



Quantification of Bioactive Compounds of Major Medicinal Plants from Bangladesh

Tupura Khatun^{✉,1}, Md. Asaduzzaman^{✉,2,3,4,*}

¹ Department of Mathematics, Chittagong College, National University, Chittagong 4203, Bangladesh

² Department of Food Engineering and Nutrition Science, State University of Bangladesh, Dhaka 1461, Bangladesh

³ State Key Laboratory of Food Science and Resources, Jiangnan University, Wuxi 214122, China

⁴ School of Food Science and Technology, Jiangnan University, 1800 Lihu Avenue, Wuxi 214122, China

Article History

Received: April 28, 2026

Accepted: August 14, 2026

Published: September 01, 2026

Abstract

The medicinal and nutritional benefits of various plant leaves originate from their rich phytochemical content, which plays vital roles in providing potential solutions for various diseases. In this study, the levels of bioactive compounds were quantified in the leaves of twenty-four medicinal plant species collected at the National Botanic Garden, Dhaka, Bangladesh, based on visual coloration and documented medicinal uses in traditional Bangladeshi medicine. Bioactive compounds, including total phenol content, flavonoids, β -carotene, anthocyanins, and lycopene levels, were quantified and evaluated. The T80 UV/Vis Spectrophotometer (PG Instruments, United Kingdom) was used to determine the levels of these bioactive compounds using a simple, rapid, and cost-effective method, where fresh leaf extracts were analyzed in triplicate at specific wavelengths, and data were subjected to one-way ANOVA followed by Duncan's Multiple Range Test ($p \leq 0.05$). The leaves of *Ipomoea batatas* (Sweet potato), *Amaranthus gangeticus* (Red spinach), *Cordyline fruticosa* (Ti plant), *Tradescantia spathacea* (Boatlily), *Tradescantia zebrina* (Wandering dude) showed the highest levels of β -carotene content (153 mg/100 g), lycopene content (109 mg/100 g), flavonoid content (810 mg/100 g RE), anthocyanin content (267 mg/100 g) and phenolic content (615 mg GAE/100 g), respectively. Pearson correlation analysis identified extremely strong positive relationships between β -carotene and lycopene ($r = 0.9264$) and between anthocyanins and total phenolic content ($r = 0.9712$), indicating common metabolic regulation. These selected plants could be considered new natural sources of bioactive compounds and could open up future applications in the food, chemical, and pharmaceutical industries. This study offers novel insights into the bioactive compositions of tropical medicinal plants.

Keywords:

bioactive compounds; medicinal plant; phytochemical profiling; flavonoids; antioxidant

1. Introduction

Numerous medicinal properties have been attributed to natural plants. Today, medicinal plants are used to formulate pharmaceuticals, healthcare products, food products, chemicals, and cosmetics. These plants are rich sources of vitamins, minerals, and phytochemicals, which support the human body and help combat various microbial and other health-related ailments. Across the globe, indigenous peoples use various herbs and plants for their diverse medicinal properties. For example, herbal teas prepared from such medicinal plants, are well known for

their antioxidant properties and benefits, including phenolics and fat-soluble vitamins, which play significant roles in human physiology. Besides vitamins and minerals, phenolics also show potential to support the body by acting as reducing agents, hydrogen donors, singlet oxygen quenchers, and metal chelators against various pathogens and diseases [1–3].

Various bioactive compounds, also known as phytochemicals, such as flavonoids, carotenoids, and phenolic compounds, along with tannins, phytoestrogens, phytoosterols, and glucosinolates, and have significant medicinal importance, including tumor-inhibitory and anticar-

* Corresponding Author:

Md. Asaduzzaman, Department of Food Engineering and Nutrition Science, State University of Bangladesh, Dhaka 1461, Bangladesh; State Key Laboratory of Food Science and Resources, Jiangnan University, Wuxi 214122, China; School of Food Science and Technology, Jiangnan University, 1800 Lihu Avenue, Wuxi 214122, China, bitatipu@gmail.com



© 2026 Copyright by the Authors.

Licensed as an open access article using a [CC BY 4.0 license](https://creativecommons.org/licenses/by/4.0/).

cinogenic potential [4,5]. Nowadays, these bioactive compounds, as secondary metabolites in plants, are considered highly important, and a new era of research is underway to explore their anticarcinogenic, antitumor, antioxidant, and wound-healing effects.

Modern techniques used to identify and isolate these bioactive compounds from various medicinal plants are intricate. While different animals, such as guinea pigs and rats, are often used to assess the antioxidant and therapeutic activities of these compounds, these findings are subsequently translated to human applications [5,6]. Consequently, the use of phytochemicals for therapeutic and antioxidant purposes requires their identification, followed by extraction and refinement into drugs with minimal or no side effects, similar to antibiotics [7].

Inhibiting mutagenic reactions in deoxyribonucleic acid (DNA) and inactivating carcinogens represent a new approach to preventing various cancers and are strategies that utilize anticarcinogens and antioxidants. Enzymatic inactivation, scavenging carcinogens, and inhibition of reactive oxygen species are notable mechanisms utilized for this purpose [8].

In modern medicine, many anticarcinogenic compounds are extracted and purified from traditional plants that have been clinically used to treat different diseases worldwide, such as flavopiridol, epipodophyllotoxin, betulinic acids, combretastatin, camptothecin, silvestrol, taxols, vinblastine, vincristine, irinotecan, and topotecan, which have shown promising results in various studies [9].

Ellagic and gallic acids, as phenolic compounds, can interrupt tumor cell spread and possess DNA-binding properties that effectively interfere with carcinogenic cell development [10]. Different plant parts, such as fruits, shoots, leaves, and roots, from species including *Amaranthus gangeticus* and *Tradescantia zebrina*, contain phenolic compounds that have significant anticarcinogenic potential [7].

Few studies have quantified the bioactive composition of plant leaves [11–14]. Comprehensive characterization, functionalization, and utilization studies of bioactive compounds from plant leaves remain scarce, as do studies using spectrophotometric methods as preliminary practical approaches for the screening, identification, and quantification of major bioactive compounds in plant leaves. Plant leaves have complex, heterogeneous matrices that lead to variable levels of pigments, phenolics, and other phytochemicals. For the precise identification and quantification of the individual bioactive compounds, high-performance liquid chromatography (HPLC) or mass spectrometry can be used; however, these techniques are expensive, time-consuming, require specialized solvents, and are not easily scalable for large sample sets. In con-

trast, UV-Vis spectrophotometry is simple, fast, cost-effective, and widely available in routine laboratories, supporting experimental replication. These experiments also enable simultaneous processing of multiple leaf samples, making them ideal for comparative screening across numerous species, such as those included in this study (24 plants). Moreover, spectrophotometric assays such as the Folin–Ciocalteu assay for total phenolic content, the aluminum chloride assay for flavonoid content, and specific, fixed-wavelength measurements for carotenoids are well-established, replicable, reproducible, and have been widely validated for leaf tissues [4,15,16]. For this reason, these methods are highly efficient as first-line tools for identifying promising leaf sources of bioactive compounds before more targeted and expensive analyses are undertaken.

This study focuses solely on the identification and quantification of the major bioactive compounds present in traditional medicinal plants widely available in Bangladesh. Variability in extraction systems—such as alkaline or enzymatic extraction—along with differences in sample preparation, yield calculation, and characterization methods, has been identified as a potential source of error affecting the accuracy and comparability of findings across studies. The identification of these bioactive compounds highlights the medicinal value of these traditional plants and their potential health benefits, introducing a new dimension to research and industrial utilization.

2. Materials and Methods

2.1. Location of the Plant Samples

A total of 24 plants were randomly selected and collected from the National Botanic Garden (23°48' N, 90°21' E) in Mirpur, Dhaka, Bangladesh, during the summer season (March–April) in 2023; their names are listed in Table S1 [17–40]. The National Botanic Garden is maintained by the government organization of the People's Republic of Bangladesh, where plants are managed using standard horticultural practices without chemical fertilizers. The National Botanic Garden is a vast managed horticultural collection rather than an experimental field or laboratory; therefore, all plants, trees, and shrubs were maintained under routine garden management practices without specific pesticide applications or intentional chemical stress treatments. No species-specific records of soil properties, irrigation schedules, or nutrient management were used because the plants were not cultivated; rather, they were collected as part of a controlled agronomic library and provided experimental samples for researchers in Bangladesh and worldwide. Therefore, no specific cultivation records

were available for individual species, as the plants were grown under natural conditions in open beds with regular irrigation. In this study, all plants were selected based on their local medicinal use in Bangladesh and nationwide availability as mature, healthy plants free from visible symptoms of disease, insect infestation, mechanical injury, or physiological disorders. For each species in this study, plant parts (leaves) were collected from three to five individual plants. The leaves were comparable in size and developmental stage and were collected during the same phenological stage. The leaves were fully expanded and mature and were harvested from the middle canopy to ensure that all samples represented the same physiological maturity stage, thereby reducing variation associated with leaf age and development. The leaves were collected between 8:00 and 10:00 AM to minimize variations in metabolite content caused by daylight exposure. After collection, the leafy parts of each plant were thoroughly washed and rinsed multiple times with tap water, and then cut into smaller pieces to obtain a uniform composite sample.

