



ANALYSIS OF THE PHYSICOCHEMICAL AND MINERAL COMPOSITION OF BAOBAB ROOT TUBERS FROM DIFFERENT SOIL SOURCES

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Abstract

The study investigated the mineral and phytochemical composition of baobab root tubers (*Adansonia digitata*) cultivated in three soil types: loamy, sandy, and clay. Mineral analysis using Atomic Absorption Spectrophotometry revealed significant levels of copper, iron, magnesium, manganese, and zinc, with variations influenced by soil conditions. Phytochemical screening identified bioactive compounds such as polyphenols, flavonoids, and carbohydrates, underscoring their antioxidant and nutritional potential. These findings highlight the value of baobab root tubers as a sustainable source of nutrients and bioactive compounds, offering applications in food security, healthcare, and industrial development. Further research is recommended to optimize their utilization and explore additional benefits.

Key words: *Adansonia digitata*, Baobab polyphenols, flavonoids, carbohydrates.

Introduction

The Baobab (*Adansonia digitata* L.) is an iconic African tree species widely recognized for its exceptional nutritional and medicinal properties (Gebauer *et al.*, 2016). While extensive research has focused on the fruit pulp and leaves, the root tubers represent

an understudied component with significant potential for nutritional and pharmaceutical applications (Kamatou *et al.*, 2011). Indigenous communities across Africa have traditionally utilized baobab root tubers as both a food source and medicinal remedy, suggesting the presence of valuable bioactive compounds (De Caluwé *et al.*, 2010).

Baobab root tubers are rich in essential minerals and phytochemicals that contribute to their nutritional profile. Studies indicate that these tubers contain significant levels of minerals such as calcium, magnesium, potassium, iron, and phosphorus, which are crucial for various bodily functions (Kamanula *et al.*, 2018). For instance, calcium levels have been recorded at approximately 69.39 mg/100g in certain populations (Kamanula *et al.*, 2018). Furthermore, the presence of iron in these tubers can be beneficial for addressing iron deficiency anaemia, a common health issue in many regions where baobab is consumed (Kamanula *et al.*, 2018).

The phytochemical constituents of baobab root tubers include flavonoids, phenols, saponins, tannins, and terpenoids. These compounds are known for their antioxidant properties and potential health benefits, including anti-inflammatory effects (Kamanula *et al.*, 2018; Wasihun *et al.*, 2023). The qualitative screening of these phytochemicals has revealed that they may play a role in enhancing the nutritional value of the tubers while also offering protective health benefits against various diseases (Wasihun *et al.*, 2023).

The medicinal applications of baobab root tubers are supported by their bioactive compounds. Previous research has highlighted the antimicrobial properties of various parts of the baobab tree, suggesting that the root tubers may also possess similar capabilities (Kamanula *et al.*, 2018). The ability of these phytochemicals to mitigate oxidative stress further emphasizes the medicinal potential of baobab roots, making them a valuable resource for both nutritional and therapeutic purposes.

Materials and Method

Reagents

Hydrochloric acid ,Sulphuric acid Molisch's reagent ,Mayer's reagent, Deionized water, Nitric acid, Ferric chloride, Ethanol, Sodium hydroxide, Methanol.

Experimental design

Sample Collection

The trial was laid out as a complete randomized design with three replicates. From 3 indigenous baobab families, all the 3 families were selected for sowing on the basis of seed quality. Seeds which were relatively small and damaged were removed before sowing. For each treatment, two seeds for each of 3 families were sown in three black polythene tubes (30cm x 15cm) at 4cm depth. Watering was carried out twice a day to keep the rooting medium moist. After germination, the seedlings were thinned to remain with one seedling per tube. The plants were cultivated under identical conditions, including watering schedules, sunlight exposure, and temperature, to ensure comparability. Fresh baobab roots (*Adansonia digitata*) were harvested from their cultivation pots once they reached maturity and were available for collection.

Sample Preparation

After four months the baobab root samples collected and were thoroughly washed under running tap water to remove soil and debris, followed by rinsing with deionized water. The roots were then sliced into smaller pieces with a sterilized blade. The root pieces were air-dried in a clean, ventilated area. Once dried, the root pieces were ground into a fine powder using a mechanical grinder. The powdered samples were then stored in airtight containers at room temperature until analysis.

