Nutritional assessment of the five neglected indigenous vegetables in Zimbabwe

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Abstract
This study examined the nutritional value of *Amaranthus, Bidens pilosa, Cucurbita maxima, Ipomea aquatica, Cnidoscolus aconitifolius, and Brassica oleracea var. acephala*. Laboratory analyses were performed to determine the proximate composition, and micronutrient content present in the selected native indigenous vegetables (NIVs). The Atomic Absorption Spectrophotometer (AAS), and Ultra Violet Visible (UV-V) were deployed to quantify Calcium (Ca), Magnesium (Mg), Zinc (Zn), Iron (Fe), Phosphorus (P), Potassium (K), and Nitrogen (N). The results revealed that *Bidens pilosa* had 0.276 ppm of Calcium, Fe 0.0081 ppm, 0.345 ppm of Magnesium, 0.00447 ppm Zinc, phosphorus was 1.96 ppm, potassium 0.835 ppm, and crude protein 1.250 %. *Cucurbita maxima* showed a concentration of 0.339ppm of calcium, 0.007ppm of iron, 0.266 ppm Magnesium, 0.00443ppm zinc, 2.05 pp phosphorus, 0.751ppm potassium and 11.042% crude proteins. Water spinach presented a concentration of 0.089 ppm of calcium, 0.0368 ppm Iron, 0.007ppm Magnesium, 0.00293 ppm Zinc, 2.34ppm phosphorus, 0.111 ppm of K and 1.708% crude protein. Further research is recommended to explore the functional properties, sensory attributes, and culinary versatility of NIVs, as well as their potential impacts on mitigating diet-related diseases and promoting well-being across diverse populations.

Keywords: *Bidens pilosa* (blackjack), *Cucurbita maxima* (pumpkin), *Ipomea aquatica* (water spinach), *Amaranthus cruentus* (amaranth), *Cnidoscolus aconitifolius* (Chaya), *Brassica oleracea var. acephala* (Covo/African kale), Nutritional components

Introduction
Indigenous vegetables are best defined as species that are locally important for the sustainability of economies, human nutrition and health, and social systems, but which have yet to attain global recognition to the same extent as major vegetable commodities such as tomato and cabbage (Keatinge, J. et al., 2015) [13]. Neglected indigenous vegetables (NIVs) like *Amaranthus, Bidens pilosa, Cucurbita maxima, Ipomea aquatica, Cnidoscolus aconitifolius and Brassica oleracea var. Acephela* are said to have higher nutritional value but their nutritional composition in different agro ecological zones is still largely unexplored. Bvenura & Sivakumar (2017) [2] observed that NIVs are known to have various nutritional profiles, potentially containing essential vitamins, minerals, and phytochemicals that are beneficial to human health. With the significant challenges of malnutrition, these NIVs may provide insights into alternative, locally available sources of nutrients contributing to efforts aiming to address malnutrition. Informed research-based awareness of the nutritional benefits of NIVs, may support the growing and consumption of these neglected vegetables.
Mabhaudhi et al., (2019) [5] argued that research on native indigenous vegetables can aid in efforts to diversify agricultural production and advance sustainable food systems by emphasizing their nutritional advantages. Policy-makers can have confidence in encouraging the cultivation, marketing, and consumption of these nutrient-rich indigenous vegetables when backed with scientific proof of the nutritional superiority of NIVs over commonly consumed vegetables like cabbage (Aguilar-Galvez et al., 2021) [14]. The anticipated rich nutritional profile and environmental adaptability of neglected indigenous vegetables have drawn attention to their potential in addressing malnutrition and improve nutrition status (Bvenura & Sivakumar, 2017) [2]. It is therefore imperative to develop nutritional profile of different indigenous vegetables to ensure informed recommendations when promoting this group of vegetables. The main objective of this study was therefore to establish and assess the nutritional value of Brassica oleracea var. Acephela, Amaranths, Biden pilosa, Cucurbita maxima, ipomea aquatica, and Cnidoscolus aconitifolius, with a particular emphasis on their important minerals content.

Methodology

Site and design

The study was carried out at the Africa University soil science laboratory (18.8968° S, 32.6013° E), Mutare, Zimbabwe. Samples were laid out in a completely randomized design (CRD) and replicated three times.

Plant sample collection protocol

Leaf samples of the different vegetables were collected from Africa University farm, Mutare, Zimbabwe were used. The leaves were cleaned and dried using an oven drier. After drying, the samples were ground into powder for nutrient content analysis.

Method 1

The Dry Ashing method was used to determine the Ca, K, Mg, and Fe content. Representative samples of the dried vegetables were weighed for analysis. The samples were ground into a fine powder and homogenized to ensure that the elements were evenly distributed throughout the samples.

Digestion: The samples were digested using an acid digestion method that dissolved the elements. Different digestion methods were used depending on the element being analyzed. Nitric acid digestion was used for calcium and phosphorus, while hydrochloric acid digestion was used for iron and zinc.

