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Determination of the Concentration of Potassium in *Lippia Multiflora* and *Bridelia Ferruginea* for the Treatment of High Blood Pressure (Hypertension)

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ABSTRACT

Concentration of Potassium together with three other major essential elements in two medicinal plants used for the treatment of hypertension at the Center of Scientific Research into Plant Medicine (CSRPM), Mampong-Akuapem, Ghana, were determined by instrumental neutron activation analysis (INAA). The medicinal plants were *Lippia multiflora* and *Bridelia ferruginea*. Concentrations of Potassium (K) together with Magnesium (Mg), Chlorine (Cl) and Sodium (Na) were determined by short and medium irradiation at the Ghana Research Reactor-1 under an average neutron flux density of 5.0×10^{11}ncm^{-2}s^{-1}. The elemental concentrations in mg/kg for each case of the medicinal plant samples varied as K > Mg > Cl > Na with *Lippia multiflora* the highest in each case except for Na as compared to *Bridelia ferruginea*. Na was found to be about 0.9% of K for *Lippia multiflora* and about 2.3% of K for *Bridelia ferruginea*. The variation in the concentration of these elements is due to factors such as the botanical structure and preferential root uptake for such elements which is also influenced by the age of the plant as well as the mineral composition of the soil in which the plant grows, use of fertilizers, irrigation water, ambient and climate conditions. The accuracy of the method was validated by analyzing the standard reference material NIST RM 1547 (Peach leaves) for which most of the elements were within ±10% of the reported values.

Keywords: *Potassium, INAA, Medicinal Plants, Hypertension*

1. INTRODUCTION

There are seven (7) major inorganic elements or minerals namely Sodium (Na), Potassium (K), Magnesium (Mg), Calcium (Ca), Phosphorus (P), Sulfur (S) and Chlorine (Cl) present in the human body that are essential to human life. Na, Cl, and K are largely responsible for maintaining the fluid balance in the body which is vital for all life processes. Na^+ and Cl^- regulated fluid balance in the extracellular fluid (outside the cell) while K in the intracellular fluid (inside the cell). Tight control of these balances is critical for normal muscle contraction, nerve impulse transmission, heart function, and blood pressure [1]. K is the key electrolyte for maintaining basic cardiovascular functions and hence helps keep an ideal blood pressure and heart beat rhythm. That is, the human body's control system of blood pressure and volume is dependent on the concentration of potassium in the body.

Potassium is widely distributed in nature and is present in all plant and animal tissues. In human diet, it is readily absorbed upon ingestion, moving quickly from the gastrointestinal tract to the bloodstream then to the muscles including the muscles of the heart. Although K is required in hundreds of milligrams per day, its concentration in humans is under homeostatic control (that is, the amount retained is actively regulated by the body to achieve the normal range required for body system functions) which is not influenced by variations in environmental levels [2, 3]. Hence, ideally, K content in the body is constant for different persons. However, an abnormality due to aging or in diet in the control of the ideal concentration resulting in low concentration of K in a persons' body system presents a general potential for high blood pressure (Hypertension) [3]. Hypertension can also be caused by underlying conditions or factors such as kidney disease or excessive alcohol (secondary hypertension), or in the case of primary hypertension, a specific cause cannot be found and this accounts for around 90% of cases. It affects approximately 25% of the adult population in developed countries with 34% and 36% of adult Americans have hypertension and pre-hypertension (blood pressure numbers that are higher than normal, but not yet in the hypertension range) respectively [4, 5].

Leaves of *Lippia multiflora and Bridelia ferruginea* are medicinal plants that are commonly used in Ghana for treatment of high blood pressure and diabetes respectively by the Centre for Scientific Research into Plant Medicine, Akwapem in the Eastern region [6, 7]. *Lippia multiflora* and *Bridelia ferruginea* belongs to the family of Verbenaceae and Euphorbiaceae respectively.

Tettey-Larbi et al. (2013) recorded high activity concentration of Potassium-40 in *Lippia multiflora* and *Bridelia ferruginea* and stated that these medicinal plants can significantly aid the therapeutic purposes for treatment of hypertension, since hypertensive patients have low concentration of Potassium in their blood stream and also since all diabetic patients are hypertensive [6]. Since Potassium-40 is about 0.012% of naturally occurring Potassium, high activity concentration of radioactive K-40 correlate a high concentration of stable K.

Since high Potassium intakes or supplements have been associated with treatment of hypertension and lower risk of stroke particularly in hypertensive patients, this work mainly seek to determine the concentration of K in *Lippia multiflora and Bridelia ferruginea* to determine the efficacy of these medicinal plants in treating hypertension. Concentration of Mg was also

determined as research suggests a preventive role in hypertension and cardiovascular disease, as well as a beneficial effect in the treatment of diabetes, osteoporosis, and migraine headaches [1]. Sodium and Chlorine were also determined since they have negative correlation with Potassium and Magnesium and are required in lower concentrations in the treatment of hypertension. Although direct linkage between elemental content and its curative capability is yet to be established, however, the data on these major elements is of great importance to understand the pharmacological actions of these medicinal plants in the treatment of High blood pressure.