2.1.1. Sample Preparation and Basis of Expression

All collected leaves were washed, cut into small pieces, and homogenized in their fresh state without drying. Bioactive compound contents are expressed as mg per 100 g of fresh weight. Fresh samples were used to avoid degradation of heat-labile compounds such as anthocyanins, lycopene, and β -carotene during drying, and to reflect the bioactive composition as consumed or initially extracted in traditional preparations.

2.2. Extraction of β -Carotene

Five grams of plant leaves were combined with 100 mL of methanol, stirred for 24 h at 25 °C and 150 rpm, and then filtered using Whatman no. 4 filter paper. The methanolic extract was collected, and 100 mg of the extract was subsequently mixed with a combination of 10 mL acetone-hexane (4:6). After vigorously shaking the mixture for one minute, it was filtered again using Whatman filter paper no. 4 [41]. A T80 UV/Vis Spectrophotometer (PG Instruments, Leicestershire, UK) was used to measure absorbance. Carotenoid absorbance was measured at 453 nm, 505 nm, and 663 nm, and carotenoid

content was calculated using Equation (1) and expressed as mg β -carotene equivalents per 100 g fresh weight.

$$\text{Carotenoids Content (mg/100g)} = 0.216 \times A_{663} - 0.304 \times A_{505} + 0.452 \times A_{453} \quad (1)$$

2.3. Extraction of Lycopene

Colorimetric determination of lycopene from plant leaves was performed by extraction with hexane, ethanol, and acetone, followed by absorbance measurement at 503 nm. 1 g of plant leaves was collected and soaked in 80 mL of a hexane-ethanol-acetone mixture (2:1:1) in a flask. Then, the solution was vortexed for 10 min, 10 mL of water was added, and the mixture was vortexed for a further 10 min [15]. Lycopene absorbance was measured at 503 nm and expressed as mg per 100 g fresh weight.

2.4. Extraction of Flavonoids

Flavonoid extract was prepared using methanol: 10 mg of plant leaves were soaked in 10 mL of methanol, and 1 mL was collected in a test tube. 5 mL of water and 0.1 mL of potassium acetate ($\text{CH}_3\text{CO}_2\text{K}$) were added to the test tube, which was then left to rest for 5 min. Then, 3 mL of aluminum chloride (AlCl_3) was added, and the mixture was allowed to stand for 30 min at room temperature [4]. QC samples for accuracy determination at six concentrations (0, 10, 20, 30, 40, and 50 $\mu\text{g/mL}$) were also prepared by serial dilution of the freshly prepared rutin stock solution and used within 24 h. Flavonoid absorbances were measured at 415 nm, using equation 2 to determine TFC, where Y is the absorbance of the sample, and X is the total flavonoid content in mg/100 g Rutin equivalents (RE) per 100 g fresh weight.

$$Y = 0.0059 \times X + 0.0527 R^2 = 0.981 \quad (2)$$

2.5. Extraction of Anthocyanin

1 g of plant samples and 40 mL of 50% ethanol were placed in a flask at pH 3.0, then kept at a warm temperature (50 °C) for 1 h. The solution was then filtered, and a 1 mL aliquot was collected in a test tube and combined with 4 mL of methanol [4]. Anthocyanin absorbance was measured at 530 nm and calculated using the following equation. Anthocyanin content was expressed as mg cyanidin-3-glucoside equivalents per 100 g fresh weight.

$$\text{Anthocyanin Content (mg/100g)} = \frac{\text{Absorbance} \times \text{Molecular Weight of cyanidin-3-glucoside (449.2)} \times \text{Dilution Factor}}{\text{Molar Absorptivity} \times \text{Sample Weight}} \times 100 \quad (3)$$

2.6. Extraction of Total Phenol

This method used 25% ethanol for extracting total phenols from plant leaves. One gram of plant leaves was soaked in 20 mL of 25% ethanol for 15 min. The solution was then filtered through Whatman No. 2 filter paper, and a 1 mL sample was collected from the filtrate, mixed with 5 mL Na₂CO₃ and 1 mL Folin reagent, and transferred to a volumetric flask. Then it was kept at room temperature for 1 h [4,16,42]. Quality control (QC) samples to assess accuracy at five concentrations (10, 20, 30, 50, and 60 PPM) were also prepared by serial dilution of the freshly prepared gallic acid stock solution, which was used within 24 h. Phenolic content was quantified at 765 nm using spectrophotometry (T80 UV/Vis Spectrophotometer, PG Instruments, UK) by comparing absorbance values with a gallic acid calibration curve and expressed as milligrams of gallic acid equivalents per 100 g fresh weight (mg GAE/100 g fresh weight). Equation 2 was used to calculate the total phenolic content (TPC), where Y is the absorbance of the sample, and X is the total phenolic content, expressed as mg GAE/100 g fresh weight.

$$Y = 0.0019 \times X + 0.2066 R^2 = 0.995 \quad (4)$$

2.7. Statistical Analysis

All measurements were performed in triplicate for each sample, and averages and standard deviations were calculated from these measurements. Data were analyzed using R statistical software (Windows version 4.3.3) and figure are generated in GraphPad Prism (Version 8.3.0). A single-factor analysis of variance was conducted. Duncan's Multiple Range Test (DMRT) was used to identify significant differences, with differences considered significant at $p \leq 0.05$.

3. Results and Discussion

3.1. β -Carotene Content

Figure 1 and Table S2 present the concentrations of extracted β -carotene from plant parts, revealing significant amounts in the respective species, in which *Ipomoea batatas* showed the maximum concentration at 153.21 mg/100 g and *Ajuga reptans* at 138.67 mg/100 g, indicating a high β -carotene content in the leaves. In addition to *Ipomoea batatas* and *Ajuga reptans*, the leaves of *Lawsonia inermis* and *Euphorbia cotinifolia* also contained significant amounts of β -carotene, comparable to those found in *Amaranthus gangeticus*, establishing them

as excellent sources of this carotenoid. To maintain a healthy life, a daily intake of 15–45 mg of β -carotene is recommended, as supported by previous nutritional studies [43]. In Bangladesh, *Ipomoea batatas* and *Amaranthus gangeticus* leaves are traditionally used in food preparations such as steaming and infusion with oil, whereas *Euphorbia cotinifolia* is highly toxic, and *Lawsonia inermis* is prohibited for direct consumption. For pharmaceutical use, all species, including toxic ones, can be processed under controlled environmental conditions into standardized extracts, powders, coated or encapsulated formulations. Additionally, although the practice is uncommon in Bangladesh, young shoots of *Ajuga reptans* can be utilized in salads in Brazil [44].

β -carotene, which is commonly present alongside water-soluble and fat-soluble vitamins, is abundant in plant leaves and has been reported to inhibit various cancers [44]. The antioxidant capacity of plant leaves varies with their content of metabolites such as vitamins, carotenoids such as β -carotene and lycopene, and other pigments [45].

Carotenoids, which are precursors to vitamin A, are typically derived from flowering plants and herbs and serve as colorants and bioactive compounds; they are very common in tropical plant species, as evidenced by previous studies [46]. Comparable levels of β -carotene have been reported in medicinal plants [11–13]. Still, certain plant leaves, such as wine palm (*Mauritia vinifera*), are promising sources of β -carotene [47].

3.2. Determination of Lycopene

There are different types of carotenoids, such as lycopene and β -carotene, with lycopene having a nearly two-fold higher capacity to reduce singlet oxygen than β -carotene [48]. Lycopene plays a crucial role in defense against carcinogenic diseases by protecting DNA, lipid particles, low-density lipoproteins, and proteins from free radical attacks [49].

According to Figure 2 and Table S2, leaves of *Amaranthus gangeticus* exhibited the highest lycopene concentrations at 109.44 mg/100 g, followed by *Tradescantia zebrina* leaves at 84.11 mg/100 g. Furthermore, leaves from *Tradescantia zebrina*, *Ipomoea batatas*, and *Lawsonia inermis* are significant sources of lycopene [50,51].

3.3. Flavonoids Determination

Figure 3 and Table S2 present the quantification of flavonoid content, showing that *Cordyline fruticosa* varieties exhibited the highest flavonoid levels, with *Cordyline fruticosa* at 810.46 mg/100 g RE, *Cordyline rubra* at 502.13 mg/100 g RE, and *Plectranthus scutellarioides* at

352.18 mg/100 g RE. The flavonoid content of these plant leaves falls within a range similar to that reported in previous studies on medicinal plants [52–55]. However, the sources of plant leaf samples vary with environmental conditions and soil composition, making direct comparisons challenging.

Notably, samples of *Cordyline* species exhibited significantly higher flavonoid levels ($p < 0.05$) than other plant leaves. For instance, 17.1 ± 2.8 mg RE/100 g d.b. for *Tradescantia zebrina* and 10.6 ± 4.0 mg RE/100 g d.b. for *Tradescantia pallida* (Malaysia), values which surpass those found in this study [14]. Similarly, 3.93 ± 0.008 mg quercetin/100 g d.b. for *Tectona grandis* and 27.2 mg RE/100 g d.b. for *Prunus cerasifera*, values close to those reported in several studies [56,57]. Again, another study reported 6.92 mg RE/100 g d.b. for *Oxalis*

corniculata, while 14.32 mg quercetin/g for *Basella alba*, both of which are notably lower than the levels observed here [58,59].