Acid Digestion

An analytical balance was used to accurately weigh 2 g of the powdered sample. The sample was transferred into a beaker, and 10 mL of concentrated nitric acid (HNO_3) was added. The sample was allowed to pre-digest at room temperature for approximately 30 minutes. Subsequently, 5 mL of concentrated sulfuric acid (H_2SO_4) was added to aid in complete digestion. The mixture was heated on a hot plate at 40°C until the solution became clear. After cooling, the digest was filtered using Whatman filter paper into a volumetric flask and diluted to a final volume of 50 mL with deionized water. Atomic Absorption Spectrophotometry (AAS) was then used

for the determination of mineral content, specifically Fe, Zn, Cu, Mn, and Mg because of their nutrition values as essential minerals need by human beings. The unit mg/kg was used as 1ppm equals 1 mg/kg.

Table 1: Sample Identification and Soil Types

Sample ID	Soil Type
Sample A	Baobab root tuber planted on loamy soil
Sample B	Baobab root tuber planted on sandy soil
Sample C	Baobab root tuber planted on clay soil

Phytochemical Screening

Glycaemic index

A 1g of dried baobab root powder was weighed and hydrolysed with 3 mL of 1 M HCl, then incubated at 37°C for 1 hour to simulate digestion. The acid was neutralized with 1 M NaOH and filtered. Molisch's reagent (α -naphthol in ethanol) was added to 2 mL of the filtered solution, and 2 mL of concentrated sulfuric acid was gently poured down the side of the test tube. The presence of carbohydrates was indicated by a purple/violet ring at the interface.

Polyphenol test

A 2 g of dried baobab root powder was extracted with 10 mL ethanol for 24 hours using a shaker, and the solution was filtered. Adding 2–3 drops of ferric chloride solution FeCl_3 (1%) to 2 mL of the ethanol extract resulted in a dark green, blue, or black colour, indicating the presence of polyphenols.

Flavonoid test

The same ethanol extract prepared for the polyphenol test was used. 2 mL of 10% NaOH solution was added to 2 mL of the extract, and the formation of a yellow colour indicated the presence of flavonoids.

Carbohydrate test

A 2 g of dried baobab root powder was boiled in 10 mL deionized water for 5 minutes, and the solution was filtered. Molisch's reagent was added to 2 mL of the water extract, and 2 mL of concentrated sulfuric acid was slowly added along the side of the test tube. The presence of carbohydrates was indicated by the formation of a purple/reddish colour.

Results and Discussion

Results

Table 2: Phytochemical Screening Results

Sample ID	Glycaemic Test	Polyphenol Test	Flavonoid Test	Carbohydrate Test
Sample A	Detected	Detected	Detected	Detected
Sample B	Detected	Not detected	Not detected	Detected
Sample C	Not detected	Detected	Detected	Detected

Table 3. Descriptive Statistics of Sample A (Loamy Soil)

Elements	Mean $\pm$ Standard deviation	Minimum	Maximum
Copper	0.257 $\pm$ 0.000	0.256	0.258
Iron	8.681 $\pm$ 0.001	8.680	8.683
Magnesium	2.382 $\pm$ 0.001	2.380	2.383
Manganese	0.330 $\pm$ 0.000	0.330	0.331
Zinc	1.175 $\pm$ 0.001	1.174	1.177

Table 4. Descriptive Statistics of Sample B (Sandy Soil)

Elements	Mean $\pm$ Standard deviation	Minimum	Maximum
Copper	0.28 $\pm$ 0.000	0.279	0.281
Iron	7.185 $\pm$ 0.002	7.182	7.189
Magnesium	2.403 $\pm$ 0.001	2.401	2.405
Manganese	0.542 $\pm$ 0.000	0.541	0.543
Zinc	0.013 $\pm$ 0.000	0.012	0.014

Table 5. Descriptive Statistics of Sample C (Clay Soil)

Elements	Mean $\pm$ Standard deviation	Minimum	Maximum
Copper	0.154 $\pm$ 0.001	0.153	0.156
Iron	7.297 $\pm$ 0.000	7.296	7.298
Magnesium	1.84 $\pm$ 0.000	1.839	1.841
Manganese	0.716 $\pm$ 0.001	0.715	0.718
Zinc	0.714 $\pm$ 0.001	0.712	0.716

Discussion

The mineral and phytochemical composition of baobab root tubers observed in this study aligns with findings by Kamanula *et al.* (2018) while highlighting some key differences due to variations in geographical and experimental conditions.

