



RESEARCH ARTICLE

Survey of the beneficial flowers available in Coimbatore District, Tamil Nadu, India

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ARTICLE HISTORY

Received: 02 November 2023

Accepted: 26 November 2023

Available online

Version 1.0 : 27 December 2023

Version 2.0 : 14 January 2024



Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

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CITE THIS ARTICLE

Muthukumaran M, Parveen M, Vetri Velavan S. Survey of the beneficial flowers available in Coimbatore District, Tamil Nadu, India. Plant Science Today. 2024; 11(1): 366–376. <https://doi.org/10.14719/pst.3068>

Abstract

The flora of an area is considered a vital part of the environment, regulating the prosperity of the biosphere and people's health. It is highly suggested that the proper utilization of plant resources in each part of a country has been useful in conserving the availability and productivity of the flora. The present investigation aimed to evaluate the survey of the beneficial flowers available in Coimbatore District, Tamil Nadu, India, from December 2019 to February 2020. The survey studies were divided into four different zones in Coimbatore District: Perur, Ganapathy, Thudiyalur, and Periyanaickenpalayam, respectively. The survey resulted in the collection of 40 plant species belonging to 38 genera, dispersed over 25 families of flowering plants / angiosperms. The dominant families were Apocynaceae and Oleaceae when compared to other families. This study reveals that species such as *Calotropis gigantean*, *Chrysanthemum morifolium*, *Couroupita guianensis*, *Nerium oleander*, *Nyctanthes arbor-tristis*, *Nelumbo nucifera*, and *Tabernaemontana divaricata* were used as ritual flowers. The beneficial flowers showed a maximum for ornamental flowers (43 percent), followed by ritual flowers (35 percent), medicinal flowers (15 percent), and cooking flowers (7 percent), respectively. The highest blooming of the flowers (14.89 percent) occurred in March, and the lowest in November and December. Flowers were documented as having economic value, with the highest rate in *Rosa* sp., and *Jasminum* sp., which were used as ornamental, medicinal, and cosmetic preparations as valuable resources. Scientific key information on taxonomy and technical approaches to beneficial flowers was analyzed. Flowers play a vital role in human life from birth to death and are used in all auspicious events in India, especially in daily prayers in temples and Indian households.

Keywords

Beneficial flowers; Coimbatore District; *Jasminum* sp.; *Rosa* sp.; Tamil Nadu; survey

Introduction

The documentation of flora in rural regions is considerably lower than the specifications of flora in specific areas, such as hills, reserve forests, green patches, groups of plants, and genera of particular families (1). Floral establishments are encouraged to foster environmental growth in agriculture through the provision of biota services (2). The major objective of the year-round analysis was to identify the patterns of postharvest responses to the profitable holding of floral preservatives and hydration with 43 cultivars of

24 genera (3). Therefore, people grow flowers around their houses, bestowing portions of their living galaxy as flower gardens. The flower extracts from plants showed better antioxidant potential (4) and antibacterial activity (5). Current advances in molecular biology and biotechnology have made it possible to scan biodiversity for molecules with potentially profitable applications. Difficulties and prospects connected with the bio-prospection of floristic diversity are deliberated (6). The natural environment is increasingly recognized for its positive effect on maintaining good psychological health. The flower color has been one area that has attracted attention as a potential enhancement in the restorative characteristics of a selected landscape (7). Worldwide, consumers demand more from their food, and adding edible flowers may enhance the appearance of certain dishes (8).

Floriculture is a branch of horticulture that involves the cultivation of flowering and/or ornamental plants for forestry and gardens, including the floral industry (9). In the present condition of the world, floriculture research reflects a model shift from traditional approaches to current technologies (10). Floriculture nowadays plays a major vital role in the economy of an area by commercializing flowers and also contributes to the economic status of the nation (11). It is a significant employer and earner of foreign exchange for several regions (12). The consumption of flowers as food is described in various cultures throughout the globe as part of traditional cooking and/or alternate medicine, including their use of ornaments (13).

The economy is the basis for the development of a nation. Flowers have provided luxury to humans for epochs (14). These flowers are part of the growing economy of various states in India. The flowers have been commercialized and sold in markets across different regions of India. Jasmine gardening has provided profitable income to flower cultivators. The cultivators employ less cost for cultivation and earn more income from jasmine farming (15). Nationwide, flower marketing has experienced vigorous growth, leading to the improved status of India's economy. Among the states, Tamil Nadu has been a leader in the development of floriculture, covering about 14,194 hectares of land for flower cultivation. Many flowers, like *Leucas aspera*, have valuable phytochemicals and high medicinal properties (16). Edible flowers are part of the diverse approach for market gardeners, specifically organic growers (17). Better financial benefits for the farmers result from cultivating flowering plants from agricultural sources, which is an important flower business in India (18).

The flowers possess medicinal properties due to the presence of beneficial phytochemicals in them (4). Since the origin of human life, plants have served humanity as a source of food, clothing, medicine, shelter, dye, and fuel. Some flowers exhibit antimicrobial and natural metabolic activities, attributed to their rich biochemical content (19). Ayurveda systematically documents the natural healing power of Pitta, Kapha Vata, etc., and flower-based preparations were used to treat many diseases in Ayurveda treatment (20). Consuming edible flowers, which are harm-

less and non-toxic, contributes to health benefits as part of the human diet (21). Lycopene extracted from edible flower parts has been used as an alternative medicine in India for treating diseases (22). Similarly, phenolic bioactive compounds extracted and characterized from the flowers of *Rosa micrantha*, *Castanea sativa*, and *Filipendula ulmaria* have demonstrated notable antifungal activities (23). The effects of *Bauhinia variegata* flower extracts on providing a hepatoprotective effect in liver injury have also been studied (24).

