

Phytochemical profiling and correlation analysis of five medicinal Euphorbiaceae species from Bangladesh

Mahabub Alam Ashik¹, Md. Shakib Al Islam¹, Arup Karmokar¹, Md. Riyadh Arefin^{1,2}, A.K.M. Azad-ud-doula Prodhana¹ and A.K.M. Golam Sarwar^{1*}

¹ Laboratory of Plant Systematics, Department of Crop Botany, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh.

² Botany Division, Bangladesh Tea Research Institute, Sreemangal 3210, Bangladesh.

* Email: drsarwar@bau.edu.bd

Receipt: 28.12.2025 Revised: 09.03.2026 Acceptance: 11.03.2026

DOI: <https://doi.org/10.53552/ijmfmap.12.1.2026.114-122>

License: [CC BY-NC 4.0](https://creativecommons.org/licenses/by-nc/4.0/) (<https://creativecommons.org/licenses/by-nc/4.0/>)

Copyright: © The Author(s)

ABSTRACT

The family Euphorbiaceae comprises a large and diverse group of flowering plants with pivotal medicinal value for human health. Bangladesh harbors 47 genera and 141 species of this family, yet a significant research gap remains in its phytochemical study. To address this situation, the present experiment was conducted to determine the phytochemical compounds and their relationships in five important Euphorbiaceae species, viz., *Euphorbia hirta* L., *Acalypha indica* L., *Jatropha gossypifolia* L., *Jatropha curcas* L., and *Acalypha hispida* Burm., collected from the Botanical Garden of Bangladesh Agricultural University. The study was accomplished by following a completely randomized design (CRD) with three replications to quantify the phytoconstituents of leaves, like chlorophyll a (Chl a), chlorophyll b (Chl b), total chlorophyll (TChl), carotenoids (CRTN), total phenolic compounds (TPC), total flavonoid contents (TFC), and total antioxidant activity (TAC). The species showed significant variation in phytochemicals, as revealed by analysis of variance. Among them, *A. indica* had the significantly highest Chl a ($2.42 \pm 0.08 \text{ mg g}^{-1} \text{ FW}$), Chl b ($1.64 \pm 0.09 \text{ mg g}^{-1} \text{ FW}$), TChl ($4.06 \pm 0.17 \text{ mg g}^{-1} \text{ FW}$), CRTN ($4.13 \pm 0.21 \text{ mg g}^{-1} \text{ FW}$), and TPC ($17.01 \pm 0.19 \text{ mg GAE g}^{-1} \text{ DW}$), whereas *J. gossypifolia* possessed the maximum amount of Chl b ($1.42 \pm 0.07 \text{ mg g}^{-1} \text{ FW}$) and TAC ($7.31 \pm 0.13 \text{ mg AAE g}^{-1} \text{ FW}$). Strong positive correlations were identified between leaf pigments and TPC, whereas negative correlations were determined with TFC and TAC. Finally, *A. indica* and *J. gossypifolia* were identified as the most promising species, with phytoconstituents that warrant more in-depth study to validate the current research.

Keywords: Antioxidants, Euphorbiaceae, flavonoids, leaf pigments, phenolics, phytochemicals.

INTRODUCTION

Plants are a rich source of organic and inorganic compounds that have diverse physiological and human health benefits. These constituents primarily include phenolic contents, flavonoids, tannins, terpenoids, etc. Plants used as herbal medicine to treat diseases are known as medicinal plants (Sadia and Ashrafuzzaman, 2025). Chemical extraction and phytochemical analysis of plants from different families play pivotal

roles in advancing and modernizing the herbal medicine industry by enabling the identification and isolation of bioactive compounds with improved efficacy and reproducibility (Vakte and Nehete, 2025).

The family Euphorbiaceae is a large and diverse group of flowering plants, comprising 300 genera and about 7,500 species, including trees, herbs, and shrubs (Mehriardestani *et al.*, 2017). For centuries, plants in this family have been used in

traditional medicine to treat various physical disorders, including skin disorders, inflammatory diseases, infections, and gastrointestinal problems. Such therapeutic applications are attributed to their secondary metabolites, including flavonoids, phenolic compounds, alkaloids, and others (Islam *et al.*, 2019).

