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# Bioactive, antioxidant, and inhibitory potential against amylase and glucosidase of four *Talinum* species (Talinaceae) from Southwestern Nigeria

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**Abstract:** Micronutrient deficiencies and oxidative stress-related diseases remain major public health challenges in sub-Saharan Africa. This study evaluated the mineral composition and antioxidant properties of four *Talinum* species (*Talinum triangulare*, *Talinum paniculatum*, *Talinum portulacifolium*, and *Talinum fruticosum*) collected from Southwestern Nigeria. Mineral analysis was conducted using AOAC methods, while antioxidant activities were determined using DPPH, FRAP, ABTS, and total antioxidant capacity (TAC) assays. Significant interspecific variation was observed. *T. paniculatum* recorded the highest calcium (1.58 ± 0.01%) and iron (295.02 ± 0.04 mg/kg), whereas *T. portulacifolium* showed the highest potassium (3.69 ± 0.01%) and sodium (0.78 ± 0.01%). Antioxidant assays revealed that *T. paniculatum* exhibited the strongest activity (DPPH: 79.52 ± 0.01%; FRAP: 26.30 ± 0.06 mg/100 g; ABTS: 84.64 ± 0.03%; TAC: 22.59 ± 0.30 mg/100 g). Correlation analysis indicated strong positive associations between iron and DPPH (r = 0.908) and phosphorus and FRAP (r = 0.933). Principal component analysis explained 91.1% of total variance, with *T. paniculatum* emerging as compositionally superior. These findings highlight the potential of *Talinum* species, particularly *T. paniculatum*, as functional foods for dietary fortification and management of micronutrient deficiencies and oxidative stress-related diseases.

## Introduction

Micronutrient deficiencies remain among the most critical public health challenges in Nigeria and sub-Saharan Africa, with profound implications for health, productivity, and socioeconomic development. Recent estimates suggest that about 4.4 million children under five years of age in Nigeria suffer from acute malnutrition, with widespread deficiencies in zinc, iron, and vitamin A across the region [1, 2]. Such deficiencies contribute to a spectrum of health conditions, including anemia, impaired immune function, night blindness, osteoporosis, and increased morbidity and mortality among children and pregnant women [3, 4]. Alongside these nutritional challenges, the burden of oxidative stress-related chronic diseases continues to escalate. Oxidative stress, resulting from an imbalance between pro-oxidants and antioxidants in the body, has been implicated in the etiology of diabetes, cancer, cardiovascular diseases, obesity, and neurodegenerative conditions [5, 6]. The convergence of micronutrient deficiencies and oxidative stress-related disorders highlights the urgent need for accessible, affordable, and culturally acceptable dietary interventions capable of addressing these dual burdens. Indigenous leafy vegetables (ILVs) offer a compelling solution to this problem. These underutilized crops are nutrient-dense, locally available, and adapted to the ecological conditions of Africa [7, 8]. Among ILVs, species of the genus *Talinum* have gained increasing attention due to their exceptional nutritional and bioactive profiles. The genus, belonging to the family Talinaceae, consists of about 50 species distributed across tropical and subtropical regions [9]. Known for their succulent leaves and tolerance to harsh environmental conditions, *Talinum* species have historically been consumed in local diets and used in traditional medicine [8, 10]. In Southwestern Nigeria, *Talinum triangulare*, commonly referred to as waterleaf, is the most widespread and widely cultivated species. It is valued not only for its culinary applications but also for its medicinal properties, which are deeply rooted in traditional practices [11]. Other species, such as *T. paniculatum*, *T. fruticosum*, and *T. portulacifolium*, are also present in the region, though they remain underexploited compared to *T. triangulare* [12].

