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Full Length Research Article

# Comparative Evaluation of Mineral Elements and Water-Soluble Vitamins Present in Leaves of Purple-Red Skin Potato *(Ipomea batatas)* and Nigerian Spinach (*Celosia argentea*)

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## ABSTRACT

Sweet potato leaves are a valuable source of essential micronutrients and have the potential to play a significant role in improving dietary diversity, particularly in addressing micronutrient deficiencies in Nigeria. This study compared the nutrient content of the leaves of purple-red skin sweet potato (*Ipomoea batatas*) and Nigerian spinach (*Celosia argentea*). Purple-red skin sweet potato leaves were sourced from a farm at Olubadan Estate, while Nigerian spinach leaves were purchased from Molete Market, both in Ibadan, Oyo State, Nigeria. The concentrations of phosphorus, iron, zinc, and calcium were determined using a spectrophotometric method, while potassium and sodium were analyzed using flame photometry. The results showed that concentrations of potassium (357.99±1.15 mg), sodium (7.83±7.83 mg), and zinc (1.69±0.03 mg) in sweet potato leaves were significantly higher ($p<0.05$) than those observed for Nigerian spinach: potassium (346.59±4.73 mg), sodium (7.04±7.04 mg), and zinc (1.33±0.01 mg). The results also showed that Vitamin A (2.13±.00 µg/100g), Vitamin C (2.69±.02 mg/100g), and Vitamin B9 (0.31±.02 mg/100g) content of sweet potato leaves were significantly higher ($p<0.05$) than that of Nigerian spinach. However, there was no significant difference ($p>0.05$) in the phosphorus content of both leaf samples. In conclusion, the findings showed that sweet potato leaves had higher micronutrient composition compared to Nigerian spinach. Promoting consumption of sweet potato leaf alongside the commonly consumed Nigerian spinach could enhance dietary diversity, improve public health, and help address micronutrient deficiencies, particularly in limited-resource communities in Nigeria.

**KEYWORDS:** Purple-red Skin Sweet Potato Leaves, Nigerian Spinach, Micronutrients

## INTRODUCTION

Vegetables are nutrient-dense foods that provide essential nutrients, including potassium, magnesium, dietary fiber, folate, and vitamins A and C. Additionally, they are rich in various bioactive compounds that contribute to overall health (Liu, 2013). Leafy vegetables, a staple in the diet of the average Nigerian, are consumed in sufficient quantities to supply substantial amounts of vital minerals (Onwordi et *al.,* 2009). Sweet potato (*Ipomoea batatas*) is a versatile starchy root crop often described as a “3-in-1” food due to its combination of cereal-like starch content, fruit-like vitamin and pectin levels, and vegetable-like mineral and vitamin richness (Padmaja, 2009). The roots are a source of macronutrients, such as starch, dietary fiber, and protein, alongside a diverse array of micronutrients, including manganese, copper, potassium, iron, and vitamins B-complex, C, and E, as well as provitamin A (carotenoids) (Anbuselvi and Muthumani, 2014; El-Sheikha and Ray,2017). The edible parts of the plant include its tuberous roots, leaves, and young shoots. Sweet potato leaves are particularly valuable, containing vitamins, minerals, antioxidants, fiber, and essential fatty acids. The leaves are also known to contain high levels of potassium, beta-carotene, zeaxanthin, and lutein, and like many vegetables, they are abundant in carotenoids. Research highlights their richness in protein, calcium, iron, and zinc, making them a significant source of nutrients (Islam *et al.,* 2003; USDA, 2019).

Nigerian spinach (*Celosia argentea*), also known as "*soko*," belongs to the Amaranthaceae family and is a prominent leafy vegetable in Nigeria, particularly in the southwestern regions. This herbaceous plant thrives in tropical climates and is notable for its vibrant appearance (Ilodibia *et al.,* 2016). Economically, *C. argentea* plays a key role for rural farmers during the dry season, serving as an essential source of income (Akinfasoye *et al.,* 2008). Nutritionally, it is rich in proteins, vitamins, iron, phosphorus, calcium, and carbohydrates (Adegbaju et *al.,* 2019). Studies suggest that sweet potato leaves may offer higher protein levels compared to other dark green vegetables, such as spinach (Chirwa-Moonga *et al.,*2020), and contain bioactive components like anthocyanins, dietary fiber, and polyphenols, all of which support human health (Islam, 2014).

