TBS Trends in Biological Sciences

OPEN ACCESS

Chemoprofiling and Nutritional Potentials of Different Plant Parts of African Tulip (*Spathodea campanulata*)

Folake Lucy Oyetayo, Aderoju Adefunke Adegboye, Tolulope Blessing Olawale, Olayemi Oluwatobiloba Modupe and Deborah Itunu Amuda
Department of Biochemistry, Ekiti State University, Ado-Ekiti, Ekiti, Nigeria

ABSTRACT

Background and Objective: The African Tulip (*Spathodea campanulata*)-a tropical tree with striking orange-red bell-shaped flowers-has long been valued for its ethno-medicinal properties. However, limited data exist on the comparative chemoprofile and nutritional composition of its leaf and flower. This study aimed to evaluate the phytochemical bioactives and proximate composition of both parts to assess their nutritional and pharmaceutical potentials. **Materials and Methods:** Leaves and flowers of *S. campanulata* were analyzed using standard phytochemical screening and quantitative assays. High-Performance Liquid Chromatography with Diode-Array Detection (HPLC-DAD) was employed for phenolic compound identification. Proximate composition, including fat, fiber, and protein contents, was determined following AOAC methods. **Results:** Phytochemical analysis confirmed the presence of saponins, flavonoids, tannins, alkaloids, and phenols in both parts. Phenols were the most abundant bioactives (leaf: 161.85 mg/100 g; flower: 152.52 mg/100 g), followed by alkaloids and tannins, whereas cardiac glycosides were the least (leaf: 0.29 mg/100 g; flower: 3.19 mg/100 g). The HPLC-DAD revealed ellagic acid, p-coumaric acid, and syringic acid in both parts, while other phenolics were unique to either the leaf or flower. The flower exhibited higher fat (10.84%), fiber (16.13%), and protein (13.64%) contents compared to the leaf, along with a diverse amino acid profile. **Conclusion:** The African Tulip's leaf and flower contain rich phytochemical and nutritional compounds with significant medicinal and dietary potential. These findings highlight *S. campanulata* as a promising source for nutraceutical and pharmaceutical applications.

KEYWORDS

African tulip tree, amino acids, phenolic bioactives, phytochemicals

INTRODUCTION

The African tulip tree (*Spathodea campanulata*), a member of the Bignoniaceae family, is native to tropical Africa and is recognized for its striking tulip-shaped flowers and medicinal use. It has been an integral part of traditional African medicine for centuries, with different parts of the plant utilized to treat various ailments[1]. Its leaves are large, featuring a pointed tip and wavy margins arranged oppositely on the stem, containing numerous bioactive compounds[2] which exhibit anti-inflammatory, antimicrobial, anticancer, and neuroprotective properties, and used in traditional medicine to treat various ailments, including

ISSN: 3105-0573 (Print)
ISSN: 3105-0581 (Online)
https://doi.org/10.21124/tbs.2026.125.135

Received: 16 Oct. 2025
Accepted: 27 Feb. 2026
Published: 30 Jun. 2026

rheumatism, skin disorders, mental disorders, infections, and malaria[3]. The large, orange-red flowers are arranged in dense clusters and are shaped somewhat like a tulip flower. Due to the folkloric acclaimed health benefits and the consumption of some of the plant parts as food in Africa, there is a need to provide scientific validation on bioactive composition and the nutritional profile of the plant to provide scientific information on its potential inclusion as part of a functional diet. Several recent research efforts are focusing on plants for safer, more affordable, and more effective alternatives due to the unwanted risks and negative effects of synthetic pharmaceuticals. An understanding of the chemical composition and nutritional significance of the two separate parts: The leaf and flower, is of importance as they can serve as sources of novel bioactive agents with potential for addition to functional diets for the prevention and management of degenerative disorders. This study will provide information on the bioactive components of the African Tulip plant parts and their potentials as candidate for novel functional diet formulation

MATERIALS AND METHODS

Sample collection and study area: African Tulip (*Spathodea campanulata*) plant was obtained from Ekiti State University botanical garden in Ado-Ekiti, Ekiti State, Nigeria. The plant was then identified and authenticated by a scientist at the Herbarium at the Department of Plant Science and Biotechnology, Ekiti State University, Ado-Ekiti, Ekiti State, Nigeria. The study was carried out between August, 2022 and July, 2023.

A voucher sample with the number UHAE-2023077 was deposited at the Herbarium. The plants were separated into leaf and flower, air-dried for a period of three weeks, and then powdered using a Kenwood blender.

Proximate composition determination: Determination of proximate (carbohydrate, crude protein, fibre, ash, moisture, and fat) composition of the leaf and flower of *Spathodea campanulatae* was carried out as described by AOAC[4].