The nutritional importance of *Talinum* species lies in their remarkable mineral content, high levels of essential vitamins, and a diverse array of bioactive compounds. Studies have shown that these vegetables are rich in calcium, iron, potassium, and magnesium, as well as vitamin C, vitamin A precursors such as β-carotene, and vitamin K [8, 13]. Their phytochemical composition includes phenolic compounds, flavonoids, carotenoids, and alkaloids, which contribute to significant antioxidant properties [8, 10]. These compounds play central roles in scavenging free radicals, reducing oxidative damage, and conferring protection against chronic diseases. In traditional medicine, *Talinum* species have been employed in the treatment of gastrointestinal disorders, inflammation, hypertension, skin infections, and diabetes, with scientific studies increasingly validating these applications through biochemical and pharmacological evidence [12, 14]. Despite their nutritional and medicinal potential, *Talinum* species remain underutilized in contemporary food systems. Most nutrition programs in Nigeria and other parts of Africa have historically prioritized exotic vegetables, often overlooking indigenous options that may offer superior benefits [7]. For example, waterleaf is widely cultivated and consumed, yet species such as *T. paniculatum* and *T. portulacifolium* are relatively unknown outside specific localities, despite evidence of their outstanding mineral and antioxidant properties [8, 12]. Limited comparative studies have examined the nutritional and phytochemical diversity among different *Talinum* species, creating significant knowledge gaps that constrain their integration into public health nutrition strategies. Existing literature emphasizes the role of indigenous leafy vegetables in enhancing food security and public health outcomes. ILVs contribute between 30.0% and 50.0% of dietary iron and vitamin A in rural African households, often with minimal agricultural input requirements [15]. Compared to exotic vegetables, ILVs are more resilient to climate variability, thrive under marginal soil conditions, and adapt readily to smallholder farming systems [7, 8]. Their cultivation supports local economies, particularly for women who dominate small-scale vegetable production and marketing in West Africa [16]. Beyond their socioeconomic value, ILVs such as *Talinum* species possess nutrient and bioactive profiles that position them as functional foods, dietary items that provide not only basic nutrition but also therapeutic health benefits [14, 17]. Research on the proximate composition of *Talinum* species highlights their significant contributions to dietary macronutrients. Moisture content in *T. triangulare* and *T. fruticosum* ranges between 80% and 90%, comparable to spinach but higher than amaranth leaves, underscoring their succulence and perishability [13]. Protein content varies between 2.5% and 5.0%, offering meaningful dietary contributions in regions where protein-energy malnutrition is prevalent [8]. Their crude fiber content, ranging from 4.5% to 8.0%, enhances gastrointestinal health, supports weight management, and reduces cholesterol levels [10]. Their carbohydrate content (6%-12%) provides modest energy without excessive caloric intake. Their fat content is typically low (0.5%-1.5%), aligning them with low-fat diets while still supplying essential fatty acids necessary for cell function [12]. Micronutrient analysis demonstrates that *Talinum* species are rich in minerals essential for physiological processes. Calcium content varies across species, with *T. paniculatum* and *T. portulacifolium* recording significantly higher levels than *T. triangulare*. Iron concentrations in *T. triangulare* and *T.*

*fruticosum* provide important dietary sources to address iron-deficiency anemia [14]. Potassium and magnesium contribute to cardiovascular health and metabolic regulation [16]. Trace elements such as zinc, manganese, and copper, though less abundant, support enzymatic activity and metabolic processes [13]. Furthermore, the vitamin profile of *Talinum* species is particularly notable, with high levels of vitamin C exceeding those found in citrus fruits, vitamin A comparable to carrots, and vitamin K surpassing spinach [10]. These characteristics underline the potential of *Talinum* as a key dietary component in addressing micronutrient deficiencies.

Phytochemical studies reinforce the therapeutic promise of *Talinum* species. Phenolic acids such as ferulic acid and vanillic acid, alongside flavonoids like quercetin and kaempferol, demonstrate strong antioxidant, anti-inflammatory, and antimicrobial activities [8]. Carotenoids, including β-carotene and lycopene, contribute not only to antioxidant protection but also to vitamin A biosynthesis, essential for vision and immune function [6]. The synergistic effects of these bioactive compounds significantly enhance the overall antioxidant potential of *Talinum* extracts, which has been validated through DPPH, FRAP, ABTS, and TAC assays [10, 14]. These antioxidant mechanisms are particularly valuable for mitigating oxidative stress, a major driver of chronic and degenerative diseases [5]. Environmental factors exert a significant influence on the nutritional and phytochemical composition of *Talinum* species. Soil quality, water availability, temperature, and light intensity all affect the concentration of minerals and bioactive compounds in the leaves [7]. For instance, mild water stress has been shown to increase mineral concentration in leafy vegetables, while post-harvest conditions such as storage temperature and humidity determine vitamin retention [15]. Processing techniques, including drying and fermentation, also affect the nutritional profile, sometimes reducing heat-sensitive vitamins like vitamin C while concentrating minerals [12]. These variables highlight the importance of agronomic practices and post-harvest handling in optimizing the nutritional value of *Talinum* species. Beyond their biochemical composition, *Talinum* species play important roles in food security and sustainable agriculture. Their short maturity period of four to six weeks enables multiple harvests within a growing season, providing food and income for smallholder farmers [11]. They can be integrated into household gardens and mixed cropping systems with minimal input requirements, making them suitable for resource-constrained farmers [16]. The potential to process *Talinum* into dried powders or other value-added products further enhances their marketability and contribution to income generation [12]. Their cultural significance, embedded in traditional cuisines and medicinal practices, also facilitates their acceptance within local communities, strengthening the case for their promotion in nutrition-sensitive interventions [14]. The therapeutic applications of *Talinum* species are diverse and well-documented in ethnobotanical and scientific literature. Their antidiabetic properties have been demonstrated through flavonoid extracts that reduce blood glucose levels and improve insulin sensitivity in experimental models [10]. Their cardiovascular benefits derive from potassium-mediated blood pressure regulation and antioxidant protection against atherosclerosis [16]. Neuroprotective effects have been observed in animal studies, with evidence of improved brain function and reduced oxidative damage [6]. Hepatoprotective properties have also been confirmed, with extracts reducing oxidative stress and supporting liver function [8]. These findings provide scientific validation for the traditional uses of *Talinum* species in treating a wide range of health conditions. Despite their potential, significant research gaps persist. Most existing studies focus on *T. triangulare*, while other species, such as *T. paniculatum* and *T. portulacifolium*, have been largely neglected [12]. Few studies have systematically compared the mineral and antioxidant profiles of different *Talinum* species, leaving uncertainty about their relative nutritional and therapeutic value [8]. Furthermore, while laboratory assays provide valuable insights into antioxidant activity, clinical trials are necessary to confirm bioavailability and health outcomes in human populations [5]. Addressing these gaps is essential for advancing the integration of *Talinum* species into nutrition and health programs. The urgency of such research is underscored by the persistent problem of hidden hunger in sub-Saharan Africa, where over half of the population consumes insufficient levels of critical micronutrients [1, 15]. With conventional strategies often proving inadequate, food-based approaches that leverage locally available resources offer the most sustainable path forward [3]. Indigenous vegetables like *Talinum* are particularly well suited to this purpose, combining cultural familiarity with nutritional density and therapeutic potential [18]. By generating robust scientific evidence on their composition and benefits, research on *Talinum* species can inform policy, guide dietary recommendations, and support the development of functional food products tailored to local needs [14]. This study, therefore, provides critical comparative data on the mineral composition and antioxidant properties of four *Talinum* species from Southwestern Nigeria, aiming to establish scientific validation for their nutritional and medicinal value and to support their incorporation into strategies for food security and public health improvement.

