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Research Article

Quality Assessment 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 the world population relies on traditional healing system for their basic health care needs. The widespread consumption of herbal medicines has risen up issues regarding its efficacy and safety. Some herbal medicinal products contain toxic materials such as heavy metals. This current study aims at evaluating the quality and safety of some selected herbal medicines sold in Wukari, Taraba State. The samples were purchased from various herbal shops scattered around the metropolis and were evaluated for their physicochemical parameters, the presence of phytochemicals and heavy metals. The study revealed highly acidic and alkaline pH in the herbal medicines and also the presence of some secondary metabolites like Alkaloids, Tannins, Terpenoid, Flavonoids, Reducing Sugars, Cardiac glycosides and Saponins in at least one of the eight herbal medicinal products analysed. Also, 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 WHO [1]. The concentration of Cadmium was below the detection limit of the instrument. 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 permissible limits of pharmacovigilance organizations while Chromium, Cobalt and Lead exceeded this limit in at least one of the herbal medicines. The study was concluded that some of these local herbal medicinal products may not be safe for consumption.

Keywords: Herbal Medicinal Products; Heavy Metals; Permissible Limit; Atomic Absorption Spectrophotometer; Phytochemical; Physicochemical; Phytotherapy; Phyto-Toxicity

Introduction

Herbal medicines and their preparations have been widely used for thousands of years in developed and developing countries owing to its natural origin and lesser side effects, or dissatisfaction with the results of synthetic drugs. Herbal medicine, also called botanical medicine, phytomedicine or plant medicine, is defined as finished labelled medicinal products that contain as active ingredients aerial or underground parts of plants or other plant materials which include in addition to herbs, fresh juice, gums, fixed oils, essential oils, resins and dry powders of herbs -leaves, bark, roots, rhizomes or other plant parts which may be entire, fragmented or powdered, or combinations thereof whether in crude state or as plant preparations [1]. Although herbal medicines have been used to treat many conditions, such as asthma, eczema, premenstrual syndrome, rheumatoid, arthritis, migraine, menopausal symptoms, chronic fatigue, and irritable bowel syndrome, among others [2]; the quality of these prepared herbal medicines still calls for concern for health authorities, pharmaceutical industries and the public at large because the sale and consumption of these herbal medicinal products are not properly regulated in Nigeria.

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 [1]. Phyto-toxicity in herbal medicines has also been reported due to the adverse effects of plants extracts used in herbal medicines preparations caused by errors in botanical identification; accidental ingestion of cardiotonic plants; inappropriate combinations in phytotherapy and/or interference of medicinal plants with conventional pharmacological therapy, such as plants containing coumarinic derivatives, a high content of tyramine, estrogenic compounds, plants causing irritation and allergic problems [3,4]. Plants may contain elements of therapeutic relevance but can be present at concentrations high enough to pose health risks [5]. In a bid to determine the quality of local herbal medicinal products, this current study would evaluate physicochemical parameters (Temperature and pH), some phytochemicals (Alkaloids, Tannins, Terpenoid, Flavonoids, Reducing Sugars, Cardiac glycosides and Saponins) and seven heavy metals (Cadmium, Chromium, Cobalt, Iron, Lead, Nickel and Zinc) in some selected herbal medicines consumed in Wukari, Taraba State.

Materials and Methods

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 herbal medicines were obtained from an herbal medicine sales point at Ibi round about area of Wukari town. Other herbal medicines 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.

Reagents, Glassware and Instrumentation

The reagents used in analysis 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.

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

Table 1: Details of the herbal medicinal products.

NA: not available; a National Agency for Food Drugs Administration and Control, Nigeria.

Determination of physicochemical parameters of the herbal medicines

Determination of temperature

The temperature of the herbal medicine samples was determined using a mercury-in-glass thermometer (GH ZEAL ltd. London) and readings were taken twice.

Determination of pH

The pH of the herbal medicine samples was determined in their aqueous form; the pH was measured using a digital pH meter (WJEUIP, model PHS-25). Calibration of the pH meter was done twice using buffer 7 and buffer 4 before taking the pH reading of the samples.

Determination of phytochemicals in herbal medicine

Methodology for qualitative analysis of phytochemicals in herbal medicines was carried out as earlier reported by Harborne [6]; Trease and Evans [7]; Sofowora [8].

Flavonoids

Two drops of 1% NH_3 solution was added to 5 ml aqueous solution of the herbal medicine in a test tube followed by the addition of concentrated H_2SO_4. A yellow colouration was observed which indicates the presence of flavonoid.