About 47 genera and 141 species have been reported in the family Euphorbiaceae in Bangladesh, making it one of the most significant plant families in the country's diverse flora (Uddin *et al.*, 2018). Plants from this family serve multiple purposes in Bangladesh, including as sources of carbohydrates, oil crops, ornamental plants, and traditional herbal medicine (Rahman and Akter, 2013). Species of the family Euphorbiaceae exhibit marked variability in phytochemical composition and antioxidant potential with associated protective mechanisms in different environmental conditions (Kumar *et al.*, 2015). Despite extensive use of Euphorbiaceae plants as traditional medicines in Bangladesh, a significant research gap persists due to minimal documentation of phytochemical profiling. This investigation aimed to quantify and compare key phytochemicals in five medicinal plants of the Euphorbiaceae family, elucidate the relationships among bioactive compounds, and identify potential phytoconstituents within these species.

MATERIALS AND METHODS

Five plant species, *viz.*, *Euphorbia hirta* L., *Acalypha indica* L., *Jatropha gossypifolia* L., *Jatropha curcas* L., and *Acalypha hispida* Burm. belonging to the Euphorbiaceae family were collected from the Botanical Garden of Bangladesh Agricultural University (BAUBG) during June and July 2024. Fresh, mature, and disease- and pest-free leaves were collected for phytochemical analysis. Fresh leaves were used for pigment tests (chlorophyll a, chlorophyll b, total chlorophyll, and total carotenoids) and total antioxidant activity analysis. In contrast, sundried leaf samples were used to quantify

total phenolic compounds and total flavonoid contents.

The leaf pigments were extracted and measured as described by Lichtenthaler (1987). 0.5 mg fresh leaf samples of each species (excluding the midrib areas) were incubated in 80% acetone in the dark for 7 days (Islam *et al.*, 2025). The prolonged incubation was applied to ensure complete pigment extraction from the leaf tissues. The samples were kept in tightly sealed amber tubes and maintained in the dark to prevent photo-oxidation of pigments. The absorbances of extracts were recorded at 470, 646.8, and 663.2 nm wavelengths by the LAMBDA 1050+ UV/Vis spectrophotometer. The amounts of chlorophyll a, chlorophyll b, total chlorophyll, and total carotenoids were quantified by following equations and expressed as mg g⁻¹ of fresh weight (FW) (Lichtenthaler, 1987):

$$\text{Chlorophyll a (Chl a)} = 12.25 A_{663.2} - 2.79 A_{646.8}$$

$$\text{Chlorophyll b (Chl b)} = 21.50 A_{646.8} - 5.10 A_{663.2}$$

$$\text{Total chlorophyll (TChl)} = 7.15 A_{663.2} + 18.71 A_{646.8}$$

$$\text{Total Carotenoids (CRTN)} = [1000 A_{470} - 1.82 \text{ Chl a} - 85.02 \text{ Chl b}] \div 198$$

Analysis of total antioxidant capacity (TAC), total phenolic compounds (TPC), and total flavonoid contents (TFC)

A fresh leaf sample was extracted with 80% methanol, and total antioxidant capacity (TAC) was determined according to the protocol of Islam *et al.* (2025). TAC was expressed as ascorbic acid equivalent (mg AAE g⁻¹ FW). Sun-dried leaf samples were used to calculate total phenolic compounds (TPC) and total flavonoid contents (TFC). The TPC and TFC were both quantified by using the methods of Islam *et al.* (2025) and expressed as gallic acid equivalent dry weight (mg GAE g⁻¹ DW) and quercetin equivalent dry weight (mg QUE g⁻¹ DW), respectively.

Experimental design and data analysis

The experiment was conducted using a completely randomized design, with three mature plants per species as the three replications. Analysis of variance and multiple comparisons (Tukey's HSD test)

were performed using Minitab (version 21). Principal component analysis and a correlation matrix were performed in RStudio using R (version: 2026.01.0+392). The hierarchical clustering heatmap was constructed by OriginPro (version 2025) statistical software.