3.4. Determination of Anthocyanins

Anthocyanins, vibrant pigments responsible for the blue, red, and purple hues in leaves and fruits, are notably abundant in various berries [60]. Among the species examined, *Tradescantia spathacea* exhibited the highest level of anthocyanins at 267.18 mg/100 g, followed by *Oxalis triangularis* at 161.67 mg/100 g and *Alternanthera dentata* at 151 mg/100 g (Figure 4 and Table S2). With their diverse colors and potential health benefits, anthocyanins are used in dietary supplements, nutraceuticals, and pharmaceutical products.

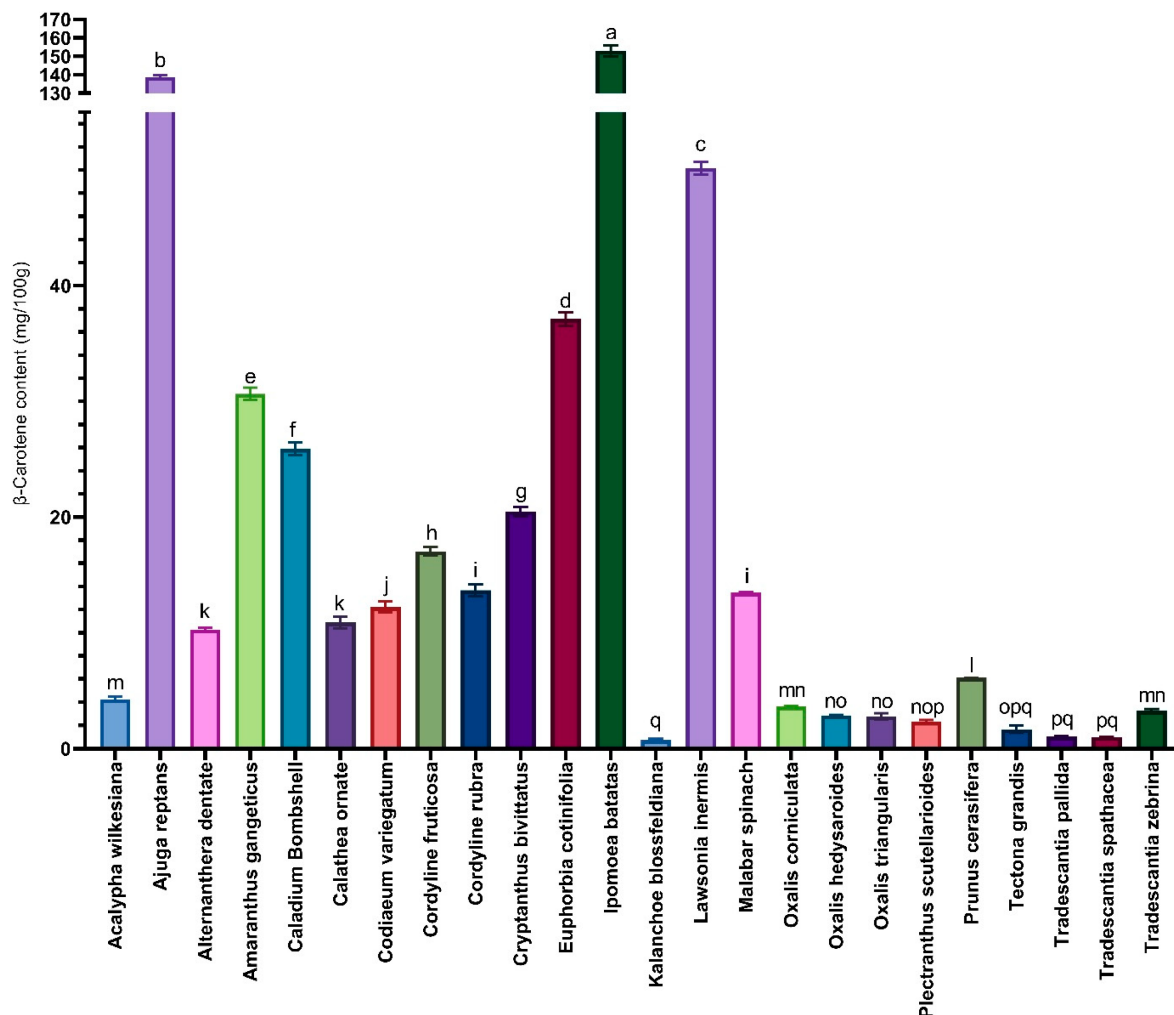


Figure 1: Quantitative distribution of β -carotene content (mg/100 g) in the leaves of 24 medicinal plant species from Bangladesh. Data are presented as mean $\pm$ standard deviation ($n = 3$). Bars with different letters indicate statistically significant differences at $p \leq 0.05$ according to Duncan's Multiple Range Test.

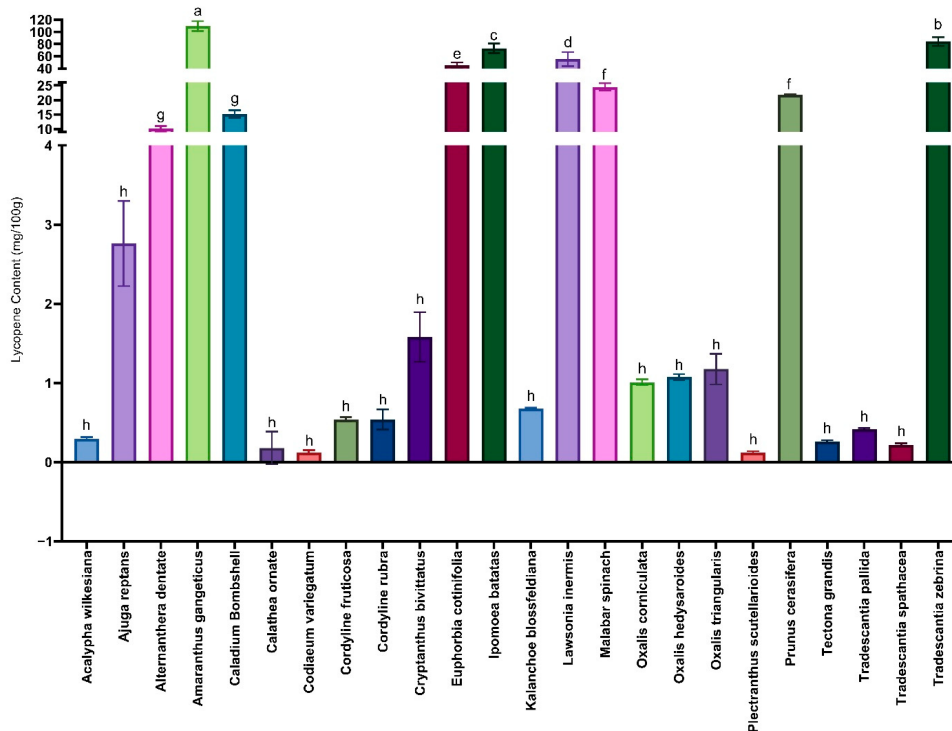


Figure 2: Quantitative distribution of lycopene content (mg/100 g) in the leaves of 24 medicinal plant species from Bangladesh. Data are presented as mean $\pm$ standard deviation ($n = 3$). Bars with different letters indicate statistically significant differences at $p \leq 0.05$ according to Duncan's Multiple Range Test.

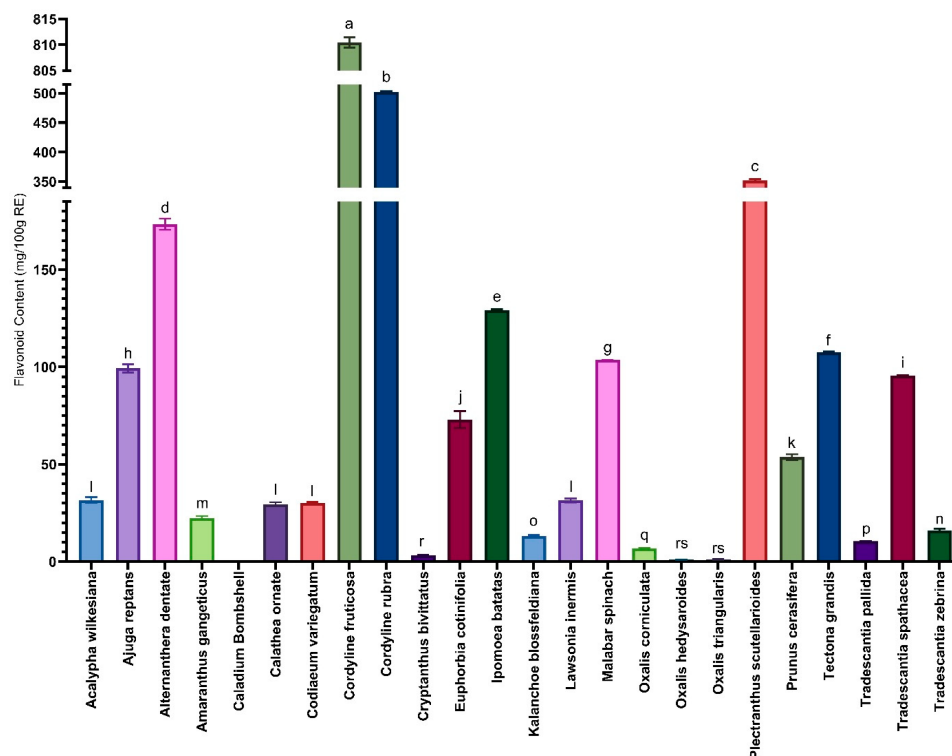


Figure 3: Quantitative distribution of total flavonoid content (mg rutin equivalents/100 g) in the leaves of 24 medicinal plant species from Bangladesh. Data are presented as mean $\pm$ standard deviation ($n = 3$). Bars with different letters indicate statistically significant differences at $p \leq 0.05$ according to Duncan's Multiple Range Test.