Determination: Elements in dried samples were determined using atomic absorption spectroscopy (AAS- Varian Model: 1275 series)

Calibration: A calibration curve was generated for each trace element being analyzed using known standards. The calibration curve was used to determine the quantity of each element in the sample.

Calculation: The quantity of each element in the dried vegetable sample was calculated based on the analysis and the calibration curve. The quantity of each element was expressed in mass per unit of dried vegetable (mg/100 g).

Method 2

Per chloric Acid Digestion (Wet Oxidation)

Kjeldahl method was used to analyze the crude protein

Sample preparation: Representative samples of the different dried vegetables were weighed for analysis. The samples were finely ground to ensure homogeneity.

Digestion: Samples were placed into a digestion flask, and digestion mixture containing concentrated sulfuric acid and Kjeldahl tablets (Selenium) were added as a catalyst. The mixture was heated to digest the sample and convert the nitrogen content into ammonium sulfate.

Distillation: After digestion, the contents were transferred to a distillation apparatus. The ammonium sulfate was then distilled into a receiving flask containing a known amount of boric acid solution. The distillation separated the nitrogen from other components in the sample.

Titration: The distilled ammonium hydroxide was titrated with a standardized solution of sulphuric acid to determine the amount of nitrogen present in the sample. The amount of nitrogen was then used to calculate the crude protein content of the sample.

Calculation: The crude protein content was calculated in mg/g using the following formula:

\[ N = (v1-v0) \times c(H+) \times MN/m \]

Where,

- \( N \) - volume of blank
- \( V1 \) - sample volume
- \( c(H+) \) - concentration of Hydrogen in sulphuric acid (H\(_2\)SO\(_4\))
- \( MN \) - molar mass of Nitrogen
- \( m \) - mass of sample tested

Data analysis

The data was analyzed using the linear additive model for the CRD as follows.

\[ Y_{ij} = \mu + \tau_i + \epsilon_{ij} \]

Where: \( Y_{ij} \) is the \( j \)th observation of the \( i \)th treatment, \( \mu \) is the population mean, \( \tau_i \) is the treatment effect of the \( i \)th treatment, and \( \epsilon_{ij} \) is the random error.

Results

Nutrient content of the selected indigenous vegetables.

The results of the entire profile of nutrient contents of some of the mineral elements are shown in the Figures 1 below. Regarding Crude Protein content, Chaya and water spinach proved to be superior in crude protein concentration; 14.771% and 14.688% respectively. Amaranths recorded 13.083%, Cucurbita maxima 11.042%, and the lowest concentration was recorded in Bidens pilosa with 1.250%, and Covo 1.708%.

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Nitrogen content

A significant difference in the nitrogen content in the six vegetables studied was also observed. Amaranths recorded the highest concentration compared to the other vegetables as it recorded 0.951ppm, followed by Biden pilosa 0.835ppm, and Ipomea aquatica 0.805ppm. Cucurbita maxima with 0.751 ppm, Chaya 0.235ppm and African kale (covo) with 0.111ppm showed a significant difference with the other vegetables.

Potassium content

A significant difference in the potassium content in the six vegetables studied was also observed. Amaranths recorded the highest concentration compared to the other vegetables as it recorded 0.951ppm, followed by Biden pilosa 0.835ppm, and Ipomea aquatica 0.805ppm. Cucurbita maxima with 0.751 ppm, Chaya 0.235ppm and African kale (covo) with 0.111ppm showed a significant difference with the other vegetables.

Phosphorus Content

There was also a significant difference in the studied vegetables regarding Phosphorus content. As indicated in Fig 3, Ipomea aquatica registered a significantly higher concentration (4.84ppm). Other vegetables did not differ significantly regardless of the variation in phosphorus content.
Zinc Content
Regarding Zinc concentration (Fig 4), Chaya showed a significant higher concentration (0.00533ppm), followed by blackjack (0.00437), pumpkin leaves (0.00443), and covo (0.00370). The least concentrated was noticed in water spinach (0.00293).

Calcium content
Amaranths calcium content was significant different when compared to the other five vegetables as it showed a concentration of 0.600ppm. *Biden pilosa*, *Cucurbita maxima*, *Ipomea aquatica* and *Cnidoscolus aconitifolius* showed no significance difference. No calcium was traced in covo (Table 1).