RESULTS AND DISCUSSION

Phytochemical constituents

The leaf pigment contents, like chlorophyll a (Chl a), chlorophyll b (Chl b), total chlorophyll (TChl), and total carotenoids (CRTN) varied from $2.42 \pm 0.08 \text{ mg g}^{-1} \text{ FW}$ to $0.68 \pm 0.05 \text{ mg g}^{-1} \text{ FW}$, $1.64 \pm 0.09 \text{ mg g}^{-1} \text{ FW}$ to $0.58 \pm 0.03 \text{ mg g}^{-1} \text{ FW}$, $4.06 \pm 0.17 \text{ mg g}^{-1} \text{ FW}$ to $1.44 \pm 0.14 \text{ mg g}^{-1} \text{ FW}$, and $4.13 \pm 0.21 \text{ mg g}^{-1} \text{ FW}$ to $0.94 \pm 0.11 \text{ mg g}^{-1} \text{ FW}$, respectively (Table 1). Leaves of *A. indica* possessed the highest Chl a, TChl, and CRTN; meanwhile, Chl b was found in maximum quantity in both *A. indica* and *J. gossypifolia*, which were statistically similar. In contrast, reduced Chl a levels were observed in *E. hirta* and *A. hispida*. Lower Chl b contents were recorded in *A. hispida*, *E. hirta*, and *J. curcas*. Similarly, TChl was comparatively low in *J. curcas*, *E. hirta*, and *A. hispida*. CRTN was lowest and statistically similar in *J. curcas* and *E. hirta*. Some previous studies also reported similar high concentrations of leaf pigments in *A. indica* (Vidhya *et al.*, 2017). In contrast, higher total carotenoids ($3.65 \text{ mg g}^{-1} \text{ FW}$) were recorded by Sumi *et al.* (2024). Different investigations also supported similar TChl contents in other plant species, such as $0.35 \text{ mg g}^{-1} \text{ FW}$ in *E. hirta* (Sumi *et al.*, 2024), $1.65 \text{ mg g}^{-1} \text{ FW}$ in *J. gossypifolia*, $1.78 \text{ mg g}^{-1} \text{ FW}$ in *J. curcas* (Farouk and El-leel, 2017), and $1.11 \text{ mg g}^{-1} \text{ FW}$ in *A. hispida* (Pavani *et al.*, 2020).

In this study, total phenolic compounds (TPC) accumulated the highest in *A. indica* ($17.01 \pm 0.19 \text{ mg GAE g}^{-1} \text{ DW}$), while the other four species showed similar lower amounts. Previous studies have also reported elevated phenolic levels ($18.68 \text{ mg GAE g}^{-1}$) in metabolic extracts of *A. indica*,

supporting its richness in phenolic compounds (Arimboor, 2021). In contrast, *E. hirta* possessed the highest ($25.08 \pm 0.18 \text{ mg QUE g}^{-1} \text{ DW}$) quantity of total flavonoid contents (TFC), whereas *A. indica* had the lowest ($14.63 \pm 0.27 \text{ mg QUE g}^{-1} \text{ DW}$). Elevated amounts of TFC in *E. hirta* leaves were also reported by Basma *et al.* (2011) as $37.97 \pm 0.003 \text{ mg g}^{-1}$ and by Tran *et al.* (2020) as 40.56 mg g^{-1} in crude extract. The probable causes of this increasing TFC of *E. hirta* may be ecological differences and changes in growth conditions.

Total antioxidant capacity (TAC) was found to be highest in *J. gossypifolia* ($7.31 \pm 0.13 \text{ mg AAE g}^{-1} \text{ FW}$). In comparison, minimum amounts were detected in both *A. indica* ($3.69 \pm 0.09 \text{ mg AAE g}^{-1} \text{ FW}$) and *E. hirta* ($3.18 \pm 0.11 \text{ mg AAE g}^{-1} \text{ FW}$), which were statistically indistinguishable. *Jatropha* species are well known for their antioxidant properties, which vary in different plant parts. For example, leaves of *J. curcas* have more antioxidant properties than those of *J. gossypifolia*, but the stem bark of *J. gossypifolia* has more potential than that of *J. curcas* (Zengin *et al.*, 2021). The overall total antioxidant capacity of *J. gossypifolia* was also reported to be higher, at $3.01 \text{ mg AAE g}^{-1} \text{ FW}$, in another study (Farouk and El-leel, 2017), and the slight deviation from the current investigation was likely due to variation in secondary metabolite accumulation across ecological locations and ecosystems.

One-way ANOVA revealed significant variation in the phytochemical content among five selected plant species of the family Euphorbiaceae (Table 2). The mean sum of squares (MSS) values of plant species were observed to be higher than the error MSS with respect to all parameters. In this study, the coefficients of variation per cent (CV%) ranged from 4.33 (low) to 12.63 (medium), indicating acceptable variability and standard data accuracy for agricultural research (Lopes *et al.*, 2021).

