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INVESTIGATION OF PHYTOCHEMICALS AND CHEMICAL ELEMENTS PRESENT IN HERBAL DRUGS MANUFACTURED AND CONSUMED IN NIGERIA.

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Abstract
The rate of acceptance and consequent consumption of herbal drugs in Nigeria is steadily increasing; this could be linked to limited access to health care, high cost of health services and perceived efficacy of herbal medicines. This study investigated the physicochemical properties as well as phytochemical contents of three herbal drugs manufactured and consumed in Nigeria using standard methods. Concentration of selected elements and heavy metals were also determined using the Atomic Absorption Spectrophotometer. The results obtained showed that the herbal drugs are coloured, very bitter, acidic liquids. Ash content obtained for the three samples were 1.490%, 1.246% and 1.746% while moisture content were 84.817%, 84.787% and 13.719% for samples A, B and C respectively. Water extractives present in the samples were 31.643%, 30.124% and 33.496% while alcohol extractives were 21.848%, 22.654% and 20.699% for samples A, B and C respectively. Results from the phytochemical analysis revealed that all three samples contained flavonoids (14.118, 11.799 and 21.921 for samples A, B and C respectively), alkaloids (22.086, 14.580 and 1.912 for samples A, B and C respectively), saponins (13.848, 10.645 and 15.297 for samples A, B and C respectively), glycosides (3.441, 3.368 and 6.016 for samples A, B and C respectively), tannins (9.344, 12.871 and 9.339 for samples A, B and C respectively) and terpenoids (1.93, 2.939 and 2.193 for samples A, B and C respectively). Some trace elements and heavy metals namely; Zn, Fe, Hg, K, Ni, Co, As, Na, Ca and Mg were found in all three herbal drugs. However, lead (Pb) was not detected in two of the herbal drugs and copper (Cu) was not detected in one of the samples. The presence of the observed phytochemicals suggests that the drugs are plant-based formulations with potential therapeutic benefit. While the essential elements found in the herbal drugs play important roles that contributes to good health of consumers, the presence of heavy metals is an evidence of drug contamination. This research therefore recommends strict compliance to standard practice in manufacturing of herbal drugs.
***Keywords**: herbal medicine, plants, phytochemicals, essential elements, heavy metals.*

Introduction
Herbal drugs may be defined as natural substances derived from plants for prevention and treatment of diseases. It usually consists of mixtures of organic compounds from raw or processed parts of plants. According to the World Health Organisation, herbal medicines include herbs, herbal materials, herbal preparations and finished herbal products that contain parts of plants as active ingredients, they may also contain other plant materials or combinations e.g. animal and mineral materials (WHO, 2000). Some popular medicinal plants used in herbal formulations are ginger, garlic, lemon grass, cloves, aloe vera, moringa, ginseng, Ethiopian pepper, neem leaves, bush buck, aidan pods to mention only a few.

Research has proven that the plants from which herbal medicines are produced possess many medicinal properties and supply important essential minerals to the body; others are rich sources of ingredients used in the synthesis and development of drugs and other pharmaceutical products (Chaachouay and Zidane, 2024). The active ingredient in medicinal plants include; tannins, carotenoids, saponins, phenolic acids, proanthocyanins, polysaccharides, flavonoids, phenols, coumarins, alkaloids, minerals, polyacetylenes, volatile oils, cardiac glycosides, cyanogenic glycosides, saponins, vitamins and terpenoids. All these phytochemicals can be found in different parts of medicinal plants such as the leaves, roots, bark, fruits, trunk, stem, seeds etc**.**

In Nigeria, some already prepared herbal medicines are produced by drug manufacturing industries and packaged in ready to serve containers for direct consumption. Some with details of drug composition, dosage, contraindications, date of production, date of expiry and number of registrations with the appropriate regulatory body clearly written on their packets while many others are sold without any information. Additionally, sale of fresh or dried herbs is as common as the prepared medicines, they are usually sold with instructions on how to prepare them for maximum efficacy. The persistent relevance of traditional medicine has been linked to the problems associated with modern health care namely; its perfunctory nature, unequal access and high cost, drug abuse, drug resistance, numerous side effects etc. In contrast, herbal drugs are believed to offer more holistic treatment, their rich bioactive content afford them the ability to act on several parts of the body simultaneously (Shirsat *et al*., 2023) thus resolving the root cause of illnesses.