QUALITATIVE PHYTOCHEMICAL SCREENING

Alkaloids test: About 0.2 g of the sample was stirred with 5 mL of 1% aqueous hydrochloric acid on a steam bath. About 1 mL of the filtrate was treated with a few drops of Draggendorff's reagent. Turbidity or precipitation was taken as preliminary evidence for the presence of alkaloids[5].

Saponin test: About 2.0 g of each sample was shaken with distilled water in a test tube. Frothing which persists on warming was taken as preliminary evidence of the presence of saponins[5].

Tannins test: Five grams of each sample were stirred with 100 mL distilled water and filtered. Ferric chloride reagent was added to the filtrate. A blue-black or blue-green precipitate determines the presence of Tannins[5].

Flavonoids test: About 5 mL of diluted ammonia solution was added to the aqueous filtrate of the test samples, followed by the addition of concentrated H_2SO_4. A yellow coloration observation determines the presence of flavonoids[5].

Cardiac glycosides (Keller-Killian test): About 5 g of each sample was mixed with 2 mL of glacial acetic acid containing a drop of ferric chloride solution. This was underlain with 1 mL concentrated H_2SO_4. A brown ring of the interface indicates a deoxy-sugar characteristic of cardenolides. A violet ring may appear below the brown ring, while in the acetic acid layer, a green ring may form and gradually spread throughout this layer[5].

Anthraquinones test: About 0.5 g of each sample was shaken with 100 mL of benzene and filtered. Five milliliters of 10% ammonia solution were added to the filtrate. The mixtures were shaken and the presence of pink, red or violet color in the lower phase of the ammonia indicates the presence of free anthraquinones[5].

QUANTITATIVE PHYTOCHEMICAL DETERMINATION

Determination of total phenol contents: The total phenolic content of the samples was determined using a modified Folin-Ciocalteu method[6]. About 200 µL of the sample was mixed with 2.6 mL of distilled water, and 200 µl of Folin Ciocalteu's reagent was added to each tube. The content was vortexed and incubated for 5 min. Then 2 mL of 7% Na_2CO_3 was added to each tube. The content in the tube was vortexed and incubated for 2 hrs with intermediate shaking. The absorbance of samples was read at 752 nm. Total phenol contents were expressed as milligrams of Gallic acid per gram of sample[7].

Determination of total flavonoids content: The content of flavonoids was determined using quercetin as a reference compound. Stock solution (0.50 µL) of each extract was mixed with 50 µl of aluminum trichloride and potassium acetate. The absorption at 415 nm was read after 30 minutes at room temperature. All determinations were carried out in duplicates. The quantity of flavonoids in extracts was expressed as quercetin equivalent (QE)/gram dry weight[8].

Saponin determination: About 2 g of each finely ground sample was weighed into a 250 mL beaker, and 100 mL of Isobutyl alcohol was added. The mixture was shaken and filtered with No 1 Whatman filter paper into a 100 mL beaker containing 20 mL of 40% saturated solution of Magnesium Carbonate ($MgCO_3$). The mixture obtained was again filtered to obtain a clean colourless solution. The 1 mL of the colourless solution was pipetted into a 50 mL volumetric flask, 2 mL of 5% Ferric Chloride ($FeCl_3$) solution was added, and made up to the mark with distilled water and allowed to stand for 30 minutes for colour development. The absorbance was read against blank at 380 nm[5].

Tannin determination: About 0.2 g of the finely ground sample was weighed into a 500 mL sample bottle. As 100 mL of 70% aqueous acetone was added and properly covered. The bottles were kept in a shaker water bath for 2 hrs at 30°C. Each solution was then centrifuged, and the sediment was stored in ice. A 0.2 mL of each solution was pipetted into test tubes, and 0.8 mL of distilled water was added. Standard tannin acid solutions were prepared from a 0.5 mg/ mL of the stock solution and the solution made up to 1 mL with distilled water. As 0.5 mL of Folin-Cocteau reagent was added to both sample and standard followed by 2.5 mL of 20% Na_2CO_3 the solutions were then shaken vigorously and allowed to incubate for 40 minutes at room temperature, its absorbance was then read at 725 nm against a reagent blank concentration of the same solution from a standard tannic acid curve was prepared[6].

Alkaloid determination: About 5 g sample was weighed into a 250 mL beaker and 200 mL of 10% acetic acid in ethanol was added and allowed to stand for 4 minutes. It was filtered, and the extract was concentrated on a water bath to one-quarter of the original volume. Concentrated ammonium hydroxide was added dropwise to the extract until the precipitation was completed. The whole solution was allowed to settle and the precipitate was collected and washed with dilute ammonium hydroxide and then filtered. The residue was then considered as an alkaloid, which was dried and weighed[9]. The mixture obtained was again filtered to obtain a clean colourless solution. The 1 mL of the colourless solution was pipetted into a 50 mL volumetric flask, 2 mL of 5% Ferric Chloride ($FeCl_3$) solution was added and made up to the mark with distilled water. It was allowed to stand for 30 minutes for colour development. The absorbance was read against a blank at 380 nm.

