Full Length Research Paper

Elemental contents of some medicinal plants using energy dispersive x-ray fluorescence (EDXRF)

Alfred Djoman Djama ABO, Aka Joseph N'GOUAN and Georges Alain MONNEHAN

Laboratory of Physics, Faculty of Sciences of Structure of Matter and Technology, University Felix Houphouet-Boigny of Cocody, Abidjan, Côte d'Ivoire.

Received 18 December, 2019; Accepted 6 April, 2020

The presence of some elements in ten plants with anti-microbial potency was analysed using x-ray fluorescence technique. The results showed there were nineteen elements in these plants. They all contain Pb, a toxic heavy metal, except one that contains As. K, S, Ca, Fe, Zn, Cu, Co, Ni, Mn and Se elements were identified and their anti-microbial properties were discussed.

Key words: Energy dispersive x-ray fluorescence, anti-microbial plants, heavy metals, Côte d'Ivoire.

INTRODUCTION

In Africa, microbial diseases like tetanus, whooping cough, diarrhea, cholera and AIDS affect both rural and urban dwellers. This can be attributed to several factors such as high cost of modern medication and inability of rural population to access modern medicines as they are sold in hospitals that are far away from them. In Côte d'Ivoire, just like most Third world countries, rural people use medicinal plants to treat diseases (Kamanzi et al., 2002). Medicinal plants are the main sources of traditional medicine for the rural population and are used for their therapeutic properties because they are known to have many essential and nutritional elements (Djama et al., 2011).

A study was done in Côte d'Ivoire mainly to identify plants used for pharmacological preparations and their properties frequently used in traditional medicine; the elemental composition of the plants in relation to their use was also studied. The study focused on the plants used in the treatment of microbial diseases which the population of Côte d'Ivoire is exposed to. Plants were selected for their therapeutic uses for various illnesses (Aké-Assi, 2001). The aim of the present study is to investigate the elemental contents in plants and review their therapeutic properties. The work also aims to evaluate the level of toxic elements present in medicinal plant samples (Djama et al., 2012). Ten medicinal plants were studied to determine their elemental contents. These are: Abrus precatorius (Subhan and Jubilee, 2006), Cassia alata (Khan et al., 2001), Justicia secunda (John et al., 2006), Manotes longiflora (Kablan et al., 2008), Ocimum merricamum (Clarkson et al., 2004), Ocimum gratissimum (Pousset, 2004), Phyllanthus amarus (Hanumanthachar and Milind, 2007), Psidium guajava (Pousset, 2004), Solenoste monmonostachyus (Adjanohoun and Aké-Assi, 1979) and Blighia unijugata (Oderinde et al., 2009).

MATERIALS AND METHODS

The plants were collected from July 2007 to July 2008 at AGBAN-Bingerville, a village in Côte d'Ivoire (Figure 1). Previous studies show that these plants were used in traditional medicine for their...
antimicrobial properties. The parts of the plants used were leaves, and stems barks. Ten plants (Table 1) were used for the study. They were cleaned with distilled water to avoid contamination, and dried at ambient laboratory temperatures in the range of 20 to 30°C. They were grinded into fine powder to make pellets. Irradiation was done using an energy dispersive X-Ray fluorescence spectrometer. Tube excited X-Ray photons from a Mo-anode in a Mo secondary target excitation were used. The tube was operated at 45 kV/5 mA. A 30 mm² active area Si (Li) detector with an energy resolution (FWHM ) of 165 eV at 5.9 keV Mn Kα was used to detect the characteristics of the photons; it was placed on the sample surface area at 45°. An ortec maestro Multichannel analyser programme was employed for the data collection (peak collection). About 300 mg of each sample was pelletized using a SPECAC material with a pressure of 2 tons/cm². Three irradiations were done for each pellet: The intermediate thick pellet, multi-element target and Pellet + Target for a spectrum collection life time of 1500 s. IAEA Linear least squares fitting of the AXIL software programme was used for the spectrum deconvolution. The emission-transmission method in QXAS package (IAEA, 2005) was used to convert
RESULTS AND DISCUSSION

The results of the elemental analysis showed that there were nineteen elements. The major elements detected were potassium, sodium and calcium. The trace elements were vanadium, chromium, manganese, iron, cobalt, nickel, copper, zinc, arsenic, selenium, bromine, rubidium and strontium at various concentrations.

