Research Paper

Concentration and Bioavailability of Iron in Some Selected Blood-Building Medicinal Plants in Southwest Nigeria

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Abstract

The use of medicinal plants for blood-building in Sub-Saharan Africa is a common practice. However, this practice is being challenged by the inadequate data on the bioavailability of both nutritional and toxic elements in the plants being used. In this study, the total iron (Fe) concentration in five (5) medicinal plants parts used by local communities in South Western Nigeria to treat anaemia: Leaves of Sorghum bicolor (Poroporo Baba), Bark of Magnifera indica (Mango), Telfaria occidentalis (Ugwu), Basella alba (Amunututu) and leaves of Hibiscus sabdariffa (Zobo) were determined employing Flame Atomic Absorption Spectrophotometry (FAAS). The level of iron observed in the plants studied, classifies them as high iron source going by WHO range of 70-200 µg/g. S. bicolor showed the highest concentration of 188.7 µg/g Fe while leaves of H. sabdariffa showed the least concentration of 69.7 µg/g Fe. Speciation patterns of Fe were also investigated using four-step Bureau Community of References' (BCR) selective sequential extraction technique to evaluate the bioavailability of iron in the plants. The result showed that S. bicolor has the highest bioavailable Fe with a concentration of 121.8 µg/g. The bioavailable Fe in the plants is in the order S. bicolor > Barks of M. indica > B. alba > T. occidentalis > leaves of H. sabdariffa.

Keywords: Speciation, Iron, Bioavailability, Blood-Building, Medicinal Plants, Spectrophotometer

1. Introduction

The philosophy of link between human life and elements dates back to the inception of practice of medicine (Cebi et al, 2011). Various metabolic activities in normal physiological processes are known to relate with metal ions, with specific importance by every element in life system. Iron, for instance, is a mineral element that plays a crucial role in the human system. It produces red blood cells (haemoglobin) which carry oxygen throughout the body and stores in myoglobin, an oxygen-carrying protein in the muscles that fuel cells growth. Iron is an essential element for man and animals. It is an essential component of haemoglobin and facilitates the oxidation of carbohydrates, protein and fat, thereby controlling body weight, which is very important factor in diabetes (Khan et al, 2008). The use of medicinal plant to treat various body diseases is gaining more patronage worldwide which may be attributed to relative low cost of herbs, low side effects of natural herbs as compared to synthetic drug (Kirmani et al, 2011) and to a large extent the increase in awareness and confidence that medicinal plants contain valuable compound especially in Africa. Omolo et al (1997) carried out an investigate on the total and extractable iron species in eight Eastern African medicinal plants used traditionally against anemia. It is reported that, whatever that is taken as food could cause metabolic disturbance, subject to the allowed upper and lower limits of trace metals (Prasad, 1976 and Khan et al, 2008). Both the deficiency and excess of essential micronutrients and trace of toxic metals may cause serious
effects on human health (Khan et al, 2008). Excessive dietary iron is toxic. The excess ferrous iron reacts with peroxides in the human body, producing free radicals. The side effects of taking high doses of iron include constipation, nausea, vomiting and stomach pain. Very high doses of iron can be fatal, particularly in children, a disease results called hemochromatosis. The excess iron accumulates in the liver, resulting in siderosis and organ damage. However, iron deficiency anaemia is the most common form of anaemic conditions in growing children due to increase in iron demand. The deficiency is also found in young girls and women due to excessive monthly menstrual bleeding. Other causes are poor digestion, long-term illness; excessive use of coffee, black tea and the sugar has been rated as the greatest causes of iron deficiency anaemia.