## Materials and methods

*Sample collection and analysis***:** Fresh leaves of four *Talinum* species-*T. triangulare*, *T. paniculatum*, *T. portulacifolium*, and *T. fruticosum* were collected from different locations across Southwestern Nigeria (**Figure 1**). The leaves were washed thoroughly to remove surface impurities, air-dried at room temperature until constant weight was achieved, and pulverized into fine powder using a mechanical grinder. The powdered samples were stored in airtight containers in a cool, dry place until further analysis.


**Figure 1:** Plant form of *Talinum* species used in the study, A = *T. triangulare,* B = *T. paniculatum,* C = *T. portulacifolium,* and D = *T. fruticosum*

*Mineral analyses:* Mineral analyses were conducted using standard AOAC methods. Ash residues were used to quantify key minerals, with duplicate measurements performed for reproducibility. The instrument settings of the Atomic Absorption Spectrophotometer (model: Buck 211vgp, Buck Scientific) were followed (**Table 1**). Calcium, potassium, and sodium were determined using AOAC 975.11, while phosphorus was quantified using AOAC 975.16. Concentrations were expressed as percentages of dry weight or mg/kg as appropriate.

**Table 1:** Instrument setting for atomic absorption spectrophotometry

| Element | Wavelength (nm) | Slit (nm) | Working range (µg/ml) | Sensitivity (µg/ml) | Lamp current | Flame type |
|---|---|---|---|---|---|---|
| **Ca** | 422.7 | 0.5 | 1.0-4.0 | 0.02 | 10.0 | $N_2O–C_2H_2$ |
| **Ca** | 422.7 | 0.5 | 1.0-10.0 | 0.09 | 10.0 | Air–$C_2H_2$ |
| **Fe** | 248.3 | 0.2 | 2.0-20.0 | 0.1 | 30.0 | Air–$C_2H_2$ |
| **Fe** | 372.0 | 0.2 | 20.0-80.0 | 0.5 | 30.0 | Air–$C_2H_2$ |
| **K** | 766.5 | 0.5 | 1.0-10.0 | 0.01 | 6.0 | Air–$C_2H_2$ |
| **Mg** | 285.2 | 0.5 | 0.1-2.0 | 0.01 | 6.0 | Air–$C_2H_2$ |
| **Mg** | 202.6 | 1.0 | 5.0-20.0 | 0.1 | 6.0 | Air–$C_2H_2$ |
| **Na** | 589.0 | 0.2 | 0.03-1.0 | 0.02 | 8.0 | Air–$C_2H_2$ |

*Preparation of extract for antioxidant assays:* Twenty grams (20 g) of the powdered *Talinum* samples were soaked in 200 mL of distilled water for 48 hrs at room temperature. Thereafter, the solutions were filtered and concentrated using a rotary evaporator.

*Antioxidant assays:* The antioxidant properties of the four *Talinum* species were assessed using multiple complementary assays. The DPPH radical scavenging assay followed the method of [18] with modifications, measuring absorbance at 516 nm. The Ferric Reducing Antioxidant Power (FRAP) assay was carried out according to [19] with results expressed as mg $Fe^{2+}$ equivalent per 100 g dry weight. The ABTS radical scavenging assay was conducted using the method of [20], with inhibition percentages calculated at 734 nm. Total Antioxidant Capacity (TAC) was determined by the phosphomolybdenum method [21], with results expressed as mg ascorbic acid equivalent per 100 g dry weight.