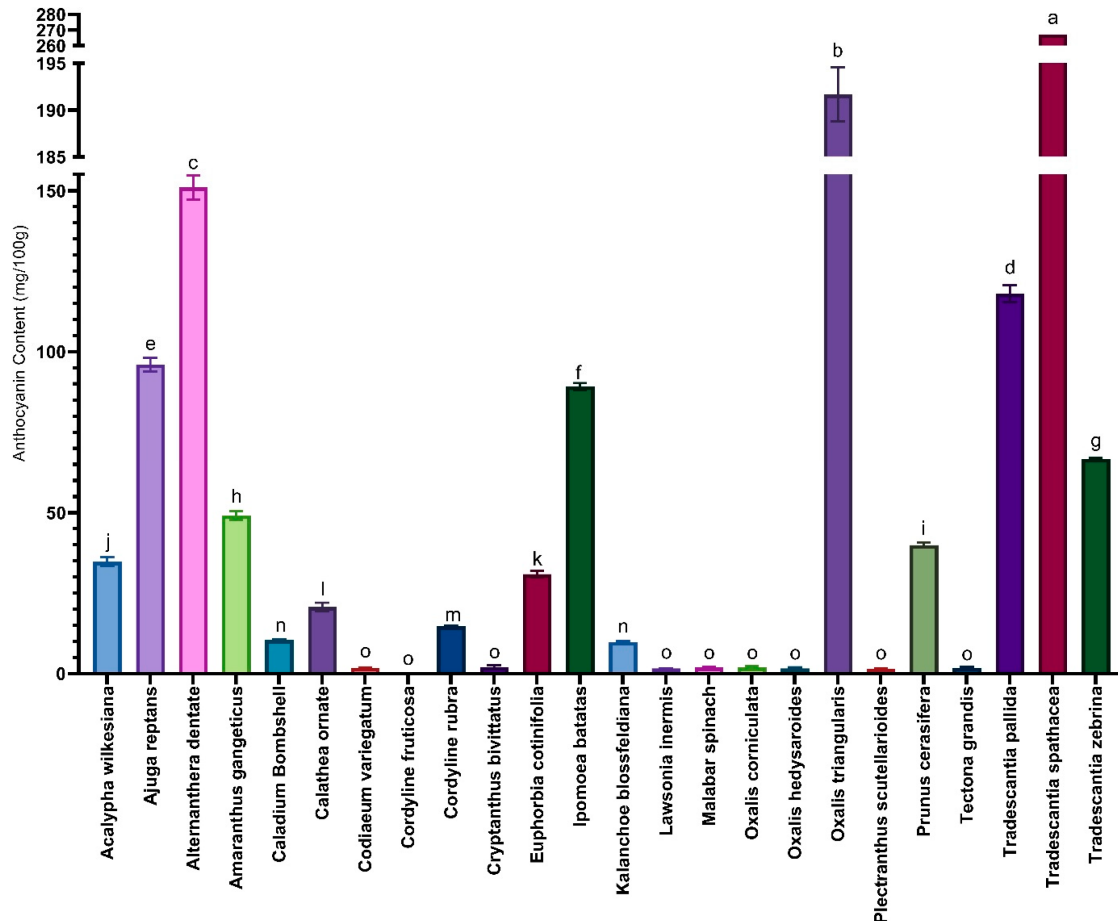


Figure 4: Quantitative distribution of total anthocyanin content (mg/100 g) in the leaves of 24 medicinal plant species from Bangladesh. Data are presented as mean $\pm$ standard deviation ($n = 3$). Bars with different letters indicate statistically significant differences at $p \leq 0.05$ according to Duncan's Multiple Range Test.

The total anthocyanin contents observed in the leaves of *Tradescantia spathacea*, *Oxalis triangularis*, and *Alternanthera dentata* were lower than those reported for various vegetable leaves. For instance, several studies have reported that purple cabbage leaves contain 629 mg/100 g d.b., red lettuce varieties contain 100 to 300 mg/100 g d.b., and purple leaves of *Perilla frutescens* contain 42.33 mg/100 g d.b. [61–63].

3.5. Total Phenolic Determination

Previous studies have categorized the phenolic content of plant leaves into three groups: low, moderate, and high. Generally, plants with phenol content below 500 mg GAE/100 g are classified as having low concentrations of phenolic compounds, those ranging from 500 to 2500 mg GAE/100 g fall into the medium concentration category, and those above 2500 mg GAE/100 g are categorized as having high concentrations of phenolic compounds [64].

Tradescantia zebrina exhibited the highest level of phenolic compounds among the plants examined, fol-

lowed by *Lawsonia inermis*, *Plectranthus scutellarioides*, and *Acalypha wilkesiana* (Figure 5 and Table S2). The leaves of these plants contain high levels of phenolic compounds, making them excellent sources. Except for *Caladium Bombshell*, the leaves of the other examined plants can be categorized as having medium levels of phenolic compounds and may still represent good sources of these compounds.

Notably, higher levels of phenolic compounds were found in *Tectona grandis*, *Tradescantia zebrina*, and *Tradescantia pallida* (Malaysia) than in this study [14,57]. However, the levels reported for *Prunus cerasifera* were comparable to those obtained in several studies [56]. Previous studies reported lower levels in *Oxalis corniculata* and *Basella alba* [58,59]. These discrepancies may be attributed to various factors affecting the properties of bioactive compounds in plant leaves, such as cultivation methods, climate, plant varieties, and the time of year of harvest [65].

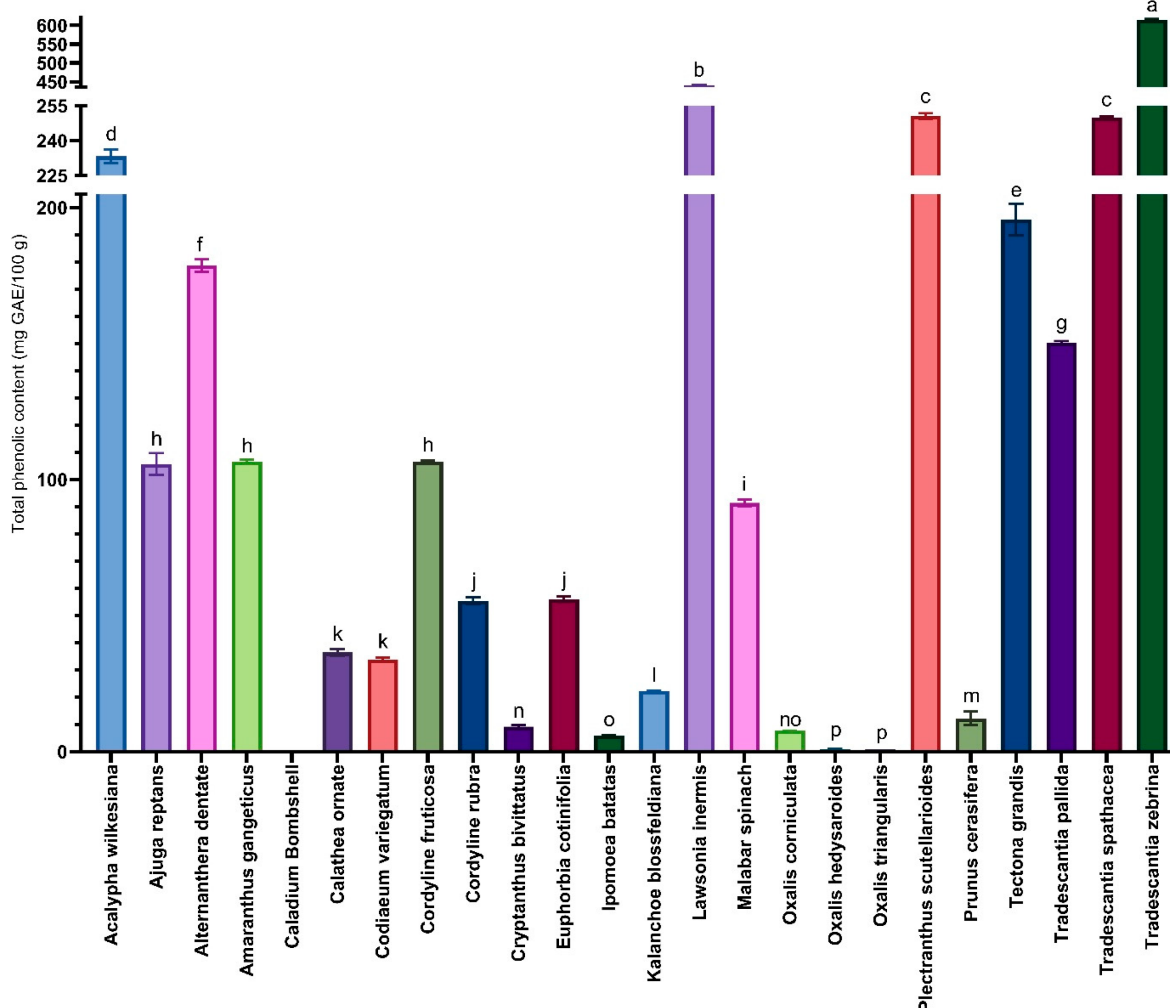


Figure 5: Quantitative distribution of total phenolic content (mg GAE/100 g) in the leaves of 24 medicinal plant species from Bangladesh. Data are presented as mean $\pm$ standard deviation ($n = 3$). Bars with different letters indicate statistically significant differences at $p \leq 0.05$ according to Duncan's Multiple Range Test.