Regardless of the soothing goodness of herbal medicines, there are serious health concerns around the source, production, administration, and safety of herbal preparations marketed as drugs. There have been several calls on the need for robust clinical analysis of herbal drugs (Awodele *et al*, 2018); (Shaikh and Chaudhari, 2024) in order to investigate the bioactive compounds responsible for their unique therapeutic effects as well as their mechanism of interaction. Such knowledge is useful for optimization of the herbal drugs, understanding of their potential side effects and for consumer protection. This research is therefore targeted at discovering the properties and components responsible for the therapeutic function of selected herbal medicines.

Materials and methods

Sample collection

Three herbal drugs well packaged in sealed ready to drink plastic bottles were purchased from a popular market in Awka, Anambra State, Nigeria. All purchased herbal drugs were properly inspected, they had NAFDAC registration numbers, batch numbers, manufacturing and expiry dates, drug indication and herbal composition. They were labelled sample A, sample B, and sample C for easy identification.

Organoleptic Properties

5ml of each sample were placed on three different petri dishes, their consistency, colour, odour and taste were evaluated by 4 assessors.

pH

pH was measured by Electrometric Method using Laboratory pH Meter Hanna model HI991300 (APHA, 2005). The electrodes were rinsed with distilled water and blotted dry. The pH electrodes were then rinsed in a small beaker with a portion of the sample. Sufficient amount of the sample was poured into a small beaker to allow the tips of the electrodes to be immersed to a depth of about 2cm. The electrode was at least 1cm away from the sides and bottom of the beaker. The temperature adjustment dial was adjusted accordingly; the pH meter was turned on and the pH of sample recorded.

Moisture Content

Moisture content was determined using the official method of analysis prescribed by (AOAC 1992).

A petri dish was washed and dried in the oven. 2g of the sample was weighed into the dish. The weight of the dish with the sample was noted before drying, the petri-dish and sample were put in the oven and heated at 105℃ for 2hours, petri-dish and sample was weighed again

and the result noted. Heating of the sample resumed followed by weighing every one hour till a constant weight of petri dish and sample was obtained.

Calculations

$$\% \text{ moisture content} = \frac{W1 - W2}{WEIGHT\ OF\ SAMPLE} \text{ X } 100$$

Where;

W1 = weight of petri-dish and sample before drying

W2 = weight of petri-dish and sample after drying

Ash Content

Ash content was determined using the official method of analysis prescribed by (AOAC, 1992).

A clean crucible was washed, dried and the weight was noted. 2g of sample was weighed into the crucible and placed in a muffle furnace at 550℃ for 3 hours. After burning, the sample was cooled in a desiccator and weighed.

Calculations

$$\% \text{ ash content} = \frac{W3 - W1}{W2 - W1} \text{ X } 100$$

Where;

W1 = weight of empty crucible

W2 = weight of crucible and sample before burning

W3 = weight of crucible and ash

Determination of Water Soluble and Alcohol Soluble Extractives

Water and alcohol extractives were determined using the official method of analysis prescribed by (AOAC,1992).

A clean 500ml boiling flask was dried in an oven at 105°C for about 30 minutes, transferred into a dessicator and allowed to cool. 10g of the sample was weighed into the flask, 100ml of ethanol was added to the flask and allowed to stand for 24hrs. After 24hrs the ethanol phase was transferred into another conical flask and evaporated to dryness and weighed. Same procedure was followed using distilled water for water extractives.

$$\% \text{ yield} = \frac{weight\ of\ extract}{Weight\ of\ sample}\ x\ 100$$

Phytochemcal Analysis

The three herbal drugs were subjected to chemical tests to determine the quantity of alkaloids, flavonoids, saponins, glycosides, tannins and terpenoids they contain.

Alkaloid Content

Alkaloid content was determined using the method described by Harbone (1973) and Obadoni and Ochuka, (2002).