These anti-microbial plants contain molecules that behave like antibiotics (Okpekon, 2006). The study was done to determine the elements in these plants that are essential for the treatment of microbial diseases. The essential ones are K, S, Ca, Fe, Cu, Zn, Ni, Co, Mn and Se. The results of the analysis are seen in Table 1.

Trace elements

Iron (Fe) is used to fight anemic disorders (Nazanin et al., 2014). The Fe content in the various medicinal plants analysed varies between 100 mg/kg in PT01_Leaf to a 1094.8 mg/kg in PT25_Leaf (Table 2). Hence, S. monostachyus has the potency to treat illnesses such as malaria and helminthiasis disorders. The Fe concentration levels in the studied plant parts renders them good enough for used in the treatment of bacterial diseases.

The Copper (Co) contents in the plant parts studied varied from 2.2 mg/kg in PT06_Leaves to a maximum of 11 mg/kg in PT25_Leaves. The adult human body contains approximately 1 mg of cobalt, 85% of which is in the form of Vitamin B12 (Lison, 2007). Cobalt constitutes a small part of Vitamin B12. The organic form of cobalt is a necessary component of Vitamin B12 and plays a very important role in forming amino acids. This element is essential for organisms to function well (Katarzyna et al., 2015). PT25_Leaves having higher Co and Fe contents suggest they are used in medicinal preparations to treat microbial diseases and anaemia.

Selenium (Se) is a well-known antioxidant (Navarro-...
Table 2. The various plant parts studied and their elemental contents in mg/kg (ppm).