3.6. Correlation Analysis

Pearson correlation analysis was performed using Prism to examine the relationships among the phytochemical components (β -carotene, lycopene, flavonoids, anthocyanins, and total phenolic content) in the plant species under investigation (Figure 6). To calculate the correlation coefficient (r) and its 95% confidence interval (CI), we used a metric to assess the relationship between each pair of variables. The correlation coefficient ranges from -1 to $+1$, where values close to $+1$ indicate strong positive relationships, while values close to -1 indicate strong negative relationships.

In this study, several variable pairs showed extremely strong positive correlations, indicating that their concentrations tend to vary in proportion to each other.

For instance, the correlation between β -carotene and lycopene was strongly positive ($r = 0.9264$) and had a 95% CI of 0.8141 to 0.9264 because they share a similar biosynthetic pathway as carotenoids. In addition, flavonoids and total phenolic content showed moderately strong positive correlations, as expected due to the fact that flavonoids are a subset of total phenolic content.

Furthermore, several pairs exhibited strong positive correlations, indicating that the concentrations of these phytochemicals tended to increase together. In particular, anthocyanins and total phenolic content showed a very strong positive correlation ($r = 0.9712$), suggesting that plant species with higher anthocyanin concentrations also possessed higher total phenolic contents.

Most remaining variable pairs showed very weak or negligible correlations, indicating no significant rela-

tionship; for instance, anthocyanins and flavonoids had a very weak correlation ($r = 0.01494$, 95% CI: 0.02131 to 0.9919). Confidence intervals (95%) for the correlation coefficient indicate the reliability of the estimates: wide confidence intervals (0.8141 to 0.9264) indicate greater uncertainty in the correlation estimate, whereas narrow confidence intervals (0.5491 to 0.9977) indicate a stronger estimate. Correlations between variables whose confidence intervals include zero were not statistically significant.

This information on the studied correlations holds significant value regarding different metabolic pathways of the studied bioactive compounds because, for instance, a positive correlation of β -carotene and lycopene sug-

gests common regulation, as carotenoids are theoretically controlled by the same genetic and environmental factors, while a lack of correlation between anthocyanins and flavonoids may be interpreted as their separate control. Again, because of resource allocation at the biosynthetic level, the strong positive correlation between anthocyanins and total phenolic content suggests that these phytochemicals accumulate concurrently in the studied ornamental plant species. This finding is biologically plausible because anthocyanins are a subclass of phenolic compounds and share common biosynthetic pathways. Therefore, increased anthocyanin accumulation is often associated with increased total phenolic content.

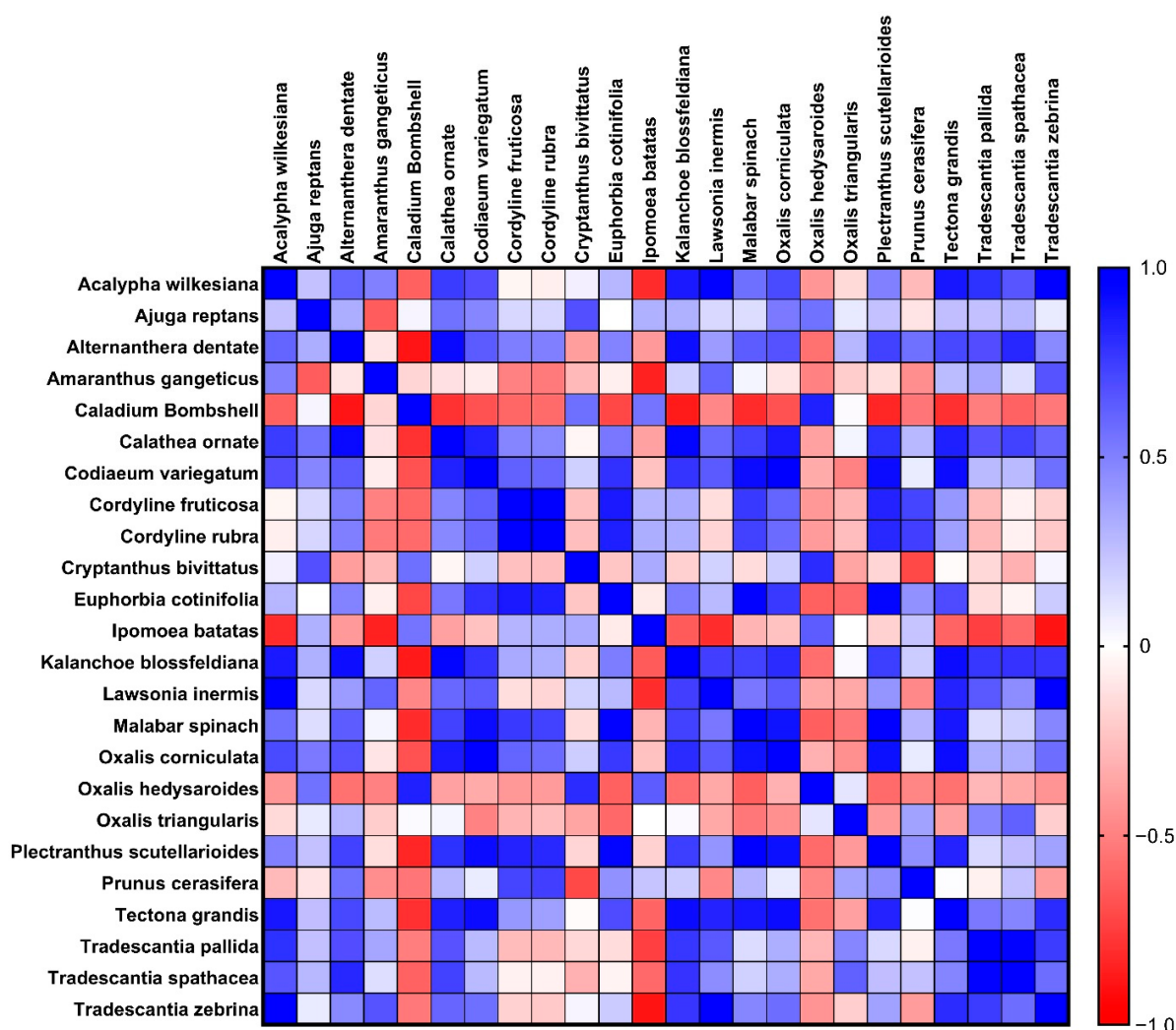


Figure 6: Pearson correlation matrix among β -carotene, lycopene, flavonoids, anthocyanins, and total phenolic content across the 24 studied medicinal plant species. The heatmap displays correlation coefficients (r) and corresponding 95% confidence intervals, with color intensity indicating the strength and direction of the linear relationships.

3.7. Practical Implications and Beneficiaries

This study provides a detailed and reliable dataset on the bioactive compound profiles of 24 medicinal plant species commonly found in Bangladesh, which may benefit several groups within the research and industrial communities. First, researchers can use this dataset as a baseline for further investigations into phytochemicals across different extraction methods, characterization, bioactivity evaluation, compound isolation, and the development of nutraceuticals, functional foods, and pharmaceutical products. Identifying plant species with varying concentrations of bioactive compounds may also provide promising candidates for advanced analytical and chemical studies using metabolomic and chromatographic techniques.

Second, the food, pharmaceutical, and nutraceutical industries may use these findings to identify economically valuable plant species as potential natural sources of antioxidants, phenolic compounds, flavonoids, anthocyanins, β -carotene, and lycopene, which may facilitate the extraction and development of natural ingredients, functional food products, dietary supplements, and plant-derived therapeutic innovative formulations.

Third, government organizations such as policymakers, different public and private agricultural extension agencies, and local and international botanical conservation authorities may use the results to prioritize the conservation, sustainable utilization, and cultivation of medicinal plant species with high bioactive compound potential. These findings also support future strategies to promote value-added utilization of indigenous plant species and strengthen the medicinal plant sector.

Finally, this study can contribute to sustainable development awareness by encouraging the use of locally grown and available medicinal plants as renewable natural resources to produce high-value bioactive compounds that are highly effective for the treatment of chronic diseases. This contribution not only potentially reduces the dependence on synthetic medicine and additives but also promotes environmentally sustainable resource utilization and creates new economic opportunities through the development of plant-based health products.