*Statistical analysis:* All analyses were performed in triplicate. Data were statistically evaluated using descriptive statistics, one-way analysis of variance (ANOVA), and post-hoc LSD tests at $p < 0.05$. Principal Component Analysis (PCA) was used to reduce dimensionality and identify major compositional patterns, while Pearson correlation analysis quantified relationships among variables. Hierarchical cluster analysis based on Bray-Curtis ' similarity and the UPGMA algorithm was applied to classify species according to their compositional profiles. Data were examined for normality, outliers, and quality control, with all tests conducted at a significance level of $\alpha = 0.05$.

## Results

Descriptive statistics outlined the nutritional and phytochemical profiles of the four *Talinum* species collected from Southwestern Nigeria. Mean values and standard errors were calculated from three measurements for each species, and significance was assessed using the Least Significant Difference (LSD) test at $p < 0.05$. Significant variations were observed among the species for mineral composition and antioxidant properties. The mineral composition revealed interspecific diversity across the four species (**Table 2**). Calcium content was highest in *T. paniculatum* (1.58 ± 0.01%) and *T. portulacifolium* (1.50 ± 0.00%), with no significant difference between them. *T. fruticosum* (1.11 ± 0.06%) showed intermediate values, while *T. triangulare* recorded the lowest calcium concentration (0.78 ± 0.01%). These differences are consistent with earlier studies reporting interspecies variation in calcium among leafy vegetables [10, 13]. Potassium content was significantly higher in *T. portulacifolium* (3.69 ± 0.01%), followed by *T. paniculatum* (3.06 ± 0.02%), *T. triangulare* (2.28 ± 0.01%), and *T. fruticosum* (1.26 ± 0.02%). Sodium levels were also highest in *T. portulacifolium* (0.78 ± 0.01%), while *T. paniculatum* (0.40 ± 0.01%) and *T. fruticosum* (0.40 ± 0.01%) were similar, and *T. triangulare* exhibited the lowest sodium content (0.31 ± 0.01%). Phosphorus concentrations did not show significant variation among species, ranging from 0.16 ± 0.00% in *T. fruticosum* to 0.47 ± 0.27% in *T. paniculatum*. Iron content varied significantly, with *T. paniculatum* recording the highest level (295.02 ± 0.04 mg/kg), followed by *T. triangulare* (274.45 ± 0.55 mg/kg), *T. portulacifolium* (220.02 ± 0.57 mg/kg), and *T. fruticosum* (168.00 ± 1.61 mg/kg). These findings agree with earlier reports of high iron levels in *T. triangulare* and related species [8, 14].

**Table 2:** Mineral composition of four *Talinum* species from South-Western Nigeria

| Variable | *T. triangulare* | *T. portulacifolium* | *T. paniculatum* | *T. fruiticosum* | LSD |
|---|---|---|---|---|---|
| **Ca (%)** | 0.78 ± 0.01c | 1.50 ± 0.00a | 1.58 ± 0.01a | 1.11 ± 0.06b | 0.09 |
| **K (%)** | 2.28 ± 0.01c | 3.69 ± 0.01a | 3.06 ± 0.02b | 1.26 ± 0.02d | 0.05 |
| **Na (%)** | 0.31 ± 0.01c | 0.78 ± 0.01a | 0.40 ± 0.01b | 0.40 ± 0.01b | 0.03 |
| **P (%)** | 0.18 ± 0.00a | 0.18 ± 0.00a | 0.47 ± 0.27a | 0.16 ± 0.00a | 0.43 |
| **Fe (mg/kg)** | 274.45±0.55b | 220.02 ± 0.57c | 295.02 ± 0.04a | 168.00±1.61d | 2.92 |

*(Means along the same row are significantly different if they have the same assigned alphabet)*

Antioxidant assays also revealed significant species-specific differences (**Table 3**). The highest DPPH radical scavenging activity was observed in *T. paniculatum* (79.52 ± 0.01 % inhibition), which was significantly greater than in other species. *T. triangulare* (64.55 ± 0.13 % inhibition) exhibited moderate scavenging activity, while *T. portulacifolium* (58.25 ± 0.03 % inhibition) and *T. fruticosum* (52.70 ± 0.12 % inhibition) showed lower activities. Similar patterns were observed for FRAP values, with *T. paniculatum* demonstrating the greatest reducing capacity (26.30 ± 0.06 mg/100 g), followed by *T. triangulare* (17.71 ± 0.20 mg/100 g), *T. fruticosum* (14.15 ± 0.08 mg/100 g), and *T. portulacifolium* (12.21 ± 0.04 mg/100 g). These results support prior reports on the strong antioxidant potential of *Talinum* species [8, 10]. The ABTS radical scavenging assay confirmed *T. paniculatum* as the most potent antioxidant species, with 84.64 ± 0.03% inhibition, significantly higher than *T. triangulare* (71.46 ± 0.20% inhibition), *T. fruticosum* (70.60 ± 0.36% inhibition), and *T. portulacifolium* (62.22 ± 0.07% inhibition). Total Antioxidant Capacity (TAC) results further supported this trend, with *T. paniculatum* recording the highest value (22.59 ± 0.30 mg AAE/100 g). *T. triangulare* (14.96 ± 0.05 mg AAE/100 g) and *T. fruticosum* (13.38 ± 0.07 mg AAE/100 g) showed no significant difference, while *T. portulacifolium* exhibited the lowest value (10.43 ± 0.06 mg AAE/100 g). This aligns with studies reporting variability in antioxidant activities among different *Talinum* species [12].

