

PIXE Analysis Of Some Medicinal Plants Usually Extracted And Drunk As Tea, Beverage, Or Used As Spice Or Flavor in Nigeria.

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Abstract. Some medicinal plants usually dried and extracted in cold or preferably hot water and drunk as a local tea or beverage, alone or in an admixture in particular ratios were analyzed using PIXE technique. Such preparations may be sweetened with honey, sugar or any sweetening agent. They are believed to serve usually as tonic in which case they can help in blood formation or as beverage like cocoa products. These medicinal plants include *Sorghum bicolor* (L) Moench (Poaceae), *Harungana madagascariensis* Lam. ex Poir. (Hypericaceae) [Dragon blood tree], *Curcuma longa* (L) syn. *Curcuma domestica* Valetton (Zingiberaceae) [Turmeric], *Zingiber officinale* Roscoe (Zingiberaceae) [Ginger], *Cymbopogon citratus* Sprengel (Poaceae) [Lemon grass], *Rumex acetosella* Linn (Polygonaceae), and mixtures or combinations of samples. PIXE measurements were carried out using 1.8 MeV collimated proton beam from the 2.5 MV AN 2000 Van de Graaff accelerator at Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Legnaro, Padova, Italy. The results showed the presence of 19 different elements at different concentrations. None of the plants contained any heavy toxic metals such as Pb, As, Cd, and Hg. The metabolic roles of the detected elements were discussed. The results of this novel study are presented and discussed.

Keywords: PIXE, Medicinal Plants, Trace Elements, Tea/Beverage, Nigeria.

INTRODUCTION

In Nigeria and some countries in Africa, some medicinal plants alone or in admixture in particular ratios are usually extracted and drunk as tea, beverage or used as spice or flavor. Sometimes the preparations are sweetened with honey, sugar or any sweetening agent. It is generally believed that they serve usually as tonic and hence help in blood formation or as any beverage such as the cocoa or coffee products. Some of these medicinal plants are *Sorghum bicolor* (L) [1. SBICLF] Moench (Poaceae), *Harungana madagascariensis* [2.HMADST] Lam. ex Poir. (Hypericaceae) [Dragon blood tree], *Curcuma longa* (L) syn. *Curcuma domestica* [3.CDOMRT] Valetton (Zingiberaceae) [Turmeric], *Zingiber officinale* [4. ZOFFRT] Roscoe (Zingiberaceae) [Ginger],

Cymbopogon citratus [5. CCITLF] Sprengel (Poaceae) [Lemon grass], [6. TEASHA] is mixture of samples 1 and 2; [7. TEACZ] is mixture of samples 3, 4 and 5; [8. TEACZI] is mixture of samples 4 and 5; [9. HMADLF] is the leaves of sample 2; [10. SLFHLF] is mixture of 1 and 9; [11. STHST] is mixture of stem of samples 1 and 2; *Rumex acetosella* [12. SORREL] Linn (Polygonaceae). The mixtures are combinations of samples in fairly the same proportions.

For *Sorghum bicolor*, the leaves of the plant are collected, oven-dried and reduced to fine powder for brewing as tea or beverage. In the case of *Harungana madagascariensis*, the stem bark of the plant is harvested and oven-dried. This is a very popular component of plant extracts which is usually incorporated in local preparations used as tonic. The fine powder resulting from it is usually extracted in

warm/hot water, cooled, strained and drunk as a beverage and for the management of diseases. In the case of *Curcuma longa* syn. *Curcuma domestica*, the yellow rhizomes of this herb are usually incorporated into local medicinal and food preparations as an anthelmintic, for skin diseases, as spice, as brain tonic and as an analgesic. Similarly, *Zingiber Officinale* just like *Curcuma longa* is a rhizomatous plant and its rhizome extracts are used for the treatment of rectal problems, as a drink and spice. The rhizomes of ginger contain about 2% of volatile oil containing terpenes, gingerol, citral, cineole etc. It is a component of many local drug and food preparations.