Terpenoid

Five ml of aqueous solution of herbal medicine sample was mixed with 2 ml of $CHCl_3$ in a test tube. Afterwards, 3 ml of conc. H_2SO_4 was carefully added to the mixture to form a layer. An interface with a reddish brown colouration was formed which shows the presence of Terpenoid.

Cardiac glycosides

Five ml of aqueous herbal mixture was treated with 2 ml of glacial acetic acid containing one drop of ferric chloride solution. This was overlaid with 1 ml of concentrated H_2SO_4. A brown ring at the interface indicates the presence of a deoxysugar characteristic of cardenolides.

Tannins

Two drops of $FeCl_3$ (0.1%) was added to 5 ml of the herbal medicines samples. A brownish-green or a blue black colouration was formed, which shows the presence of tannins.

Saponins

Twenty ml of 20% aqueous solution of the sample was shaken in a graduated cylinder for 15 min. A 2 cm layer of foam was formed which indicates the presence of saponins.

Reducing sugars

Five ml of the sample was measured in a test tube; 1 ml of ethanol was then added to the sample. Thereafter, 1 ml of Fehling solution A and 1 ml of Fehling solution B were added to another test tube and heated to boil after which it was poured inside the aqueous solution of the sample and boiled in a water bath for 10 minutes. A colour change to yellow and then brick red precipitate indicates positive result.

Alkaloids

- **Mayer's test:** 5 ml of the sample, two drops of Mayer's reagent was added along the sides of the test tube. A white creamy precipitate indicates the presence of alkaloids.
- **Wagner's test:** 5 ml of the sample, two drops of Wagner's reagent was added along the sides of the test tube. A brown precipitate was formed which confirms the presence of Alkaloids.
- **Dragendroff's test:** 5 ml of the sample was warmed with 2% H2SO4 for about 2 min, then filtered after which three drops of Dragendroff's reagent is added; a brick red precipitate indicates the presence of alkaloids.

Digestion of the herbal medicine samples

Digestion method for heavy metal analysis of herbal medicines as described by WHO - Guidelines for assessing quality of herbal medicines with reference to contaminants and residues (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).

Result and Discussion

The result of physicochemical and phytochemical analysis of the herbal medicine consumed in Wukari Local Government area of Taraba State is presented in the Tables below.

The mean temperature of the herbal medicines is presented in (Table 2). All the analysed herbal medicines had almost constant temperature of 28.00 °C which is normal for aqueous solutions at room temperature.

The results of the mean pH value of the herbal medicinal products are presented in (Table 3). The herbal medicines had pH values between the ranges of 1.05 - 12.30 with a total mean value of 3.88

Sample	Temperature (°C)
A	28.00 ± 0.01
B	28.00 ± 0.01
C	28.00 ± 0.01
D	28.00 ± 0.01
E	28.00 ± 0.01
F	28.00 ± 0.01
G	28.00 ± 0.01
H	28.00 ± 0.01

Table 2: Mean Temperature of Herbal Medicinal Products Consumed in Wukari, Taraba State.

Sample	pH Value
A	1.05 ± 0.01
B	1.51 ± 0.01
C	2.75 ± 0.01
D	3.30 ± 0.01
E	12.30 ± 0.01
F	3.55 ± 0.01
G	3.40 ± 0.01
H	3.15 ± 0.01

Table 3: Mean pH Value of Herbal Medicinal Products Consumed in Wukari, Taraba State.

Sample	Phytochemicals						
	Tannins	Alkaloids	Saponins	Flavonoids	Terpenoid	Cardiac Glycoside	Reducing sugars
A	–	+	+	–	+	–	+
B	–	+	–	–	–	+	–
C	+	+	+	–	–	+	+
D	+	+	+	+	–	+	+
E	–	+	+	–	–	+	–
F	+	+	+	+	+	+	+
G	+	+	+	+	+	+	+
H	+	+	+	+	–	+	+

Table 4: Phytochemical Parameter of the Herbal Medicine Samples

+ represents a positive result and – represents a negative result.

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

Table 5: Mean Heavy Metal Concentrations (mg/Kg) in Herbal Medicinal Products consumed in Wukari, Taraba State

ND = Not Detected; Mean Concentration ± Standard Deviation.