Five grams (5g) of the sample was weighed into a 250mL beaker and 200mL of 20% acetic

acid in ethanol was added, mixture was covered and allowed to stand for 4 hours at 25^0C. After 4 hours, mixture was filtered with filter paper No. 42 and the filtrate was concentrated using a water bath (Memmert) to one quarter of the original volume. Concentrated ammonium hydroxide was added drop wise to the extract until the reaction was complete. The whole solution was allowed to settle and the precipitate was collected and washed with dilute NH_4OH (1% ammonia solution). Then, filtered with pre-weighed filter paper. The residue on the filter paper is the alkaloid, this is dried in the oven (precision electrothermal model BNP 9052 England) at 80^0C. The alkaloid content was calculated and expressed as a percentage of the weight of the sample analyzed (Harborne, 1993; Obadoni and Ochuka, 2002).

Calculation

$$\% \text{ weight of alkaloid} = \frac{\text{weight of filter paper with residue} - \text{weight of filter paper}}{\text{Weight of sample analyzed}} \times 100$$

Tannin Content

The Follins Dennis titrating method as described by Pearson (1974) was used to determine the tannin content.

20g of the sample was placed in a conical flask followed by 100mL of petroleum ether, they were covered for 24 hours. The mixture was then filtered and left to stand for 15 minutes allowing petroleum ether to evaporate. Sample was re-extracted by soaking in 100ml of 10% acetic acid in ethanol for 4hrs. The sample was then filtered and the filtrate collected.

25ml of NH_4OH was added to the filtrate to precipitate the Tannin followed by heating to remove some of the NH_4OH still in solution. The remaining volume was measured to be 33ml. 5ml of this was taken and 20ml of ethanol was added to it. It was titrated with 0.1M Na0H using phenolphthalein as indicator until end point is reached.

Tannin content was then calculated using $C_1V_1 = C_2V_2$.

Where, C_1 = concentration of tannic Acid, C_2 = concentration of base, V_1 = Volume of tannic acid and V_2= Volume of base.

Therefore, $C_1 = \frac{C2V2}{V1}$

$$\% \text{ of tannic acid content} = \frac{C1}{\text{Weight of sample analyzed}} \times 100$$

Saponin Content

Saponin content was determined according to the method described by Obadoni and Ochuko (2002). Exactly 5g of the sample was put into 20% acetic acid in ethanol and allowed to stand in a waterbath at 50^0C for 24hours. This was filtered and the extract was concentrated using a waterbath to one-quarter of the original volume. Concentrated NH_4OH was added drop-wise to the extract until precipitation was complete. The whole solution was allowed to settle and the precipitate was collected by filtration and weighed.

Calculation

$$\% \text{ saponin content} = \frac{(\text{weight of filter paper} + \text{residue}) - (\text{weight of filter paper})}{\text{Weight of sample analyzed}} \times 100$$

Flavonoid Content

Flavonoid content was determined according to the methods described by Boham and Kocipai, (1994). 10g of the plant sample was extracted repeatedly with 100ml of 80% aqueous methanol at room temperature. The whole solution was filtered through Whatman filter paper No. 42 (125mm). The filtrate was later transferred into a crucible and evaporated into dryness over a water bath and weighed to a constant weight.

Calculation

$$\% \text{ flavonoids} = \frac{(\text{weight of crucible + residue}) - (\text{weight of crucible})}{\text{Weight of sample analyzed}} \times 100$$

Cardiac Glycoside Content

Cardiac glycoside content was determined by the colorimetric method as described by Wang *et al* (2017). 1ml of 2% solution of 3,5-DNS (dinitro salicylic acid) in methanol and 1ml of 5% aqueous NaOH was added to 1ml of the sample. The mixture was boiled for 2 minutes, brick-red precipitate was observed and the boiled sample was filtered. The weight of the filter paper was taken before filtration. The filter paper with the absorbed residue was dried in an oven at 50^0C, weight of the filter paper with residue was noted.
The cardiac glycoside was calculated in %.
Calculation

$$\% \text{ Cardiac glycoside} = \frac{(\text{weight of filter paper + residue}) - (\text{weight of filter paper})}{\text{Weight of sample analyzed}} \times 100$$

Terpenoid Content

Terpenoid content was determined with the method by Okwu and Omodamiro (2005).
1.0g of the sample was weighed and mixed in 100ml of distilled water in a conical flask. The mixture was filtered and the filtrate eluted with 0.1N ammonium hydroxide solution. 2ml of the eluent was put in a test tube and mixed with 2ml of chloroform. 3ml of ice-cold acetic anhydride was added to the mixture in the flask. 2 drops of (200mg/dl) standard sterol solution was prepared and treated as described for test as blank. The absorbance of standard and test sample were measured zeroing the spectrophotometer with blank at 420nm.
Calculation

$$\text{Terpenoid(mg/100ml)} = \frac{\text{Absorbance of sample}}{\text{Absorbance of standard}} \text{ X concentration of standard}$$

Chemical Element and Metal Determinations
Heavy metal analysis was carried out using atomic absorption spectrophotometer (Agilent FS34OAA). The method described by APHA (1995), was used.