Despite these benefits, sweet potato leaf consumption in Nigeria remains limited compared to other African countries like Kenya and Ghana, and Asian countries like China and Taiwan (Omoba et *al.,* 2019). This limited popularity may stem from misconceptions about their taste and nutritional value, particularly when compared to commonly consumed vegetables like waterleaf, amaranthus, and spinach (Omoba *et al.,* 2020). Barriers to vegetable consumption, in general, include factors such as taste preferences, cost, familiarity, availability, and preparation time (Haynes-Maslow *et al.,* 2013).

Malnutrition, particularly micronutrient deficiency, remains a significant public health problem in Nigeria (Anjorin *et al.,* 2019). Micronutrients are essential for immune function, cognitive development, maintenance of body physiological processes, and overall health status. These deficiencies disproportionately affect the vulnerable group, under-five children and women of reproductive age, increasing their risk of anemia, impaired growth, and increased susceptibility to infections (Bailey *et al*., 2015; Hasan *et al.*, 2022). Despite the availability of diverse food resources, the diet patterns of many Nigerians, especially these vulnerable groups, remain monotonous and lack diversity (Adeomi *et al*., 2022; Falola *et al.*, 2023). There is an over-reliance on energy-dense staple foods and a low consumption of nutrient-dense vegetables. Exploring underutilized locally available food sources could enhance dietary diversity (Ebert, 2014; Hunter *et al*., 2019) and contribute to meeting the daily micronutrient requirements of Nigerians.

Sweet potato leaves offer a valuable source of essential micronutrients and could play a critical role in improving dietary diversity and nutrition, particularly in addressing micronutrient deficiencies prevalent in Nigeria. Understanding their precise nutritional composition, sensory attributes, and consumer preferences is crucial for integrating these leaves into local diets. This study evaluates the micronutrient composition of sweet potato leaves and Nigerian spinach (*soko)*.

## MATERIALS AND METHODS

### Chemicals, Reagents, and Equipment

The following chemicals and reagents were used in this study: 1.0 M hydrochloric acid (HCl), Sodium chloride (NaCl) and potassium solutions standards with concentrations of 20, 40, 60, 80, and 100 ppm, Aqueous ammonium heptamolybdate, 5% potassium hydroxide (KOH) solution, isopropyl alcohol, diethyl ether,1% metaphosphoric acid, 2,6-di chlroindophenol, hydrogen peroxide, activated charcoaland whatman No 4. filter paper. Flame Photometer (Jenway Digital Flame Photometer) and Atomic Absorption Spectrophotometer (Model 210VGP, Buck Scientific, USA) were some of the equipment used for analysis.

### Source of Plant Materials

The purple-red-skinned sweet potato leaves were sourced from a farm located at Olubadan Estate, New Ife Road, Ibadan, Oyo State, Nigeria, while Nigerian spinach (commonly known as "*soko*" in the Yoruba language) leaves were procured from Molete Market, Ibadan, Oyo State, Nigeria.

### Determination of Mineral Elements Composition of Purple-Red-Skinned Sweet Potato and Nigerian Spinach Leaves

A 2 g sample was ashed in a muffle furnace at 550°C for 5 hours. The ash was dissolved in 10 ml of 1.0 M hydrochloric acid (HCl), filtered into a 100 ml volumetric flask, and diluted to the mark with distilled water. Potassium and sodium levels were analyzed using the flame photometric method with a Jenway Digital Flame Photometer. An Atomic Absorption Spectrophotometer (Model 210VGP, Buck Scientific, USA) was employed to determine the phosphorus, iron, zinc, and calcium contents, following the AOAC (2005) procedure. Element-specific electrode lamps were utilized for each mineral analysis, and the equipment was calibrated using standard solutions of the respective minerals before measurement.