Flowers have been a luxury in human life for several epochs (14). Flowers are used in the "daily life" of humankind as decorations in festival rooms and for important ceremonies, as well as for personal cleanliness and beautification in religious and funeral rituals. Edible flowers have been part of traditional cooking and phytotherapy for several centuries. The consumption of edible flowers and their phytochemicals has increased considerably, and they are known to have many health benefits (25). Ornamental plants play a major and vital role in the festivals, contributing to emotional well-being and serving as a symbol of non-violent philosophy (26). Edible flowers represent rich sources of both food and pharmaceutical resources (27,28).

Many flowers have been traditionally claimed to be useful for medicinal and other purposes. Henceforth, the major objectives of the present investigations are: a) to survey and document the flowers available in Coimbatore; b) to find out the beneficial features of the flowers; c) to list out their medicinal and economic value; and d) to create awareness about the benefits of those flowers.

Materials and Methods

Study Area

Coimbatore is the main city in Tamil Nadu, India. It is also known as Koyamuthur or Kovai. It is situated on the banks of the Noyyal River, bounded by the Western Ghats. Coimbatore is situated at a latitude of 11°1'6"N and a longitude of 76°58'21"E. It has an elevation of 411 m (1,348 ft). The development region of the city borders was 105.6 sq. km. The annual rainfall throughout the year is 616.7 mm. A project plan was framed on the theme of beneficial and ornamental flowers available in Coimbatore. The local community was an important part of this study. The Coimbatore district was divided into four zones: i) Perur, ii) Ganapathy, iii) Thudiyur, and iv) Periyanaickenpalayam, and various flowers were identified with the help of the local people residing in the particular regions and confirmed through the available resources. A map of the study area of beneficial flowers available in Coimbatore District, Tamil Nadu, India, is shown in Fig 1.

Methods of data collection

The present investigation was undertaken to document the literary study of the beneficial flowers of the Coimbatore district. Before commencing fieldwork, preliminary information about the geographical area of study, its physiological features, climatic seasons, etc., was collect-