4. Conclusions

Different plant parts contain various pigments, such as β -carotene, lycopene, anthocyanins, and flavonoids, supporting the value of utilizing these plant species, given their significant amounts of bioactive compounds and diverse macro- and micronutrients, particularly anthocyanins, flavonoids, and phenolic compounds. This study

provides valuable evidence confirming the nutritional properties of medicinal plant leaves, particularly the diverse properties of identified pigments and compounds, which are not only rich sources of bioactive compounds but also can be utilized as low-cost, renewable resources for the pharmaceutical industry, thereby providing positive economic and environmental impacts. From a traditional preparation perspective, *Ipomoea batatas* and *Amaranthus gangeticus* leaves are locally processed through light steaming or infusion in Bangladesh, making them accessible sources of bioactive compounds and vitamins for local populations. For pharmaceutical and nutraceutical applications, all studied species, including *Tradescantia zebrina*, *Cordyline fruticosa*, *Lawsonia inermis*, and even the toxic *Euphorbia cotinifolia*, can be processed into standardized extracts, powders, or encapsulated formulations through controlled chemical, physical, or mechanical extraction methods. These findings confirm that bioactive compounds may play significant roles in protecting against various diseases, suggesting broader applications beyond their use as sources of medicine.

5. Limitations

This study did not involve controlled cultivation because, in Bangladesh, dedicated cultivation practices do not exist for these plants, except for *Amaranthus gangeticus* and *Ipomoea batatas*. Consequently, the plant materials were collected from a managed botanical garden rather than a controlled cultivation experiment. No specific agronomic variables or cultivation parameters, such as soil nutrient composition, irrigation schedules, and fertilizer history, were available for individual plant species; therefore, these factors could not be standardized. Although these factors can influence bioactive profiles, future studies should build on this work by conducting controlled cultivation experiments to separate genotypic effects from environmental influences on bioactive compound accumulation.

List of Abbreviations

AlCl ₃	Aluminum chloride
ANOVA	Analysis of Variance
CI	Confidence Interval
d.b.	Dry basis
DMRT	Duncan's Multiple Range Test
DNA	Deoxyribonucleic acid
GAE	Gallic acid equivalent
HPLC	High-Performance Liquid Chromatography
Na ₂ CO ₃	Sodium carbonate
PPM	Parts Per Million

QC	Quality control
r	Correlation coefficient
RE	Rutin equivalent
rpm	Revolutions per minute
TFC	Total Flavonoid Content
TPC	Total Phenolic Content
UV/VIS (or U/VIS)	Ultraviolet–Visible (Spectrophotometer)

Author Contributions

Methodology, investigation, formal analysis, data curation, writing—original draft preparation: T.K.; Conceptualization, validation, software, resources, writing—review & editing, visualization, supervision, and project administration: M.A. All authors have read and agreed to the published version of the manuscript.

Availability of Data and Materials

Data are available from the corresponding author upon reasonable request.

Ethics Committee Approval

Not applicable. This study did not involve human participants or animal subjects; therefore, ethical approval was not required. The plant leaf samples were collected from the National Botanic Garden (Mirpur, Dhaka, Bangladesh) in accordance with the garden's regulations and relevant national guidelines, and no specific collection permits were required for the small quantities of plant material used.

Conflicts of Interest

The authors declare no conflicts of interest.

Funding

The study did not receive any external funding and was conducted using only institutional resources.

Acknowledgments

The authors would like to acknowledge the support and facilities provided by the Laboratory of Food Processing and Technology, Department of Food Engineering and Nutrition Science, State University of Bangladesh, where this study was conducted. EndNote was used for reference management and citation formatting during the preparation of this manuscript.

Supplementary Materials

The supplementary material contains data supporting the findings of this study. Supplementary Tables S1 and

S2 provide experimental data and supporting information. References [17–40] are cited in the Supplementary Materials and are available at: <https://doi.org/10.69709/SustainFoodConn.2026.172787>

AI Declaration

The authors used Grammarly Pro (v1.2.289.1946) solely for language editing during manuscript preparation. No AI-based tools were used to generate the scientific content, analysis, or conclusion. The authors take full responsibility for the accuracy, originality, integrity, and scientific content of the manuscript.

References

- [1] Udaya Kumar, V.; Sharma, A.; Bisht, P.; Dhingra, S.; Ravichandiran, V.; Ramesh, M.; Murti, K. The Possible Role of Selected Vitamins and Minerals in the Therapeutic Outcomes of Leishmaniasis. *Biol. Trace Elem. Res.* **2023**, *201*(4), 1672–1688. [[CrossRef](#)] [[PubMed](#)]
- [2] Jomova, K.; Cvik, M.; Lauro, P.; Valko, M.; Cizmar, E.; Alomar, S.Y.; Alwasel, S.H.; Oleksak, P.; Chrienova, Z.; Nepovimova, E.; et al. The Role of Redox Active Copper(II) on Antioxidant Properties of the Flavonoid Baicalein: DNA Protection Under Cu(II)-Fenton Reaction and Cu (II)-Ascorbate System Conditions. *J. Inorg. Biochem.* **2023**, *245*, 112244. [[CrossRef](#)] [[PubMed](#)]
- [3] Jomova, K.; Cvik, M.; Orolinova, T.; Alomar, S.Y.; Alwasel, S.H.; Aldahmash, W.; Alqarzae, S.; Al-Juaimlani, A.; Nepovimova, E.; Kuca, K.; et al. Antioxidant Versus Prooxidant Properties of the Flavonoid, Galangin: ROS Scavenging Activity, Flavonoid-DNA Interaction, Copper-Catalyzed Fenton Reaction and DNA Damage Study. *J. Agric. Food Res.* **2024**, *16*, 101112. [[CrossRef](#)]
- [4] Asaduzzaman, M.; Haque, M.E.; Rahman, J.; Hasan, S.K.; Ali, M.A.; Akter, M.S.; Ahmed, M. Comparisons of Physiochemical, Total Phenol, Flavonoid Content and Functional Properties in Six Cultivars of Aromatic Rice in Bangladesh. *Afr. J. Food Sci.* **2013**, *7*(8), 198–203. [[CrossRef](#)]
- [5] Guo, H.C.; Xu, X.R.; Zhang, J.X.; Du, Y.J.; Yang, X.B.; He, Z.H.; Zhao, L.J.; Liang, T.M.; Guo, L. The Pivotal Role of Preclinical Animal Models in Anti-Cancer Drug Discovery and Personalized Cancer Therapy Strategies. *Pharmaceuticals* **2024**, *17*(8), 1048. [[CrossRef](#)] [[PubMed](#)]
- [6] Weiss-Tessbach, M.; Reiter, B.; Gludovacz, E.; Boehm, T.; Jilma, B.; Rager-Resch, M. Recombinant Human Diamine Oxidase Prevents Hemodynamic Effects of Continuous Histamine Infusion in Guinea Pigs. *Inflamm. Res.* **2023**, *72*(10–11), 2013–2022. [[CrossRef](#)] [[PubMed](#)]
- [7] Latif, R.; Nawaz, T. Medicinal plants and human health: A comprehensive review of bioactive com-