Results and Discussion
Physical Test
Organoleptic properties of the herbal drugs are shown below;

Table 1: Organoleptic properties of the herbal drug samples.

Sample	Consistency	Colour	Odour	Taste
A	watery	dark brown	None	bitter
B	Watery	dark brown	None	bitter
C	Watery	light brown	None	bitter

The results in table 1 above show that all three samples have similar organoleptic properties, they are all brown in colour, watery, very bitter and possess no odour. Organoleptic evaluation of herbal products by other researchers shows similar appearance and astringent or slightly bitter taste (Aziz *et al*, 2019). Consumer's acceptability of food and food products can be influenced by the physical appearance while taste particularly contributes to the overall enjoyment of a meal (Zuluaga, 2024). The watery and odourless property of the samples (A, B & C) can make them appealing to consumers, however their bitter taste can be a major sensory turn-off rendering them difficult to drink. Bitterness and astringency in herbal products are influenced by the presence of secondary metabolites such as alkaloids, flavonoids, glycosides, phenolic compounds etc. According to Zuluaga, 2024, bitter taste is produced

almost entirely by organic substances, therefore the observed bitterness in the three samples is as a result of the bitter plant materials including, neem, aloe vera, bitter leaf, bush buck etc. listed as part of the herbal formulations as shown in table 2 below.
Table 2: Composition of the herbal drug samples.

Kambest	**Goko Cleanser**	**Herbal Mixture**
Aloe Vera	Vernonia amygdalina	Aloe Barbadenis
Fennel Flower	Saccharum Officinarum	Xylopia Aethiopica
Zingiber Officinale	Allium sativum	Gongroneria Latifolium
Ginseng	Cajanus Cajan	Dichrostyschys cinerea
Moringa Oleifera leaves	Zingiber Officinale	Water
Liquified natural honey	Caramel	
Azadirachita Indica (Neem tree)	Water	
Rauwolfia Serpentia (Indian snake root)		

Some strategies during the cultivation, processing and post processing period can improve the sensory quality of herbal product; this includes agronomic practices like selection and breeding of cultivars, shade treatment, pruning, fertilization and enzymatic treatment, roasting or baking, oxidation as well as microbial fermentation methods of processing (Ye *et al*, 2022). Many traditional formulas also include sweeteners, seasonings and flavourings in minimal amounts as a way of balancing flavours and reducing bitter taste (Zuluaga, 2024). The therapeutic value of bitter phytochemicals have also been investigated with findings suggesting that they possess anti-inflammatory and anticancer effects (Gradinaru *et al*, 2023). They also facilitate digestion through stimulation of the gastrointestinal tracts (WHO, 2011).

Physicochemical Analysis
The results from the investigated physicochemical properties of **the herbal samples are shown below.**

Table 3: Physicochemical properties of the herbal drug samples

Sample	**pH**	**%moisture content**	**%ash content**	**%water extractive**	**% alcohol extractive**
A	4.09	84.817	1.490	31.643	21.848
B	3.65	84.787	1.246	30.124	22.654
C	4.00	13.719	1.746	33.496	20.699

pH
The three herbal drugs were found to be acidic with pH between 3.65 and 4.09. Previous studies have shown that most herbal products are acidic. In a study by Ubbor *et al*, 2022, herbal teas produced from moringa leaves and lemon peels were found to possess pH between 4.36 and 6.07 while Aziz *et al*, 2019 reported a pH of 6 for aqueous solution of polyherbal powder. Also, 17 herbal decoctions analysed in Ghana by Kumadoh *et al*, 2024 had pH between 3.507 and 6.755. The pH of drug formulations typically shows how acidic or alkaline a drug is, pH can affect certain characteristics of drugs such as its viscocity, absorption, solubility, stability, quality, chemical reactions, microbiological and pharmacological activities. According to Kumadoh *et al*, 2024, lower pH in herbal preparations results in lower bacterial contamination while higher pH encourages bacterial growth; additionally, high pH level reduces antioxidant character of plant extracts (Bayliak *et al*, 2016). Therefore, the acidic pH recorded for the three

samples is an indication of good quality.