| Element | PT12_Leaf | PT27_stem_bra | PT01_Leaf | PT02_Leaf | PT26_Leaf | PT18_Leaf | PT33_Leaf | PT06_Leaf | PT25_Leaf | RDA (per day) | UL per day |
|---------|-----------|---------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|--------------|------------|
| S       | 1.7±0.9   | 1.1±0.8       | 1.6±0.7   | 3.8±1.2   | 2.7±0.8   | 1.8±1.1   | 1.3±1.1   | 1.4±0.9   | 2.4±1.1   | 18±4,5       | 40±7.5     |
| Cl      | -         | -             | -         | -         | -         | -         | -         | -         | -         | -            | -          |
| K       | 4102.7±2437.9 | 3140.1±1089.1 | 2585.5±179.4 | 687.5±12.9 | 865.8±137.9 | 5247.6±1021.6 | 8781.3±6561.1 | 4068.3±2474.6 | 3426.1±255.7 | 10000.0±4000.0 | 800-1200 mg |
| Ca      | 3879.7±2302.7 | 14500.0±4900.0 | 3160.5±193.6 | 1899.3±124.6 | 4289.7±555.8 | 4750±885.1 | 7262.8±5422.1 | 3181.2±1931.7 | 2372.3±139.3 | 10600.0±4300.0 | -          |
| Ti      | 42.3±26.6 | -             | -         | -         | -         | -         | -         | -         | -         | -            | -          |
| V       | -         | -             | -         | -         | -         | -         | -         | -         | -         | -            | -          |
| Cr      | 11.1±7.2 | -             | -         | -         | -         | -         | -         | -         | -         | -            | -          |
| Mn      | 49.9±27.8 | 9.1±4.1       | 7.0±2.1   | 5.6±3.2   | 205.8±23.8 | 29.7±9.2  | 9.0±7.6   | 64.6±36.7 | 7.9±2.4   | 57.6±23.9    | 8-18 mg    |
| Fe      | 364.4±192.4 | 119.6±38.8   | 100±5.9   | 191.4±11.6 | 108.6±12.3 | 145±26.4  | 104.5±76.9 | 244.3±131.6 | 119.4±6.6  | 1094.8±493.9 | -          |
| Co      | 3.1±2.6  | -             | -         | 2.7±2.2   | 1.4±1.2   | 3.1±2.1   | -         | -         | 3.8±2.7   | 2.2±1.4      | 11.6±5.3   |
| Ni      | 1.9±1.4  | 2.3±1.1       | 2.4±0.7   | 1.9±1.5   | 8.4±1.2   | 1.4±1.3   | 3.0±2.4   | 2.9±1.7   | 2.5±0.8   | 3.8±2.0      | 0.9 mg     |
| Cu      | 6.6±3.0  | 5.3±1.7       | 2.7±0.7   | 6.1±0.9   | 4.6±0.8   | 10±2.0    | 11.6±8.0  | 7±3.1     | 7±3.0     | 10.8±4.3     | 11 mg      |
| Zn      | 27.7±1.6 | 4.9±1.5       | 13.2±1.0  | 35.4±2.0  | 6±0.8     | 40.2±6.0  | 38.4±25.0 | 37.8±14.6 | 21±1.2    | 150.3±54.7   | -          |
| As      | -         | -             | -         | -         | -         | -         | -         | -         | -         | 55 µg        | 400µg      |
| Se      | 0.4±0.3  | 1.4±0.3       | -         | -         | -         | -         | -         | -         | -         | 1.5-2.5 mg   | -          |
| Br      | 7.3±1.6  | 10.7±1.7      | 6.2±0.4   | 17.9±1.0  | 5.1±0.4   | 3.2±0.6   | 14.0±6.0  | 11.7±2.6  | 11.6±0.7  | 18.±4.6      | -          |
| Rb      | 32.4±5.7 | 8.9±1.2       | 20.2±1.0  | 18.8±1.0  | 31.2±1.7  | 20.6±1.7  | 27.9±9.5  | 16.8±2.9  | 23.9±1.1  | 29.6±6.1     | -          |
| Sr      | 38.1±6.0 | 73.1±8.2      | 22.9±1.1  | 62±2.8    | 42±2.2    | 17.8±1.3  | 35.8±11.0 | 24.0±3.7  | 14.7±0.8  | 40.8±7.5     | -          |
| Pb      | 1.7±0.9  | 1.1±0.8       | 1.6±0.7   | 3.8±1.2   | 2.7±0.8   | 1.8±1.1   | 1.3±1.1   | 1.4±0.9   | 2.4±1.1   | 4.9±1.8      | -          |

UL: Tolerable upper intake levels; RDA: Recommended Dietary Allowance; Concentrations of elements are in mg/kg (ppm); Stem b.: Stem barks.

Alarconet al., 2008). This element is needed for the proper functioning of the immune system, and is a key nutrient in countering the development of virulence and inhibiting HIV progression to AIDS (Rayman, 2000). Only three plants contain Se: PT12_Leaf (0.4 mg/kg), PT01_leaf (1.4mg/kg) and PT18_Leaf (0.4 mg/kg). It is suggested for use in the treatment of AIDS infection.

Essential elements

Peter and Kowey (2002)'s study shows that potassium is very important in regulating water balance and acid-base balance in the blood and tissues. It is essential in the transmission of electrical impulses in the heart. All plants contain K. The minimum concentration is 68.5 mg/kg and the maximum is 10,000 mg/kg. The higher K content in PT25_leaves suggests its uses in medicinal preparation for good heart impulses and can help to treat hypokalaemia.

Calcium element in the human organism is essential. It regulates muscle contraction, oocyte activation, and building of strong bones and teeth (Piste et al., 2013).

The works of Ralf Mueller showed that sulfur is necessary in clinical applications, for treating skin disease. Two of the analyzed plants contain S: P. amarus (1779.8 mg/kg) and B. unijugata (1023.5 mg/kg). This element causes irritant reactions (Ralf, 2008).