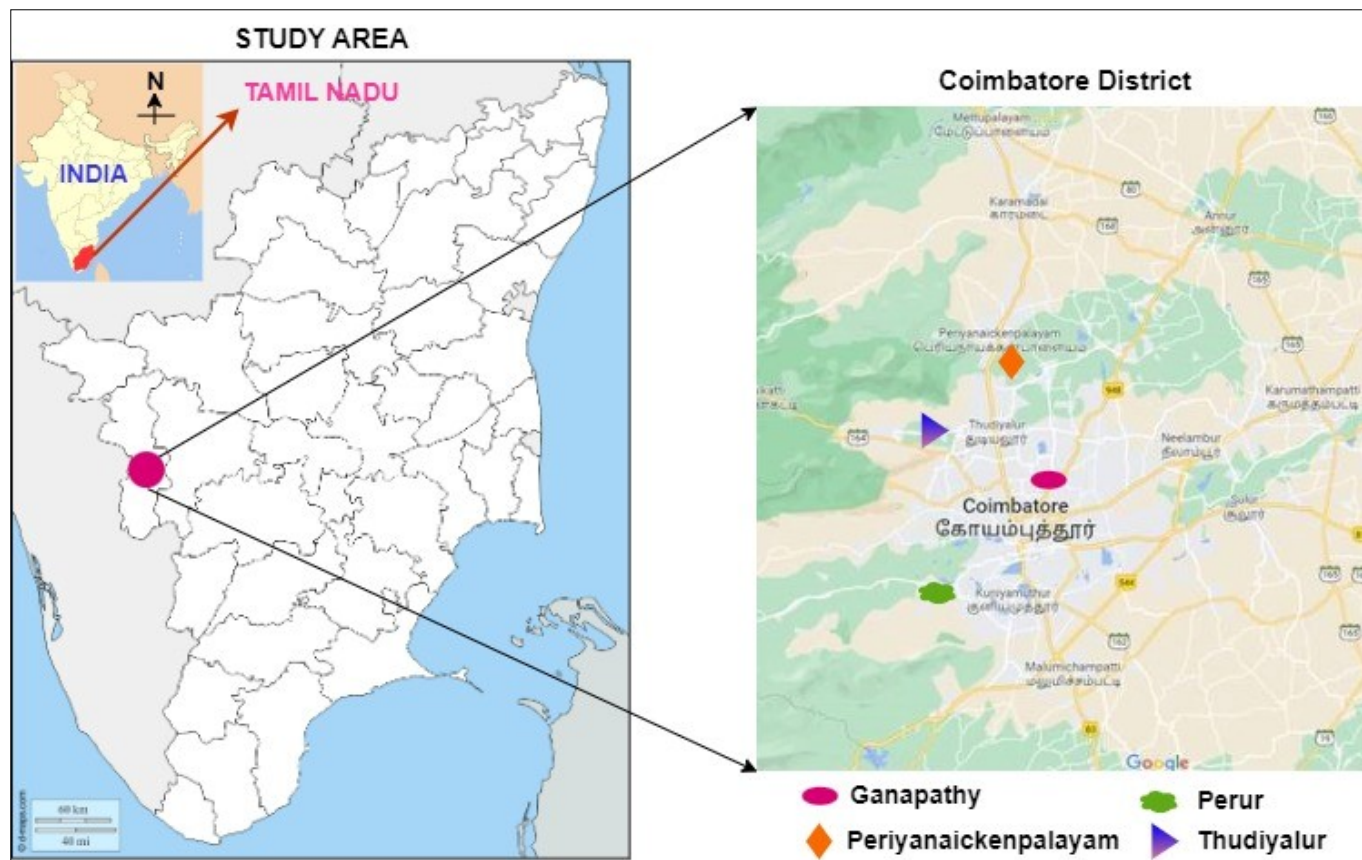


Fig. 1. Map of the study area of beneficial flowers available in Coimbatore District, Tamil Nadu, India

ed. During this course of investigation, several periodical field trips were conducted from December 2019 to February 2020. At each visit, different zones were selected in different flowering seasons to collect more information. Repeated interviews through questionnaires were conducted in different areas of the people in the Coimbatore district to authenticate the information. Personal interviews were used to acquire evidence of flowers with their vernacular names, ornamental benefits, medicinal and economic values, and flowering seasons.

Identification of plant flowers

Informers were invited to the collection field to demonstrate plants with vernacular names. Taxonomic identification of the mentioned plant species was carried out using voucher specimens, referring to established botanical resources such as the Flora of Madras Presidency (29–31), Flora of India (32), and various accessible sources, including the World Wide Web (WWW), along with the expertise of taxonomists.

Results

Survey of the beneficial flowers available in the Coimbatore District, Tamil Nadu

A survey of the beneficial flowers available in the Coimbatore District of Tamil Nadu, India, was investigated. The results revealed the identification of 40 plant species belonging to 38 genera, distributed across 25 families of flowering plants/angiosperms, including herbs, shrubs, climbers, hydrophytes, and trees. It was analyzed that the dominant families include Apocynaceae (20 percent), Oleaceae (16 percent), Acanthaceae (12 percent), Amaranthaceae, Asteraceae, Ceaselpinaceae, Fabaceae, Malvaceae, and Nyctaginaceae (8 percent), with other families constituting 4 percent each. The findings highlighted Apocynaceae and Oleaceae as the dominant families when compared to others. The results are tabulated in Table 1. Figs. 2 and 3 depict the distribution.

Table 1: Survey of the beneficial flowers available in Coimbatore district, Tamil Nadu, India

S.No	Scientific Name	Family of Plant	Local Name	Season of Flowering	Medicinal Uses
1	<i>Andrographis paniculata</i> (Burm.f.) Nees	Acanthaceae	Siriyangai	October to December	Anticancer, antidiabetic, prevent leprosy, dysentery, malaria, skin diseases, and ulcers.
2	<i>Artabotrys hexapetalus</i> (L.F.) Bandari	Anonaceae	Manorangitham	Throughout the year	Herbal tonic and stimulant.
3	<i>Barleria cristata</i> L.	Acanthaceae	December poo	September to December	Heals burns, edema, wounds, dental carries, gingivitis, and cracked heels.
4	<i>Bougainvillea glabra</i> Choisy	Nyctaginaceae	Kagitha poo	Throughout the year	Control diabetes, diarrhea, cough, and sore throat and reduces stomach acidity.

