Heavy Metal Evaluation of some Selected Herbal Medicinal Products Consumed in Wukari, Taraba State

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Abstract

According to the World Health Organization (WHO) about 70% of world population relies on traditional healing system for their basic health care needs. The widespread consumption of herbal medicines has raised issues regarding its safety. Some herbal medicinal products contain toxic materials such as heavy metals. This study aims at evaluating the heavy metal contents of some selected herbal medicines sold in Wukari local government of Taraba State, Nigeria. The samples were purchased from various herbal shops scattered around the metropolis and was evaluated for the presence of heavy metals. Seven heavy metals (Cadmium, Chromium, Cobalt, Iron, Lead, Nickel and Zinc) were determined in the eight herbal medicinal products using Atomic Absorption Spectrometry after acid digestion with aqua regia and hydrogen peroxide (30 %) as specified by the World Health Organization. Cadmium was not detected in any of the herbal medicines. Chromium concentration ranged from 2.354 ± 0.009 mg/Kg to 21.681 ± 0.030 mg/Kg, Cobalt concentration ranged from 0.644 ± 0.031 mg/Kg to 5.607 ± 0.112 mg/Kg, Iron concentration ranged from 61.853 ± 0.311 mg/Kg to 230.486 ± 0.377 mg/Kg, Lead concentration ranged from 6.44 ± 0.073 mg/Kg to 25.104 ± 0.129 mg/Kg, Nickel and Zinc concentrations were in the range of 4.715 ± 0.031 mg/Kg to 15.457 ± 0.244 mg/Kg and 16.005 ± 0.145 mg/Kg to 24.118 ± 0.027 mg/Kg respectively. All of the analysed herbal medicines had Iron, Nickel and Zinc concentrations below the recommended permissible limits while Chromium, Cobalt and Lead exceeded this limit in at least one of the herbal medicines..

Key words: Herbal medicinal products; Heavy metals; permissible limit; Therapy, Concentration, Toxicity.

1. Introduction

Concerns have been stressed for decades on the presence of contaminants in herbal medicines. Contaminants, ranging from toxic metals and non-metals, persistent organic pollutants, radionuclide and biological toxins, to microorganisms and organic solvents, get into the food chain through the intake of herbal medicines and related products (WHO, 2007). Herbal medicine preparations have been widely used for thousands of years in different parts of the world owing to its natural origin and lesser side effects, or dissatisfaction with the results of synthetic drugs. Over the last decade, the use of herbal medicines has greatly increased. A World Health Organization report has proven that about 70 - 80% of the world population relies on herbal medicines for their primary health care (Akerele 1993). Therefore, the safety of these prepared herbal medicines calls for concern for health authorities, pharmaceutical industries and the public at large. The sale and consumption of these herbal medicinal products are not properly regulated in Nigeria and owing to the fact that most manufacturers do not reveal composition of their herbal medicinal products due to poor scientific quality control methodology (as done in conventional drugs), the safety of such medicines is poorly understood (Obi *et al.*, 2006). Plants,

which are commonly the major source of herbal remedies may contain elements of therapeutic relevance but can be present at concentrations high enough to pose health risks (Edebi *et al*., 2011). For example, Copper and Iron which are present in plants are essential to life and play an important role in the functioning of critical enzyme systems but have the potential to be toxic at very high concentrations in the body (Fosmire, 1990). The toxicity of metals on humans most commonly involves the brain and the kidney but other manifestations occur, and some metals, such as arsenic, are clearly capable of causing cancer (Fosmire, 1990). Due to potential of these metals to become toxic at high concentrations and because of the high consumption of herbal medicines in Nigeria, this study would evaluate the concentration of seven heavy metals (Cadmium, Chromium, Cobalt, Iron, Lead, Nickel and Zinc) in some selected herbal medicines consumed in Wukari, Taraba State, Nigeria.