Calcium concentrations varied from 1899.3 mg/kg in J. secunda leaves to 14,500 mg/kg in stem barks of B. unijugata. Appreciably high concentrations of the element was found in P. amarus (3181.2 mg/kg), C. alata (3140.1 mg/kg), 1/5
Headsy and Yedjou (2008), and Yedjou et al. (2006) revealed that Lead (Pb) is a toxic element. All the analyzed plants contain Pb. The minimum concentration is 1.1 mg/kg in PT12_leaf while the maximum is 4.9 mg/kg in PT25_leaf. It is only O. americanum that contains arsenic (2.1 mg/kg) that is toxic, especially in its inorganic form (WHO, 2018). These different plants’ parts should be used with recommendation and prudence.

Conclusion

This work lists ten plants used by traditional healers in Côte d’Ivoire to treat illnesses resulting from microbial infections. The data obtained in the present work revealed the curative potency of the analyzed plants; it will also be necessary to determine the dosage to be administered to patients considering the elemental contents and their concentrations in these plants. This study sought to identify the presence of elements in these plants that can improve patients’ state of health from their metabolic properties. From the analysis of the results obtained, the concentrations of the essential elements in the plants contributed effectively to the healing of bacterial diseases. These plants are indicated in the treatment of microbial diseases as pointed out previously. However, some are more effective than others. The leaves of S. monostachys can be recommended for parasitic infections, leaves of A. precatorius, C. alata and O. gratissimum may be recommended for patients with bacterial infections and AIDS as they contain potassium, calcium, iron, nickel, copper, manganese, zinc and selenium. These plants can correct the side effects of diseases such as anaemia, weakening of the immune system and general fatigue. In addition, the leaves of J. secunda, the stems of B. unijugata and the leaves of M. longiflora are effective for curing anaemia and strengthening of the immune system. All parts of the plants should be used with moderation and prudence.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors are grateful to the Université Felix Houphouët-Boigny de Cocody Abidjan Côte d’Ivoire and to the Ghana Atomic Energy Commission (GAEC) for their contribution to this work.

REFERENCES

Adjohouen E, Aké-Assi L (1979). Contribution aquarecense des plantes médicinales de Côte d’Ivoire. Centre Nationale de floristique. Abidjan (Ivory Coast) 357 pp

Aké-Assi L (2001). Flore de la Côte d’Ivoire: catalogue systématique, biogéographie et écologie. Conservatoire et Jardin Botaniques de Genève. Genève.

Clarkson C, Maharaj VJ, Crouch NR (2004). Antiplasmodial In vitro activity of medicinal plants native to or naturalized in South Africa. Journal of Ethnopharmacological 92(2-3):177-191.

Djama AAD, Kouassi Goffi MC, Koua AA, Ofosu FG, Aboh JK (2011). Trace Elements Analysis of Some Antiparasitic Medicinal Plants in Côte d’Ivoire Using Energy-Dispersive X-ray Fluorescence (EDXR) Technique. Current Research Journal of Biological Sciences 3(3):209-215.

Djama AAD, Kouassi GMC, Koua AA, Ofosu FG, Aboh UK (2012). Heavy Metal Analysis of Some Anti-Diabetic Medicinal Plants in Côte d’Ivoire. Current Research Journal of Biological Sciences 4(5):633-637.

Hanumanthachar J, Milind P (2007). Pharmacological evidences for anti amnesic potentials of Phyllanthus amarus in mice. African Journal of Biomedical Research 10:165-173.

IAEA (2005). Quantitative X-Ray Analysis System (www.iaea.org/OurWork/ST/NA/NAAL/pci/ins/xtf/.../XQAS_Manual.pdf).

John JR, Ochoa VJ, Ocampo SA, Munoz JF (2006). Screening for antimicrobial activity often medicinal plants used in Colombian folkloric medicine: A possible alternative in the treatment of non–nosocomial infections. BMC Complementary and Alternative Medicine 6(2):1472-6882.

Kablan B, Adiko M, Abrogoua D (2008). Évaluation invitro de l’activité antimicrobienne de Kalanchoechenaeaete Manotes longiflora utilisées dans lespitalmises en Côte d’Ivoire. Phytotérapy 6(5):282-288.