The concentration of each mineral (ppm) was recorded, and the total mineral concentration in mg/100 g was calculated using the equation:

$$Mineral\ Concentration\ \left({}^{mg}/_{100g}\right) = \frac{Concentration\ (ppm)\ \times Dilution\ factor\ \times 100}{weoght\ of sample\ \times 1000}$$

### Determination of Sodium (Na) and Potassium (K) by Flame Photometry

Sodium (Na) and Potassium (K) in the samples were determined using a flame photometer. Standard calibration curves were generated using sodium chloride (NaCl) solutions and standard potassium solutions with concentrations of 20, 40, 60, 80, and 100 ppm. The sodium concentration and potassium concentration in the ash solution were then interpolated from the corresponding standard curve. The mineral concentrations were initially recorded in parts per million (ppm) and subsequently converted to mg/100 g for reporting purposes.

### Determination of Phosphorus (P) by Spectrophotometry

The phosphorus content of each sample was analyzed using a spectrophotometer (Model: LemfieldSpectrulab 23A) (AOAC, 2005). To prepare the color reagent, 12.5 g of aqueous ammonium heptamolybdate was dissolved in 400 ml of deionized water to form solution A. Separately, 1.25 g of ammonium vanadate was dissolved in 300 ml of boiling deionized water to form solution B. Solution B was added to solution A and allowed to cool to room temperature. Subsequently, 250 ml of concentrated nitric acid was added, and the mixture was diluted to 1 liter to produce the final color reagent.

For the analysis, 1 ml of each ash solution was combined with 4 ml of deionized water in a beaker. Then, 5 ml of the prepared color reagent was added, and the total volume was adjusted to 25 ml. Over time, the solution developed a yellow color. A sample of the yellow solution was placed in a cuvette and analyzed using the spectrophotometer. The absorbance readings were compared against a standard curve prepared from known phosphorus concentrations to determine the phosphorus content in parts per million (ppm). Finally, the total phosphorus concentration was expressed in mg/100 g.

### Vitamins Analysis

Vitamin A, B2, B9, and vitamin C (ascorbic acid) were determined using AOAC (2000 and 2005).

**Determination of Vitamin A(µg/100g)**
The analysis was conducted spectrophotometrically using a modified version of the standard Method (AOAC, 2000). 0.5 g of the extract sample was homogenized and saponified with 2.5 ml of 12% alcoholic potassium hydroxide in a water bath at 60°C for 30 minutes. The saponified mixture was transferred to a separating funnel containing 10–15 ml of petroleum ether and thoroughly mixed. The aqueous lower layer was separated into another funnel, while the upper petroleum ether layer, containing the carotenoids, was collected. The extraction process was repeated until the aqueous layer became colorless. To remove excess moisture, anhydrous sodium sulfate was added to the petroleum ether extract. The final volume of the petroleum ether extract was measured, and the absorbance of the yellow solution was recorded at 450 nm using a visible spectrophotometer, with petroleum ether serving as the blank. The Vitamin A was determined by measuring the absorbance of carotenoids in the petroleum ether extract.

**Determination of Vitamin C (Ascorbic acid) (mg/100g)**
The determination of ascorbic acid was performed following the method described by AOAC (2005). A 20 mg sample of each extract was mixed with 10 ml of 1% metaphosphoric acid (Union) and allowed to extract for 45 minutes at room temperature. The mixture was then filtered through the Whatman No. 4 filter paper. One milliliter of the resulting filtrate was combined with 9 ml of 2,6-dichloroindophenol (Sigma), and the absorbance was recorded at 515 nm within 15 seconds using a blank as the reference. The ascorbic acid content was quantified based on a calibration curve.

**Determination of Vitamin B2 (Riboflavin)**
Riboflavin content was determined spectrophotometrically using a modified version of the AOAC Official Method 944.33 (AOAC, 2000). Dried and finely ground purple-fleshed potato leaves (1 g) were hydrolyzed in 0.1 N hydrochloric acid at 100 °C for 30 minutes to release bound riboflavin. The hydrolysate was cooled, neutralized with sodium acetate buffer (pH 4.5), and treated with takadiastase enzyme (1%, w/v) at 37 °C for 3 hours to enhance extraction. The mixture was then filtered, and the filtrate was subjected to oxidative deproteinization using potassium permanganate, followed by hydrogen peroxide. Activated charcoal was added to decolorize the extract, which was then filtered through Whatman No. 1 filter paper. The final filtrate was analyzed using a UV-Visible spectrophotometer at 444 nm. Riboflavin concentration in (mg/100g) was quantified using a calibration curve prepared with standard riboflavin solutions (0–10 µg/mL).