Mineral Composition

The mineral composition of baobab root tubers planted on different soils types (loamy, sandy, and clay) as shown in Table 3,4 and 5, revealed varying levels of essential nutrients. Copper levels were highest in Sample B (0.28 ± 0.00 mg/kg, sandy soil), followed by Sample A (0.257 ± 0.00 mg/kg, loamy soil) and finally Sample C show the lowest copper, (0.154 ± 0.001 mg/kg, clay soil). These values exceed the maximum copper concentration of 0.155 mg/100 g reported by Kamanula *et al.* (2018), indicating a richer copper content in this study, possibly influenced by soil type and that copper is essential nutrient for plants. Iron concentrations were found higher in Sample A (8.681 ± 0.001 mg/kg loamy soil), followed by Sample C (7.185 ± 0.002 mg/kg sandy soil) and Sample C (7.182 ± 0.00 mg/kg clay soil). These findings are in agreement with the maximum iron level of 8.89 mg/100 g observed in Karonga populations by Kamanula *et al.* (2018), suggesting that baobab root tubers are consistently a good source of iron regardless of soil type.

Magnesium levels were relatively low in this study, ranging from 2.403 ± 0.001 mg/kg in Sandy soil to 1.84 ± 0.00 mg/kg in clay soil, this may be attributed to

porosity in sandy soil, with loamy soils shows a greater absorption of magnesium with concentration of 2.382 ± 0.001 mg/kg. Loamy soil contains significant amount of humus. These values are in disagreement with the 44.16 mg/100 g magnesium content reported by Kamanula *et al.* (2018) in Chikhwawa populations, suggesting a potential influence of soil type or environmental factors on magnesium uptake. Manganese concentrations were highest in sandy soil (0.542 ± 0.00 mg/kg), followed by (0.330 ± 0.00 mg/kg) and clay soil has the highest manganese concentrations. (0.716 ± 0.001 mg/kg). These findings are in partial agreement with Kamanula *et al.* (2018), who recorded manganese levels as high as 0.815 mg/100 g in Karonga populations, indicating that sandy and clay soils may enhance manganese uptake compared to loamy soils.

Finally, zinc content was highest in loamy soil (1.175 ± 0.001 mg/kg), followed by clay soils (0.71 ± 0.001 mg/kg) and sandy soil shows the lowest absorption of zinc (0.013 ± 0.00 mg/kg). The zinc levels in Sample A significantly surpass the maximum of 0.221 mg/100 g reported by Kamanula *et al.* (2018), demonstrating the potential of loamy soil to enhance zinc accumulation in baobab root tubers. These findings highlight the influence of soil type on the mineral composition of baobab root tubers. In agreement with Kamanula *et al.* (2018), environmental and genetic factors are likely contributors to these variations.

Phytochemical Composition

The results of the phytochemical screening as shown in **Table 2:** revealed the presence of polyphenols, flavonoids, and carbohydrates in varying concentrations across samples. For example, polyphenols were consistently detected in Samples A and C but not detected in Sample B. Kamanula *et al.* (2018) similarly identified saponins and terpenoids as predominant phytochemicals in baobab root tubers, albeit with the absence of flavonoids and alkaloids across all regions studied. The absence of flavonoids in Kamanula *et al.* (2018) contrasts with their presence in this study, suggesting potential environmental or methodological influences.

Both studies emphasized the medicinal relevance of these phytochemicals. Kamanula *et al.* (2018) highlighted the antimicrobial potential of saponins and terpenoids, while this study underscored the antioxidant properties of polyphenols and flavonoids. These differences reflect the diverse phytochemical profiles that may result from variations in soil type, cultivation practices, and analytical methodologies.

Conclusion

This study has established that baobab root tubers are rich in essential minerals and bioactive phytochemicals, which can contribute to nutritional and medicinal benefits. The variability in composition based on soil type underscores the importance of environmental factors. These findings provide a foundation for the expanded utilization of baobab root tubers in nutrition and pharmacology.

Recommendations

- i. **Further Research:** Conduct in-depth studies to explore the bioavailability of identified minerals and phytochemicals.
- ii. **Agricultural Practices:** Investigate optimal soil and cultivation conditions to enhance the nutrient content of baobab root tubers.
- iii. **Product Development:** Develop value-added products such as supplements and functional foods using baobab root extracts.
- iv. **Awareness Campaigns:** Promote the benefits of baobab root tubers among communities where the tree is endemic.

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