Relationships between the phytochemicals

Usually, a correlation matrix was constructed using Pearson's correlation coefficient to assess relationships among the variables (Arefin *et al.*, 2020). In this study, several positive and negative relationships among the phytochemicals in the selected species were identified using a correlation matrix based on Pearson's correlation coefficient (Figure 1). The leaf pigments (Chl a, Chl b, TChl, and CRTN) and TPC were found to be positively interlinked with each other. Conversely, TFC and TAC were negatively associated with each other and with the other phytochemicals (Chl a, Chl b, TChl, CRTN, and TPC) as well. Plants absorb light energy through leaf pigments and convert it into photosynthates (sugars and carbohydrates) through photosynthesis, serving as their own food and energy source. Chlorophyll a acts as the primary photosynthetic pigment, whereas chlorophyll b serves as the additional light-capturing source. They are also interconvertible; chlorophyll b is synthesized from chlorophyll a and is converted again to chlorophyll a through the chlorophyll cycle (Tanaka and Tanaka, 2019). Again, total carotenoids are important plant pigments that enhance photosynthetic efficiency by absorbing violet and blue-green light and also serve as precursors of many stress-signaling molecules, such as abscisic acid (ABA). These leaf pigments, such as carotenoids, have profound therapeutic benefits for human health; for example, beta-carotene is converted to vitamin A (Sun *et al.*, 2022). Leaf pigments were observed to interlink with one another, supported by the studies mentioned above. Generally, plant leaf pigments also have a strong relationship with phenolic compounds; for example, mature leaves (more pigment) possess higher phenolic compounds than the younger leaves (less pigment) (Degrâce *et al.*, 2025). A similar observation is also observed in the current investigation. Generally, TAC increases when plants are subjected to any stress conditions. But no stress was applied in

this study; therefore, a negative correlation was observed between pigments and TAC. In some previous experiments, insignificant, lower, or sometimes negative associations between leaf pigment and TAC were also observed (Islam *et al.*, 2025; Sumi *et al.*, 2025).

Arrangement of the species by principal component analysis (PCA) and clustering heatmap

Principal component analysis (PCA)

Four principal components (PCs) were identified through principal component analysis (PCA) of phytochemical contents of selected plant species. First, two components (PC1 and PC2) had eigenvalues greater than 1 and accounted for 84.29% of the total variation (Table 3). A PCA biplot was also constructed, where PC1 and PC2 were responsible for 69.31% and 14.98% of total variation, respectively (Figure 2). In a PCA biplot, the genotypes or species located farthest from the center are generally indicated as the most potential one(s) (Sumi *et al.*, 2024). Here, *A. indica* and *J. gossypifolia* were located far from the midpoint (center), indicating higher phytochemical potential for these two species. On the other hand, the remaining three species, *E. hirta*, *J. curcas*, and *A. hispida*, were found in a single quadrant, indicating similar phytochemical content. Usually, variable directions (vectors of traits) residing within a 90° angle in a PCA biplot represent positive correlation, and vice versa (Arefin *et al.*, 2024). The lower angle between the leaf pigments (Chl a, Chl b, TChl, and CRTN) and the TPC variables indicated positive correlations, consistent with the correlation matrix (Figure 1).

Clustering of the species

The plant species were classified based on their phytochemical content using a hierarchical clustering heatmap (Figure 3). Five plant species were categorized into two clusters, *viz.*, Cluster-1 (C-1) and Cluster-2

(C-2). C-1 comprised *A. indica* and *J. gossypifolia*; *A. indica* contained the highest amount of leaf pigments and TPC, whereas *J. gossypifolia* had a higher amount of CHB and TAC with a moderate amount of TFC among the species. The C-2 consisted of the remaining three species, *E. hirta*, *J. curcas*, and *A. hispida*, which had the minimum amount of phytochemicals, except *E. hirta*, which possessed the highest amount of TFC.

Several studies have found that performing PCA and clustering heatmaps to identify potential species or genotypes that contain higher levels of phytochemicals or exhibit greater stress tolerance (Arefin *et al.*, 2020, 2024; Islam *et al.*, 2025). In the present investigation, PCA indicated higher phytochemicals in *A. indica* and *J. gossypifolia* than in the remaining three species, *E. hirta*, *J. curcas*, and *A. hispida* (Fig. 2). A similar arrangement is also observed in the clustering heatmap (Figure 3). The clustering heatmap classified *A. indica* and *J. gossypifolia* into a single cluster (C-1), which can be named as the 'Superior' cluster for having more phytochemicals. Conversely, the other three species, *E. hirta*, *J. curcas*, and *A. hispida*, were identified in the C-2 cluster, which can be termed the 'Inferior' cluster, as it comprises fewer phytochemicals.