Qualitative-quantitative high performance liquid chromatography analysis: About 0.2 g of each sample was homogenized in 0.8 mL aqueous ascorbic acid solution (12.5%), 0.2 mL aqueous EDTA solution (0.33M), and 4 mL 3.75M NaOH (to give a final concentration of 3M). The mixture was shaken for 90 minutes at ambient temperature whilst protected from light. After base hydrolysis, the pH of the extract was adjusted to ≈ 6 using HCl (2M). The mixture was vortexed for 1 minute. After centrifugation (10 min, 4000 g), an aliquot of the supernatant was filtered through a syringe filter (0.45µm pore size) and stored under nitrogen atmosphere at -40°C until HPLC analysis.

Phenolics were quantified by HPLC with UV detection (Agilent 1100, Agilent Technologies, Santa Clara, USA). Phenolic acid compounds samples were separated on a reverse-phase C18 column (Luna, 250×4.6 mm, 3 µm, 100 Å; Phenomenex, Torrance, USA) with a guard column (3.0×4.0 mm; Phenomenex, Torrance, USA) containing the same packing material. The column was thermostatically controlled at 25°C. The flow rate was set at 1.0 mL/min, the injection volume was 20 µL, and the total run time was 60 min. Complete separation was achieved using the following mobile phase composition: Solvent A (1% aqueous formic acid) and solvent B acetonitrile/methanol/water (8:1:1, v/v/v). The gradient started at 6% solvent B and was maintained for 34 min, after which solvent B was increased to 23% within 1 min. After 1 min, solvent B was further increased to 50% within 1 min and held at 50% for 4 min. Solvent B was then decreased to 6% over 1 min and maintained there for a further min to recondition the column before the next injection. The detection wavelengths were manually set at 260 nm (p-hydroxybenzoic acid, vanillic acid, ellagic acid), 270 nm (gallic acid, 2,3,4-trihydroxybenzoic acid), 275 nm (3,4-dihydroxybenzaldehyde, vanillin, syringic acid, benzoic acid, o-coumaric acid, cinnamic acid), 310 nm (p-coumaric acid, syringaldehyde), and 325 nm (gentisic acid, caffeic acid, chlorogenic acid, ferulic acid, sinapic acid). The sample preparation and Reverse-Phase UV-HPLC methods were adapted as reported[10].

Amino acid analysis: The amino acid profile was determined using methods described by a researcher[11]. About 0.2 g of powdered samples were defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the automatic amino acid analyzer, Technicon Sequential Multi-Sample (TSM) analyzer. The sample was hydrolyzed for the determination of all amino acids except tryptophan in consistent boiling hydrochloric acid for 22 hrs under a nitrogen flush. Predicted Nutritional qualities were determined based on the amino acid profiles.

Essential Amino Acid Index (EAAI): Nutritional qualities were determined based on the amino acid profiles. The Essential Amino Acid Index (EAAI) was calculated using the equation below[12]:

$$EAAI = \frac{\sqrt{n\,(100a \times 100b \times ... \times 100j)}}{(a_v \times b_v \times ... \times j_v)} \quad (1)$$

where, n = Number of essential amino acids, a, b .....j = Represent the concentration of essential amino acids (lysine, tryptophan, isoleucine, valine, arginine, threonine, leucine, phenylalanine, histidine and the sum of methionine and cystine) in test sample and a_v, b_v ..... j_v = Content of the same amino acids in standard protein (%) (egg or casein), respectively.

Predicted protein efficiency ratio: The predicted protein efficiency ratio (P-PER) was determined using one of the equations derived[12]:

$$P–PER = -0.468+0.454\ (Leu)-0.105\ (Tyr) \quad (2)$$

Biological value (BV): Biological values were determined according to the methods of Oser, respectively. The following equation was used for BV determination.

$$BV = 1.09\ (EAA\ Index)-11.7 \quad (3)$$

Nutritional index (NI): The nutritional index of the food samples was calculated using the formula below as described by Chang and Hayes[13]:

$$\text{Nutritional index (\%)} = \frac{\text{EAAI} \times \text{protein (\%)}}{100}$$

EAAI = Essential Amino Acid Index

Data analysis: The experiments were conducted in triplicate and expressed as Mean±Standard Deviation (SD). Statistical analysis was performed using Student's t-test, and differences were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