Cymbopogon citratus is a perennial herbaceous plant with strongly aromatic green leaves in dense tufts. Its leaf extracts are used as substitute for tea and it is strongly antipyretic and anti-malarial. It also contains volatile oil which is strongly anti-microbial. In the case of *Rumex acetosella*, the red calyx of the fruit is harvested and extracted as a drink. It is known to be very rich in minerals and it is therefore a rich food supplement. It is usually brewed locally into a popular reddish drink. It is important to analyze these medicinal plants and their mixtures to ascertain their elemental compositions and the level of ash present in these drinks. It is also necessary to ascertain if toxic elements are present in them and in what quantities.

EXPERIMENTAL

Sample Preparation

Reasonable quantities of the listed plant materials were extracted and dried. Different parts of the plants were used. For instance, in the case of *Sorghum bicolor*, the leaf of the plant was collected, oven-dried and reduced to fine powder and pelletized for PIXE analysis. However, the stem bark of *Harungana madagascariensis* was collected, oven-dried, ground into powder and pelletized. In the case of *Curcuma longa*, the yellow rhizomes of the plant were prepared for analysis. Similarly for *Zingiber officinale* Roscoe, the rhizome extracts were dried and pelletized for PIXE analysis. However, in the case of *Cymbopogon citratus*, the leaf extracts were dried, ground into powder and pelletized. For *Rumex acetosella*, the red calyx of the fruit was extracted, dried, ground into powder and pelletized. In the case of the mixtures, the same proportion of the samples was used and prepared in the same way for analysis.

PIXE Analysis

The 1.8 MeV collimated proton beam was delivered by the 2.5 MV AN-2000 Van De Graaff accelerator at Istituto Nazionale di Fisica Nucleare (INFN), Laboratori Nazionali di Legnaro (LNL), Legnaro (Padova), Italy. The diameter of the collimated proton beam which was used to bombard the pelletized samples was 6mm. All the pelletized samples were coated with 5 $\mu\text{g}/\text{cm}^2$ carbon to ensure good electrical contact. A 150 μm thick Mylar “funny” filter with 3.3% porosity was used for the measurement of the light elements together with the medium and heavy elements. This led to the reduction of the count rates and ensured a dead time of less than 10% with beam currents of 5-20 nA. The details of the PIXE set up used in this work are given in References ^{1,2}. The emitted X-rays were detected using a 30 mm² Si (Li) detector with an energy resolution of 180 eV (FWHM) at 5.9 keV. A 200 $\mu\text{g}/\text{cm}^2$ gold diffuser was used to homogenize the beam on the target samples. The generated X-ray data were stored and analyzed using the computer code GUPIX ³. The quality of the results was checked against the values obtained from the certified reference materials.

RESULTS AND DISCUSSION

The results of the PIXE analysis of these samples are shown in Table 1. Nineteen different elements namely Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Mn, Fe, Ni, Cu, Zn, Br, Rb, Sr, and Ba were detected at different concentrations. Many of these elements play significant roles in human metabolism and are very important with regards to life processes in man. The concentrations of potassium, calcium and silicon are relatively high and are the major elements in these plants. The minor elements include magnesium, aluminum, phosphorus, sulfur, chlorine, iron and manganese. The trace elements include titanium, vanadium, nickel, copper, zinc, bromine, strontium and barium.

The concentrations of magnesium in all the medicinal plants are quite significant and vary between 1446 ppm and 4371 ppm. Magnesium is very useful to human body because it is needed for growth, formation and function of man's bones and muscles ⁴. Magnesium also helps in preventing some heart disorders and high blood pressure. Thus the medicinal plants drunk as tea, beverage, and used as spice and flavor are very beneficial to human body. The concentrations of aluminum vary between 430 and 2036 ppm. The role of aluminum in human body is not quite certain but it may be involved in the function of a small number of enzymes. Silicon's concentrations are significantly high in all the plants and vary from

Table 1. Concentrations (ppm) of Medicinal Plants Usually Drunk As Tea, Beverage, or Used As Spice or Flavor.