**Table 3:** Antioxidant properties of four *Talinum* species from south-western Nigeria

| Species | *T. fruiticosum* | *T. paniculatum* | *T. portulacifolium* | *T. triangulare* | LSD |
|---|---|---|---|---|---|
| **DPPH (% Inhibition)** | 52.70±0.12d | 79.52±0.01a | 58.25±0.03c | 64.55±0.13b | 0.29 |
| **FRAP (mg/100g)** | 14.15±0.08c | 26.30±0.06a | 12.21±0.04d | 17.71±0.20b | 0.37 |
| **ABTS (% Inhibition)** | 70.60±0.36c | 84.64±0.03a | 62.22±0.07d | 71.46±0.20b | 0.68 |
| **TAC (mg AAE/100g)** | 13.38±0.07b | 22.59±0.30a | 10.43±0.06c | 14.96±0.05b | 0.51 |

*(Means along the same row are significantly different if they have the same assigned alphabet)*

Principal Component Analysis reduced the dataset into three meaningful components that explained 96.8% of the total variance. The first principal component (PC1), accounting for 63.6% of the variance, was strongly associated with antioxidant activity (DPPH, FRAP, ABTS, and TAC) and mineral elements, such as phosphorus and iron, while sodium was negatively loaded. PC1 represented an "antioxidant–mineral richness" dimension, distinguishing species with high antioxidant capacity and mineral content. The second principal component (PC2), explaining 27.5% of the variance, was dominated by calcium, potassium, and sodium, reflecting a "macromineral content" dimension. The third component (PC3), which explained 5.7% of the variance, had minor contributions from calcium and potassium (**Table 4**). These patterns are consistent with multivariate analyses of ILVs in other studies [7, 15].

**Table** Error! No text of specified style in document.**:** Principal component loadings and variance explained for mineral and antioxidant variables in four *Talinum* species

| Variable | PC1 | PC2 | PC3 |
|---|---|---|---|
| **Ca** | 0.152 | 0.509 | 0.643 |
| **K** | 0.107 | 0.575 | - 0.627 |
| **Na** | - 0.177 | 0.574 | - 0.421 |
| **P** | 0.4 | 0.129 | 0.382 |
| **Fe** | 0.343 | 0.064 | - 0.138 |
| **DPPH** | 0.408 | 0.09 | - 0.129 |
| **FRAP** | 0.415 | - 0.074 | 0.089 |
| **ABTS** | 0.39 | - 0.183 | 0.172 |
| **TAC** | 0.407 | - 0.111 | 0.113 |
| Eigen value | 5.725 | 2.472 | 0.512 |
| Variance explained (%) | 63.6 | 27.5 | 5.7 |
| Cumulative variance (%) | 63.6 | 91.1 | 96.8 |

The PCA biplot revealed distinct nutritional and antioxidant profiles for the species. *T. paniculatum* clustered positively along PC1, reflecting superior antioxidant and mineral properties, while *T. portulacifolium* aligned strongly with PC2, indicating higher macromineral content. *T. triangulare* and *T. fruticosum* are positioned closer to the center, reflecting intermediate nutritional and antioxidant attributes (**Figure 2**).