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

Table 6: Summary of Heavy Metal Concentrations (mg/Kg) in Herbal Medicinal products consumed in Wukari, Taraba State

ND = Not Detected; SD = Standard Deviation

± 1.25. The herbal medicines analysed were acidic with the exception of sample E (Gbogbonise Ajurawalo) which was highly basic. The herbal medicines were all liquid samples and Chionyedua., *et al.* [9] reported similar pH values for liquid herbal medicines. The pH acceptable range for fruits, vegetables, grasses, flowers, trees, shrubs and annual is 4.0 - 7.5, while that of food is given as pH 2 - 9 [5]. None of the herbal medicines analysed fell within this range. The effect of body pH imbalance has been documented. High acidity level can have a negative effect on all body systems, particularly the digestive, intestinal, circulatory, and respiratory and immune system [10]. All cells, organs and bodily fluid need a specific pH to function at their best. Enzymes are very sensitive to acidity levels, they take on specific shape according to the pH of the medium they are in and consequently, they function below standard unless they are in a medium with the specific pH [10]. The direct effect of the oral ingestion of these highly acidic herbal medicines is that it increases acidity of the stomach fluids above the level needed for metabolism thereby inhibiting the action of enzymes. Also, when acids accumulate in the body, the body neutralises them using buffer systems, but when these systems are overloaded, the body utilises alkaline minerals from vital organs and bones to help neutralise the acidic compounds and eliminate them. This process, over time, can weaken vital organs and bones, and in the latter case, causes osteoporosis. Other effects, as shown from scientific studies includes dark urine with strong odour, poor digestion, fatigue, muscle and joint pain, excessive perspiration, migraine, bad breadth [10].

The result of the qualitative phytochemical screening presents various phytochemicals considered as active medicinal chemical constituents. Phytochemicals of medicinal importance such as Terpenoid, reducing sugar, flavonoids, alkaloids, saponins, tannins and cardiac glycosides were present in the samples (Table 4). The result of the phytochemical analysis shows that the eight herbal medicines are rich in at least one of these phytochemicals. All the herbal medicines had alkaloids present in them. Tannins and reducing sugars were found present in 62.5% and 75% of the herbal medicines respectively. Flavonoids were present in 50% of the herbal medicines. Saponins and cardiac glycosides were both present in 87.5% of the herbal medicines while Terpenoids was found absent in 62.5% of the herbal medicine. The presence of secondary metabolites in the herbal medicines screened may attribute to their use in treating various ailments and diseases as indicated on the product label. The presence of Alkaloids in the herbal medicines complements the results of Agbo., *et al.* [11] in the ten herbal medicines screened for alkaloids, including the ethanol extract while Adenike., *et al.* [12] had contradicting results as only eight out of the twenty-one herbal medicines screened had alkaloids present. Alkaloids are used in medicines for reducing headache and fever; these are attributed for antibacterial and analgesic properties [13]. Alkaloids were also found present in some herbal teas (antimalarial, antihypertensive, antidiabetic and antiobesity) [14]. Also, Cardiac glycosides and saponins were found present in all samples except in sample A (Lamgib traditional medicine) and sample B (Gbogbonise Epajebu) respectively. Similar research carried out on Cleistophoris patens, one of the components of the herbal mixtures had Cardiac Glycosides and Saponins present in both the leaf and stem bark [15]. Adenike., *et al.* [12] and Omogbai., *et al.* [14] found saponins present respectively in 71% and 40% of the herbal medicines screened while Agbo., *et al.* [11] found cardiac glycosides and saponins present respectively in 90% and 20% in the herbal medicines analysed. One of the common health function of saponins and cardiac glycosides is cholesterol reduction and cure of some heart related diseases respectively. Furthermore, reducing sugars were absent in two herbal medicines out of eight herbal medicine samples, i.e. sample B and sample E. Sample F (Koko Fresh) and sample G (Zee Herbs) had all the phytochemicals present while sample D and sample H (Super 7 and Al-Mufeed) had all present but Terpenoid. Terpenoid has been reported to have anti-inflammatory, anti-viral, anti-malarial, inhibition of cholesterol synthesis and anti-bacterial [16]. The herbal medicine with the least amount of phytochemicals present was sample B which gave positive result for Alkaloids and cardiac glycosides.

Chromium concentration in the herbal medicines was in the range of 2.35 ± 0.01 mg/Kg - 21.68 ± 0.03 mg/Kg (Table 6) 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 5). 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 [17] limit. The permissible limit of Chromium is 5.00 mg/Kg [17]. Igweze., *et al.* [18] reported chromium concentrations in herbal medicines below the limit of the WHO/FAO [17] while Ekeanyanwu., *et al.* [19] did not detect chromium in any the herbal medicines analysed. Exposure to high level of chromium causes lungs cancer and dermatitis [20,21].