2. EXPERIMENTAL

Sample Preparations

Leaves of *Lippia multiflora and Bridelia ferruginea* were harvested into labeled polyethylene bags from the Centre for Scientific Research into Plant medicine to the laboratory between the month of October and December, marking the end of the raining season and the beginning of the dry season which allows for fresh sampling and a good weather condition for drying the samples. At the GHARR-1 NAA laboratory, distilled water was run on the leaves to dissociate sediment particles from the leave should there have been any at all. The leaves were then open air dried on trays for a period of one week and then oven dried at a temperature of 105 ^{o}C (± 5 ^{o}C) for 2 to 4 hours at the laboratory. The oven dried samples were then grounded into powdered form with a stainless steel ball grinder. The powdered leave samples were then separately weighed (200 mg each) 6 replicate each and wrapped in a transparent polyethylene film recipient. The samples were further encapsulated into irradiation capsules and heat sealed for neutron activation (irradiation).

Sample Activation and Quantitative Analysis

The samples together with sample control Standard Reference Material (SRM) 1547, *Peach Leaves* and internal Quality Control material (104IPE2) obtained through participation in Wageningen Evaluation Program for Analytical Laboratories (WEPAL)'s International Plant-Analytical Exchange (IPE)] were irradiated in the Ghana Research Reactor-1 under an average neutron flux density of 5.0×10^{11}ncm^{-2}s^{-1}. Table 1 presents the nuclear data and irradiation scheme used for the elemental determination in this work. An irradiation time of 5 minutes were applied for the determination of short-lived radionuclide (element) and 6 hours for the determination of medium-live radionuclide.

Table 1: Nuclear data and irradiation scheme used for the elemental analysis [8]

Target isotope	Target (Reaction) radionuclide	Gamma Energy (keV)	Half Life	Irradiation Category
K	^{41}K (n, γ)^{42}K	1524.58	12h	Medium-lived
Mg	^{26}Mg (n, γ)^{27}Mg	1014.4	9.46m	Short-lived
Na	^{23}Na (n, γ)^{24}Na	1368.6 / 2754.1	15h	Medium-lived
Cl	^{37}Cl (n, γ)^{38}Cl	1642	37.2m	Short-lived

Radioactivity measurement of induced radionuclide(s) were performed by a PC-based γ-ray spectrometry set-up. It consisted of an N-type High purity Germanium detector (HpGe-coaxial type) coupled to a computer based multi-channel analyzer (MCA) via electronic modules. The relative efficiency of the detector is 40%. It energy resolution is 1.8keV at a γ-ray energy of 1332keV of ^{60}Co. The data acquisition and identification of γ-rays of product radionuclide were identified by their γ-ray energies via *ORTEC MAESTRO-32*.

Gamma spectrum evaluation and quantitative analysis of each sample and control were done by a multipurpose γ-ray spectrum analysis software; WinSPAN-2010 version 2.10 which works on the basis of relative comparator methodology. Standard reference materials were use concurrently as comparator reference standard and control.

3. RESULT AND DISCUSSION

A total of four (4) elements namely, K, Mg, Na, Cl were detected in the leaves of *Lippia multiflora and*

Bridelia ferruginea. The mean elemental concentrations with their corresponding standard deviations are given in Tables 2. The precision was calculated as a mean deviation of four measurements.

Table 2: Mineral composition of *Lippia multiflora* and *Bridelia ferruginea*

Elements	Concentration mg/kg	
	Lippia multiflora	***Bridelia ferruginea***
K	13860±401.94	9297±288.207
Mg	6662±199.86	3345±177.285
Na	125±4.125	217.1±6.2959
Cl	3813±99.138	2338±65.464

The accuracy of the method was validated by analyzing the standard reference material NIST RM 1547 (Peach leaves) for which most of the elements in it were within ±10% of the reported values (Table 3). Table 3 also compares the accuracy of the reported values of the elements understudy in the standard reference material NIST RM 1547 (Peach leaves) and internal quality control material 104IPE2 with those obtained in this work while figure 1 shows the QC/QA-Standard ratio and z-score distributions for NIST RMS 1547 (*Peach leaves*) and in-house reference material (*104IPE2*). Our values agree very well with the reported values within the limits of experimental errors.

Table 3: Quality control results for NIST RM 1547 (Peach leaves) and internal quality control material 104IPE2

Control material	**Peach Leaves NIST SRM 1547**		**104IPE2**		
Elements	This Work	Certificate	This Work	NDA	NDA ST.Dev
K	30000 ± 2940	24300 ± 300	11590 ± 1510	10490	590
Mg	3818 ± 636	4320 ± 80	3445 ± 544	2602	150
Na	42.07 ± 10.52	24 ± 2	51.78 ± 9.48	42.15	16.7
Cl	365.52 ± 37.65	360 ± 19	177 ± 28.7	270.3	176