However, pH below 5.5 can lead to dental erosion hence manufacturers are advised to include instructions for consumers to dilute such products before drinking or to rinse their mouths afterwards to prevent tooth problems (Kumadoh *et al*, 2024).

Ash and Moisture Content

Ash content and moisture content values can be used to access various characteristics of food products including, texture, nutritional value, taste, storage and overall quality.

Ash content obtained for the three herbal drinks are, 1.490, 1.246 and 1.746 respectively. These values are lower than 3.45- 7.65% obtained by Gois *et al*, 2023 for complex herbal mixtures and 7.3% reported by Ubbor *et al*, 2022 for herbal teas produced with moringa leaves and lemon peels. Inorganic matter present in a substance make up its ash value, ash content particularly shows the extent to which food is processed. Natural foods have lower ash content as opposed to more processed ones. The lower ash value obtained for the three herbal drugs indicates that they are free from foreign matter.

Moisture content is the chemical property that indicates storage stability, it is very essential especially in the processing of solid herbs and spices, in order to prevent chemical, microbial and all forms of degradation.

Moisture content obtained for herbal samples A and B were very close, 84.82% and 84.79 % respectively while 13.72% obtained for sample C differed substantially. The high moisture content of samples A and B may be due to the nature of the plant materials in the drugs. These values agree with the findings of Builders *et al*, 2020 who discovered the moisture content for fresh ginger and *moringa orifera* as up to 89% and 86% respectively. Sample A contains 10% ginger and 20% moringa leaves in its formulation while sample B contains 0.5% ginger. Sample C on the other hand contains neither ginger nor moringa. High moisture content facilitates drug decomposition, bacterial and fungal growth and hydrolysis of the drug contents. Such drugs like Samples A and B which are more susceptible to moisture induced degradation require proper packaging and storage conditions. Additionally, they must be discarded if signs of degradation are observed.

Water and Alcohol Soluble Extractives

Extractive value is a measure of the number of active components in a given quantity of medicinal plant material. It is basically used to determine adulteration or exhaustion of drugs (Chaudhari and Girase, 2015). The water extractive matter obtained for the herbal drinks were 31.643, 30.124 and 33.496 for A, B and C respectively. These values are much higher than the 17% obtained by Builders *et al*, 2020 and 12.4 - 14.8% reported by Singh *et al*, 2011 for water soluble extractives using leaves of *Ficus Benghalensis*. However, a study by Gois *et al*, 2023 on complex herbal mixtures containing between 5-30 herbs also showed high value for water soluble extractives (20.13 - 42.91 %).

Similarly, high values of alchohol extractives were obtained for the three herbal drugs (21.848, 22.654 and 20.699 for samples A, B and C respectively). A study by Chaudhari and Girase, 2015 reported 10.16% alcohol soluble extractive for a medicinal plant (*Sesbania sesban (L.) Merrill*) while Adegbolagun *et al*. (2021) reported that the alcohol extractive values for eight polyherbal products ranged from 8.40 to 47.50.

All three herbal samples analysed in this research were made from 4 to 9 different medicinal herbs, this may have contributed to the high soluble extractive matter obtained.

Phytochemical Determination

The quantity of the phytochemical compounds found in the drug samples are presented in fig 1.