CONCLUSION

Five selected species of the family Euphorbiaceae exhibited significant variation in phytochemical constituents. Among the phytochemicals, leaf pigments and total phenolic compounds exhibited strong positive correlations, whereas total flavonoid content and total antioxidant capacity showed negative correlations. *A. indica* and *J. gossypifolia* showed higher phytochemical content, whereas the rest of the species (*E. hirta*, *J. curcas*, and *A. hispida*) had the lowest. Therefore, a detailed phytochemical study of *A. indica* and *J. gossypifolia* is recommended to identify, quantify, and elucidate their therapeutic potential for human health.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES:

- Arefin, M. R., Haque, M. S. and Sarwar, A. K. M. Golam. 2024. Characterization and genetic diversity of tea (*Camellia sinensis* (L.) O. Kuntze) genotypes for waterlogging tolerance. *Phyton-Int. J. Exp. Bot.*, **93**(12): 3411–3442. doi: 10.32604/phyton.2024.058893
- Arefin, M. R., Hossain, M. I. and Rahaman, M. R. U. 2020. Determination of green tea recovery percentage and its relation to different weather parameters. *Asian Plant Res. J.*, **5**(4): 48–56. doi: 10.9734/aprj/2020/v5i430115
- Arimboor, R. 2021. Plant phenolics with antiviral activities against human corona virus and structure-activity relationships – A review. *Phcog Rev.*, **15**(30): 96–106. doi: 10.5530/phrev.2021.15.12
- Basma, A. A., Zakaria, Z., Latha, L. Y. and Sasidharan, S. 2011. Antioxidant activity and phytochemical screening of the methanol extracts of *Euphorbia hirta* L. *Asian Pac. J. Trop. Med.*, **4**(5): 386–390. doi: 10.1016/s1995-7645(11)60109-0
- Degrâce, Z. N. H., Carole, Z. S., Drissa, T. F., Benjamin, K. K. and Rosly, B. S. 2025. Evaluation of phytochemical compounds in the leaves and fruits of *Alchornea cordifolia* in three localities in Côte d'Ivoire. *GSC Biol. Pharm. Sci.*, **31**(1): 268–279. doi: 10.30574/gscbps.2025.31.1.0160
- Farouk, O. and El-leel, A. 2017. Morphological, phytochemical and molecular characterization on some *Jatropha* species cultivated in Egypt. *Int. J. Pharm. Sci. Res.*, **3**(1): 01-13. doi: 10.25141/2471-6782-2017-1.0001

- Islam, M. S. A., Ashik, M. A., Karmokar, A., Arefin, M. R., Prodhan, A. K. M. A. and Sarwar, A. K. M. Golam. 2025. Phytochemical analysis of selected medicinal plants belonging to family Fabaceae. *Turk. J. Agri. Food. Sci. Technol.*, **13**(s3): 3785–3794. doi: 10.24925/turjaf.v13is3.3785-3794.8004
- Islam, M. S., Ara, H., Ahmad, K. I. and Uddin, M. M. 2019. A review on medicinal uses of different plants of Euphorbiaceae family. *Univers. J. Pharm. Res.*, **4**(1): 45–49. doi: 10.22270/ujpr.v4i1.236
- Kumar, A., Kaur, R., Thind, T. S., Arora, R., Kaur, P. and Arora, S. 2015. Relative evaluation of two Euphorbiaceae plants for their hydrogen donating and hydroxyl radical scavenging activities. *J. Chem. Pharm. Res.*, **7**(11): 86–90.
- Lopes, B. G., Faria, G. A., Maltoni, K. L., Rocha, P. S., Peixoto, A. P. B., Oliveira, T. A. de, Fonseca, A. D. da. and Felizardo, L. M. 2021. Classification of the coefficient of variation for experiments with *Eucalyptus* seedlings in greenhouse. *Rev. Ciênc. Agron.*, **52**(4). doi: 10.5935/1806-6690.20210050
- Lichtenthaler, H. K. 1987. Chlorophylls and carotenoids: Pigments of photosynthetic biomembranes. In *Methods in Enzymology*. L Packer and R Douce (ed). Academic Press. pp. 350–382. doi: 10.1016/0076-6879(87)48036-1
- Mehriardestani, M., Aliahmadi, A., Toliati, T. and Rahimi, R. 2017. Medicinal plants and their isolated compounds showing anti-*Trichomonas vaginalis* activity. *Biomed. Pharmacother.*, **88**: 885–893. doi: 10.1016/j.biopha.2017.01.149
- Pavani, N. A., Naik, M. R., Nagaraju, R., Rao, G. S., Padmaja, V. V. and Srinivasulu, B. B. 2020. Response of ornamental plants, study sites and their interaction to various pollutants in respect of APTI, API, physiological and biochemical attributes. *Int. J. Curr. Microbiol. Appl. Sci.*, **9**(12): 37–49. doi: 10.20546/ijcmas.2020.912.007
- Rahman, A. H. M. M. and Akter, M. 2013. Taxonomy and medicinal uses of Euphorbiaceae (Spurge) family of Rajshahi, Bangladesh. *Res. Plant Sci.*, **1**(3): 74–80. doi: 10.12691/plant-1-3-5
- Sadia, H. T. and Ashrafuzzaman, M. 2025. Documenting conservation status and medicinal potential of selected non-edible fruit-bearing plants in the Bangladesh Agricultural University Botanical Garden. *Int. J. Minor Fruits Med. Aroma Plants*, **11**(1): 15–28. doi: 10.53552/ijmfmap.11.1.2025.15-28
- Sumi, M. J., Serity, S. A., Roy, S. A., Akter, T. K. R., Rasul, S., Jaman, M., Abdullah, M. and Uddin, N. 2025. Nutrition and antioxidant potential of three cauliflower (*Brassica oleracea* L. var. *Botrytis*) cultivars cultivated in southern part of Bangladesh. *Turk. J. Agri. Food Sci. Technol.*, **13**(1): 158–168. doi: 10.24925/turjaf.v13i1.158-168.7065
- Sumi, M. J., Zaman, S. B., Imran, S., Sarker, P., Rhaman, M. S., Gaber, A., Skalicky, M., Moulick, D. and Hossain, A. 2024. An investigation of the pigments, antioxidants and free radical scavenging potential of twenty medicinal weeds found in the southern part of Bangladesh. *PeerJ*, **12**: e17698. doi: 10.7717/peerj.17698
- Sun, T., Rao, S., Zhou, X. and Li, L. 2022. Plant carotenoids: Recent advances and future perspectives. *Mol. Hortic.*, **2**(1). doi: 10.1186/s43897-022-00023-2
- Tanaka, A. and Tanaka, R. 2019. The biochemistry, physiology, and evolution of the chlorophyll cycle. In: *Advances in Botanical Research*. B. Grimm (ed). Academic Press, UK, pp. 183–212. doi: 10.1016/bs.abr.2019.03.005
- Tran, N., Tran, M., Truong, H. and Le, L. 2020. Spray-drying microencapsulation of high concentration of bioactive compounds fragments from *Euphorbia hirta* L. extract and their effect on diabetes mellitus. *Foods*, **9**(7): 881. doi: 10.3390/foods9070881