The proximate composition of the African tulip tree leaf and flower investigated in this study is presented in Table 1. The leaf contains higher concentrations of carbohydrates % (54.72; 47.68), ash (5.52; 3.93), and moisture (10.26; 7.77) than the flower, while the flower contained higher percentages of fiber(10.96; 16.13), protein (9.75; 13.64) and fat (8.83; 10.84) than the leaf. The percent carbohydrate concentrations (54.72; 47.68%) obtained in this research were higher than 40.60 and 50.6% reported for *Albizia zygia* and *Crateva adansonii*[14]. Carbohydrates are the primary source of energy for humans and generally add to the bulk of the diet. The moisture content of the leaf and flower (10.26; 7.77) was lower than 14.71%, 13.7%, and 14.78%, respectively, reported for *Brillantaisia patula*[15] and *Adenia cissampeloides* leaves[16]. The level of moisture in a food is an indication of water activity, it is used to determine food susceptibility and stability of spoilage microorganisms. Low moisture content in the leaf and flower supports its resistance to microbial deterioration, thus improving shelf life. The ash content of African tulip leaf and flower was 5.52 and 3.93%. Also referred to as ash, the inorganic portion of any food sample contains the mineral elements. The % crude fibre content of the leaf was 10.96, while that of the flower was 16.13. Fibre is significant in the prevention of absorption of trace elements in the gut and in elimination of undigested food materials[17]. The crude fat values of the plant leaf and flower (8.83 and 10.84%) were low. Fats in any food enhance palatability serves as storage and transport of metabolic fuel form, and serve as electrical insulators for subcutaneous tissues and emulsifiers for drug preparation[18]. The red bean protein (14.36%) is reported to be high[19] compared favourably with crude protein values of flower (13.64%) and the leaf (9.75%). Protein is involved in several essential processes in human physiology.

Table 2 shows the qualitative phytochemical screening of the African tulip (*Spathodea campanulata)* plant flower and leaf. Alkaloids, saponin, flavonoids, phenols, and tannins were present (+) in both leaf and flower, while steroids were absent (-). Cardiac Glycosides and Anthraquinones were present in the leaf and were sparingly present in the flower. Phytochemicals are found in plants, and their consumption generally provides beneficial health effects. Alkaloids have many pharmacological activities, including being able to increase blood pressure, as a trigger for the nervous system, reducing pain, as an antimicrobial compound, as a sedative and as a medicine for heart disease[20]. Phenolics perform important roles in counteracting the deleterious effects of free radicals. Saponins have various health benefits, including its hypocholesterolemic, antioxidative, anti-stress, and anti-aging activities[21]. Flavonoids are effective antioxidants, free radical scavengers, anti-mutagenic, anti-inflammatory, and anti-carcinogenic; they also protect the immune system[22]. The *Spathodea campanulata* plant is generally composed of polyphenolic compounds which further possess antimicrobial properties.

Table 3 shows the quantitative phytochemical composition of African tulip tree leaf and flower. Phenol was the most concentrated phytochemical in the flower (161.85 mg/100 g) followed by the leaf (152.52 mg/100 g). The study also showed tannin as the next concentrated phytochemical, with the flower

Table 1: Proximate (%) composition of african tulip (*Spathodea campanulata*) leaf and flower

Nutrient	Leaf	Flower
Moisture	10.26^{a}±0.00	7.77^{a}±0.01
Ash	5.52^{a}±0.01	3.93^{a}±0.00
Fat	8.83^{a}±0.00	10.84^{a}±0.01
Fiber	10.96^{a}±0.00	16.13^{b}±0.00
Protein	9.75^{a}±0.00	13.64^{b}±0.00
Carbohydrate	54.72^{a}±0.02	47.69^{b}±0.01

Data are means of triplicates determinations (X±SD) and values with same superscripts are not significantly different (p>0.05)

Table 2: Qualitative phytochemical screening of african tulip plant (*Spathodea campanulata*) leaf and flower

Phytochemical	Flower	Leaf
Saponin	+	++
Steroids	-	-
Flavonoids	+++	++
Tannins	+++	++
Glycosides	-	+
Alkaloids	+++	+++
Phenols	+++	+++
Cardiac glycosides	+	-
Reducing sugar	+	+
Anthraquinones	+	-

Prominent ++= Moderate, + = Slightly present and - = Absent

Table 3: Quantitative phytochemical composition (mg/100g) ofafrican tulip plant (*Spathodea campanulata*) flower and leaf

Parameter (mg/100 g)	Flower	Leaf
Alkaloid	42.75^{a}±0.00	91.14^{b}±0.01
Anthraquinone	5.65^{a}±0.00	0.85^{b}±0.00
Cardiac glycosides	3.19^{a}±0.10	0.29^{b}±0.00
Flavonoid	71.66^{a}±0.00	50.16^{b}±0.03
Glycosides	1.37^{a}±0.00	10.66^{b}±0.00
Phenol	161.85^{a}±0.01	152.52^{b}±0.00
Tannin	75.17^{a}±0.00	39.69^{b}±0.01
Reducing sugar	12.58^{a}±0.01	9.14^{b}±0.00
Saponin	18.91^{a}±0.00	33.45^{b}±0.00