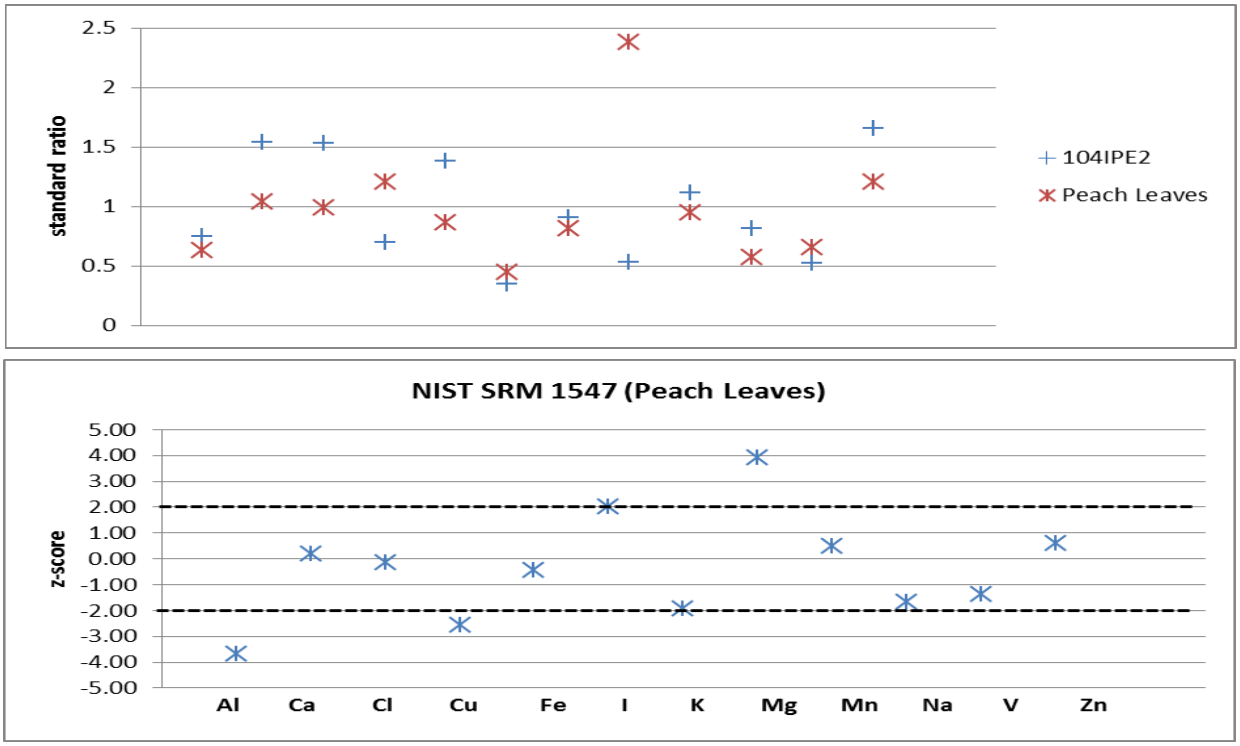

Figure 1 QC/QA-Standard ratio and z-score distributions for NIST RMS 1547 (*Peach leaves*) and in-house reference material (*104IPE2*)

From the results recorded in Table 2, for each case of the medicinal plant samples, the elemental concentrations in mg/kg varied as K > Mg > Cl > Na with *Lippia multiflora* recording the highest concentrations in each case except for Na as compared to *Bridelia ferruginea*. *Lippia multiflora* recorded the highest concentration in K in this study as in Tettey-Larbi et al., 2013 as compare to *Bridelia ferruginea*. The result also show the negative correlations between K with Cl and Na. This was more evident with Na. Na was found to be about 0.9% of K for *Lippia multiflora* and about 2.3% of K for *Bridelia ferruginea*.

The variation in the concentration of these elements within these two medicinal plants is due to factors such as the botanical structure and preferential root uptake for such elements which is also influenced by the age of the plant. Other factors responsible for the variation in elemental concentration includes the mineral composition of the soil in which the plant grows, use of fertilizers, irrigation water as well as its ambient and climate conditions.

K being the key electrolyte for maintaining basic cardiovascular functions and hence helps keep an ideal blood pressure and heart beat rhythm while Mg is involved in heart muscle contraction and relaxation and proper nerve functioning [3, 9], the high concentration of K and Mg recorded in these medicinal plants will go a long way to boost the levels of K and Mg in hypertensive and diabetic patients (since all diabetic patients are hypertensive but not all hypertensive patients are diabetic). Also these plants can serve as plant elemental base supplements for patients with high blood pressure since K and Mg under normal conditions is required in hundreds of milligrams per day in the body. The negative correlation between K and Na is a positive indication of these plants in the treatment of high blood pressure since blood pressure is reduces when K and Na are taken simultaneously under such concentrations [9].

4. CONCLUSION

The elemental concentrations recorded in mg/kg obtained in this study varied as K > Mg > Cl > Na with *Lippia multiflora* recording the highest concentrations in each case except for Na as compared to *Bridelia ferruginea*. The results obtained from this study can be used to evaluate the potential of *Lippia multiflora* and *Bridelia ferruginea* in their therapeutic purposes for the treatment of high blood pressure and diabetes.

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