Table 1: Calcium, Iron and Magnesium contents of the selected vegetables commonly used in Zimbabwe

<table>
<thead>
<tr>
<th>Samples</th>
<th>Calcium</th>
<th>Iron</th>
<th>Magnesium</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Biden pilosa</em> (1)</td>
<td>0.276ab</td>
<td>0.008c</td>
<td>0.345b</td>
</tr>
<tr>
<td><em>Cucurbita maxima</em> (2)</td>
<td>0.339ab</td>
<td>0.007c</td>
<td>0.266b</td>
</tr>
<tr>
<td><em>Ipomea aquatica</em> (3)</td>
<td>0.089ab</td>
<td>0.037a</td>
<td>0.117b</td>
</tr>
<tr>
<td>Amaranthus (4)</td>
<td>0.600a</td>
<td>0.010c</td>
<td>0.887a</td>
</tr>
<tr>
<td><em>Cnidoscolus aconitifolius</em> (5)</td>
<td>0.502ab</td>
<td>0.046a</td>
<td>0.171b</td>
</tr>
<tr>
<td><em>Brassica oleracea var. acephala</em> (6)</td>
<td>0.000a</td>
<td>0.029ab</td>
<td>0.037b</td>
</tr>
<tr>
<td>LSD</td>
<td>0.524</td>
<td>0.011</td>
<td>0.406</td>
</tr>
<tr>
<td>CV%</td>
<td>97.8</td>
<td>27.1</td>
<td>75.2</td>
</tr>
</tbody>
</table>

NB: Means with the same superscript are not significantly different at a 5% level.
Iron contents
Iron concentrations was significantly higher in Chaya (0.461ppm) compared to other studied vegetables. Ipomea aquatica ranked second with 0.037ppm. Covo 0.029ppm while pumpkin leaves had the lowest concentration 0.007ppm which did not differ significantly with Bidens pilosa, and amaranths.

Magnesium contents
Amaranths ranked highest in Mg concentration with 0.887ppm while the remaining five (5) vegetables had the same levels statistically.

Discussion
Unlike Ndhlouv et al. (2014) who concluded that amaranths had the highest protein percentages, results revealed that Chaya and Water spinach were the best (15%) regarding crude protein content followed by Amaranths (13%), and Cucurbita maxima (11%). Bidens pilosa protein content was not significantly different from that of Covo indicating that in areas of protein challenges, vegetable Chaya can be recommended in favour of the other five vegetables.

The high potassium levels in Amaranths, Bidens pilosa, and water spinach with 0.951, 0.835, and 0.805ppm respectively is an indication that if they are included in the daily diet, they may help to alleviate potassium deficiency problems. In the absence of the three, pumpkin leaves which recorded 0.751ppm can be recommended.

With phosphorus, all six vegetables indicated substantial content though water spinach was the best (0.484g/kg) which is in the same range (0.25 to 0.56 g/kg) reported by Lin et al. (2015). Du et al., (2016) testified that phosphorus concentrations in water spinach ranged from 0.27 to 0.39 g/kg fresh weight while covo and pumpkin leaves had 0.234g/kg, and 0.205 g/kg. Bidens pilosa, and amaranths, showed the least concentration (0.196) g/kg and 0.163 respectively.

Chaya had a great composition of zinc content registering 0.00533 ppm. Regardless of the failure to find relevant literature to show the actual range of zinc in Chaya, the current study showed that, Chaya has a better composition of zinc compared to other vegetables studied. This indicates its potential to contribute a substantial amount of zinc to the diet though not meeting the RDA of zinc set at 12mg/day (U.S Food and Drug Administration 2020). Pumpkin leaves, Bidens pilosa, and Covo registered only 0.00443ppm, 0.00437ppm, and 0.00370 ppm respectively which is far below what Mtaita et al., (2023) reported concerning Bidens pilosa, (57 ppm), and pumpkin leaves (67 ppm). Ali et al., (2018) indicated that zinc concentration in pumpkin leaves ranged from 14.6 to 30.9 ppm fresh weight. According to USDA data, kale contains approximately 5.8 ppm of zinc per 100 grams of raw kale. Even though zinc content in water spinach and amaranths was lower than the other vegetables, they can be incorporated into diets as they can contribute to zinc nutrient requirement.

As Magnesium content (0.887 ppm) in Amaranths is above the observed USDA value (approximately .550 ppm). The current study therefore recommends inclusion of amaranths in diets.

High Iron composition (0.0461ppm) in Chaya over all other studied vegetables justifies nutritionists to recommend Chaya consumption to reduce incidences of iron deficiencies. Water spinach with 0.0368ppm and Covo, 0.0294ppm can also be recommended for the provision of iron in diets as it helps in formation of haemoglobin. Regarding covo iron content, results contradicts with Mariga et al., (2012) who observed that the four different variety of Brassica oleracea var. acephala presents different iron contents from 0.89ppm to 4.04ppm. In terms of calcium concentration, Amaranths registered 0.600ppm followed by Chaya 0.502ppm. Calcium concentration was not significantly different from that of Bidens pilosa, pumpkin leaves, and water spinach. No calcium was detected in Covo.

Conclusion and Recommendation
Amaranths and Water spinach should be recommended to alleviate nutritional disorders because they have better level of nutrients composition compared to the other studied vegetables. Besides consumers’ preferences, more investigations on nutrient profiling of indigenous vegetables in different localities are critical to establish the need for information on nutrient composition to aid their promotion.

References
12. USDA. Brassica oleracea var. acephala. United States Department of Agriculture, Agricultural Research

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