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Elemental profiles of herbal plants commonly used for cancer therapy in Ogun State, Nigeria. Part I

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ABSTRACT

The concentrations of 51 elements in 32 herbal plants belonging to 22 botanical families commonly used as recipe for cancer treatment in Abeokuta, Ogun State, Nigeria were determined using inductively coupled plasma mass spectrometry (ICPMS). A closed vessel nitric acid microwave assisted digestion method, using an UltraCLAVE III was employed for the digestion of the plants. The accuracy of the results was checked by using certified reference materials: peach leaves (NBS CRM 1547), pine needles (NBS CRM 1575) and trace elements in water (NIST SRM 1643e). The results obtained for these reference materials showed good agreement with the certified concentrations. Elemental composition in the analyzed plant samples varied widely. The highest concentrations of the minerals Ca (67.4 mg g^{-1}), K (55 mg g^{-1}), Na (5.59 mg g^{-1}), Mg (8.99 mg g^{-1}) and P (5.89 mg g^{-1}) were found in *Terminalia avicennioides*, *Nicotina tabacum*, *Pyrenacantha staudii*, *Chenopodium ambrosioides* and *N. tabacum* respectively. Cd, Co, Fe Pb, Hg, Ni and Zn exceeded the FAO/WHO limits in some herbal plants. Estimated infusion concentrations for mineral and essential trace elements showed that some of the plants may be present in the 50th percentile of the FAO/WHO limit. Rare earth elements concentration ranged from <0.04 μg g^{-1} for Ho in some of the plants to 24.1 μg g^{-1} for Ce in *P. staudii*. The variation in some essential but toxic elements in *Pistia stratiotes*, *P. staudii*, *Parquetina nigrescens*, *N. tabacum* and *C. ambrosioides* calls for further investigation of these plants.

1. Introduction

Herbal plants are very popular in Africa. They are cheap and readily available for the treatment of several ailments. They are relatively low-cost alternative therapy which is widely used in place of conventional/orthodox medicine, thus playing an important role in the general state of human health with 70–80% of the developing nation's population relying on it as source of primary healthcare [1–6]. They are generally believed not to have any side effects in the time past. However, recent toxicological studies have shown their pungency on health [2,7–9]. It should be stated that sources of most of these herbal plants are generally unknown to consumers in urban centers.

Due to continued urbanization and industrialization in many countries especially in the developing nations, trace and toxic metals are often released into the environment through a number of anthropogenic sources such as erosion, undersurface weathering, industrial emission, improper waste and sewage disposal; metal plating facilities, mining, tanneries, agricultural activities, and vehicular emissions among others [10–12]. Trace metals are known to play a key role in the production of active chemical constituents present in herbal plants and consequently responsible for their medicinal and toxic effects [13,14]. Herbal plants can take up trace and toxic metals, ingestion of which by human could pose serious health effects such as injury to the kidneys, renal failure and liver damage in the subject [6,15].

The number of Nigerians living with cancer and cancer related diseases is increasing in recent years with about 100,000 new cases reported annually [16,17]. Majorities of the affected subjects were basically from the lower economic class of the society, with little or no education, and lived at subsistence level [18]. Thus, most of them depend on recipes given by traditional healers which are often prepared from different herbal plants due to their inability to afford treatment through the conventional healthcare. Ezeome and Anarado [16] showed in their study that about 52% of cancer patients in Nigeria prefer to use herbs (21% reported unwanted side effects). However, the reasons for reported side effects are largely unknown.

Ethnobotanical studies in Nigeria have reported over 80 different herbal plants that are commonly used as recipe for cancer and other ailments [19–21]. Preparation of herbal plants for human consumption in the Nigerian context is often different from methods reported in literatures for infusion studies [3,22]. Herbal plants are usually selected in different ratios and cooked with clean water and or sometimes with pap

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water gotten from pap preparation [23]. They are cooked for an average of 45 to 90 minutes or even more. To prevent the growth of microorganisms and keep the prepared herbs from spoiling; they are usually rewarmed every morning for about 30 minutes before consumption.

Notwithstanding, no previous work had extensively reported on mineral and essential elements, rare earth elements and toxic metals in Nigerian herbal plants commonly used as recipe for cancer treatment and other diseases. When studies were conducted, fewer plants were usually taken into considerations which do not reflect the true status of the Nigerian herbal plants used for treating various diseases [24–26]. The objectives of our work are to assess the content of mineral and essential elements, rare earth elements and toxic metals and evaluate if the elements may be released from commonly used herbal plants for cancer treatment in Abeokuta, Ogun State.

2. Material and methods

2.1. Reagents and chemicals

Milli-Q water (18.2 MΩ cm, Millipore, Bedford, USA) was used throughout all experiments. All other reagents used were of analytical reagent grade. Nitric acid (65%, Merck, Darmstadt, Germany) was submitted to a quartz sub-boiling distillation apparatus (MLS, Leutkirch, Germany). Trace elements mixed standards were obtained from Merck,(Merck, Darmstadt, Germany). Rare earth elements mix standard and Sn were purchased from CPI, USA, while Na, Ca, Sb, Hg, K, P and Mg were purchased from Roth, Germany. Working and calibration standards were prepared daily by proper dilution from 10.0 mg L^{-1} mix trace and rare earth elements; 10,000 mg L^{-1} of Ca, Mg and P and 1000 mg L^{-1} of Na and K in 10% nitric acid. The calibration curves were constructed in the range of 0.01–100 μg L^{-1} for rare earth and trace metals while the curves for Na, Ca, Mg, K and P are in the range of 0.10–10.0 mg L^{-1}.