- Uddin, M. N., Rahman, M. O. and Rahman, M. 2018. New records of three species and a genus of the Euphorbiaceae for Bangladesh. *Bangladesh J. Plant Taxon.*, **25**(1): 93–99. doi: 10.3329/bjpt.v25i1.37185
- Vakte, S. R. and Nehete, J. Y. 2025. Phytochemical and antioxidant studies on dried leaves of *Crotalaria gajureliana* Gholave, Madhav & Gosavi. *Int. J. Minor Fruits Med. Aroma Plants*, **11**(1): 196–203. doi: 10.53552/ijmfmap.11.1.2025.196-203
- Vidhya, R., Sankareswari, M., Malliga, P., Selvi, B. and Neyvasagam, K. 2017. Effect of UV screening nature of *Cu-TiO₂* thin films on the protection of chlorophyll content in medicinal plants. *J. Nano. Adv. Mat.*, **5**(2): 75. doi: 10.12785/jnam/050205
- Zengin, G., Mahomoodally, M. F., Sinan, K. I., Ak, G., Etienne, O. K., Sharmeen, J. B., Brunetti, L., Leone, S., Di Simone, S. C., Recinella, L., Chiavaroli, A., Menghini, L., Orlando, G., Jekó, J., Cziáky, Z. and Ferrante, C. 2021. Chemical composition and biological properties of two *Jatropha* species: Different parts and different extraction methods. *Antioxidants*, **10**(5): 792. doi: 10.3390/antiox10050792

Table 1: Phytochemical profiling of five plant species belonging to family Euphorbiaceae.

Plant Species	Chl a (mg g ⁻¹ FW)	Chl b (mg g ⁻¹ FW)	TChl (mg g ⁻¹ FW)	CRTN (mg g ⁻¹ FW)	TPC (mg GAE g ⁻¹ DW)	TFC (mg QUE g ⁻¹ DW)	TAC (mg AAE g ⁻¹ FW)
<i>E. hirta</i>	0.77 ± 0.09 c	0.69 ± 0.07 b	1.46 ± 0.16 c	1.65 ± 0.06 c	13.13 ± 0.28 b	25.08 ± 0.18 a	3.18 ± 0.11 c
<i>A. indica</i>	2.42 ± 0.08 a	1.64 ± 0.09 a	4.06 ± 0.17 a	4.13 ± 0.21 a	17.01 ± 0.19 a	14.63 ± 0.27 c	3.69 ± 0.09 c
<i>J. gossypifolia</i>	1.27 ± 0.11 b	1.42 ± 0.07 a	2.69 ± 0.18 b	2.63 ± 0.13 b	13.19 ± 0.31 b	23.79 ± 0.19 ab	7.31 ± 0.13 a
<i>J. curcas</i>	1.01 ± 0.13 b	0.58 ± 0.03 b	1.59 ± 0.16 c	1.66 ± 0.16 c	13.63 ± 0.22 b	15.84 ± 0.17 bc	6.70 ± 0.16 ab
<i>A. hispida</i>	0.68 ± 0.05 c	0.76 ± 0.09 b	1.44 ± 0.14 c	0.94 ± 0.11 d	13.22 ± 0.14 b	17.83 ± 0.29 b	5.45 ± 0.09 b