Data are means of triplicate determinations (X±SD). Values with same superscripts are not significantly different (p>0.05)

showing 75.17 mg/100 g and the leaf 39.69 mg/100 g. Tannin shows anti-diarrhea and anti-nausea properties while phenol exhibits antioxidant, anti-inflammatory, and anti-proliferative propperties[23]. Hence, the appreciable concentrations of phenol and tannins in the African tulip leaf and flower shows the pharmacological potentials of these plant parts[23]. Flavonoids were also found in high concentration in the flower and leaf with concentrations of 71.66 mg/100 g and 50.16 mg/100 g, respectively. Alkaloid content of the leaf (91.14 mg/100 g) was found to be higher compared to the concentration in the flower (42.75 mg/100 g). Alkaloids and Flavonoids are found in most plants to have anti-microbial, anti-inflammatory and anti-cancer properties[24].

Table 4 shows the phenolic constituents in the African Tulip plant leaf and flower as resolved by HPLC-DAD. Ellagic acid (47.89; 47.18 µg/g), P-coumaric acid (40.39; 39.86 µg/g), syringic acid (23.87; 23.73 µg/g), vanillic acid (18.01; 17.00 µg/g) and gallic acid (3.23; 3.23 µg/g) were present in the leaf and flower respectively, with ellagic acid being the highest concentrated phenolic compound present in both the leaf and flower. Ellagic acid exhibits antioxidant properties and has diverse pharmacological effects, including hypolipidemic, pro-inflammatory mediators modulating, and influencing factors related to metabolic syndrome and diabetes. Chlorogenic acid (30.80 µg/g), vanillin (22.98 µg/g), caffeic acid (22.24 µg/g), P- hydroxybenzoic acid (12.02 µg/g) and 2,3,4- Trihydroxybenzole acid (6.59 µg/g) were identified only in the flower and not the leaf while cinnamic acid (49.81 µg/g),

Table 4: Phenolic Constituents of the African Tulip Plant leaf and flower (µg/g)

Phenolics	Leaf	Flower
Gallic acid	3.23	3.23
Vanillic acid	18.01	17.00
Syringic acid	23.87	23.72
Benzoic acid	36.63	-
P-coumaric acid	40.39	39.86
Sinapic acid	44.30	-
O-coumaric acid	47.54	-
Ellagic acid	47.89	47.18
Cinnamic acid	49.81	-
2,3,4-Trihydroxybenzole acid	-	6.59
P-Hydroxybenzoic acid	-	12.02
Caffeic acid	-	22.24
Vanillin	-	22.98
Chlorogenic acid	-	30.80

Table 5: Essential amino acids composition of African Tulip (*Spathodea campanulata*) leaf and flower (g/100 g)

Essential amino acids	Leaf	Flower
Lysine	3.15±0.02	2.79±0.03
Histidine	2.20±0.03	2.02±0.02
Arginine	5.20±0.04	4.74±0.10
Threonine	2.45±0.85	2.19±0.13
Valine	3.25±0.08	3.28±0.11
Methionine	1.07±0.03	0.89±0.03
Leucine	6.68±0.02	5.87±0.03
Isoleucine	3.39±0.02	3.23±0.06
Phenylalanine	3.41±0.07	3.18±0.02

Data are means of triplicate determinations (X±SD)

O-coumaric acid (47.54 µg/g), sinapic acid (44.30 µg/g) and benzoic acid (36.63 µg/g) were identified only in the leaf of the plant with cinnamic acid being the most concentrated bioactive constituent in the leaf of the plant. The antioxidant, anti-inflammatory, and neuroprotective effects of cinnamic acid and its potential in the management of neurodegenerative diseases, such as Alzheimer's and Parkinson's diseases, have been reported by Tian *et al.*[25]. Hence, the presence of the bioactives in the African Tulip plant leaf and flower indicates the therapeutic significance of the plant and the potential as a functional food supplement.

The protein quality of a food depends on its amino acid content, and especially the essential amino acids must be provided in the diet for protein synthesis to proceed. Table 5 shows the essential amino acid composition of the African Tulip plant leaf and flower. Leucine was the most concentrated amino acid in both leaf (6.68 g/100 g) and flower (5.87 g/100 g) of the *Spathodea campanulata* plant, followed by Arginine (5.20; 4.74 g/100 g), respectively. Leucine is an essential amino acid for protein synthesis, muscle growth, and the regulation of blood sugar by stimulating insulin secretion and thus supports energy production. Hence, the presence of leucine in both the leaf and flower implies that both plant parts possess nutritional potentials and several pharmaceutical applications, while Methionine was the least concentrated essential amino acid in both leaf (1.07 g/100 g) and flower (0.89 g/100 g) of the plant. The indirect antioxidant effects of arginine is well documented[26]. The Lys/Arg ratio is important in the determination of the atherogenicity of a diet. Lys/Arg ratio of less than 2.0 is desirable; this ratio (leaf (0.58) and flower (0.60)) were lower than the critical value. Lys/Arg ratio above 2.0 is considered as critical for atherogenicity hence, *Spathodea campanulata* plant parts show a low atherogenic potential.