5	<i>Calotropis gigantea</i> L.	Apocynaceae	Erukku	March to May	Heals skin, elephantiasis, control nausea, vomiting and diarrhea.
6	<i>Canna indica</i> L.	Cannaceae	Kalvazhai	August to October	Demulcent, diaphoretic, diuretic. Used to treat women's ailments .
7	<i>Catharanthus roseus</i> L.	Apocynaceae	Nithyakalyani	January to August	Anti-cancer, anti-microbial, antidiabetic and wound healer.
8	<i>Cassia fistula</i> L.	Cesalpiniaceae	Konrai	March	Suppress inflammation. Used to treat skin disease, liver problems and , diabetes
9	<i>Celosia argentea</i> L.	Amaranthaceae	Kozhikondai	Annual plant	Used to treat constipation, hemorrhoid bleeding, uterine bleeding, and diarrhea.
10	<i>Chrysanthemum morifolium</i> (Ramat.) Hemsl	Asteraceae	Samanthi	March to October	Used to cure chest pain, diabetes, fever, cold, headache, dizziness and swelling.
11	<i>Clitoria ternatea</i> L.	Fabaceae	Sangu poo	January to March	Protects skin against premature aging, and improves eyesight.
12	<i>Courouputa guianensis</i> Aubl.	Lecythidaceae	Nagalingam	Throughout the year	Used to cure hypertension, neural pain, and inflammatory reactions.
13	<i>Crossandra infundibuliformis</i> (L.) Nees	Acanthaceae	Kanagambaram	March to May	Used to treat fever, headache, , and pain.
14	<i>Datura metel</i> L.	Solanaceae	Oomathai	June to July	Helps to clear endoparasites (worms) , suppress toothache, and inflammation.
15	<i>Epiphyllum oxypetalum</i> (DC.) Haworth	Cactaceae	Nishagandhi	January to March	Used to treat urinary infections, spasmodic pain, and hemorrhage.
16	<i>Gomphrena globosa</i> L.	Amaranthaceae	Vadamalli	March to May	Flowers are boiled to make tea which is used for baby gripe, cough, and diabetes.
17	<i>Hibiscus rosasinensis</i> L.	Malvaceae	Sembaruthi	Seasonal bloomer	Controls pitta disease, treats pimples, and bleeding gums, good for the heart.
18	<i>Ixora coccinea</i> L.	Rubiaceae	Idli poo	March to May	Used as an astringent, cures dysentery, tuberculosis, fever, and headache.
19	<i>Jasminum sambac</i> L.	Oleaceae	Gundumalli	March to May	Anti-depressant, anti-septic, sedative. Used to remove intestinal worms, it cures jaundice.
20	<i>Jasminum auriculatum</i> Vahl	Oleaceae	Utchi malli (or) Mullai	9 months /year	Cures burning micturition, wounds, diseases of the oral cavity, headaches and poison cases.
21	<i>Jasminum grandiflorum</i> L.	Oleaceae	Jaathimalli	July to October, May to December	The wound heals, ulcers, headaches, skin, and eye diseases.
22	<i>Lilium candidum</i> L.	Liliaceae	Alli	May to September	Cures skin ulcers, inflammation, rashes, burns, eye irritation, and wounds.
23	<i>Lantana camara</i> L.	Verbenaceae	Unni poo	January to March	It cures cancer, leprosy, chicken pox, asthma, skin itches, rabies, ulcers, and measles.
24	<i>Leucas aspera</i> (Willd.) Link	Lamiaceae	Thumbai	September to February	Anti-fungal, anti-oxidant, anti-microbial, used for scorpion bites and fever.
25	<i>Magnolia champaca</i> L.	Magnoliaceae	Chenbagam	June to September	Treats diabetes, wound, cardiac problems, and gout.
26	<i>Millingtonia hortensis</i> L.f.	Bigoniaceae	Maramalli	January to March	Used to treat asthma, sinusitis, cholagogue.
27	<i>Mirabilis jalapa</i> L.	Nyctaginaceae	Anthi mantharai	January to March	Used to cure inflammation, wounds, gonorrhea, dysentery, and diarrhea.
28	<i>Moringa oleifera</i> Lam.	Moringaceae	Murungai	March to August	Helps to cure edema, cancer, stomach complaints.
29	<i>Musa paradisiaca</i> L.	Musaceae	Vazhai	Throughout the year	Cures ulcer, dysentery, bronchitis, and cooked flowers are good for diabetes.
30	<i>Nelumbo nucifera</i> Gaertn.	Nelumbonaceae	Thamarai	July to August	Used to recover acne, insomnia, uterus problems, and low sperm count.
31	<i>Nerium oleander</i> L.	Apocynaceae	Arali	March to May, November to January	Cures cardio disorders, asthma, epilepsy, cancer, leprosy, malaria, and indigestion.

32	<i>Nyctanthes arbortristis</i> L.	Oleaceae	Pavizhamalli	February to June	It cures fever, enlargement of the spleen, malaria, blood dysentery, cough and gastritis.
33	<i>Plumeria rubra</i> L.	Apocyanaceae	Perunkalli	January to March	Anti-inflammatory, anti-oxidant, anti-microbial, treats toothache.
34	<i>Rosa damascena</i> Mill.	Rosaceae	Paneer rose	May to June	Cures abdominal disorders, and chest pain, strengthens the heart and digestive problems.
35	<i>Senna auriculata</i> L.	Caesalpinaceae	Aavaram	March	Used to cure diabetes, eye infections, jaundice, constipation
36	<i>Sesbania grandiflora</i> L.	Fabaceae	Agaththi	March to August	Helps in weight loss treats abdominal tumors and improves memory.
37	<i>Tagetes erecta</i> L.	Asteraceae	Samanthi	April, May	Used as a diuretic, sedative and stomachic properties. Heals indigestion and fever.
38	<i>Tabernaemontana divaricate</i> L.	Apocynaceae	Nanthiyavattam	January to April	Anti-oxidant, anti-tumor, anti-infection and analgesic.
39	<i>Thespesia populnea</i> (L.) Sol.	Malvaceae	Poovarasam	February to March	Heals skin diseases, dysentery, and swollen joints.
40	<i>Tribulus terrestris</i> L.	Zygophyllaceae	Nerunchi	April to October	To recover cough, piles, Cardiac disorder, urinary infection, and dysuria.





Fig. 2. Survey of the beneficial flowers available in Coimbatore District, Tamil Nadu, India