2.0 METHODOLOGY

The samples of herbal medicine products used were obtained from various herbal medicine stores in Wukari metropolis. The herbal medicines named *Med-Bunch* herbal mixture and *Super-7* herbal mixture were obtained from spring herbal medicine store at *Takum* junction area of Wukari town. Also, some herbal medicines named *Gbogbonise Epajebu* and *Gbogbonise Ajurawalo* were obtained from an herbal medicine sales point at *Ibi* round-about area of Wukari town. Other samples named *Koko Fresh* herbal medicine, *Al Mufeed* herbal medicine and *Zee* herbal medicine were obtained from an herbal medicine shop located at the old market area of Wukari town and finally, an herbal medicine named *Lamjib* traditional medicine was obtained from a retail hawker along *Puje* road, Wukari town. The herbal medicines were labelled samples A to sample H (Table 1) and kept in the refrigerator prior to analysis.

2.1 Reagents, Glassware and Instrumentation.

The nitric acid (HNO_3), hydrochloric acid (HCl) and 30 % hydrogen peroxide (H_2O_2) reagents used in digestion of the herbal medicines were of analytical grade. They were manufactured by BDH Limited Poole England. Deionized water was used throughout the course of analysis. Glassware used were soaked in diluted Nitric acid for 24 hours and washed with deionized water. Heavy metals were evaluated using a PG 990 Atomic Absorption Spectrophotometer (AAS), inter-phased to a printer. All instruments were calibrated before use.

2.2 Digestion of the herbal medicine samples

Digestion method for heavy metal analysis of herbal medicines described by WHO (2007), was adopted. The samples were digested using HNO_3, HCl and H_2O_2 (30 %) in the ratio 3:1:1. To 1 ml of the sample placed in a 250 mL beaker, 5 mL of freshly prepared acid mixture of concentrated HNO_3, concentrated HCl and 30% H_2O_2 in the ratio 3:1:1 was added. Afterwards, the mixture was heated gently on a hot plate maintaining a heating temperature of 150 °C until the sample had completely dissolved to give a clear solution. During the digestion process, the inner walls of the beaker were washed with deionized water to prevent sample loss. After digestion, the samples were made up to 50 mL with deionised water and analysed using Atomic Absorption Spectrophotometer (PG 990 AAS).

Table 1: Details of the herbal medicinal products

SAMPLE	Herbal Medicinal Product	NAFDAC Reg. No.[a]	Other info.
A	*Lamjib* Traditional Medicine	A1-5578	Mfg. Date: 01/01/2018 Exp. Date: 01/01/2019
B	*Gbogbonise* (*Epajebu*) Herbal Medicine	NA	
C	*Med-Bunch* Herbal Mixture	A7-2124L	Mfg. Date: 08-2016 Exp. Date: 08-2020 Batch no.: 003
D	*Super 7* Herbal Mixture	A7-2061L	Mfg. Date: 10-02-2017 Exp. Date: 10-02-2020.
E	*Gbogbonise* (*Ajurawalo*) Herbal Medicine	NA	
F	*Koko fresh* Herbal Medicine	NA	Mfg. Date: 15/03/2017. Exp. Date: 15/03/2020
G	*Zee Herbal* Medicine	NA	Mfg. Date: 15/03/2018. Exp. Date: 15/03/2021
H	*Al- Mufeed* Herbal Medicine	NA	Mfg. Date: 15/03/2018. Exp. Date: 15/03/2021

NA – not available; [a] National Agency for Food Drugs Administration and Control, Nigeria

Table 2: Mean Heavy Metal Concentrations (mg/Kg) in Herbal Medicinal Products consumed in Wukari, Taraba State

Sample	Cd	Cr	Co	Fe	Pb	Ni	Zn
A	ND	5.73 ± 0.05	4.37 ± 0.09	230.49 ± 0.38	ND	10.27 ± 0.04	16.01 ± 0.15
B	ND	ND	0.64 ± 0.03	77.97 ± 0.06	8.35 ± 0.05	4.72 ± 0.03	19.38 ± 0.18
C	ND	ND	3.38 ± 0.10	63.03 ± 0.31	22.45 ± 0.10	10.37 ± 0.24	23.17 ± 0.19
D	ND	ND	4.81 ± 0.15	131.51 ± 0.43	15.46 ± 0.03	9.03 ± 0.09	22.36 ± 0.13
E	ND	ND	2.57 ± 0.13	79.21 ± 0.02	16.38 ± 0.13	10.56 ± 0.09	16.10 ± 0.10
F	ND	2.35 ± 0.01	ND	71.29 ± 0.22	6.44 ± 0.07	15.46 ± 0.24	24.12 ± 0.03
G	ND	21.68 ± 0.03	5.16 ± 0.07	120.81 ± 0.35	14.18 ± 0.02	12.84 ± 0.22	17.91 ± 0.05
H	ND	21.01 ± 0.04	5.61 ± 0.11	61.85 ± 0.15	25.10 ± 0.13	14.28 ± 0.11	17.99 ± 0.16