Table 6 shows the non-essential amino acid composition (g/100 g) of the African Tulip plant leaf and flower. Glutamic acid was the most concentrated non-essential amino acid in the leaf (10.21 g/100 g) and flower (8.67 g/100 g) of *Spathodea campanulata* and this was followed by aspartic acid (7.26; 6.20 g/100 g). Cysteine was the least concentrated non-essential amino acid in the plant

Table 6: Non-essential amino acids composition of African Tulip (*Spathodea campanulata*) leaf and flower (g/100g)

Non-essential amino acids	Leaf	Flower
Aspartic acid	7.26±0.13	6.20±0.20
Serine	2.21±0.85	2.19±0.13
Glutamic acid	10.21±0.13	8.67±0.16
Proline	2.37±0.03	2.02±0.02
Glycine	2.86±0.06	2.40±0.30
Alanine	4.01±0.11	4.32±0.06
Cystine	0.86±0.05	0.63±0.02
Tyrosine	2.20±0.04	1.84±0.06
Lysine: Arginine	0.58	0.60

Data are means of triplicate determinations (X±SD)

Table 7: Estimated nutritional quality of protein for African Tulip (*Spathodea campanulata)* leaf and flower based on their amino acid profile

Parameter	Leaf	Flower
Total amino acids (TAA)	62.78	56.46
Total non-essential amino acids (TNEAA)	31.98	28.27
TNEAA (%)	50.94	50.07
Total essential amino acids (TEAA)	30.80	28.19
TEAA (%)	49.06	49.93
EAAI (%)	95.26	86.83
TEAA with histidine	30.80	28.19
Without histidine	28.60	26.17
Total surphur amino acid	1.93	1.52
P-PER	2.33	2.00
Biological value (BV) (%)	91.85	82.00
Nutritional value (NI) (%)	9.26	11.73
Cysteine in TSAA (%)	44.56	41.44

leaf (0.86 g/100 g) and flower (0.63 g/100 g). Therefore, the most abundant amino acids in the African tulip plant parts were Glutamic acid, Aspartic acid, Leucine and Arginine while Methionine, Tryptophan and Cysteine were the least abundant amino acids. Lysine, histidine, isoleucine, and valine were higher than the WHO (2022)[27] recommended requirements for children aged 2-5 years. Lysine is a limiting amino acid in most cereals, with reported values of 0.23 g/100 g in rice and 0.33 g/100 g in barley[28]. However, the African Tulip was found to contain a higher concentration of lysine (3.15 g/100 g). This suggests that it can serve as a valuable addition to traditional cereals in preparing weaning diets, particularly in regions where access to nutrient-rich diets is unaffordable.

The total amino acid and total non-essential amino acid composition of African tulip *(Spathodea campanulata*) is presented in Table 7. The leaf exhibited higher levels of total amino acid (TAA) (62.78 g/100 g), Total non-essential amino acid (TNEAA) (31.98 g/100 g), and % TNEAA (50.94 g/100 g) compared to the flower. The plant parts could contribute significantly to the supply of amino acids in diets. The percentage of TNEAA with histidine was slightly higher in the leaf (30.80%) than in the flower (28.19%), while the percentage of TNEAA without histidine followed a similar trend (28.6% in the leaf; 26.17% in the flower). The total sulfur amino acid (TSAA) content was higher in the leaf (1.93 g/100 g) than in the flower (1.52 g/100 g), and the proportion of cysteine within TSAA was marginally higher in the leaf (44.5%) compared to the flower (41.4%). The TSAA for the leaf (1.93) and flower (1.52) of African Tulip (*Spathodea campanulata*) were lower than the 5.8 g/100 g crude protein recommended for infants[27]. Based on the FAO/WHO provisional pattern[29], African Tulip (*Spathodea campanulata)* was adequate in the essential amino acids histidine (His), isoleucine (Ile), leucine (Leu), phenylalanine+tyrosine (Phe+Tyr), and valine. However, it showed low concentrations of methionine+cysteine (Met+Cys), lysine (Lys), and threonine (Thr). African Tulip (*Spathodea campanulata*) may require supplementation with other rich sources of these amino acids to be used as a food supplement. The Predicted Protein efficiency ratio (P-PER) of the plant leaf and flower were 2.33 and 2.00, respectively. The P-PER evaluates and