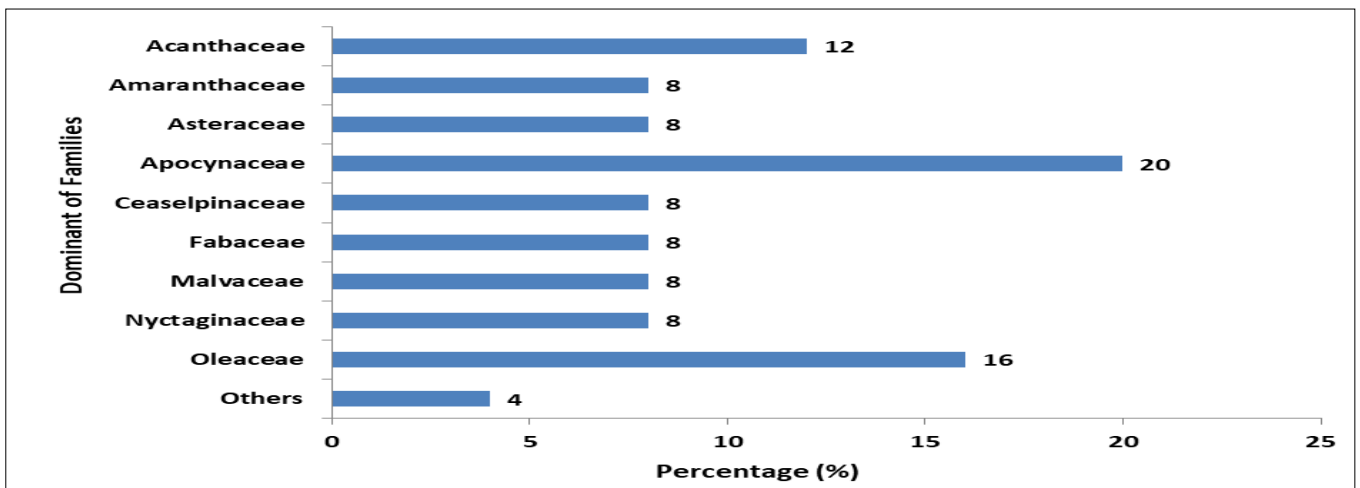


Fig. 3. Dominant families of the beneficial flowers available in Coimbatore District

Habits of the beneficial flowers

The growth habit of beneficial flowers in plants was documented across 40 species, belonging to 38 genera, and dispersed over 25 families of flowering plants. The findings indicated that 35 percent of the species were trees, 30 percent were shrubs, 27 percent were herbs, 5 percent were hydrophytes, and 3 percent were climbers. These results are visually presented in Fig. 4.

Seasonal blooming of the beneficial flowers

The seasonal blooming of the beneficial flowers, which was documented in 40 species, which belong to 38 genera,

dispersed over 25 families of flowering plants from December 2019 to February 2020 in Coimbatore District, Tamil Nadu, India. The findings revealed that the peak of floral blooming transpired in March at 14.89 percent, followed by February at 8.51 percent, May at 10.63 percent, April at 9.92 percent, and January at 7.80 percent. Conversely, the lowest occurrences were noted in December and November, each at 3.54 percent. The overall annual distribution indicated that March had the highest percentage of blooming flowers, while November and December exhibited the lowest. The results are shown in Fig. 5.