| Sample Code | Mg | Al | Si | P | S | Cl | K | Ca | Ti | V |
|-------------|-----------|-----------|------------|-----------|-----------|-----------|------------|------------|-------------|-------------|
| 1. SBICLF | 2835 ± 43 | 1285 ± 56 | 23319 ± 48 | 895 ± 29 | 611 ± 10 | 513 ± 18 | 3447 ± 9 | 5188 ± 15 | 24.3 ± 1.2 | 3.29 ± 1.06 |
| 2. HMADST | 2311 ± 41 | 1013 ± 32 | 1739 ± 24 | 995 ± 23 | 952 ± 14 | 1001 ± 13 | 5675 ± 14 | 13890 ± 26 | 51.2 ± 1.8 | 4.09 ± 1.38 |
| 3. CDOMRT | 3661 ± 63 | 1991 ± 72 | 2784 ± 46 | 4489 ± 31 | 1248 ± 21 | 1662 ± 19 | 39080 ± 31 | 2846 ± 70 | 86.5 ± 1.5 | - |
| 4. ZOFFRT | 3217 ± 48 | 2219 ± 56 | 5776 ± 36 | 1882 ± 24 | 1241 ± 15 | 480 ± 12 | 21723 ± 19 | 3337 ± 42 | 164.0 ± 1.0 | 3.79 ± 1.41 |
| 5. CCITLF | 1930 ± 55 | 767 ± 82 | 9997 ± 53 | 2141 ± 34 | 1243 ± 21 | 4775 ± 24 | 35379 ± 28 | 5603 ± 67 | 9.9 ± 1.07 | - |
| 6. TEASHA | 2434 ± 41 | 1095 ± 50 | 10488 ± 38 | 1371 ± 27 | 1220 ± 14 | 702 ± 11 | 8074 ± 14 | 7220 ± 24 | 8.4 ± 1.03 | 2.5 ± 0.92 |
| 7. TEACCZ | 3203 ± 56 | 2036 ± 74 | 9068 ± 50 | 2808 ± 33 | 1585 ± 19 | 3260 ± 21 | 29643 ± 26 | 5457 ± 57 | 87.5 ± 1.6 | - |
| 8. TEACZI | 2686 ± 53 | 1885 ± 65 | 7095 ± 43 | 1914 ± 27 | 1376 ± 17 | 2656 ± 19 | 25962 ± 25 | 4598 ± 51 | 104.0 ± 1.0 | - |
| 9. HMADLF | 2296 ± 40 | 862 ± 33 | 1371 ± 24 | 1635 ± 23 | 1417 ± 16 | 147 ± 11 | 9642 ± 17 | 10409 ± 30 | 25.1 ± 1.3 | - |
| 10. SLFHLF | 2014 ± 39 | 943 ± 50 | 15926 ± 43 | 971 ± 26 | 856 ± 12 | 412 ± 9 | 7720 ± 13 | 5962 ± 22 | 7.5 ± 0.92 | - |
| 11. SSTHST | 1446 ± 42 | 430 ± 44 | 3743 ± 31 | 1088 ± 22 | 971 ± 15 | 1324 ± 14 | 14486 ± 8 | 5468 ± 33 | 11 ± 1 | 3.0 ± 0.91 |
| 12. SORREL | 4371 ± 66 | 1536 ± 69 | 3484 ± 47 | 2189 ± 39 | 2700 ± 26 | 1280 ± 21 | 31661 ± 31 | 20942 ± 71 | 55.2 ± 2.2 | 4.59 ± 1.79 |

Table 1. (Continued) Concentrations (ppm) of Medicinal Plants Usually Drunk As Tea, Beverage, or Used As Spice or Flavor.