compares the protein quality of foods. The P-Per values for S*pathodea campanulata* suggests that the plant parts have moderate protein quality being lower than 2.71 reported for *Crateva adansonii* and 2.91for *Calotropis procera*[14]. A protein efficiency ratio below 1.5 indicates a protein of poor quality; between 1.5 and 2.0 an intermediate quality and above 2.0 good quality proteins. Hence, the African tulip leaf and flower contain good-quality proteins. The predicted biological value (P-BV) of the African tulip leaf (91.85%) and flower (82%). The nutritional index (NI) for African tulip leaf was 9.26%, whereas for the flower part, it was 11.73% while the percentage of the essential amino acid index of the African tulip leaf and flower were 95 and 86%, respectively. African tulip leaf and flower showed a low nutritional index compared to Anclote leaf (17.71%). A PER of 2.7, a biological value of >70% and an essential amino acid index EAAI of 0.70 for a protein-based food signify its quality as high. A PER of 2.7, biological value of >70% and essential amino acid index EAAI of 0.70 for a protein-based food signifies its quality as high[12,30]. Hence, the leaf and flower can be regarded as good quality protein sources that can complement other foods with certain limiting amino acids.

CONCLUSION

The African Tulip plant (*Spathodea campanulata*) is a rich source of phytochemicals and nutrients, including phenols, flavonoids, alkaloids, and essential amino acids. Both leaf and flower exhibit significant bioactive diversity, with the flower showing higher fat, fiber, and protein content. These properties suggest strong potential for medicinal, nutritional, and functional food applications. Further studies on in vivo bioactivities and product development could establish *S. campanulata* as a valuable nutraceutical and pharmaceutical resource.

SIGNIFICANCE STATEMENT

This study explains the importance of the African Tulip (*Spathodea campanulata*) plant parts as important sources of health-benefiting bioactive chemicals. The leaf and flower show high crude fibre and protein concentrations and contain various amino acids. The plant parts can also serve as an additional nutrient source. This preliminary study will form a background for further research in unraveling the potential of natural, commonly obtainable, unexplored herbals in the formulation of a functional diet for the prevention and management of degenerative disorders.

ACKNOWLEDGMENT

The authors thank all colleagues for their technical expertise.

REFERENCES

1. Queiroz, A.C.M., F.A.L. Contrera and G.C. Venturieri, 2014. The effect of toxic nectar and pollen from *Spathodea campanulata* on the worker survival of *Melipona fasciculata* Smith and *Melipona seminigra* Friese, two Amazonian stingless bees (Hymenoptera: Apidae: Meliponini). Sociobiology, 61: 536-540.
2. Padhy, G.K., 2021. *Spathodea campanulata* P. Beauv.-a review of its ethnomedicinal, phytochemical, and pharmacological profile. J. Appl. Pharm. Sci., 11: 017-044.
3. Ngnameko, C.R., L. Marchetti, B. Zambelli, A. Quotadamo and D. Roncarati *et al*., 2020. New insights into bioactive compounds from the medicinal plant *Spathodea campanulata* P. Beauv. and their activity against *Helicobacter pylori*. Antibiotics, Vol. 9. 10.3390/antibiotics9050258.
4. AOAC., 2019. Official methods of analysis of the Association of Analytical Chemists. 21st Edn., AOAC International, Washington, DC., USA, ISBN-13: 978-0935584899.
5. Evans, W.C. and G.E. Trease, 1989. Trease and Evans' Pharmacognosy. 13th Edn., Baillière Tindall, London, ISBN: 9780702013577, Pages: 832.
6. Song, F.L., R.Y. Gan, Y. Zhang, Q. Xiao, L. Kuang and H.B. Li, 2010. Total phenolic contents and antioxidant capacities of selected chinese medicinal plants. Int. J. Mol. Sci., 11: 2362-2372.
7. Sim, K.S., A.M.S. Nurestri and A.W. Norhanom, 2010. Phenolic content and antioxidant activity of *Pereskia grandifolia* Haw. (Cactaceae) extracts. Pharmacogn. Mag., 6: 248-254.