Kamanzi AK, Koné M, Terreaux C, Traoré D, Hostettmann K, Dosso M (2002). Evaluation of the antimicrobial potential of medicinal plants from the Ivory Coast. Wiley Interscience 6(5):497-502.

Katarzyna C, Terpiłowska S, Swicki A (2015). Review paper Selected aspects of the action of cobalt ions in the human body. Central-European Journal of Immunology 40(2):236-242.

Khan MR, Kihara M, Omoloso AD (2001). Antimicrobial activity of Cassia alata. Fitoterapia 72(5):561-564.

Lison D (2007). In Hand book on the Toxicology of Metals (Third Edition). In: Handbook on the Toxicology of Metals (Third Edition). Academic Press. Copyright Elsevier. ISBN 978-0-12-369413-3. pp 1024.

Lewis JA (1984). The role of copper in inflammatory disorders. Agents and Actions 15:513-519.

Navarro-Alarcon M, Cabrera-Vique C (2008). Selenium in food and the human body: A review. Science Total Environment 400(1-3):115-141.

Nazanin A, Richard H, Roya K (2015). Review on Zinc and its importance for human health. Journal of Research in Medical Science 18(2):144-157.

Nazanin A, Richard H, Roya K (2014). Review on iron and its importance for human health. Journal of Research in Medical Science 19(2):164-174.

Okpekon TA (2006). Biological and chemical activities of Antiparasitic plants used in traditional medicine in Côte d’Ivoire: Aframomum scepctum K. Schum. (Zigiberaceae), Bridelia ferruginea Benth. (Zigiberaceae), Bridelia ferruginea Benth. (Euphorbiaceae), Isolona cooperi Hutch & Dalz. Et Uvariaazzeli Sc. Elliot (Annonaceae), Ph.D. in Chemistry. Department of Pharmacy Châtenay-Malabry, University of Paris.
Oderinde RA, Ajayi A, Adewuyi A (2009). Preliminary toxicological evaluation and effect of the seed oil of Huracrepitans and Blighia unjugata bark on the lipid profile of rat. Electronic Journal of Environmental, Agricultural and Food Chemistry 8(3):209-217.

Piste P, Didwagh S, Mokashi A (2013). Calcium and its Role in Human Body. International Journal of Research in Pharmaceutical and Biomedical Sciences 4(2):2229-3701.

Peter RK (2002). Part of the Medical Science Symposia. Book Series, Volume 17. Springer Science and Business Media, New York.

Pouset JL (2004). Plantes médicinales d'Afrique. 286p.

Ralf SM (2008), in Small Animal Clinical Pharmacology (Second Edition).

Rayman MP (2000). The importance of selenium to human health. Lancet 356(9225):233-241.

Subhan C, Jubilee P (2006). Biological activities of ethnomedical claims of some plant species of Assam. Indian Journal of Traditional Knowledge 5(2):229-236.

Tchounwou PB, Yedjou CG, Fox D, Ishaque A, Shen E (2004). Lead-induced cytotoxicity and transcriptional activation of stress genes in human liver carcinoma cells (HepG2). Molecular and Cellular Biochemistry 255(1-2):161-170.

Whitehouse MW (1976). Ambivalent role of copper in inflammatory disorders. Agents and Actions 6:201-206.

WHO (2018). Arsenic. Available at: https://www.who.int/fr/news-room/fact-sheets/detail/arsenic

Yedjou GC, Tchounwou PB (2008). N-acetyl-cysteine affords protection against lead-induced cytotoxicity and oxidative stress in human liver carcinoma (HepG2) cells. International Journal of Environmental Research and Public Health 4(2):132-137.

Yedjou CG, Steverson M, Paul T, chounwou PB. (2006). Lead nitrate-induced oxidative stress in human liver carcinoma (HepG2) cells. Metalions BiolMed 9:293-297.

Zdrojewicz Z, Popowicz E, Winiarski J (2016). Nickel-role in human organism and toxic effects. Polski Merkuriusz Lekarski 41(242):115-118.