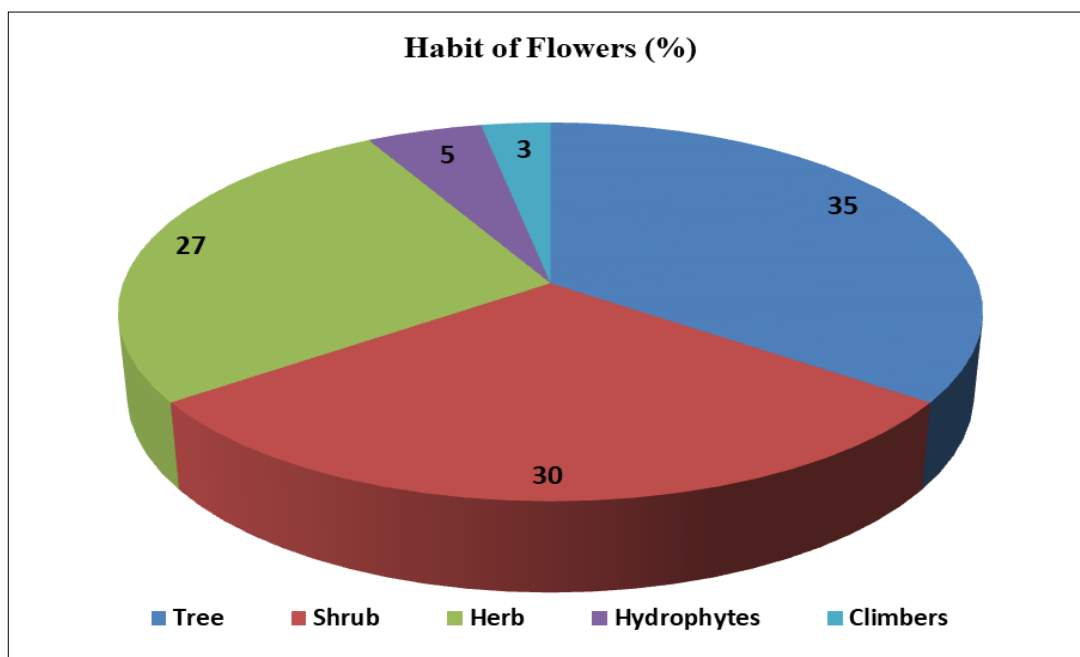


Fig. 4. Habit of the beneficial flowers available in Coimbatore District

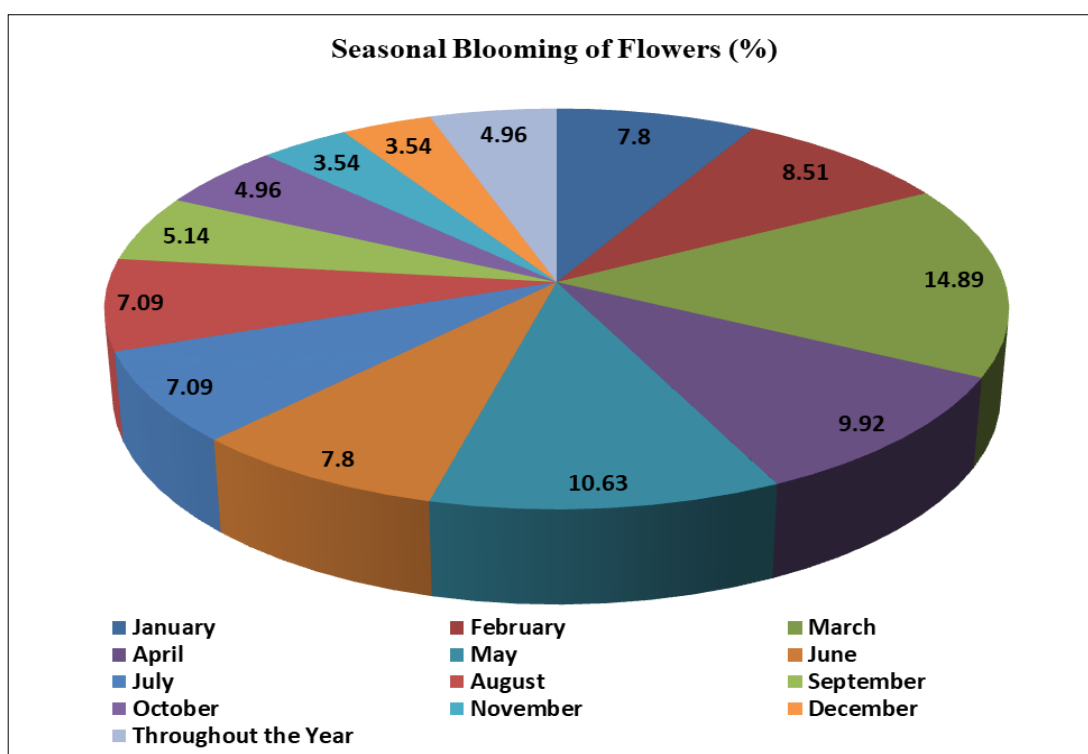


Fig. 5. Seasonal blooming of the beneficial flowers available in Coimbatore District

The beneficial value of the flowers

The beneficial value of the flowers was reported for 40 plant species, which belong to 38 genera and are dispersed across 25 families of flowering plants in the Coimbatore District, Tamil Nadu, India. The findings indicated that ornamental flowers constituted 43 percent of the total, followed by ritual flowers at 35 percent, medicinal flowers at 15 percent, and cooking flowers at 7 percent. The results are shown in Fig. 6.

Cost of the ornamental flowers

The findings of the present study revealed that the cost of ornamental flowers (Rs/kg) was distributed as follows: 0 – 100 at 8 percent, 100 – 200 at 16 percent, 200 – 300 at 17 percent, 300 – 400 at 17 percent, and above 500 at 25 percent. Notably, *Rosa* sp. and *Jasminum* sp. emerged as the flowers with the highest economic value, serving as valuable resources in ornamental, medicinal, and cosmetic preparations. The detailed results can be observed in Fig. 7.