Anaemia is characterized by fatigue, shortness of breath, pale skin, concentration problems, dizziness, a weakened immune system and energy loss. Other condition- ons include hypo-copraemia, hypo-proteinemia and dwarf-ism (Klaassen et al, 1986). Iron deficiency varies greatly with geographical and socio-economic factors. Infections, excessive sweating and staple food stuffs like vegetables or cereals with high bran and phytate content are some of the factors that account for high anaemic incidence in developing countries as compared to developed nations with temperate climatic conditions (Bjorn-Rasmussen, 1974). Regular body activities such as urination, defecation, sweating and menstruation in women lead to continuous loss of blood. The consequential daily iron loss of body in adult male is 1.0 mg, while that of female is 0.8 mg (Mertz, 1987). Conditions like pregnancy and administration of antibiotics also increase the requirement for Iron. In order to balance this loss, a daily absorption of 2.0 mg of iron is considered necessary (Anderson et al, 1981). This is achieved through balanced nutrition; iron fortification or supplementations supplement.

The history of herbal medicine for amelioration of human sufferings pre date modern medicine and its continuous existence till today confirms its validity. Herbal treatments of ailment are enjoying strong patronage because of their accessibility and safety, with very few cases of side reactions or allergy (Rates, 2001). An herb or medicinal plant is a plant, which in one or more of its organ contains substances that can be used for therapeutic purposes or which are precursors for the synthesis of useful drugs. Worldwide, there is a growing trend for research, development, documentation utilization and promotion of traditional medicine (Abou-Arab & Abou Donia, 2001). The World Health Organization (WHO) acknowledges the growing need and potentials of traditional medicine and continues to encourage and support research in traditional medicine with a view to further develop its potentials and use, especially in developing countries. According to the World Health Organization report, almost 80% of people in marginal communities use only medicinal plants for the treatment of various diseases (Pirzada et al, 2009). It further implored countries to fully utilize the positive aspects of traditional medicine to increase access of its citizens to quality health care services. Traditional medicines have also become a huge job and wealth creation avenue worldwide.

Traditional medicines and the use of herbal medicinal plants have been and will continue to be a strong part of Nigerian history as well as her culture and beliefs. It is a fact that over 85% of the population patronizes traditional practitioners for their health care and other needs (NNMDA, 2007). In spite of this high patronage, the products and practices are still highly misunderstood and mystified. This is largely due to the inadequate and sometimes lack of information on the composition and the active ingredients in the plant and toxicity of such ingredient. Since the toxicity of heavy metals is related to their existing species, speciation of these cations is increasing more attentions (Nassef et al, 2006). The toxicity of heavy metals depends upon the chemical form of elements (Kirmani et al, 2011). Heavy metals are dangerous in the form of their cations and are highly toxic when bonded to the short chains of carbon atoms (Hussain et al, 2006).

Environmental conditions like type of soil, rainfall, vicinity of industry and extensive agricultural activity influence the level of bioavailable elements in plants (Konieczynski & Wesolowski, 2007). Unlike in soils, where chemical speciation studies of metals have been extensively investigated, there still remains little information on metal speciation in medicinal plants particularly in West African states. Quite a number of investigators have employed sequential extraction methods to fractionate heavy metals in soil and sediments. Speciation studies are carried out by single or sequential extraction with reagents having different chemical properties. In order to evolve the best Sequential Extraction Procedure (SEP) for the speciation metals in medicinal plants, various sequential extraction procedures were compared (Oyeiyiola et al, 2009). The SEP developed included a modified Tessier’s procedure carried out in 5-steps, the 3-step original BCR and the four step modified BCR techniques. The results showed that the modified BCR and Tessier extract more in the reducible phase and consequently a decrease in the Oxidizable phase than the original BCR, hence modified BCR technique was adopted in this study. Sorghum bicolor (poroporo baba), Basella alba (Amunutu), Bark of Magnifera indica (Mango), Telfaria occidentalis (Ugwu) and leaves of Hibiscus sabdariffa (Zobo) were medicinal plants used in the study. These medicinal plants are used as blood-builder with a geographical spread around the three (3) major ethnic groups in Nigeria.
Though, a number of studies had been carried out on metals concentration in Nigerian vegetables and medicinal plants, not much has been reported about speciation pattern of these cations. This paper is, therefore, aimed at establishing the total concentration of iron in some medicinal plants used in treatment and management of anaemia in Nigeria, as well as investigating their speciation pattern.