8. Kim, D.O., O.K. Chun, Y.J. Kim, H.Y. Moon and C.Y. Lee, 2003. Quantification of polyphenolics and their antioxidant capacity in fresh plums. J. Agric. Food Chem., 51: 6509-6515.
9. Harborne, J.B. and C.A. Williams, 2000. Advances in flavonoid research since 1992. Phytochemistry, 55: 481-504.
10. Hefni, M.E., L.S. Amann and C.M. Witthöft, 2019. A HPLC-UV method for the quantification of phenolic acids in cereals. Food Anal. Methods, 12: 2802-2812.
11. Spackman, D.H., W.H. Stein and S. Moore, 1958. Automatic recording apparatus for use in chromatography of amino acids. Anal. Chem., 30: 1190-1206.
12. Ijarotimi, O.S., F.T. Nathaniel and O.O. Faramade, 2015. Determination of chemical composition, nutritional quality and anti-diabetic potential of raw, blanched and fermented wonderful kola (*Bucholzia coriacea*) seed flour. J. Hum. Nutr. Food Sci., Vol. 3. 10.47739/2333-6706/1060.
13. Chang, S.T. and W.A. Hayes, 1978. The Biology and Cultivation of Edible Mushrooms. Academic Press, New York, ISBN: 978-0-12-168050-3, Pages: 819.
14. Akinsola, A.F., I. Osasona, C.O. Ojo, A. Awe and P.E. Omolayo, 2022. Phytochemical screening, proximate and amino acid compositions of two edible indigenous leafy vegetables from Ekiti State, Nigeria. Int. J. New Technol. Res., 8: 5-13.
15. Akinsola, A.F., O.C. Olatunde, I. Osasona, O.F. Sekayo and F.O. Omotayo, 2021. Nutritional evaluation of *Brillantaisia patula* leaves. Asian Plant Res. J., 8: 63-73.
16. Magdalene, O.A., V.E. Okpashi, M. Agiang and J.E. Egbung, 2019. Evaluation of selected novel delicacies of wild plants using Wistar rats: An insight into nutritional quality. Curr. Res. Nutr. Food Sci., 7: 469-478.
17. Chiba, M., T. Tsuji, K. Nakane and M. Komatsu, 2015. High amount of dietary fiber not harmful but favorable for crohn disease. Permanente J., 19: 58-61.
18. Antia, B.S., E.J. Akpan, P.A. Okon and I.U. Umoren, 2006. Nutritive and anti-nutritive evaluation of sweet potatoes (*Ipomoea batatas*) leaves. Pak. J. Nutr., 5: 166-168.
19. James, S., T.U. Nwabueze, J. Ndife, G.I. Onwuka and M.A. Usman, 2020. Influence of fermentation and germination on some bioactive components of selected lesser legumes indigenous to Nigeria. J. Agric. Food Res., Vol. 2. 10.1016/j.jafr.2020.100086.
20. Thawabteh, A., S. Juma, M. Bader, D. Karaman, L. Scrano, S.A. Bufo and R. Karaman, 2019. The biological activity of natural alkaloids against herbivores, cancerous cells and pathogens. Toxins, Vol. 11. 10.3390/toxins11110656.
21. Marrelli, M., F. Conforti, F. Araniti and G.A. Statti, 2016. Effects of saponins on lipid metabolism: A review of potential health benefits in the treatment of obesity. Molecules, Vol. 21. 10.3390/molecules21101404.
22. Asad Ullah, S. Munir, S.L. Badshah, N. Khan and L. Ghani *et al*., 2020. Important flavonoids and their role as a therapeutic agent. Molecules, Vol. 25. 10.3390/molecules25225243.
23. Cushnie, T.P.T. and A.J. Lamb, 2005. Antimicrobial activity of flavonoids. Int. J. Antimicrob. Agents, 26: 343-356.
24. Roy, A., A. Khan, I. Ahmad, S. Alghamdi and B.S. Rajab *et al*., 2022. Flavonoids a bioactive compound from medicinal plants and its therapeutic applications. BioMed Res. Int., Vol. 2022. 10.1155/2022/5445291.
25. Tian, Y., X. Jiang, J. Guo, H. Lu and J. Xie *et al*., 2025. Pharmacological potential of cinnamic acid and derivatives: A comprehensive review. Pharmaceuticals, Vol. 18. 10.3390/ph18081141.
26. Wu, G., C.J. Meininger, C.J. McNeal, F.W. Bazer and J.M. Rhoads, 2021. Role of L-Arginine in Nitric Oxide Synthesis and Health in Humans. In: Amino Acids in Nutrition and Health: Amino Acids in Gene Expression, Metabolic Regulation, and Exercising Performance, Wu, G. (Ed.), Springer International Publishing, Switzerland, ISBN: 978-3-030-74180-8, pp: 167-187.
27. FAO, IFAD, UNICEF, WFP and WHO, 2022. The State of Food Security and Nutrition in the World 2022: Repurposing Food and Agricultural Policies to Make Healthy Diets More Affordable. FAO, IFAD, UNICEF, WFP and WHO, Rome, Italy, ISBN-978-92-5-136499-4, Pages: 260.

28. Tomičić, Z.M., L.L. Pezo, N.J. Spasevski, J.M. Lazarević, I.S. Čabarkapa and R.M. Tomičić, 2022. Diversity of amino acids composition in cereals. Food Feed Res., 49: 11-22.
29. WHO, FAO and UNU Expert Consultation, 2007. Protein and Amino Acid Requirements in Human Nutrition: Report of a Joint FAO/WHO/UNU Expert Consultation. WHO, Rome, Italy, ISBN-9241209356, Pages: 265.
30. Ayalew, Y., N. Retta, G. Desse, A. Mohammed and A. Mellesse, 2016. Amino acid profile and protein quality in tuber and leaf of *Coccnia abyssinica* (Lam.) (Cogn.) accessions of Ethiopia. Food Sci. Nutr., 5: 722-729.