| Sample Code | Mn | Fe | Ni | Cu | Zn | Br | Rb | Sr | Ba |
|-------------|------------|------------|-------------|-------------|------------|-------------|------------|-------------|-------------|
| 1. SBICLF | 176 ± 2 | 367 ± 3 | - | 4.09 ± 0.88 | 12.4 ± 1.2 | 8.19 ± 2.99 | - | 61.6 ± 7.2 | 70.2 ± 4.7 |
| 2. HMADST | 395 ± 3 | 522 ± 4 | 7.59 ± 1.43 | 12.5 ± 1.2 | 54.5 ± 2.2 | - | 17.5 ± 6.1 | - | 118.0 ± 7.0 |
| 3. CDOMRT | 71.0 ± 1.7 | 789 ± 5 | - | 4.9 ± 1.18 | 21.3 ± 1.7 | - | 40.7 ± 7.8 | 19.1 ± 7.5 | - |
| 4. ZOFFRT | 432 ± 2 | 663 ± 4 | 6.7 ± 1.07 | 5.29 ± 1.08 | 37.3 ± 1.7 | - | 27.5 ± 5.4 | - | 32.7 ± 11.7 |
| 5. CCITLF | 123 ± 2 | 121 ± 2 | - | 5.09 ± 1.12 | 26.6 ± 1.7 | 10.0 ± 3.7 | 61.3 ± 9.4 | 26.0 ± 8.5 | 15 ± 4 |
| 6. TEASHA | 356 ± 2 | 141 ± 2 | 3.79 ± 1.09 | 11.6 ± 1.1 | 27.0 ± 1.6 | - | 16.8 ± 5.6 | 25.3 ± 6.7 | 32.5 ± 3.6 |
| 7. TEACCZ | 262 ± 2 | 460 ± 4 | 3.2 ± 1.25 | 9.0 ± 1.18 | 34.7 ± 1.9 | - | 36.6 ± 8.0 | - | - |
| 8. TEACZI | 229 ± 2 | 474 ± 4 | 3.2 ± 1.12 | 5.29 ± 1.2 | 32.7 ± 1.8 | - | 45.8 ± 7.8 | 30.6 ± 8.0 | 28.3 ± 9.5 |
| 9. HMADLF | 778 ± 4 | 187 ± 4 | 7.29 ± 1.27 | 24.3 ± 1.4 | 52.2 ± 2.1 | - | - | 29.1 ± 7.9 | 58.1 ± 5.1 |
| 10. SLFHLF | 319 ± 2 | 125 ± 2 | - | 8.0 ± 1.04 | 30.0 ± 1.4 | - | 17.5 ± 5.6 | - | 21.3 ± 3.4 |
| 11. SSTHST | 139 ± 1 | 68.2 ± 2.0 | - | 7.09 ± 1.05 | 48.7 ± 2.2 | - | 17.3 ± 5.7 | - | 45.2 ± 3.8 |
| 12. SORREL | 515 ± 3 | 395 ± 4 | 9.19 ± 1.76 | 4.79 ± 1.31 | 78.5 ± 3.0 | 25.8 ± 5.4 | 35.5 ± 8.7 | 83.5 ± 12.2 | 166 ± 8 |

1371ppm to 2.33%. This is important because silicon is very useful to human body in the sense that it combines with calcium to grow and maintain strong bones in the body. Besides, it is involved in the formation of connective tissues like ligaments and tendons, and for the growth of hair, skin and fingernails.

The concentration of phosphorus in all the medicinal plants varies from 895 ppm to 4489 ppm. Phosphorus is required for the healthy formation of bones and teeth in human body. It is also necessary for human bodies to process many of the foods eaten. Besides, phosphorus is a part of human body's energy storage system and is useful in maintaining healthy blood sugar levels. Sulfur in all the medicinal plants is at minor levels and its concentration varies between 611 ppm and 2700 ppm. Sulfur is quite useful to human body because it helps in protecting the cells in the body from environmental hazards like air pollution and radiation. Hence it helps to slow down the aging process and extends the life span of man. Besides, it

helps human liver function properly and helps in the digestion of the food man eats, and turns that food into energy ⁴. The concentrations of chlorine in the plants vary from 147 ppm to 3260 ppm. Chlorine is another important element to human body and it is found in the blood, fluid, inside cells and the fluid between cells of the human body. It carries electrical charge when it dissolves in the body fluids just like sodium and potassium; and the electrical charge which it carries allows nerve cells to work. Chlorine combines with potassium and sodium to regulate the amount of fluids and the pH in the body. Besides, chlorine helps man to digest his food properly and to absorb other important elements that he needs to survive.