Mean values bearing the dissimilar letter within the column differ significantly, and having similar letters do not differ significantly.

Chl a: chlorophyll a, Chl b: chlorophyll b, TChl: total chlorophyll, CRTN: total carotenoids, TPC: total phenolic compounds, TFC: total flavonoid contents, and TAC: total antioxidant capacity.

Table 2: Analysis of Variance (ANOVA) for phytochemical constituents in five different plant species of Euphorbiaceae family.

Sources of variations	df	Mean sum of squares (MSS)						
		Chl a	Chl b	TChl	CRTN	TPC	TFC	TAC
Species	4	0.004	0.686	3.89	20.51	8.39	66.96	9.85
Errors	8	0.003	0.017	0.019	0.012	0.008	0.046	0.015
<i>F-value</i>		525.34	41.72	201.13	1690.84	986.91	1447.91	633.98
CV (%)		4.33	12.63	6.19	4.98	10.84	11.74	9.87
Level of significance		***	***	***	***	***	***	***

*** significant at 0.1% level of probability,

df: degree of freedom, CV: coefficients of variation, Chl a: chlorophyll a, Chl b: chlorophyll b, TChl: total chlorophyll, CRTN: total carotenoids, TPC: total phenolic compounds, TFC: total flavonoid contents, and TAC: total antioxidant capacity.

Table 3: Principal component analysis of phytochemical contents of five plant species of family Euphorbiaceae.

Principal components (PCs)	Eigen values	Contribution to total variation (%)	Cumulative contribution to total variation (%)
PC1	4.85	69.31	69.31
PC2	1.048	14.98	84.29
PC3	1.019	14.57	98.86
PC4	0.079	1.14	100

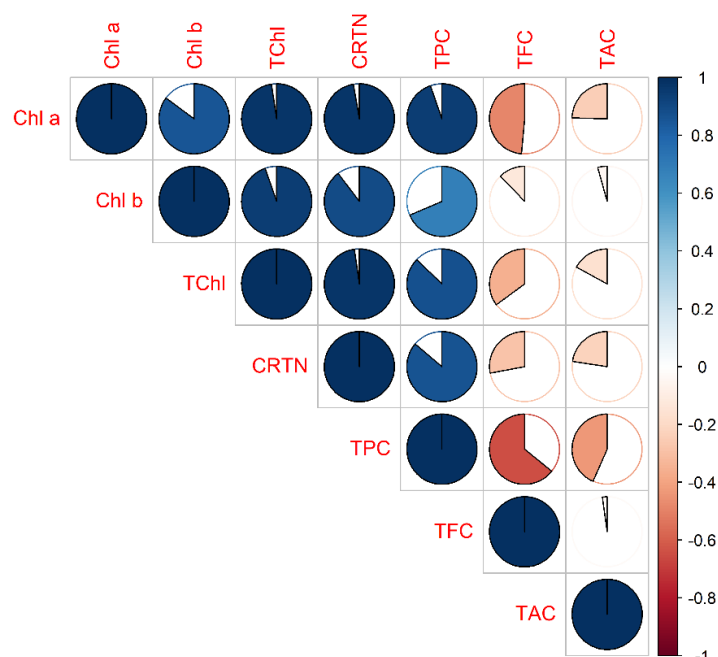


Figure 1: Relationship between the phytochemicals presented in the selected plant species. The extent of relationships was illustrated by the color gradient on Pearson's correlation scale, from -1 (deep red) to 1 (deep blue).

Chl a: chlorophyll a, Chl b: chlorophyll b, TChl: total chlorophyll, CRTN: total carotenoids, TPC: total phenolic compounds, TFC: total flavonoid contents, and TAC: total antioxidant capacity.