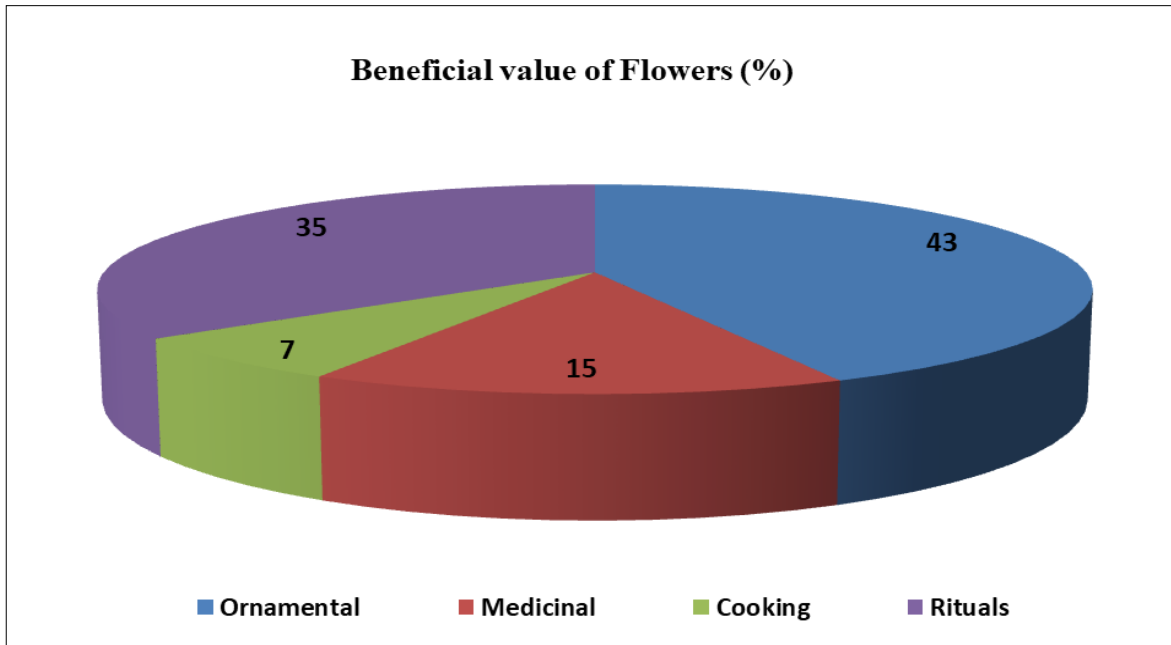


Fig. 6. Beneficial value of the flowers available in Coimbatore District

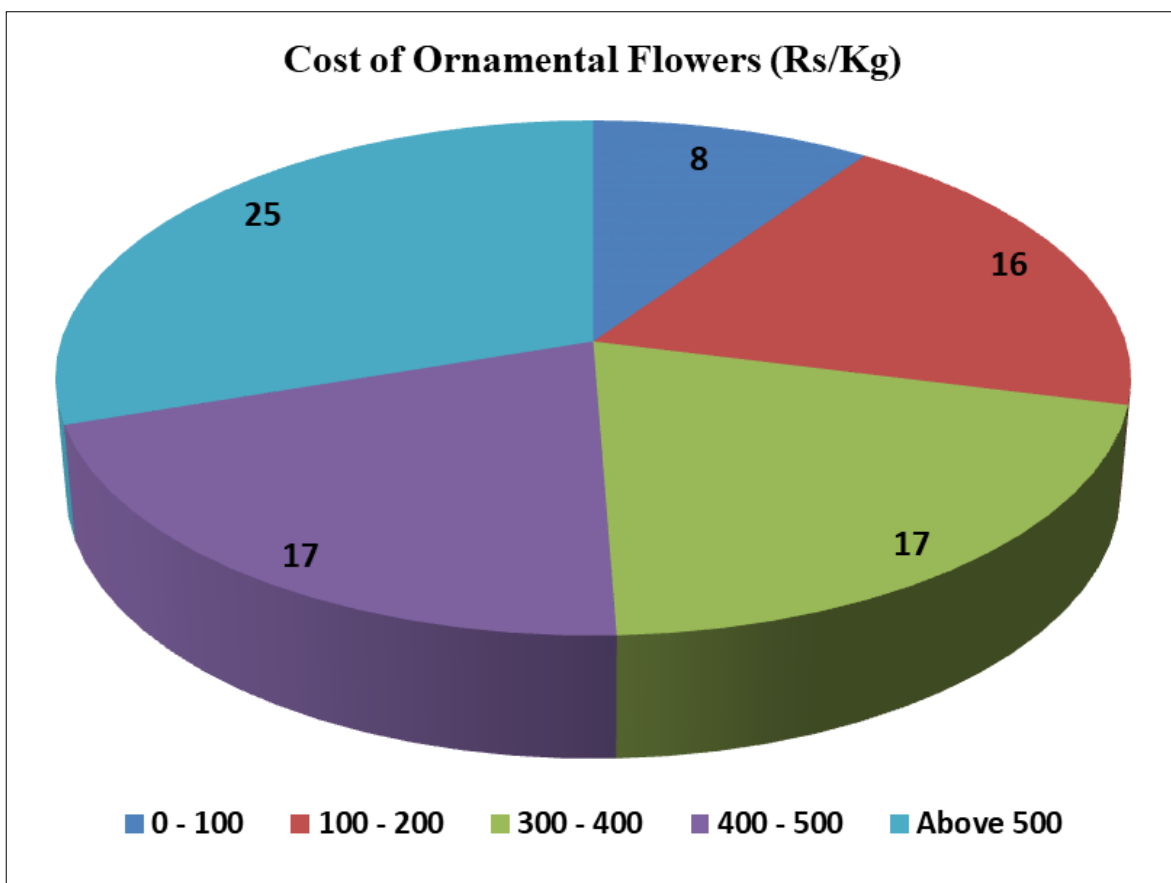


Fig. 7. Cost of the ornamental beneficial flowers available in Coimbatore District

Discussion

Nature is the place for having several plants with diverse medicinal properties. Medicinal plants have been used as an alternate source of healing drug with the use of their plant parts. Many plants are used for herbal drugs preparation as an indigenous method of medicine. Traditional healers have been using local herbal plants for many medicinal purposes with their original knowledge (33). The fragrance of the flowers awakens our senses, especially relaxation, harmony, love, and calmness. The flowers are grown for social function, extracting essential oils, and the aesthetic and industrial production of perfumes. An essential oil of the flowers is extracted by effleurage, which is enthusiastically used for the production of jasmine alters in India. Conservation of the ornamental flowering plants is also one of the alternative schemes to preserve their diversity (34). The entire part of the plant, *Syzygium cumini*, has been extensively used in the treatment of many diseases in folk and traditional medicine (35). *Leucas aspera*, which belongs to the Lamiaceae commonly known as "Thumbai" is one such medicinal plant flower that is also being used traditionally as an insecticide and anti-pyretic control (36). The survey of the plant's diversity is a very important movement to assess the existing flora. The documentation of the flora diversity in the rural area of Udumalpet Taluk in Tiruppur District, Tamil Nadu, from December 2017 to December 2018 was investigated. The results showed that a total of 370 taxa, which belong to 263 genera, and 82 families of angiosperms have been reported (1).