2. Materials and Methods

2.1. Sampling

Plant samples of *Sorghum bicolor* (Poroporo baba), *Basella alba* (Amunututu), Bark of *Magnifera indica* (Mango), Leaves of *Hibiscus sabdariffa* (Zobo) and *Telfaria occidentalis* (Ugwu) were obtained from the open markets at Mushin, Igando, Iyana Iba, all in Lagos State, South-Western Nigeria. The samples were identified at Lagos University Herbarium: *Sorghum bicolor* (LUH 1467A), *Basella alba* (LUH 1471A), Bark of *Magnifera indica* (LUH 1469A), Leaves of *Hibiscus sabdariffa* (LUH 1468A) and *Telfaria occidentalis* (LUH 1470A).

2.2. Sample Preparation

Composite samples of the various plants were sun-dried for seven days. The dried samples were crushed with the aid of pre washed ceramic mortar and pestle and made to pass through a 2 mm mesh.

2.3. Determination of Total Iron

1.0 g of powdered each plant sample was weighed into a 125 ml of Erlenmeyer flask which has been previously washed with 0.1 M HNO₃ and rinsed with distilled water. 4 ml of perchloric acid, 25 ml concentrated HNO₃ and 2 ml concentrated H₂SO₄ (all chemicals were of analar grade) were added. The content was mixed and heated, initially at low heat about 60 °C and then on a hotplate under an acid fume-hood, the heating continued until dense white fumes appeared. The mixture was strongly heated for half a minute afterward. The content was allowed to cool after heating. 50 ml of distilled water was added after cooling and boiled further for half a minute on the same hot plate. The solution was allowed to cool again and filtered using a Whatman No. 42 filter paper. The solution was made up to the 100 ml mark with distilled water and analyzed for iron using 210 VGP Flame Atomic Absorption Spectrophotometer. Each sample was analysed twice to test it for reproducibility. General laboratory quality assurance measures were observed to prevent sample contamination and instrumental errors.

2.4. Sequential Extraction

The Bureau Community of Reference (BCR) method, having four steps, was employed to speciate the metal load in the samples into various factions. The steps are as follows:

**Step 1: Exchangeable**

40 ml of 0.1 M acetic acid was added to 1.0 g of plant sample in a 250 ml flat bottom flask. The flask was shaken for 16 hours at room temperature on a flask shaker at 400 rpm. The solution was filtered and the filtrate was analysed for iron. The residue was washed with 20 ml of deionised water by shaking for 15 minutes and then filtered. The supernatant liquid was discarded without any loss of residue.

**Step 2: Reducible**

The residue from step 1 was washed and stirred in a 250 ml flask by adding 40 ml of 0.1 M hydroxylamine hydrochloride solution adjusted to pH 2.0 with nitric acid. The mixture was shaken for 16 hours at room temperature. The extract was filtered and analyzed for iron and the residue was washed with 20 ml of deionised water.

**Step 3: Oxidizable**

To the residue from step 2, 10 ml of 8 M hydrogen peroxide solution was carefully added in small aliquots to avoid losses due to violent reaction. The flask was digested at room temperature for 1 hour with occasional manual shaking. The flask was placed on a water bath and heated at 85 °C and evaporated to near dryness. A second aliquot of 10 ml of hydrogen peroxide was added to the residue and digestion procedure was repeated. 50 ml of 1.0 M ammonium acetate solution (adjusted to pH 2 with nitric acid) was added to the moist residue. The mixture was shaken and filtered. The filtrate was analyzed for iron while the residue was washed with 20 ml of deionised water.

**Step 4: Residual**

5 ml of distilled water and 12 ml of aqua-regia solution were added to the remaining residue and evaporated to near dryness on an electric heater. The procedure was repeated using 8 ml aqua-regia solution. 20 ml of 0.1 M nitric acid was then added in small aliquots to the residue and filtered. The filtrate was analyzed for iron.