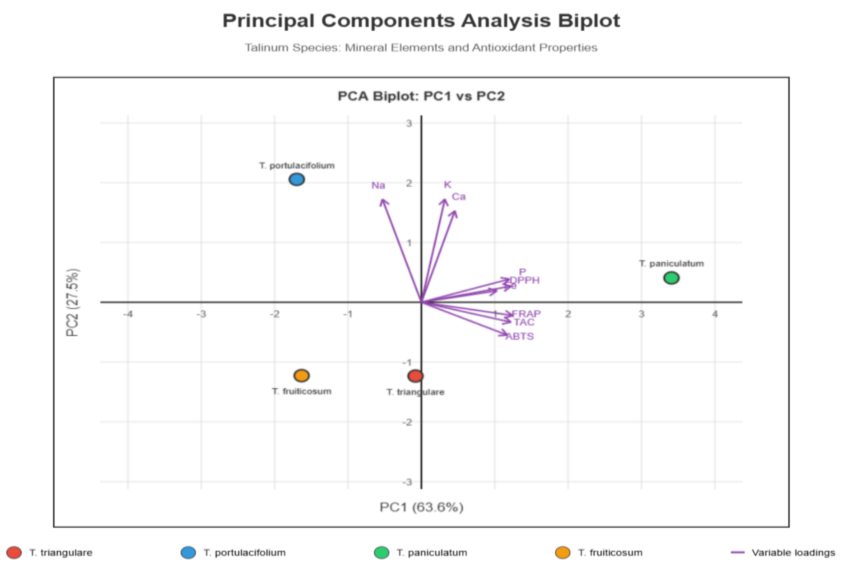


**Figure 2:** Principal components analysis biplot showing the distribution of four *Talinum* species along PC1 and PC2

Correlation analysis demonstrated strong positive associations between mineral content and antioxidant properties (**Table 5**). Iron content was strongly correlated with DPPH activity (r = 0.908), while phosphorus showed a strong positive correlation with FRAP values (r = 0.933). These relationships highlight the link between mineral richness and antioxidant potential among the species and align with earlier findings on the synergistic contributions of minerals and phytochemicals to antioxidant defense [6, 8]. Cluster analysis based on Bray-Curtis's similarity further categorized the species into distinct groups. *T. paniculatum* emerged as compositionally superior due to its high antioxidant and mineral concentrations, while *T. portulacifolium* was grouped separately due to its high macromineral profile. *T. triangulare* and *T. fruticosum* clustered more closely together, reflecting their moderate mineral and antioxidant characteristics. These findings are consistent with clustering patterns observed in comparative analyses of ILVs (**Figure 3**) [7].

**Table 5:** Pearson correlation coefficients among nutritional and phytochemical variables in four *Talinum* species

| Variable | Ca | K | | Na | P | Fe | DPPH | FRAP | ABTS | TAC |
|---|---|---|---|---|---|---|---|---|---|---|
| **Ca** | 1.000 | 0.647 | | 0.603 | 0.324 | 0.110 | 0.387 | 0.282 | 0.207 | 0.278 |
| **K** | 0.647 | 1.000 | | 0.674 | 0.222 | 0.497 | 0.437 | 0.140 | -0.093 | 0.048 |
| **Na** | 0.603 | 0.674 | | 1.000 | -0.095 | -0.302 | -0.301 | -0.523 | -0.639 | -0.559 |
| **P** | 0.324 | 0.222 | | -0.095 | 1.000 | 0.391 | 0.521 | 0.520 | 0.485 | 0.535 |
| **Fe** | 0.110 | 0.497 | | -0.302 | 0.391 | 1.000 | 0.908 | 0.784 | 0.613 | 0.702 |
| **DPPH** | 0.387 | 0.437 | | -0.301 | 0.521 | 0.908 | 1.000 | 0.947 | 0.833 | 0.903 |
| **FRAP** | 0.282 | 0.140 | | -0.523 | 0.520 | 0.784 | 0.947 | 1.000 | 0.965 | 0.991 |
| **ABTS** | 0.207 | -0.093 | | -0.639 | 0.485 | 0.613 | 0.833 | 0.965 | 1.000 | 0.988 |
| **TAC** | 0.278 | 0.048 | | -0.559 | 0.535 | 0.702 | 0.903 | 0.991 | 0.988 | 1.000 |

Very Strong Positive (≥0.9) Strong Positive (0.7-0.9) Moderate Positive (0.5-0.7) Weak Positive (0.3-0.5) Very Weak (-0.3 to 0.3)
Weak Negative (-0.5 to -0.3) Moderate Negative (-0.7 to -0.5) Strong Negative (-0.9 to -0.7) Very Strong Negative (≤-0.9)