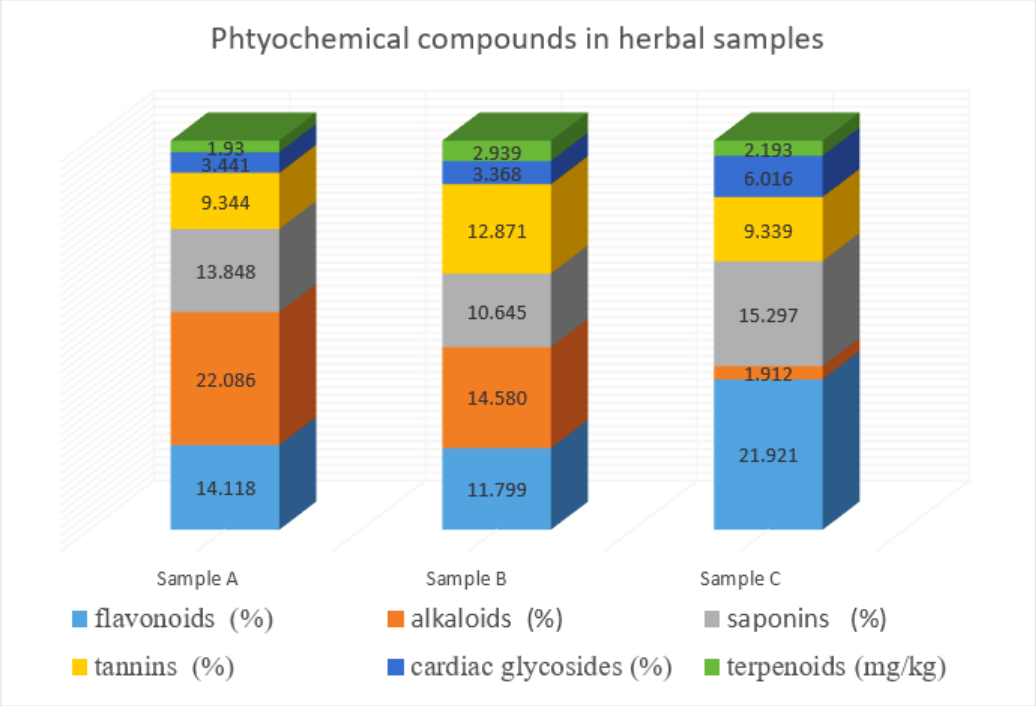

Figure 1. Phytochemical compounds in herbal drug samples.

The results clearly shows that the herbal samples contain flavonoids, alkaloids, saponins, tannins, cardiac glycosides and terpenoids in varying amounts. The presence of these phytochemicals in the herbal drinks is expected given the claims that they have been produced from plant materials. This is consistent with the findings of other researchers (Zhang *et al*., 2024, Gois *et al*., 2023 and Ubbor *et al*., 2022) who found several phytochemical compounds in herbal products. The variations observed in the phytochemical content of these herbal drinks could be due to the different plants and plant parts used in the formulations. Methods of preparation and processing of herbal drinks may also affect its levels of bioactive compounds (Shaik *et al*, 2023). This explains why a particular herbal drug made from different medicinal plants may offer a combination of diverse pharmacological benefits such as antioxidative, anti-inflammatory, antifungal and antimicrobial, antibacterial, anti-diabetic, anticancer and antitumor activities, wound healing properties and effects on the cardiovascular system.

For both samples A and B, alkaloids were the most predominant bioactive compound (22.086% and 14.580%) respectively, in contrast, the same alkaloid was the least phytochemical observed for sample C (1.912%). Flavonoids were rather the most predominant phytochemical found in sample C (21.921 mg/g). Research on phytochemical profile of complex herbal mixtures by Gois *et al*, 2023 confirmed the presence of flavonoids (24.89 - 56.25 mg/g) as well as total phenolics (88.06 to 185.28 mg/g) in herbal products. Zhang *et al*, 2024 in their evaluation of the phytochemical profile of four herbal teas also reported the presence of flavonoids and phenols. More investigations could reveal many other phytochemicals present in theses herbal samples.

Phytochemical composition of herbal materials gives information on their potential therapeutic effects on human health (Zhang *et al*, 2024). Their absence in herbal products is an indication

of adulteration or fraud. Flavonoids and phenolic compounds have bioactive potentials, their antioxidative potentials have been linked to prevention or reduction of the risk of chronic diseases. (Zhang *et al*, 2024, Gois *et al*, 2023). A previous study of the aqueous solution of polyherbal powder, confirmed the presence of glycosides, flavonoids and tannins, all of which are effective in controlling blood glucose level (Aziz *et al*, 2019).