Potassium is quite significant in all the medicinal plants and its concentrations vary between 3447 ppm and 3.9%. The role of potassium in combination with sodium and chlorine has been mentioned above. Besides, potassium is very important to cells, such as brain cells, skin cells, liver cells, lung cells, nerve cells, etc and without potassium it may be difficult for

human bodies to survive. Calcium is of cardinal importance in human body. It is therefore nice that all the medicinal plants have significant concentrations of calcium which vary between 2846 ppm and 2.09%. It is a common knowledge that calcium in the body helps to build and maintain strong bones and teeth. Besides, it helps to maintain proper blood pressure and enables other molecules in the body to digest food and make energy for the body. Titanium was at trace levels in all the medicinal plants. Its concentrations vary from 7.5 ppm to 164 ppm. In humans, titanium acts as a stimulant. Its other functions in man are not quite known.

Only six plants have trace levels of vanadium which vary between 2.5 ppm and 4.59 ppm. Other medicinal plants show no presence of vanadium at all. There is not much known about the function of vanadium in human body. However, it helps the body convert some foods into energy and helps to stabilize the blood sugar levels in diabetics' patients. Manganese is present at minor levels in all the medicinal plants with concentrations that vary between 71 ppm and 778 ppm. Manganese helps human body to digest food taken and supports the immune system. It also helps in the production of energy, cell reproduction and bone growth. The concentration of iron in all the medicinal plants varies from 68 ppm to 663 ppm. Iron has several functions in human body. It helps to make tendons and ligaments, and helps in maintaining a healthy immune system and in the digestion of food taken. Besides, iron helps in converting food into energy and it is an important part of hemoglobin which carries oxygen in the blood to the entire body.

The concentration of nickel was at trace levels and in only seven of the plants, and varies between 3.2 ppm and 9.19 ppm. The role of nickel in human body is not quite known; however, perhaps nickel affects hormones, cell membranes and enzymes in human body. Copper was present in all the medicinal plants at trace levels with concentration that varies between 4.09 ppm and 24.3 ppm. Copper is very important in human health for many reasons. For instance, it is a major component of the oxygen carrying part of blood cells. Besides, it combines with vitamin C in keeping blood vessels and skin elastic and flexible. The concentration of zinc also was at trace levels in all the medicinal plants and varies between 12.4 ppm and 78.5 ppm. Zinc is another very important element in humans. For instance, zinc helps teeth, bones, nails, skin and hair to grow in humans⁴. It also helps to form connective tissue like ligaments and tendons. Besides, zinc is involved in the release and use of hormones in the human body. Human senses of sight, taste and smell depend on zinc. Zinc deficiency may lead to hair loss, mental apathy and damage to reproductive

organs. Only three of the plants contain bromine at trace levels with concentration that varies from 8.19 ppm to 25.8 ppm. Bromine has no specific role in human health. The roles of rubidium, strontium and barium in human health are not known. Rubidium is present in ten of the plants at trace levels with concentrations that vary between 16.8 ppm and 61.3 ppm. There was no rubidium in *Sorghum bicolor* and the leaves of *Harungana madagascariensis*. Similarly, strontium is present in only seven of the plants with concentrations at trace levels that vary between 19.1 ppm and 83.5 ppm. Ten of the plants contain barium with concentrations at trace levels that vary between 15 ppm and 166 ppm.

CONCLUSION

The elemental composition of some medicinal plants that are usually extracted and drunk as tea, beverage, or used as spice or flavor in Nigeria were determined using PIXE technique. These medicinal plants have been listed above. Nineteen elements were detected at various concentrations. Many of these elements have beneficial effects in human health and confirm the usefulness of these plants as beverages and other applications. None of the plants contained any heavy toxic metals like lead, arsenic, cadmium and mercury. The metabolic roles of these useful elements to human bodies and hence the justification of their use were discussed.

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