Crossandra infundibuliformis, in the family Acanthaceae, is a popular tropical flower known as "fire racker". Due to its high medicinal value, various parts of this plant are used to treat many diseases (37). *Couroupita guianensis* is one of the largest evergreen tree plants with rich medicinal properties (38,39). *Lantana camara* significantly controls diabetic rates by reducing blood glucose levels and exhibits anti-hyperglycemic activity against alloxan induced diabetic rates (40). Assessing the stability of flowering herbs as food sources with nutritional and medicinal value is crucial (41). *Zantedeschia aethiopia* is an important ornamental plant used in floral arrangements, garden landscapes, and for its medicinal properties (42). The polyphenolic extracts of the edible flower *Sesbania gradiflora* were effectively tested against pathogenic antimicrobial activity (43). *Rinorea dentata* medicinal plant decoction was used for ethnomedicinal properties (44). The flower *Hosta plantaginea* is a famous folk medicine of Mongolian in China, demonstrating better therapeutic results for severe pharyngitis (45).

Edible flowers represent rich sources of both food and pharmaceutical resources (27,28). Some edible flowers, rich in anthocyanin, have been designated for their better bioactive properties, and are used for medicinal purposes (46). Specialized metabolites and antioxidant properties of edible flowers were analyzed in plant species such as *Calendula officinalis*, *Tagetes erecta*, *Tropaeolum majus*, *Cucurbita pepo*, and *Centaurea cyanus*, showing better medicinal properties (47). Valuable bioactive com-

pounds extracted from the flowers of *Antirrhinum majus* and *Viola wittrockiana* showed highly medicinal properties. Rich phenolic content, including flavones, quercetin, isorhamnetin glycosides, apigenin glycosides, and anthocyanins, was present in *V. wittrockiana*, with high bioactive compounds such as flavonol glycosides and anthocyanins in the flower of *A. majus*. The total carotenoid content was highest at 146 µg/mg and 29 µg/mg for *V. wittrockiana* and *A. Majus*, respectively, with lutein being the dominant (48). Edible flowers of Rose and Nasturtium are rich in phytochemicals commonly used for food and medicinal applications. These flower extracts effectively addressed simulated gastrointestinal digestion problems (49). Phenolic content and their bioactive compounds were estimated in hydromethanolic extracts of flowers such as *Calendula officinalis*, *Dahlia mignon*, *Rosa damascene*, *R. galoica*, and *R. canina*. Results showed that *Dahlia* and *Rose* had high phenolic profiles and better antimicrobial activities (50).

The primary aim of the present investigation was to document the flora of available flowers, comprising 40 species across 38 genera, dispersed over 25 families of flowering plants by herbs, shrubs, climbers, hydrophytes, and trees in Coimbatore District of Tamil Nadu, from December 2019 to February 2020. It was analyzed that the dominant families were the Apocynaceae and Oleaceae. This study highlights specific species such as *Calotropis gigantean*, *Chrysanthemum morifolium*, *Couroupita guianensis*, *Nerium oleander*, *Nyctanthes arbortristis*, *Nelumbo nucifera*, and *Tabernaemontana divaricata* which were used as ritual flowers. The flowers with the highest documented economic value were *Rosa* sp., and *Jasminum* sp., used for ornamental, medicinal, and cosmetic purposes. Beneficial flowers showed the highest prevalence in ornamental flowers at 43 percent, followed by ritual flowers at 35 percent, medicinal flowers at 15 percent, and cooking flowers at 7 percent. Seasonal blooming peaked at 14.89 percent in March, while the lowest recorded blooming of 3.54 percent was observed in November and December. For future studies, exploring the additional phytochemical and antimicrobial properties of the flowers is recommended. Some flowers demonstrated bactericidal and antimicrobial properties, suggesting potential use in herbal medicine. Therefore, further research could enhance the economical, medicinal, and nutritional value of these flowers. Flowers, with their whiff of purity and fresh breath, symbolize selflessness and diversification. They embody strength, liveliness, and generosity, becoming landmarks in individuals' lives from birth to death.

Conclusion

The present study aimed to assess the survey of useful flowers available in Coimbatore District, Tamil Nadu, India. The documentation of the flora of 40 species, belonging to 38 genera and dispersed over 25 families of angiosperms, was carried out. Among the recorded flowers, the Apocynaceae family was found to be dominant, and some flowers were used for medicinal and ritual purposes. The highest blooming of flowers occurred in March, while the low-

est was observed in November and December. The survey study revealed that beneficial flowers were used for most ornamental purposes in 43 percent, rituals in 35 percent, medicinal applications in 15 percent, and cooking in 7 percent, respectively. The flowers were documented for their economic value, with *Rosa* sp., and *Jasminum* sp., being utilized as ornamental, medicinal, and cosmetic preparations at a high rate. Scientific information on taxonomy and technical approaches to beneficial flowers was analyzed with the aim of establishing knowledge about useful flowers and promoting research on their role in human well-being.

For future studies, exploring the phytochemical properties, essential oil extracts, and nutritional values of the flowers is recommended. Some flowers exhibit antimicrobial properties, suggesting potential use in herbal medicine. Therefore, further research can enhance the economical, medicinal, and nutritional value of these flowers. Flowers play a vital role in human history, from birth to death. They have consistently held significance in Indian culture, carrying mythological importance.

Acknowledgements

The authors are profusely thankful to the Secretary, the Principal and PG and Research Department of Botany, Kongunadu Arts and Science College (Autonomous), Coimbatore and Ramakrishna Mission Vivekananda College (Autonomous), Chennai, Tamil Nadu, India for providing the necessary support and laboratory facilities to complete in this research work.

Authors contributions

MM Designed the experimentations, methodology, formal analysis, prepared the manuscript and editing. MP Planned the experiments, methodology, formal analysis, prepared the manuscript and editing. SV Conducted the experiments, devised methodology, data collection and provided the specimens. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

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