2.2. Instrumentation

Digestions were performed with a microwave autoclave digestion system (UltraCLAVE III™, MLS, Leutkirch, Germany). Measurements were carried out with an Agilent 7500ce ICPMS (Agilent Technologies, Waldbronn, Germany).

2.3. Sampling and sample preparation

Thirty two (32) different herbal plants (Table 1) were purchased from herbal vendors at the popular herbal market, Itoku, Abeokuta the Ogun State, Nigeria. Samples were purchased following the ethnobotanical study of Soladoye et al. [19] for medicinal plants used in cancer treatment. The plant samples obtained from the vendors consist of leaves, barks, fruit, seeds and roots. Samples were transported to the laboratory, after initial identification by the vendors. The samples were further identified by botanists from the Departments of Botany and Forestry and Wildlife Management, Federal University of Agriculture, Abeokuta, Nigeria. All samples were washed with distilled water and oven dried at 60 °C for 24 hours. The samples were grinded using mortar and pestle and transferred into a Ziploc® bag, and stored for analysis.

2.4. Samples digestion

Approximately 250 mg (weighed to 0.1 mg) of the dried plant sample or the reference material (Pine Needles NBS SRM 1575 and Peach Leave NBS SRM 1547 purchased from NIST, Gaithersburg, USA) was weighed into 12 mL quartz vessels and 5 mL concentrated nitric acid (65%) was added for the acid digestion with the autoclave system. The quartz vessels were then closed with Teflon® caps and placed in the sample rack. The samples were digested with the autoclave according to the following program. The digestion program including the cooling time was 150 minutes with the temperature ramped from 25 °C to

Table 1
Herbal plants investigated for trace element.

Family name	Botanical name	Local name	Plant part used	Sample code
Anacardiaceae	*Lannea egregia* (*Hiern*) Engl.	Ekundan	Leaves	BK 4
Apocynaceae	*Alafia barteri* Baker	Agbari-etu	Leaves	PLT 5
Araceae	*Pistia stratiotes* Linn	Oju oro	Leaves	PLT 6
Araceae	*Culcasia scandens* P. Beauv	Agumona	Leaves	LV 1
Asclepiadaceae	*Calotropis procera* R.B.	Bomubomu	Leaves	LV 3
Bignoniaceae	*Kigelia africana* Benth	Pandoro	Leaves	LV 4
Chenopodiaceae	*Chenopodium ambrosioides* Linn	Arunpale	Leaves	LV 5
Euphorbiaceae	*Securinega virosa* (Roxb) Bail.	Iranje	Leaves	LV 2
Icacinaceae	*Pyrenacantha staudii* Engl.	Arukuna	Leaves	PLT 8
Nympheaceae	*Nymphaea lotus* Linn	Ewe osibata	Leaves	PLT 4
Periplocaceae	*Parquetina nigrescens* (Afzel) Bullock	Oogbo	Leaves	PLT 11
Rubiaceae	*Coffea bracteolate* L.	Poropiwo	Leaves	PLT 12
Solanceae	*Nicotina tabacum* Linn	Tabajuku	Leaves	PLT13
Annonaceae	*Uvaria chamae* P. 8Beauv	Eruju	Bark	BK 1
Apocynaceae	*Alstonia congensis* De wild	Awun	Bark	BK 5
Bignoniaceae	*Spathodea companulat* P. beauv	Orudu	Bark	PLT 3
Bignoniaceae	*Kigelia africana* Benth	Pandoro	Bark	BK 3
Combretaceae	*Terminalia avicennioides* Gull et Perr	Idin	Bark	BK 2
Euphorbiaceae	*Bridelia ferruginea* (Benth)	Ira	Bark	PLT 2
Guttiferae	*Psorospermum febrifugum* Spach	Legun-oko	Bark	PLT 1
Hyperiaceae	*Harungana madagascarensis* Lan. ex poir	Aroje	Bark	BK 6
Palmae	*Elaeis guineensis* (Jacq)	Ope	Bark	PLT 9
Piperaceae	*Piper guineense* Schum and Thonn	Iyere	Seed	PLT 15
Zingiberaceae	*Aframomum melegueta* (Loskoe) K. Schum	Atare	Seed	PLT 10
Solanaceae	*Capsicum frutescens* (Benth)	Ata ijosi	Fruit	PLT 14
Annonaceae	*Uvaria chamae* P. Beauv	Eruju	Root	RT 2
Annonaceae	*Uvaria afzelii* Elliot	Gbogbonse	Root	RT 3
Celastraceae	*Celastrus indica* L	Ponju owiwi	Root	RT 5
Crassulaceae	*Bryophyllum pinanatum* (Lam) Oken	Abamoda	Root	RT 6
Guttiferae	*Garcinia kola* Heckel	Orogbo	Root	RT 4
Phytolacaceae	*Petiveria alliacea* Linn	Awogba	Root	PLT 7
Rutaceae	*Citrus aurantium* Linn	Ijaganyin	Root	RT 1