ND = Not Detected; Mean Concentration ± Standard Deviation

Table 3: Summary of Heavy Metal Concentrations (mg/Kg) in Herbal Medicinal products consumed in Wukari, Taraba State

Total Samples	Cd	Cr	Co	Fe	Pb	Ni	Zn
Mean ± SD	ND	12.69 ± 10.09	3.79 ± 1.74	104.52 ± 57.14	15.48 ± 6.79	10.94 ± 3.35	19.63 ± 3.20
Range value	ND	2.35 ± 0.01 – 21.68 ± 0.03	0.64 ± 0.03 – 5.61 ± 0.11	61.85 ± 0.31 – 230.49 ± 0.38	6.44 ± 0.07 – 25.10 ± 0.13	4.72 ± 0.03 – 15.46 ± 0.24	16.01 ± 0.15 – 4.12 ± 0.03

ND = Not Detected; SD = Standard Deviation

3.0 Results and Discussion

The result of heavy metal analysis of the herbal medicine purchased from various herbal medicinal stores in Wukari Local Government area of Taraba State is presented in the Table 2.

Chromium concentration in the herbal medicines was in the range of 2.35 ± 0.01 mg/Kg – 21.68 ± 0.03 mg/Kg (Table 3) and was highest in sample G (Zee Herbs herbal medicine) with a value of 21.68 ± 0.03 mg/Kg and lowest in sample A (*Lamjib* herbal medicine) with a value of 2.35 ± 0.01 mg/Kg (Table 2). Chromium in samples B, C, D and E were not detected. The mean concentration of Chromium in all the herbal medicine samples exceeded the WHO/FAO (2006) limit. The permissible limit of Chromium is 5.00 mg/Kg (WHO/FAO, 2006). Igweze *et al.*, (2012) reported chromium concentrations in herbal medicines below the limit of the WHO/FAO (2006) while Ekeanyanwu *et al.*, (2013) did not detect chromium in any the herbal medicines analysed. Exposure to high level of chromium causes lungs cancer and dermatitis (FNB, 2001; ATSDR, 2004).

Cobalt concentration in the herbal medicines ranged from 0.64 ± 0.03 mg/Kg – 5.61 ± 0.11 mg/Kg (Table 3). Highest concentration was detected in sample H (*Al-mufeed* herbal medicine) with a value of 5.61 ± 0.11 mg/Kg while lowest concentration was detected in sample E (*Gbogbonise Ajurawalo*) with a value of 0.64 ± 0.03 mg/Kg (Table 2). The permissible limit of the WHO/FAO (2009) for Cobalt in herbal medicines is 3.50 mg/Kg and the total mean concentrations of cobalt in all the herbal medicines exceeded this limit. In a recent research conducted on heavy metals in herbal medicines, cobalt concentration was below the WHO (2009) limit (Igweze *et al*., 2012). Jabeen *et al*., (2010) reported a concentration range of 3.41 ± 0.60 µg/g – 11.26 ± 0.30 µg/g in some herbal plants found in Pakistan. At low concentrations, cobalt plays a prominent role in the formation of cyanocobalmin vitamin B 12, an essential vitamin in man. Exposure to high concentrations may lead to some adverse effects in man. Signs and symptoms of cobalt poisoning can include visual impairment, hypothroidism, peripheral neuropathy, rashes (Smith *et al*., 1981), cardiomyopathy, cognitive and auditory impairment (Karovic *et al.*, 2007).