- pounds, therapeutic effects, and applications.
- Phytochem. Rev.*
- 2026**
- , 25(3), 2299–2342. [CrossRef]
- [8] Ansari, W.A.; Srivastava, K.; Nasibullah, M.; Khan, M.F. Reactive oxygen species (ROS): Sources, generation, disease pathophysiology, and antioxidants. *Discov. Chem.* **2025**, 2(1), 191. [CrossRef]
- [9] Ramawat, K.; Goyal, S. Natural Products in Cancer Chemoprevention and Chemotherapy. *Herb. Drugs Ethnomed. Mod. Med.* **2009**, 153–171. [CrossRef]
- [10] Ouma, R.B.O.; Raza, U.; Ngari, S.M.; Kibet, J.K.; Nisar, U.; Ali, M.W. Experimental and Theoretical Assessment of Salvianolic Acid B, Ellagic Acid, and Phorbol Esters as Drug Candidates Against Breast and Prostate Cancer. *Discov. Chem.* **2025**, 2(1), 352. [CrossRef]
- [11] Noumedem, J.A.K.; Tamokou, J.D.; Teke, G.N.; Momo, R.C.D.; Kuete, V.; Kuete, J.R. Phytochemical Analysis, Antimicrobial and Radical-Scavenging Properties of Leaves. *Springerplus* **2013**, 2, 1–6. [CrossRef] [PubMed]
- [12] Agustina, N.; Purwestri, Y.A.; Nugroho, L.H. Antioxidant Activity and Histochemical Analysis of *Acalypha indica* L. and *Acalypha wilkesiana* Muell. Arg. Vegetative and Generative Organs. *Intl. J. Pharm. Phytochem Res.* **2016**, 8, 1657–1662. [View Online]
- [13] Onuah, C.; Monago, C.; Omeodu, S. Ethanol Extract of *Acalypha wilkesiana* Muel Arg Leaves Ameliorates Paracetamolinduced Hepatotoxicity in Rats. *Int. J. Biochem. Res. Rev.* **2016**, 12(2), 1–7. [CrossRef] [PubMed]
- [14] Tan, J.B.L.; Yap, W.J.; Tan, S.Y.; Lim, Y.Y.; Lee, S.M. Antioxidant Content, Antioxidant Activity, and Antibacterial Activity of Five Plants from the Comelinaceae Family. *Antioxidants* **2014**, 3(4), 758–769. [CrossRef] [PubMed]
- [15] Asaduzzaman, M. Lycopene—A Review: Chemistry, Source, Health Role, Extraction, Applications. *Annu. Res. Rev. Biol.* **2022**, 37(2), 87–101. [CrossRef]
- [16] Asaduzzaman, M.; Akter, M.S.; Rahman, M. Enhancing Nutritional Value and Quality of Cookies Through Pumpkin Peel and Seed Powder Fortification. *PLoS ONE* **2025**, 20(2), e0307506. [CrossRef] [PubMed]
- [17] Alade, P.I.; Irobi, O.N. Antimicrobial Activities of Crude Leaf Extracts of *Acalypha wilkesiana*. *J. Ethnopharmacol.* **1993**, 39, 171–174. [CrossRef] [PubMed]
- [18] Maliuvanchuk, S.; Grytsyk, A.; Popadynets, O.; Koryk, T.; Raal, A.; Koshovyi, O. *Ajuga reptans* L. Herb Extracts: Phytochemical Composition and Pharmacological Activity Screening. *Plants* **2025**, 14, 219. [CrossRef] [PubMed]
- [19] Pires, J.M.; Negri, G.; Duarte-Almeida, J.M.; Carlini, E.A.; Mendes, F.R. Phytochemical Analysis and Investigation of Analgesic, Anti-Inflammatory, and Antispasmodic Activities of Hydroethanolic Extracts of *Alternanthera dentata*, *Ocimum carnosum*, and *Plectranthus barbatus*, Three Species with Vernacular Names Derived from Analgesic Drugs. *J. Ethnopharmacol.* **2024**, 334, 118508. [CrossRef] [PubMed]
- [20] Sarker, U.; Oba, S. Polyphenol and Flavonoid Profiles and Radical Scavenging Activity in Leafy Vegetable *Amaranthus gangeticus*. *BMC Plant Biol.* **2020**, 20, 499. [CrossRef] [PubMed]
- [21] Udo, M.; Eyoh, G.; Jimmy, C.; Ekpo, U. Nutrient Composition, Mineral and Anti-Nutrient Components of Processed Wild Cocoyam (*Caladium bicolor*, (Ait) Vent). *Curr. Agric. Res. J.* **2020**, 8, 137–145. [CrossRef]
- [22] Badawy, E.-S.M.; El-Meadawy, E.E.; El-Ezawy, W.H. Micropropagation of *Calathea medallion* an Ornamental Plant. *Plant Arch.* **2020**, 20, 1483–1489.
- [23] Dinakaran, V.S.; Vontoor, N.; Hussain, T.S.; Reji, S. A Systematic Review on Ethnobotanical and Pharmacological Aspects of Croton Plant *Codiaeum variegatum* (L.). *Asian J. Res. Chem.* **2024**, 17, 159–168. [CrossRef]
- [24] Alphianti, L.T.; Bachtiar, E.W.; Suniarti, D.F.; Fauziah, E. Identification of Bioactive Compounds in *Cordyline fruticosa* (L.) A. Chev. Leaf Extract and Its Antimicrobial Activity against Cariogenic Microorganisms. *J. Adv. Pharm. Technol. Res.* **2025**, 16, 156–162. [CrossRef] [PubMed]
- [25] Yang, M.-H.; Blunden, G.; Patel, A.; Crabb, T.A.; Griffin, W.J. Rubragenin, Chenogenin and Wallogenin, Steroidal Sapogenins from *Cordyline rubra*. *Phytochemistry* **1989**, 28, 3171–3173. [CrossRef]
- [26] Cruceru, S. The Collection of Plants from the Bromeliaceae Family of the Botanical Garden of the University of Craiova. *Ann. Univ. Craiova Agric. Montanol. Cadastre Ser.* **2025**, 55, 43–46. [CrossRef]
- [27] Jayalakshmi, B.; Raveesha, K.A.; Amruthesh, K.N. Isolation and Characterization of Bioactive Compounds from *Euphorbia cotinifolia*. *Future J. Pharm. Sci.* **2021**, 7, 9. [CrossRef]
- [28] Bi, H.; Teng, W.; Wang, J.; Wang, X.; Zhang, Z.; Wang, M. Recent Developments in Non-Starch *Ipomoea batatas* (L.) Lam. Polysaccharides: Extractions and Purifications, Structural Characteristics, Pharmacological Activities, Structure-Activity Relationships, and Applications A Review. *Int. J. Biol. Macromol.* **2025**, 309, 142808. [CrossRef] [PubMed]
- [29] Stefanowicz-Hajduk, J.; Nowak, A.; Hering, A.; Kucharski, Ł.; Graczyk, P.; Kowalczyk, M.; Sulikowski, T.; Muzykiewicz-Szymańska, A. Antiaging Properties of *Kalanchoe blossfeldiana* Ethanol Extract—Ex Vivo and In Vitro Studies. *Molecules* **2024**, 29, 5548. [CrossRef] [PubMed]
- [30] Revathi, S.; Nasser, E.K.; Wafaa, H.K.; Altemimi, A.B.; Sutikno, S.; Kartika, T.; Guswenrivo, I.; Awlqadr, F.H.; Abedelmaksoud, T.G. *Lawsonia inermis* Extract: Antibacterial, Anticancer and Antioxidant Properties. *Food Syst.* **2025**, 8, 73–80. [CrossRef]
- [31] Linsaenkart, P.; Ruksiriwanich, W.; Sringarm, K.; Arjin, C.; Rachtanapun, P.; Chittasupho, C.;

