended by the United States Foods and Drug Administration (FDA) 2003.

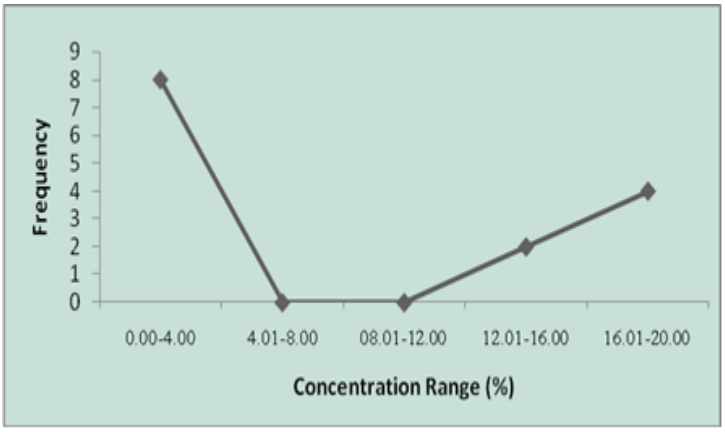

Fig. 1: Frequency distribution pattern of Al in Antiperspirant samples

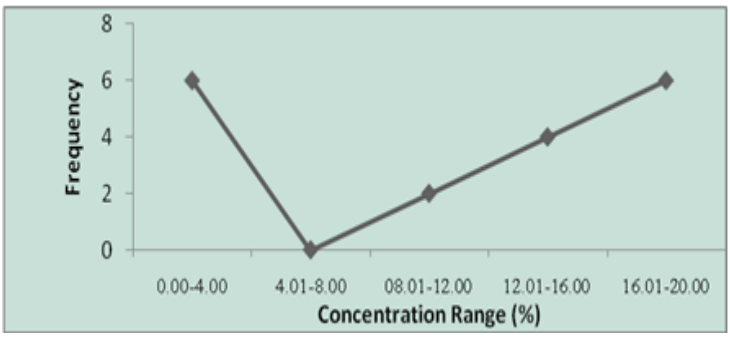

Fig. 2: Frequency distribution pattern of Al in Deodorant samples.

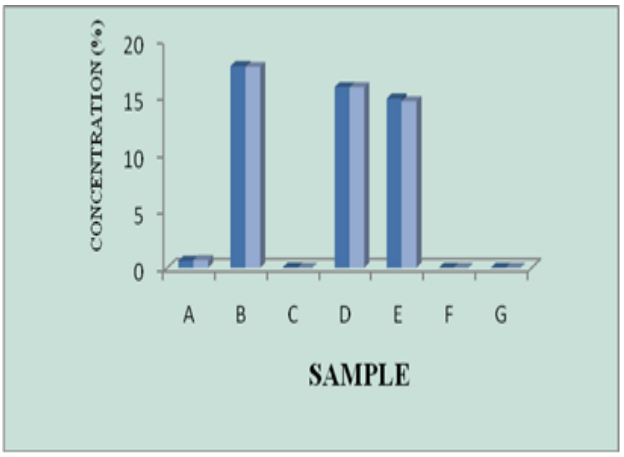

Fig. 3: Bar chart of Al in Antiperspirant samples.

Key:

Samples purchased from S/G Market

Samples purchased from Supermarkets

Fig. 3 illustrates aluminium contents in different brands of Antiperspirants (samples A – G). For each brand, one was obtained from Sabon Gari and the other from a supermarket. Samples B, D and E have the highest levels of Al whereas brand A has the lowest content. It is evident from the chart that samples C, F and G were all aluminium free (0 %). While Fig. 4 represents Al content in deodorant samples (A to I). The levels in samples A, B, and D were relatively higher than in samples H, F and E and a very low content in samples G and C. Sample I is Al free.

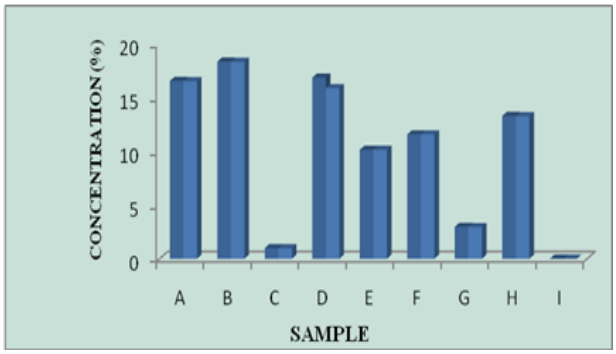

Fig. 4: Bar chart of Al in Deodorants samples.

Key:

Samples purchased from S/G Market

Samples purchased from Supermarkets

Overall, with the exception of sample D in (fig. 4), the level of Al in same brands purchased from Sabon Gari Market and Supermarkets appeared equal. Statistical computations using t-test revealed that there is no significant difference in mean concentration of Al between Antiperspirants and Deodorants samples of same brands purchased from Sabon Gari and Supermarkets at 0.05 levels of significance.

The two charts (Fig. 4 and 5) revealed variation in the level of Al in different brands. This finding is in agreement with that of Madrakran (2004) who reported that the Al contents differed for different brands. It seems reasonable to choose the Antiperspirant or deodorant containing the least amount of aluminium.

The results of this work were similar with that obtained by Kasim *et al.*, 2013 in which the Al concentration in nine out of ten samples of Antiperspirants were all within the safe level of 1 – 25%.

However, the results obtained in this study were in contrast with that of some researches like Zen *et al.*, 2009 who reported values ranging from 99.23 to 101.91 ppm.

Comparing the mean Al concentration in Antiperspirants with the deodorant a significant difference is indicated ($P< 0.05$). The deodorant is having the higher value than Antiperspirants. Analysis of variance (ANOVA) revealed that the Al content in deodorants is significantly higher than that in Antiperspirants.

The level of Al in the samples were of the order of B> D>E>A>C>F=G and B>A>D>H>F>E>G>C>I in Antiperspirants and deodorants respectively.

This study only determined the level of Al in the samples but did not study the target patients e.g. breast cancer patients.

Therefore, the findings may not translate the correlation between the levels in the samples and the patients.

The investigated samples have different manufacturing and expiration dates which may affect the consistency of the results.

Conclusion

The results obtained from the study shows that the concentration of Al observed in both the antiperspirants and deodorants samples were all within the permissible limit set by the United States Food and Drug Administration (FAD).

However, the Al content differed for different brands of Antiperspirants and deodorants.

Recommendations

More researches are needed to establish the fact and to specifically examine whether the use of deodorants or antiperspirants can cause breast cell changes that may lead to cancer.

Even though the levels of Al in the samples (from this study) are within the recommended limit, but frequent application should be avoided to prevent the accumulation of aluminium in the body tissues. People should be cautious in buying cosmetics to avoid toxic levels of metals in fake products.

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