Iron concentration ranged from 61.85 ± 0.31 mg/Kg – 230.49 ± 0.38 mg/Kg (Table 3). The herbal medicine with the highest concentration was sample A (*Lamgib* Traditional Medicine) with a value of 230.49 ± 0.38 mg/Kg while the herbal medicine with the lowest concentration was sample H (*Al-Mufeed* Herbal Medicine) with a value of 61.85 ± 0.31 mg/Kg (Table 2). All the herbal medicines exceeded the WHO/FAO (2009) permissible limits of 48.00 mg/Kg but were below the Food and Nutrition Board (FNB, 2001) of the Institute of Medicine (IM) recommended dietary allowance of 7.00 – 10.00 mg/day for children, 8 mg/day for adults and 27 mg/day during pregnancy for mothers. Edebi *et al*., (2011) recorded iron concentration below this limit. Chionyedua *et al*., (2015) recorded Fe concentrations in the range of 5.11 – 257.00 mg/Kg. Fe is a component of the respiratory pigments (haemoglobin and myoglobin) and enzymes e.g. cytochromes, catalases, peroxidases, aldehyde oxidase, and succinic dehydrogenase etc. concerned in tissue oxidation. Iron is essential for oxygen and electron transport within the body (Fraga *et al.,* 2002). The ingestion of large quantities of iron salts may lead to severe necrotising gastritis with vomiting, haemorrhage and diarrhoea followed by circulatory shock, also diseases of aging such as Alzeihermer's disease, other neurodegenerative disease, arteriosclerosis, diabetes mellitus may all be contributed to by excess iron and copper (Brewer, 2010). Mtunzi *et al*., (2012) also recorded iron below the permissible limits of WHO/FAO (2009). A concentration range 8.60 – 2731.80 µg/g of iron had been found in a selected group of branded herbal products in Pakistan in a study to detect the concentration range of several heavy metals including iron (Saeed *et al.*, 2010). Another study with a similar approach had been conducted and iron concentration range was 65.68 – 1652.89

µg/g in different products of herbal medicine purchased from various places in Karachi city of Pakistan (Hina *et al.*, 2011).

Lead concentration in the herbal medicines ranged from 6.44 ± 0.07 mg/kg – 25.10 ± 0.13 mg/Kg (Table 3) and was highest in sample H (*Al-Mufeed* herbal medicine) with a value of 25.10 ± 0.13 mg/Kg and lowest in sample F (*Koko Fresh* herbal medicine) with a value of 6.44 ± 0.07 mg/kg (Table 2). Permissible limit of lead in herbal medicines is 10.00 mg/kg (WHO/FAO, 2006) and this limit was exceeded in more than 62 % of the analysed herbal medicines. Edebi *et al*., (2011) recorded high lead concentrations in 50 % of the analysed herbal medicines. Igweze *et al.*, (2012) recorded lead concentrations below WHO (2006) limit in liquid herbal samples. Chionyedua *et al.*, (2015) recorded lead concentrations in the powdered and capsulated herbal medicines; however lead was not detected in liquid herbal medicines. Lead content in herbal medicines sold in South African market was below permissible limits (Mtunzi *et al.*, 2012) while it exceeded the permissible limits in Iranian herbal formulations (Mousavi *et al*., 2014). In Pakistan, lead concentrations were found in the range of 3.26 – 30.46 µg/g and 71.40 % of the samples were beyond the permissible limit (Hina *et al.*, 2011) while in China, natural herbal medicines analyzed for lead content had results in the range of 0.13 – 4.79 µg/g (Qi *et al.*, 1998). Lead concentration was more than the permissible limit in some Malaysian herbal medicines (Ang, 2008). Lead is associated with impairment of childhood cognitive function (Canfield *et al.*, 2003). A high lead level during pregnancy is directly related to several outcomes such as spontaneous abortion, low birth weight and impaired neurodevelopment (Rabinowitz *et al.,* 1987). Lead poisoning occur when the concentration reach between 100.00 – 140.00 µg/L (Goldfrank *et al*., 1998). According to the international Agency for Research on cancer (IARC) (IARC, 1987), inorganic lead is carcinogenic to human.