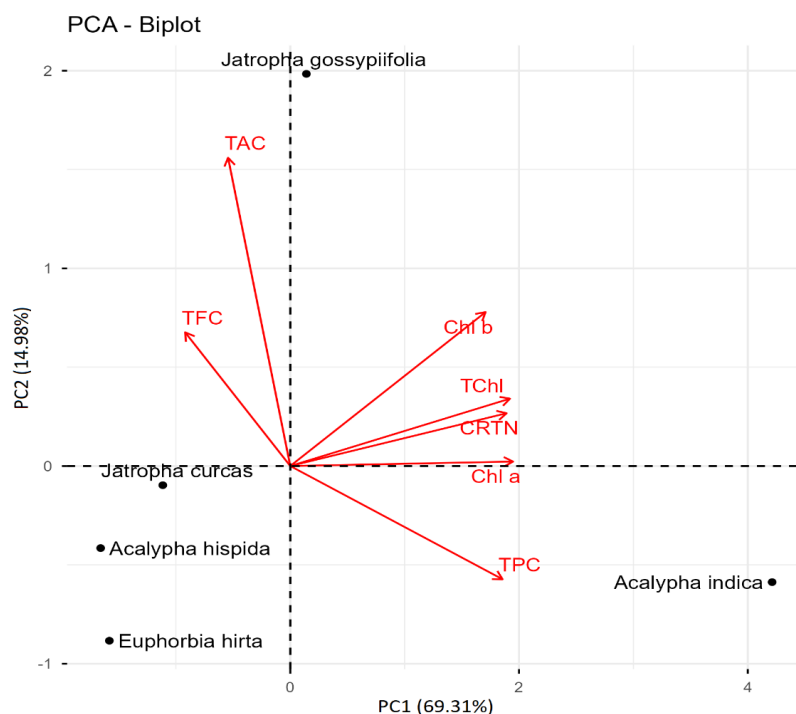


Figure 2: PCA-biplot illustrates the phytochemical profiling and classification of the selected plant species.

Chl a: chlorophyll a, Chl b: chlorophyll b, TChl: total chlorophyll, CRTN: total carotenoids, TPC: total phenolic compounds, TFC: total flavonoid contents, and TAC: total antioxidant capacity.

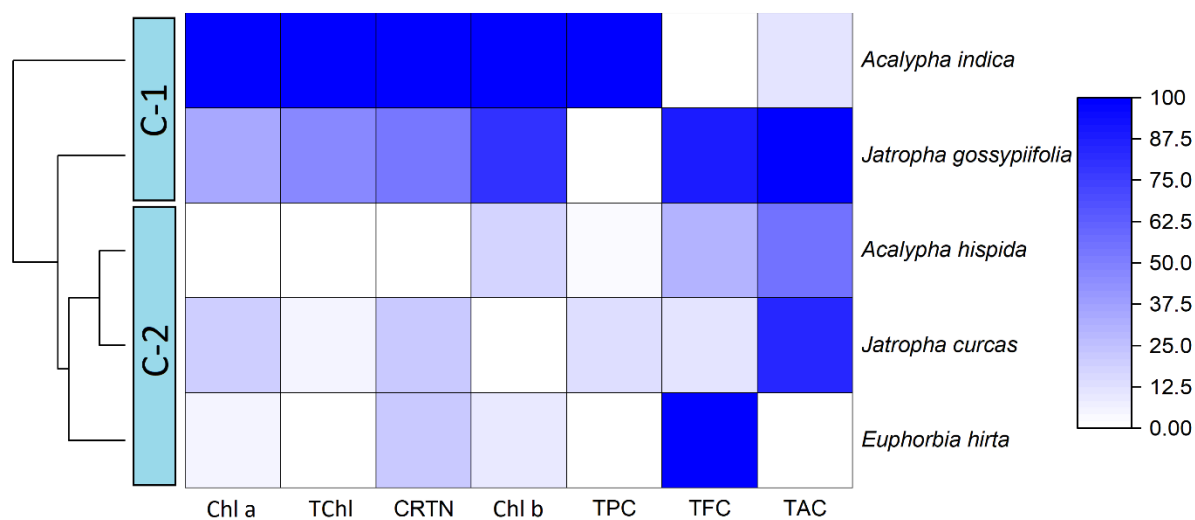


Figure 3: Hierarchical clustering heatmap represented the classification of species by phytochemicals. The mean phytochemical concentrations were normalized to the range 0 (white) to 100 (dark blue).

Chl a: chlorophyll a, Chl b: chlorophyll b, TChl: total chlorophyll, CRTN: total carotenoids, TPC: total phenolic compounds, TFC: total flavonoid contents, and TAC: total antioxidant capacity.