Table 4: Chemical Elements and Metal content of the herbal drug samples

Metals	**Sample A (ppm)**	**Sample B (ppm)**	**Sample C (ppm)**	**Standard Limit (ppm) (WHO,2007)**
Lead	0.1385	0.00	0.00	10
Nickel	0.022	0.8600	0.0295	
Iron	1.3981	0.7998	1.4411	
Arsenic	0.020	0.018	0.067	5
Mercury	0.092	0.025	0.018	0.5
Copper	3.2548	0.0972	0.00	20
Cobalt	0.093	0.082	0.043	
Zinc	0.322	0.319	0.646	50
Potassium	5.056	7.095	7.085	
Sodium	7.045	10.078	9.078	
Calcium	6.422	7.945	8.945	
Magnesium	7.189	8.078	9.067	

The results show that the herbal drugs contain several chemical elements including; essential macro-minerals (K, Na, Ca and Mg), trace minerals (Fe, Cu, Co, and Zn) and heavy metals (Pb, Ni, As and Hg,). Pb was not detected in samples B and C while Cu was not detected in sample C. Notably, the detected heavy metals were found in minute concentrations and were all below the WHO limits, their occurrence in the drug samples were in the order; Pb > Hg > Ni> As in Sample A; Ni > Hg > As in sample B and As> Ni> Hg in sample C. Previous studies on herbal products in Nigeria also reported small amounts of heavy metals in herbal materials. Among the 10 medicinal drinks assessed by Bolawa *et al*, 2020, only four drinks contained Pb while nine contained Ni, a similar study by Onyeaghala *et al*, 2015 reported presence of Pb in herbal preparations marketed in Nigeria. These researchers however noted that the heavy metals were within the WHO permissible limits. Contamination of herbal materials with toxic substances can be attributed to many causes. These include environmental pollution from multiple sources such as, contaminated emissions and effluents from industries and homes, gaseous emissions from automobiles which pollutes the soil and water with which these plants are grown. Metal contamination in herbal products can also result from packaging materials, harmful agro-cultures including use of some pesticides, and fertilizers.

Each of the macro-minerals and trace elements found in these drugs play important roles that contributes to proper functioning of the body and general wellness. Their occurrence in the herbal products depends on the plant species used for drug formulation, mineral composition of the soil on which the plants are grown, method of extraction among other things (Kilic and Soylak, 2020). Previous studies by Onyeaghala *et al*, 2015 also found trace elements Fe, Zn and Cu in herbal preparations, with the Fe and Zn occurring in concentrations above WHO/EPA levels. Similarly, a study by Cifcti *et al*, 2020 reported the presence of essential minerals (Cr, Al, Zn, Fe, Mn and Cu) as well as heavy metals (Pb and Ni) in some medicinal plants.

Conclusion

Herbal products have been in use for ages for the prevention and management of illnesses. They are fast becoming a reliable alternative to conventional drugs across the globe. Herbal drugs have the potential to be commercialised and consumed by the general public due to its health benefits. The Herbal drugs investigated in this study were found to contain various phytochemicals that may help in reducing the risk of diseases. Their excellent physicochemical properties discovered in this study including low ash value, low pH, high water and alcohol soluble extractives show that the investigated herbal drugs are of good quality. High moisture content observed for two of the three drug samples require proper handling and storage, consumers are therefore advised to purchase drugs whose manufacturing dates are more recent and avoid prolonged storage. Furthermore, each of the three herbal drugs used for this study were formulated from a mixture of 4 to 9 medicinal plants, this gave rise to the many phytochemical compounds observed.

Most information on safety and effectiveness of herbal products lack scientific data. It is therefore important for scientists to investigate the composition, dosage, drug indications, pharmacology, contraindications, and possible adverse effects of herbal medicines. Clinical studies on the quality, safety, storage, and pharmacological properties of herbal drugs are necessary, in order to ascertain the safety of these drugs. Caution should be taken in the formulation of herbal medicines to ensure that targeted health benefits of the drugs are met and at the same time prevent excessive dominance of bio-active compounds or elements in amounts higher than is recommended by the appropriate regulatory authority. Consumer feedback on the benefits and side effects of herbal product is also important. Regulation and standardization of traditional medicine practice is essential in Nigeria to prevent cases of adulteration, contamination, abuse and counterfeits. Strict compliance to standard practice in manufacturing of herbal drugs in addition to enforcement of the established herbal medicines guidelines by the National Agency for Food and Drugs Administration and Control (NAFDAC) are also recommended.

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