**Determination of Vitamin B9 (Folic acid) (mg/100g)**
The determination was performed spectrophotometrically using a modified version of the standard method (AOAC 2000). A 500 mg portion of homogenized leaf powder was weighed into a 100 ml volumetric flask, dissolved in 50 ml of 3% disodium hydrogen orthophosphate solution, and shaken for 20 minutes. The solution was then made up to the mark with the same solvent and filtered. Similarly, 28 mg of standard folic acid powder was weighed and treated using the same procedure.

For the analysis, 40 ml of the filtrate from the test sample and 3 ml of the filtrate from the standard sample were transferred to separate 100 ml volumetric flasks and diluted to the mark with 3% disodium hydrogen orthophosphate. From each solution, 5 mL was taken into a 50 mL volumetric flask, and the following steps were carried out for color development, 2 ml of 0.4% potassium permanganate ($KMnO_4$) was added and allowed to stand for 1 minute then 2 ml each of 2% sodium nitrate and 5M hydrochloric acid (HCl) were added, and the solution was shaken. To the solution, 2 ml each of 5% sulfuric acid ($H_2SO_4$) and 5% sodium edetate (EDTA) were added, and the solution was shaken and allowed to stand for 10 minutes. Finally, 2 ml of 0.1% azodye solution was added and allowed to stand for another 10 minutes, then the absorbance of the resulting solution was measured at 550 nm. Vitamin B9 of the test sample was calculated using the formula:

$$\text{Potency (mg/100g)} = AT/AS \times WS/WT \times 3/100 \times 100/40 \times \text{Average fill weight}$$

Where: AT = Absorbance of the test sample; AS = Absorbance of the standard sample; WS = Weight of the standard; WT = Weight of the test sample; Average Fill Weight = 480 mg

## RESULTS

**Mineral Composition of Sweet Potato and Nigerian Spinach Leaves**
The result is presented in Table 1. These findings demonstrate distinct differences in mineral content between the two vegetables, with sweet potato leaves generally showing higher concentrations of potassium, sodium, phosphorus, and zinc, while Nigerian spinach leaves exhibited higher levels of calcium and iron. There was a significant difference ($p<.05$) in potassium, calcium, sodium, iron, and zinc between the two leaves, while there was no significant difference in phosphorus ($p>.05$).

**Water-Soluble Vitamin Composition of Sweet Potato and Nigerian Spinach Leaves**

The result is presented in Table 2. These findings demonstrate distinct differences in mineral content between the two vegetables, with sweet potato leaves showing higher concentrations of Vitamins A, C, and B9, while Nigerian spinach leaves exhibited higher levels of vitamin B2 only.

**Table 1:** Minerals Composition of Sweet Potato and Nigeria Spinach Leaves

| SAMPLES | POTASSIUM | CALCIUM | SODIUM ( (mg/100g) | IRON | PHOSPHORUS | ZINC |
|---|---|---|---|---|---|---|
| **Sweet Potato** | 357.99±1.15[a] | 327.71±2.31[b] | 7.83±7.83[a] | 1.87±1.87[b] | 579.00±8.54[a] | 1.69±.03[a] |
| **Nigerian Spinach** | 346.59±4.73[b] | 332.59±1.52[a] | 7.04±7.04[b] | 2.52±2.52[a] | 573.33±16.07[a] | 1.33±.01[b] |

Data are mean ± standard deviation of triplicate determinations. Values with different superscripts in the same column are significantly different at $p < 0.05$.

**Table 2:** Water Soluble Vitamin Composition of Sweet Potato and Nigerian Spinach Leaves

| SAMPLES | VITAMIN A (µg/100g) | VITAMIN C (mg/100g) | VITAMIN B2 (mg/100g) | VITAMIN B9 (mg/100g) |
|---|---|---|---|---|
| **Sweet Potato leaves** | 2.13±.00[a] | 2.69±.02[a] | 0.32±.01[b] | 0.31±.02[a] |
| **Nigerian Spinach leaves** | 1.31±4.73[b] | 2.17±.03[b] | 0.58±.02[a] | 0.18±.01[b] |

Data are mean ± standard deviation of triplicate determinations. Values with different superscripts in the same column are significantly different at $p < 0.05$.