Cobalt concentration in the herbal medicines ranged from 0.64 ± 0.03 mg/Kg - 5.61 ± 0.11 mg/Kg (Table 6). 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 5). 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 [22], limit [18]. Jabeen., *et al.* [23] 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 [24], cardiomyopathy, cognitive and auditory impairment [25].

Iron concentration ranged from 61.85 ± 0.31 mg/Kg - 230.49 ± 0.38 mg/Kg (Table 6). 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 5). All the herbal medicines exceeded the WHO/FAO [22] permissible limits of 48.00 mg/Kg but were below the Food and Nutrition Board [20](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.* [5] recorded iron concentration below this limit. Chionyedua., *et al.* [9] 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 [26]. 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 [27]. Mtunzi., *et al.* [28] 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 [29]. 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 [30].

Lead concentration in the herbal medicines ranged from 6.44 ± 0.07 mg/kg - 25.10 ± 0.13 mg/Kg (Table 6) 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 5). Permissible limit of lead in herbal medicines is 10.00 mg/kg [31] and this limit was exceeded in more than 62% of the analysed herbal medicines. Edebi., *et al.* [5] recorded high lead concentrations in 50% of the analysed herbal medicines. Igweze., *et al.* [18] recorded lead concentrations below WHO [17] limit in liquid herbal samples. Chionyedua., *et al.* [9] 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 [25] while it exceeded the permissible limits in Iranian herbal formulations [32]. 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 [30] while in China, natural herbal medicines analyzed for lead content had results in the range of 0.13 - 4.79 µg/g [3]. Lead concentration was more than the permissible limit in some Malaysian herbal medicines [34]. Lead is associated with impairment of childhood cognitive function [35]. A high lead level during pregnancy is directly related to several outcomes such as spontaneous abortion, low birth weight and impaired neurodevelopment [36]. Lead poisoning occur when the concentration reach between 100.00 - 140.00 µg/L [37]. According to the international Agency for Research on cancer (IARC) [38], inorganic lead is carcinogenic to human.

Nickel concentration ranged from 4.72 ± 0.03 mg/Kg - 15.46 ± 0.24 mg/Kg (Table 6) 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 5), but all the entire herbal medicines fell below the permissible limits of WHO [39]. Exposure to Nickel may result in a variety of pathological effects. Oral exposure to large doses of nickel mainly targets the cardiovascular system [40]. The common adverse health effect of nickel in humans is allergic skin reaction in those who are sensitive to nickel [41]. 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 [9]. Igweze., *et al.* [18] 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.* [19] 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 [29] while the result of the second study showed that Ni concentration in the range of 0.48 - 76.97 µg/g [30].

Zinc concentration was in the range of 16.01 ± 0.15 mg/Kg - 24.12 ± 0.03 mg/Kg (Table 6) 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 5). Zinc concentration in all the analysed herbal medicines fell below the WHO [31] permissible limits of 50.00 mg/Kg. Edebi., *et al.* [5] 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 par-

ticipate in cell signaling, release of hormones and apoptosis [42]. 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 [43]. The National Research Council (NRC) recommended daily Zn intake is between 10,000.00 and 20,000.00µg/day [44]. 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.* [28] reported Zn concentration below the WHO [31] permissible limits. In Pakistan, using FAAS, Zinc was found in concentration range 5.1 - 1071 µg/g [29]. 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 [30,45].

Conclusion

From this quality assessment of the eight herbal medicinal products consumed in Wukari area of Taraba State, it was revealed that the pH levels of the herbal medicinal products were acidic beyond the specified limits, some of which were highly acidic (Gbogbonise Epajebu Herbal Medicine and Lamjib Traditioal Medicine) while one was highly basic (Gbogbonise Ajurawalo) and therefore are not recommended for ingestion. The study also revealed the presence of some phytochemicals (Alkaloids, Tannins, Terpenoids, Flavonoids, Reducing Sugars, Cardiac glycosides and Saponins) and therefore ascertains the acclaimed therapeutical functions given by the manufacturers. The analgesic, antimalarial, antibacterial, antifungal, antidiuretic, etc. activities prescribed on these herbal products are due to these phytochemicals. Furthermore, the heavy metal analysis revealed the presence of heavy metals such as Cobalt, Chromium, Iron, Lead, Nickel and Zinc; some of which exceeded the permissible limits of pharmacovigilance organisations. But Cadmium, Iron and Zinc did not reach toxic levels in any of the herbal medicines. Therefore, from a toxicological point of view, some of these herbal medicines may not be safe for consumption and they may pose health risks to consumers because they were found to be toxic in at least one of the heavy metals.

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