3. Results

Table 1 shows detail of the plants analysed including the names, parts of plant used as well as the medicinal properties of the plants analysed while Table 2 shows the concentration of total iron observed in each of the medicinal plant investigated as well as in some other plants in...
literature. Table 3 reveals the speciation pattern of iron in the plants studied and correlation coefficient among the fractions are given in Table 4. Figure 1 gives the pictorial representation of percentage fractions in the plants and Figure 2 gives the dendrogram of the blood building medicinal plants investigated.

Table 1. Names and Pharmacognostic Features of the Blood Building Plants

<table>
<thead>
<tr>
<th>Plants Species</th>
<th>Local Name</th>
<th>Parts Analysed</th>
<th>Medicinal Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum bicolour</td>
<td>Poroporo Baba</td>
<td>Stem</td>
<td>Blood Building</td>
</tr>
<tr>
<td>Besella alba</td>
<td>Amunututu</td>
<td>Stem</td>
<td>Blood Building</td>
</tr>
<tr>
<td>Telfaria occidentalis</td>
<td>Ugwu</td>
<td>Leaves</td>
<td>Blood Building</td>
</tr>
<tr>
<td>Magnifera indica</td>
<td>Mango</td>
<td>Bark</td>
<td>Blood Building, Anti-Malaria</td>
</tr>
<tr>
<td>Hibiscus sabdarifia</td>
<td>Ewe Zobo</td>
<td>Leaves</td>
<td>Blood Building</td>
</tr>
</tbody>
</table>

Table 2. Total Concentration of Iron in Plant Parts of Present Study and Other Published Works (µg/g)

<table>
<thead>
<tr>
<th>Plants Species</th>
<th>Total Iron Conc.</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum bicolour</td>
<td>189±20</td>
<td>Present study</td>
</tr>
<tr>
<td>Besella alba</td>
<td>107±7</td>
<td>Present study</td>
</tr>
<tr>
<td>Telfaria occidentalis</td>
<td>142±11</td>
<td>Present study</td>
</tr>
<tr>
<td>Magnifera indica</td>
<td>167±23</td>
<td>Present study</td>
</tr>
<tr>
<td>Hibiscus sabdarifia</td>
<td>70±4.2</td>
<td>Present study</td>
</tr>
<tr>
<td>Pipper nigrum</td>
<td>640±7.0</td>
<td>Lavilla et al, 1999</td>
</tr>
<tr>
<td>Brassica rapa</td>
<td>8.8±0.01</td>
<td>Hashmi et al, 2007</td>
</tr>
<tr>
<td>Trachyspermum ammi</td>
<td>2486±28</td>
<td>Lavilla et al, 1999</td>
</tr>
</tbody>
</table>

Table 3. Mean Concentration of Iron in Various Fractions (µg/g)

<table>
<thead>
<tr>
<th>Plant Species</th>
<th>Exchangeable</th>
<th>Reducible</th>
<th>Oxidizable</th>
<th>Residual</th>
<th>Sum of Fractions</th>
<th>Bio-available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum bicolour</td>
<td>46.6</td>
<td>41.7</td>
<td>33.5</td>
<td>63.7</td>
<td>186</td>
<td>122</td>
</tr>
<tr>
<td>Besella alba</td>
<td>28.8</td>
<td>14.5</td>
<td>24.8</td>
<td>37.4</td>
<td>106</td>
<td>68.1</td>
</tr>
<tr>
<td>Telfaria occidentalis</td>
<td>7.00</td>
<td>42.6</td>
<td>3.80</td>
<td>85.5</td>
<td>139</td>
<td>53.4</td>
</tr>
<tr>
<td>Magnifera indica</td>
<td>13.2</td>
<td>52.8</td>
<td>12.5</td>
<td>84.0</td>
<td>163</td>
<td>78.8</td>
</tr>
<tr>
<td>Hibiscus sabdarifia</td>
<td>9.60</td>
<td>19.2</td>
<td>2.50</td>
<td>36.2</td>
<td>67.5</td>
<td>31.3</td>
</tr>
</tbody>
</table>

4. Discussion

The concentrations of iron, given in Table 2, in all the medicinal plants examined are in the range that classifies them as high source of iron according to FAO/WHO (1984) and World Health Organisation (2005). Sorghum bicolour showed the highest concentration of iron with a value of 189 µg/g while Hibiscus sabdarifia showed the least concentration of 7.0 µg/g. The total iron concentrations order in the plants is: Sorghum bicolour > Bark of Magnifera indica > Telfaria occidentalis > Besella alba > Leaves of Hibiscus sabdarifia. Khan et al (2008) suggested that the high amount of Fe in plants may also be due to the foliar absorption from the surroundings air.