## DISCUSSION

This study comparatively evaluated the mineral elements and water-soluble vitamins present in leaves of purple-red skin potato *(Ipomea batatas*) and Nigerian spinach (*Celosia argentea*), locally known as "*soko*" in the Yoruba language. Minerals are vital for maintaining key bodily functions, such as regulating acid-base balance and managing water levels, and vegetables are valuable sources of minerals, making them an accessible and vital component of a balanced diet (Onwordi *et.al.,* 2009). Findings from this study revealed a significant difference ($p<0.05$) in mineral composition between the purple-red-skin sweet potato leaves and Nigerian spinach. Purple-red-skin sweet potato leaves have significantly higher levels of potassium, sodium, phosphorus, and zinc than Nigerian spinach leaves. The nutrient composition of these minerals falls within the range reported in previous studies (Hongnan *et al.,* 2014; Chirwa-Moonga *et al*., 2020; Hoang *et al.,* 2021). These micronutrients play an important role in regulating several physiological processes, including the regulation of fluid and electrolyte balance, acid-base homeostasis, nerve and muscle function, bone health, energy production, immune defense, and overall cellular metabolism (Ahmed and Chaudhary, 2009; Ajiboye *et al.,* 2014; Ilodibia *et al.,* 2016). Although the zinc levels in the samples from this study were relatively low, their consumption remains beneficial due to zinc's numerous roles in the body (Chirwa-Moonga *et al.,* 2020). Similarly, a study conducted in Nsukka reported a lower zinc content of Nigerian spinach0.823±0.01 mg/100 g (Ilodibia *et al.,* 2016).

Nigerian spinach (*soko*) leaves, however, have a higher composition of calcium and iron than the purple-red-skin sweet potato leaves, which are similar to the compositions observed in previous studies (Hongnan *et al.,* 2014; Omoba *et al.,* 2020; Chirwa-Moonga *et al.,* 2020; Hoang *et al.,* 2021) but higher than the findings from Onwordi *et al.* (2009). Iron is a mineral essential for the production of hemoglobin, which transports oxygen during respiration and cellular metabolism, and is also responsible for the proper functioning of the central nervous system, underscoring its importance in maintaining overall health (Onwordi *et al.,* 2009; Ajiboye *et al.,* 2014).

Sweet potato leaves are gaining recognition for not only their mineral but also their vitamin composition, especially vitamins B and C (Neela and Solomon, 2019). While sweet potato is often considered a staple food for the economically disadvantaged in many parts of Africa, its leaves are a nutrient-rich resource that can help alleviate nutritional deficiencies across the continent (Nkongho *et al.,* 2014). This indicates their potential as a valuable dietary component in improving public health and nutrition.

There was a significant difference in the vitamin composition of sweet potato leaves and Nigerian spinach (*soko*) leaves in this study. Sweet potato leaves have a significantly higher amount of vitamins A, C, and B9 compared to the Nigerian spinach (*soko*) leaves. The high levels of vitamins A and C in sweet potatoes, along with the functional properties of their leaves, highlight their antioxidant potential and protective effects against oxidative stress-related conditions such as allergies, cancer, aging, cardiovascular diseases, and HIV infection (Islam, 2006). Hence, promoting the consumption of sweet potato leaves could serve as a strategy to address vitamin A deficiency, especially in rural communities where the consumption of leafy vegetables is common due to their availability (Nkongho *et al.,* 2014).

These findings show that sweet potato leaves hold significant potential in addressing food security challenges in developing countries, particularly Nigeria. Also, promoting the consumption may offer a promising solution in managing diseases linked to oxidative stress, stating their health benefits beyond mere nourishment (Akinsola et *al.,* 2017).

## CONCLUSION

This study highlights the higher mineral and vitamin composition in leaves of purple-red skin sweet potato compared to Nigerian spinach, with significantly higher levels of potassium, sodium, phosphorus, zinc, and vitamins A, C, and B9. Although Nigerian spinach showed higher calcium and iron content, sweet potato leaves stand out as a nutrient-dense, underutilized vegetable with strong antioxidant properties. Promoting their consumption could enhance dietary diversity, improve public health, and help address micronutrient deficiencies and food insecurity, particularly in limited-resource communities in Nigeria.

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