Nickel concentration ranged from 4.72 ± 0.03 mg/Kg – 15.46 ± 0.24 mg/Kg (Table 3) and was highest in sample F (Koko Fresh) with a value of 15.46 ± 0.24 mg/Kg and lowest in sample B (*Gbogbonise Epajebu*) with a value of 4.72 ± 0.03 mg/Kg (Table 2), but all the entire herbal medicines fell below the permissible limits of WHO, (2004). Exposure to Nickel may result in a variety of pathological effects. Oral exposure to large doses of nickel mainly targets the cardiovascular system (Das, 2009). The common adverse health effect of nickel in humans is allergic skin reaction in those who are sensitive to nickel (Duda-Chodak *et al*., 2008). Most of the toxicity of nickel might be attributed to its interference with the physiological processes of zinc and calcium. In a similar study, the concentrations of Ni ranged from 0.73 to 54.00µg/g (Chionyedua *et al.*, 2015). Igweze *et al.,* (2012) also detected Nickel concentrations in all the herbal medicines analysed but liquid herbal medicines fell below the permissible limits while powdered and capsulated herbal medicines exceeded the permissible limits. However, Ekeanyanwu *et al.*, (2013) did not detect nickel concentration in all the nine herbal medicines analysed. In Pakistan, two studies had been reported for Ni concentration in herbal products; in the first study, Nickel was found in concentration range of 0.25 – 6.30 µg/g (Saeed *et al.,* 2010) while the result of the second study showed that Ni concentration in the range of 0.48 – 76.97 µg/g (Hina *et al.,* 2011).

Zinc concentration was in the range of 16.01 ± 0.15 mg/Kg – 24.12 ± 0.03 mg/Kg (Table 3) and was highest in sample F (*Koko Fresh*) with a value of 24.12 ± 0.03 mg/Kg and lowest in sample A (*Lamgib* traditional medicine) with a value of 16.01 ± 0.15 mg/Kg (Table 2). Zinc concentration in all the analysed herbal medicines fell below the WHO (2006) permissible limits of 50.00 mg/Kg. Edebi *et al.,* (2011) carried out similar analysis and reported Zn range from ND to 14.64 ± µg/g for all the four *Pax* herbal products investigated. Zinc is known to play vital roles in a number of physiological activities in man. The catalytic

activity of about one hundred (100) enzymes are Zn dependent in the human body and also participate in cell signaling, release of hormones and apoptosis (Truong-Tran *et al.,* 2000). The recommended dietary allowances are 4000.00 – 5000.00 µg/day, 9000.00 – 13000.00 µg/day and 13000.00 – 19000.00 µg/day for children, women and men respectively (Brown *et al.,* 2004). The National Research Council (NRC) recommended daily Zn intake is between 10,000.00 and 20,000.00µg/day (NRC, 1980). Although human body can accommodate high concentrations of zinc, acute Zn toxicity (oral dose of 225000-450000 µg) can cause eminent health problems such as stomach cramps, skin irritations, vomiting, nausea and anemia, while chronic exposure could lead to copper deficiency in man (FBN, 2001). Mtunzi *et al.,* (2012) reported Zn concentration below the WHO (2006) permissible limits. In Pakistan, using FAAS, Zinc was found in concentration range 5.1 – 1071 µg/g (Saeed, 2010). Another study was conducted in Pakistan for the detection of heavy metals including Zn in selected herbal products purchased from different places in Karachi. The results showed that Zn was found in the range of 83.74 – 433.76 µg/g, exceeding the WHO limits (Hina *et al.*, 2011).

4 Conclusion

From this study of the eight herbal medicinal products consumed in Wukari area of Taraba State, the heavy metal analysis revealed the presence of heavy metals such as Cobalt, Chromium, Iron, Lead, Nickel and Zinc. Cobalt, Chromium and Lead had mean concentrations which exceeded the permissible limits of pharmacovigilance organisations. Therefore, from a toxicological point of view, some of these herbal medicines may not be safe for consumption as they may pose health risks to consumers. The consumption of such herbal medicines may have to be discouraged and societal awareness should be created to integrate the masses with the toxic effect of herbal medicines. Also, since the use of herbal medicines is the prevalent therapeutic system, more work should be done to ensure its safety.

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