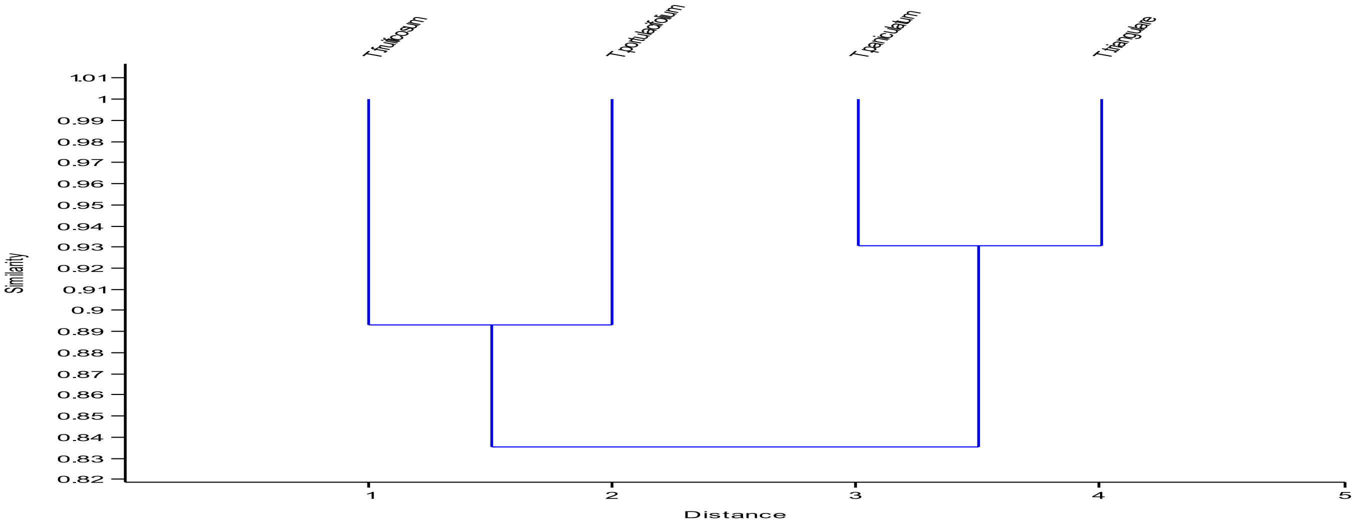


**Figure 3:** Hierarchical cluster dendrogram of four *Talinum* species based on Bray-Curtis's similarity analysis of nutritional and phytochemical profiles

## Discussion

The findings of this study reveal significant interspecific variation in the mineral composition and antioxidant properties of the four *Talinum* species, underscoring their nutritional relevance and functional potential. These observed differences support the growing body of evidence that indigenous leafy vegetables contribute meaningfully to micronutrient intake and protection against oxidative stress. This aligns with the previous results [8, 12], which similarly reported notable nutritional and antioxidant variability among commonly consumed plant species. The comparatively higher mineral concentrations observed in *T. paniculatum* and *T. portulacifolium*, particularly in calcium, potassium, and sodium, further emphasize their dietary importance. The elevated calcium and iron levels recorded in *T. paniculatum* corroborate the findings, which reported significant interspecies variation in mineral composition among leafy vegetables [13]. The high iron content observed in this species also supports an earlier report, which highlighted its relevance in managing anemia and related conditions [14]. Also, the prominence of potassium and sodium in *T. portulacifolium* is consistent with the observations of [10], who associated mineral-rich vegetables with improved electrolyte balance and cardiovascular function. The iron concentrations reported in this study are particularly significant in the context of iron-deficiency anemia, a major public health concern in Nigeria. The relatively high levels in *T. paniculatum* and *T. triangulare* are in agreement with the previous findings, which emphasized the importance of plant-based iron sources in improving nutritional outcomes [1]. This corroborates the report [11], which documented the ethnomedicinal use of these species in managing blood-related disorders. The substantial potassium content in *T. portulacifolium* also supports the conclusions of Lobo et al. [6], who identified potassium as a key factor in blood pressure regulation and cardiovascular health. However, the sodium levels observed, although physiologically relevant, suggest the need for balanced intake, as also noted [2].

The antioxidant activities recorded across the species further reinforce their health-promoting potential. *T. paniculatum* consistently exhibited the highest antioxidant capacity across all assays, which aligns with the findings of [8] who reported strong antioxidant activity in mineral-rich plant species. The positive correlations observed between iron and DPPH activity, as well as phosphorus and FRAP, are consistent with the results of [10], indicating that mineral composition may enhance antioxidant performance through synergistic interactions. These findings provide additional evidence that the antioxidant potential of plant species is not solely dependent on phytochemicals but may also be influenced by their mineral content [22-24]. The relatively lower but appreciable antioxidant activities observed in *T. triangulare*, *T. fruticosum*, and *T. portulacifolium* are in agreement with previous reports. For instance, the moderate antioxidant capacity of *T.*