Koniczynski & Wesolowski (2007) also conducted research on total and extractable iron in selected herbs collected from natural areas in Northern Poland. The total iron content in medicinal plants in this study compare well with plants like Brassica rapa (Hashmi et al, 2007) but lower than Pipper nigrum and Trachyspermum ammi (Lavilla et al, 1999) as shown in Table 2.

However, the information on the forms (species) of metal is very important so as to be able to predict the impact of the metal on human body system. The concentration of iron in various factions is presented in Table 3. The bioavailable form of iron in investigated plants revealed that Sorghum bicolour exhibited high value of 122 µg/g, compared to Bark of Magnifera indica, Besella alba, Telfaria occidentalis and Leaves of Hibiscus sabdarifia i.e. 78.8, 68.2, 53.5 and 31.3 µg/g respectively. The bioavaila-
fractions are: Residual > Exchangeable > Reducible > Oxidizable with 65% of total Fe as bioavailable; Basella alba: Residual > Exchangeable > Oxidizable > Reducible with 64% as bioavailable; Bark of Magnifera indica: Residual > Exchangeable > Oxidizable > Reducible with 48% of total Fe as bioavailable; Leaves of Hibiscus sabdariffa: Residual > Reducible > Exchangeable > Oxidizable with 47% of total Fe as bioavailable; Bark of Magnifera indica: Residual > Reducible > Exchangeable > Oxidizable with 37% of total Fe as bioavailable. Substantial amounts of Fe are associated with the residual fractions of all the medicinal plants examined, an indication that Fe is strongly bonded in the tissues of the plants. The correlation coefficient between the fractions as shown in Table 4, reveal that, there are various sources of what make up total iron concentration. There is a strong positive correlation between reducible and residual fractions as well as between Oxidizable and exchangeable, an indication of similarity in the source(s) whiles other fraction reveal negative correlation, a reflection of uncommon source(s).

Table 4. Correlation Coefficient Between the Fractions Iron Speciated

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchangeable</td>
<td></td>
<td>-0.042</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reducible</td>
<td></td>
<td>0.972</td>
<td>0.006</td>
<td></td>
</tr>
<tr>
<td>Oxidizable</td>
<td></td>
<td></td>
<td>0.933</td>
<td>-0.160</td>
</tr>
<tr>
<td>Residual</td>
<td></td>
<td>-0.232</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Exch.: Exchangeable  
Red.: Reducible  
Oxid.: Oxidizable  
Res.: Residual

It is however recommended that more research work be conducted in the area of clinical to investigate the rate of absorption and utilization of iron in the plants.

5. Conclusion

Based on the findings of this research work, it was concluded that Sorghum bicolor, Bark of Magnifera indica, Basella alba, Telfaria occidentalis and Leaves of Hibiscus sabdariffa have high iron contents and are suitable for use as blood-building herbs. The bulk of the iron is available to humans and animals. The speciation pattern revealed that a substantial amount of iron in the plants is associated with the residual fraction. The effectiveness of the various plants investigated, in blood-building is in the following order: Sorghum bicolor > Bark of Magnifera indica > Basella alba > Telfaria occidentalis > Leaves of Hibiscus sabdariffa. This is based on the bioavailability of iron. It is however recommended that more research work be conducted in the area of clinical to investigate the rate of absorption and utilization of iron in the plants.

Acknowledgement

The authors appreciate the effort of Mr. Toms Briggs in...
the identification of plants used in this study.

References