- Castagnini, J.M.; Chutoprapat, R.; Mueller, A.; Boonpisuttinant, K. Anti-Melanogenic Potential of Malabar Spinach (*Basella alba*) in Human Melanoma Cells with Oxidative Stress Suppression and Anti-Inflammatory Activities. *Foods* **2024**, *13*, 2943. [CrossRef] [PubMed]
- [32] Bharti, R.; Priyanka, P.; Bhargava, P.; Khatri, N. Ethnopharmacology and Therapeutic Potentials of *Oxalis corniculata*: An In-Depth Study. *Beni-Suef Univ. J. Basic Appl. Sci.* **2024**, *13*, 81. [CrossRef]
- [33] Kumaresan, V.; Parthibhan, S.; Lavanaya, R.; Rao, M. In Vitro Propagation of *Oxalis corniculata* L. In *Micropropagation of Medicinal Plants*; Bentham Science Publishers, 2024; pp. 318–337. [CrossRef]
- [34] Sharma, S.; Bhuyan, N.R.; Mohanty, J.P. A Pharmacognostic, Phytochemical, and Antioxidant Potential of *Oxalis triangularis*. *J. Appl. Pharm. Res.* **2024**, *12*, 133–145. [CrossRef]
- [35] Kowalczyk, T.; Sikora, J.; Merez-Sadowska, A.; Kukula-Koch, W.; Synowiec, E.; Majda, A.; Juda, D.; Śliwiński, T.; Sitarek, P. Biological Properties of Extracts Obtained from In Vitro Culture of *Plectranthus scutellarioides* in a Cell Model. *Int. J. Mol. Sci.* **2024**, *25*, 1043. [CrossRef] [PubMed]
- [36] Karakaya, S.; Aydın, B.; Yuca, H.; Öztürk, G.; Tekman, E.; Göger, G.; Önal, M.; Demirci, B.; Güvenalp, Z.; Sytar, O. Fruitful Remedies: Analyzing Therapeutic Potentials in Essential and Fatty Oils, and Aqueous Extracts from *Prunus cerasifera*, *Malus sylvestris*, and *Cornus mas* Using LC-MS and GC-MS. *J. Fac. Pharm. Ankara Univ.* **2025**, *49*, 402–424. [CrossRef]
- [37] Sanni, O.; Nkomozepe, P.; Islam, M.S. Ethyl Acetate Fractions of *Tectona Grandis* Crude Extract Modulate Glucose Absorption and Uptake as Well as Antihyperglycemic Potential in Fructose–Streptozotocin-Induced Diabetic Rats. *Int. J. Mol. Sci.* **2024**, *25*, 28. [CrossRef] [PubMed]
- [38] Intiaz, F.; Islam, M.; Saeed, H.; Ahmed, A. Phenolic Compounds from *Tradescantia pallida* Ameliorate Diabetes by Inhibiting Enzymatic and Non-Enzymatic Pathways. *J. Biomol. Struct. Dyn.* **2023**, *41*, 11872–11888. [CrossRef] [PubMed]
- [39] Kushwaha, S.; Kukshaal, M.; Patil, S.M. Review on *Tradescantia spathacea* (Medicinal Plant). *J. Res. Appl. Sci. Biotechnol.* **2024**, *3*, 104–115. [CrossRef]
- [40] Baghalpour, N.; Ayatollahi, S.A.; Naderi, N.; Hosseinabadi, T.; Taheri, Y.; Mahroo-Bakhtiyari, J.; Shinwari, Z.K.; Sharifi-Rad, A.T.K.A.J. Antinociceptive and Antiinflammatory Studies on *Tradescantia zebrina*. *Pak. J. Bot.* **2021**, *53*, 357–365. [CrossRef] [PubMed]
- [41] Khatun, T.; Asaduzzaman, M. Effect of Sweet Potato Flash Powder on the Proximate, Functional, and Bioactive Properties of Fortified Confectionery Products. *Food Humanit.* **2025**, *5*, 100771. [CrossRef]
- [42] Saikia, S.; Dutta, H.; Saikia, D.; Mahanta, C.L. Quality Characterisation and Estimation of Phytochemicals Content and Antioxidant Capacity of Aromatic Pigmented and Non-Pigmented Rice Varieties. *Food Res. Int.* **2012**, *46*(1), 334–340. [CrossRef]
- [43] Oh, Y.; Kim, J.; Park, Y.J.; Kim, Y. Male-Specific Effects of β -Carotene Supplementation on Lipid Metabolism in the Liver and Gonadal Adipose Tissue of Healthy Mice. *Molecules* **2025**, *30*, 909. [CrossRef] [PubMed]
- [44] Almeida, M.M.B.; de Sousa, P.H.M.; Arriaga, A.M.C.; do Prado, G.M.; Magalhaes, C.E.D.; Maia, G.A.; de Lemos, T.L.G. Bioactive Compounds and Antioxidant Activity of Fresh Exotic Fruits From Northeastern Brazil. *Food Res. Int.* **2011**, *44*(7), 2155–2159. [CrossRef]
- [45] Von Lintig, J. Colors With Functions: Elucidating the Biochemical and Molecular Basis of Carotenoid Metabolism. *Annu. Rev. Nutr.* **2010**, *30*, 35–56. [CrossRef] [PubMed]
- [46] Pierson, J.T.; Dietzgen, R.G.; Shaw, P.N.; Roberts-Thomson, S.J.; Monteith, G.R.; Gidley, M.J. Major Australian Tropical Fruits Biodiversity: Bioactive Compounds and Their Bioactivities. *Mol. Nutr. Food Res.* **2012**, *56*(3), 357–387. [CrossRef] [PubMed]
- [47] Castro-Muñoz, R. Nanofiltration-Assisted Concentration Processes of Phenolic Fractions and Carotenoids from Natural Food Matrices. *Separations* **2024**, *11*(2), 64. [CrossRef]
- [48] Costa, P.A.; Sampaio, C.I.; Dias, A.M. Lycopene and Beta-Carotene as Colorful and Versatile Tools to Illustrate Chromatography, Colorimetry, Alkene-Reactions and Health-Benefits. *J. Chem. Educ.* **2025**, *102*(2), 829–838. [CrossRef]
- [49] Aguayo-Morales, H.; Poblano, J.; Berlanga, L.; Castillo-Tobías, I.; Silva-Belmares, S.Y.; Cobos-Puc, L.E. Plant Antioxidants: Therapeutic Potential in Cardiovascular Diseases. *Compounds* **2024**, *4*(3), 479–502. [CrossRef]
- [50] Butnariu, M.; Quispe, C.; Herrera-Bravo, J.; Fernández-Ochoa, A.; Emamzadeh-Yazdi, S.; Aдетунji, C.O.; Memudu, A.E.; Otlewska, A.; Bogdan, P.; Antolak, H.; et al. A Review on *Tradescantia*: Phytochemical Constituents, Biological Activities and Health-Promoting Effects. *Front. Biosci.-Landmark* **2022**, *27*(6), 197. [CrossRef] [PubMed]
- [51] Mourtala, I.Z.M.; Innocent, N.M.; Habibou, M.; Oselebe, H. Recent Progress in Breeding for Beta-Carotene, Dry Matter Content and Sugar in Sweet Potato [*Ipomoea Batatas* (L.) Lam]-A Review. *Eur. J. Agric. Food Sci.* **2023**, *5*(1), 6–13. [CrossRef]
- [52] Edo, G.I.; Ugbune, U.; Ezekiel, G.O.; Nwosu, L.C.; Onoharigho, F.O.; Agbo, J.J. Medicinal Plants Used for the Treatment of Sexual Dysfunction; Ethnobotanical Study and Phytochemical Analysis. *Ecol. Front.* **2024**, *44*(2), 247–256. [CrossRef]
- [53] Nwozo, O.S.; Effiong, E.M.; Aja, P.M.; Awuchi, C.G. Antioxidant, Phytochemical, and Therapeutic Properties of Medicinal Plants: A Review. *Int. J. Food Prop.* **2023**, *26*(1), 359–388. [CrossRef]
- [54] Alemu, M.; Lulekal, E.; Asfaw, Z.; Warkineh, B.; Debella, A.; Abebe, A.; Degu, S.; Debebe, E. An-

- tibacterial activity and phytochemical screening of traditional medicinal plants most preferred for treating infectious diseases in Habru District, North Wollo Zone, Amhara Region, Ethiopia. *PLoS ONE* **2024**, *19*(3), e0300060. [[CrossRef](#)] [[PubMed](#)]
- [55] Thilagavathi, R.; Begum, S.S.; Varatharaj, S.D.; Balasubramaniam, A.K.; George, J.S.; Selvam, C. Recent Insights Into the Hepatoprotective Potential of Medicinal Plants and Plant-Derived Compounds. *Phyther. Res.* **2023**, *37*(5), 2102–2118. [[CrossRef](#)] [[PubMed](#)]
- [56] Kaulmann, A.; Jonville, M.C.; Schneider, Y.J.; Hoffmann, L.; Bohn, T. Carotenoids, Polyphenols and Micronutrient Profiles of and Plum Varieties and Their Contribution to Measures of Total Antioxidant Capacity. *Food Chem.* **2014**, *155*, 240–250. [[CrossRef](#)] [[PubMed](#)]
- [57] Pepi, B.; Suroto, S.; Brian, W.; Diah Kurnia, M. *Tectona Grandis* Leaves: Determination of Total Flavonoid Content, Phenolic Content, Characterization of the Leaves, and Compound Identification in GC-MS. *Pharmacogn. J.* **2023**, *15*(1), 165–170. [[CrossRef](#)]
- [58] Khan, M.R.; Zehra, H. Amelioration of CCl₄-Induced Nephrotoxicity by *Oxalis corniculata* in Rat. *Exp. Toxicol. Pathol.* **2013**, *65*(3), 327–334. [[CrossRef](#)] [[PubMed](#)]
- [59] Zhang, Y.; Cheng, W.; Di, H.; Yang, S.; Tian, Y.; Tong, Y.; Huang, H.; Escalona, V.H.; Tang, Y.; Li, H.; et al. Variation in Nutritional Components and Antioxidant Capacity of Different Cultivars and Organs of *Basella alba*. *Plants* **2024**, *13*(6), 892. [[CrossRef](#)] [[PubMed](#)]
- [60] Dutt, M.; Zalewska, M.; Moczowska-Wyrwicz, M.; Wyrwicz, J.; Kurek, M.A. Green and Efficient Extraction Strategies for Anthocyanins From Purple Plant Sources: Advances, Challenges, and Functional Potential. *J. Food Process. Preserv.* **2026**, *2026*(1), 6295116. [[CrossRef](#)]
- [61] Zhang, N.; Jing, P. Anthocyanins in Brassicaceae: Composition, Stability, Bioavailability, and Potential Health Benefits. *Crit. Rev. Food Sci.* **2022**, *62*(8), 2205–2220. [[CrossRef](#)] [[PubMed](#)]
- [62] Shi, M.; Gu, J.; Wu, H.; Rauf, A.; Emran, T.B.; Khan, Z.; Mitra, S.; Aljohani, A.S.M.; Alhumaydhi, F.A.; Al-Awthan, Y.S.; et al. Phytochemicals, Nutrition, Metabolism, Bioavailability, and Health Benefits in Lettuce—A Comprehensive Review. *Antioxidants* **2022**, *11*, 1158. [[CrossRef](#)] [[PubMed](#)]
- [63] Lee, J.; Shin, Y. Antioxidant Compounds and Activities of *Perilla frutescens* var. *crispa* and Its Processed Products. *Food Sci. Biotechnol.* **2024**, *33*(5), 1123–1133. [[CrossRef](#)] [[PubMed](#)]
- [64] Andrade, A.C.; Borsoi, F.T.; Saliba, A.S.; de Alencar, S.M.; Pastore, G.M.; Arruda, H.S. Optimization of Ultrasonic-Assisted Extraction of Phenolic Compounds and Antioxidant Activity from Araticum Peel Using Response Surface Methodology. *Plants* **2024**, *13*, 2560. [[CrossRef](#)] [[PubMed](#)]
- [65] Deng, S.X.; West, B.J.; Jensen, C.J. A Quantitative Comparison of Phytochemical Components in Global Noni Fruits and Their Commercial Products. *Food Chem.* **2010**, *122*(1), 267–270. [[CrossRef](#)]

Disclaimer/Publisher's Note: The views expressed in this article are those of the author(s) and do not necessarily reflect the views of the publisher or editors. The publisher and editors assume no responsibility for any injury or damage resulting from the use of information contained herein.