*triangulare* aligns with the findings of [12], who reported its effectiveness in managing inflammatory and metabolic disorders. Similarly, the measurable antioxidant activity in *T. fruticosum* and *T. portulacifolium* supports the observations of [13], confirming that even species with lower relative values contribute to overall dietary antioxidant intake. Multivariate analyses provided further support for the observed compositional differences. The separation of *T. paniculatum* as the most compositionally robust species is consistent with the findings of [7, 15], who emphasized the importance of nutrient-dense indigenous vegetables in addressing nutritional deficiencies. Likewise, the distinction of *T. portulacifolium* based on its macromineral profile aligns with earlier reports highlighting species-specific nutritional advantages. The clustering of *T. triangulare* and *T. fruticosum* reflects their relatively moderate profiles, further supporting the notion of complementary roles among these species, as also suggested [12]. The strong correlations observed between mineral composition and antioxidant capacity in this study further corroborate existing literature. The positive association between iron and antioxidant activity is in agreement with the findings of [8, 10], both of which highlighted the contribution of minerals to oxidative stress mitigation. These relationships underscore the dual role of minerals in supporting physiological functions and antioxidant defense mechanisms. The superior performance of *T. paniculatum* in mineral and antioxidant parameters corroborates earlier findings, reinforcing its potential for dietary and therapeutic applications [14]. The importance of indigenous vegetables observed in this study aligns with the conclusions of previous studies, which emphasized their role in improving food and nutrition security in sub-Saharan Africa [3, 11]. The continued underutilization of these species suggests the need for increased awareness, research, and policy support [15]. The reliance on *in vitro* assays, while informative, does not fully capture the bioavailability and physiological effects of the nutrients and antioxidants [25]. This observation is consistent with [5], who emphasized the complexity of translating antioxidant activity into *in vivo* outcomes. The focus on a limited number of species suggests the need for broader investigations [12]. Thus, more studies should explore clinical validation, nutrient bioavailability, and optimized processing techniques to enhance the applicability of these findings. The superior profile of *T. paniculatum*, the macromineral richness of *T. portulacifolium*, and the complementary contributions of *T. triangulare* and *T. fruticosum* collectively reinforce their potential as functional foods. These findings align with existing literature and further establish *Talinum* species as viable dietary resources for addressing micronutrient deficiencies and oxidative stress-related diseases in Nigeria and similar settings.

*Conclusion:* This study delivers a systematic comparative assessment of the mineral composition and antioxidant capacity of four *Talinum* species from Nigeria, providing new insights into their nutritional and functional significance. The pronounced interspecific variability observed underscores the importance of species-level characterization in harnessing the full potential of indigenous vegetables for nutritional and therapeutic applications. *T. paniculatum* demonstrated a distinctly superior profile, characterized by elevated calcium and iron concentrations alongside consistently high antioxidant activity. This compositional advantage highlights its strong candidacy for functional food development and supports its ethnomedicinal relevance in mitigating anemia and oxidative stress-related disorders. In contrast, *T. portulacifolium* was differentiated by its enrichment in potassium and sodium, indicating a targeted role in electrolyte regulation and cardiovascular health. The significant associations identified between mineral constituents and antioxidant capacity point to synergistic interactions that extend beyond basic nutrient provision, suggesting integrated mechanisms of oxidative stress modulation.

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## إمكانات نشطة بيولوجيًا ومضادة للأكسدة ومثبطة ضد الأميليز والجلوكوزيداز لأربعة أنواع من التالينوم (Talinaceae) من جنوب غرب نيجيريا

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**ملخص:** لا يزال نقص المغذيات الدقيقة والأمراض المرتبطة بالإجهاد التأكسدي من التحديات الصحية العامة الرئيسية في أفريقيا جنوب الصحراء الكبرى. هدفت هذه الدراسة إلى تقييم التركيب المعدني وخصائص مضادات الأكسدة لأربعة أنواع من نبات التالينوم (تالينوم مثلث الشكل، تالينوم بانيكولاتوم، تالينوم بورتولاسيفوليوم، وتالينوم فروتيكوزوم) جُمعت من جنوب غرب نيجيريا. أُجري تحليل المعادن باستخدام طرق AOAC، بينما حُددت أنشطة مضادات الأكسدة باستخدام اختبارات DPPH وFRAP وABTS واختبارات السعة الكلية لمضادات الأكسدة (TAC). لوحظ تباين كبير بين الأنواع. سجل نبات التالينوم بانيكولاتوم أعلى نسبة من الكالسيوم (1.58 ± 0.01%) والحديد (295.02 ± 0.04 ملغم/كغم)، بينما أظهر نبات التالينوم بورتولاسيفوليوم أعلى نسبة من البوتاسيوم (3.69 ± 0.01%) والصوديوم (0.78 ± 0.01%). أظهرت فحوصات مضادات الأكسدة أن نبات التالينوم بانيكولاتوم يتمتع بأعلى فعالية (DPPH: 79.52 ± 0.01%؛ FRAP: 26.30 ± 0.06 ملغم/100 غرام؛ ABTS: 84.64 ± 0.03%؛ TAC: 22.59 ± 0.30 ملغم/100 غرام). وأشارت تحليلات الارتباط إلى وجود علاقات إيجابية قوية بين الحديد وDPPH (r = 0.908)، وبين الفوسفور وFRAP (r = 0.933). وفسّر تحليل المكونات الرئيسية 91.1% من التباين الكلي، حيث برز نبات التالينوم بانيكولاتوم كأفضلها من حيث التركيب. تُبرز هذه النتائج إمكانات أنواع التالينوم، وخاصةً التالينوم بانيكولاتوم، كأغذية وظيفية لتدعيم النظام الغذائي ومعالجة نقص المغذيات الدقيقة والأمراض المرتبطة بالإجهاد التأكسدي.