

From Garden to Table: *Viola* spp., Ornamental and Edible Flowers

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ABSTRACT

Objective: To provide a comprehensive review of the ornamental, cultural, nutraceutical, and food-related importance of the genus *Viola*, with an emphasis on the edible species *Viola cornuta* and *Viola × wittrockiana*.

Design/methodology/approach: An extensive review of recent scientific literature was conducted, focusing on the diversity, morphology, traditional uses, nutraceutical value, and production of two *Viola* species, highlighting their use as ornamental and edible flowers.

Results: The species *Viola cornuta* and *Viola × wittrockiana* display outstanding ornamental and nutritional attributes. Both are rich in relevant bioactive compounds such as flavonoids, anthocyanins, and carotenoids, which contribute to their nutraceutical and functional properties in gastronomy. Their demand as edible flowers has grown significantly, driven by consumer trends favoring differentiated, healthy, and value-added food products. This review describes their taxonomic diversity, morphological characteristics, phytochemical composition, nutraceutical potential, and the main challenges and prospects associated with their production and use in floriculture and the food industry.

Limitations of the study/implications: There remains a need to generate specific agronomic and food safety information for these species, particularly under Mexican production conditions, to ensure the quality and safety of flowers intended for human consumption.

Findings/conclusions: Edible *Viola* species represent a high value-added resource with great potential to diversify Mexican floriculture and the functional food market, provided that sustainable production systems are implemented and research on agronomic and food safety aspects is strengthened.

Keywords: Edible flowers, floriculture, phytochemicals, nutraceuticals.

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IMPORTANCE OF ORNAMENTAL AND EDIBLE PLANTS

Ornamental plants are defined as those cultivated for their aesthetic qualities, such as the beauty of their form and colors, their foliage, flowers, fruits, and, when present, their fragrance. They are widely used in gardening, landscaping, and interior design [1]. These plants provide multiple benefits to humans, including positive effects on emotional and physiological health, social dynamics, and economic development, through sensory, biochemical, and productive mechanisms [2]. Beyond their aesthetic value, ornamental plants play a significant role in environmental



improvement through various mechanisms: providing pollen for pollinating organisms, thermal regulation, oxygen production, modulation of rainfall patterns, mitigation of desertification, carbon capture, reduction of urban glare, control of water and soil erosion, buffering of climate impacts through windbreak barriers, and reduction of atmospheric, water, and noise pollution [3].

The use of ornamental plants is associated with a wide range of emotional and mental health benefits, including reduced anxiety and stress levels, improvement of attention deficit symptoms, positive visual responses to fractal patterns, decreased depressive symptoms, enhanced memory retention, increased happiness and life satisfaction, mitigation of post-traumatic stress disorder, stimulation of creativity, improved productivity and concentration, alleviation of dementia-related effects, and improved self-esteem [4]. Additionally, plants provide cognitive benefits that also influence quality of life. These include strengthening of place attachment and community belonging, reduction in crime rates, increased disaster resilience, access to locally produced food, promotion of socialization among children, improved academic performance, and therapeutic effects in community settings [5]. Ornamental flowers, in particular, act as cultural catalysts by promoting social cohesion, intergenerational learning, and the expression of human values, while reinforcing cultural identity, social health, and the connection with nature [6].

In terms of physiological well-being and its impact on quality of life, ornamental plants have demonstrated positive effects in multiple areas: improved sleep quality, increased birth weight, reduced diabetes incidence, alleviation of eye discomfort, strengthening of the immune system, regulation of circadian rhythm, improved rehabilitation processes, decreased cardiovascular and respiratory diseases, lower mortality rates, enhanced digestion, reduced allergies, increased physical activity, and cognitive development [4].

On the other hand, edible flowers (EFs) are specific floral structures that contain bioactive compounds with potential health benefits when consumed [7,8]. Since ancient times, these flowers have been used as food ingredients, flavoring agents, and decorative elements in culinary preparations, and they are currently experiencing a resurgence in contemporary gastronomy [9].

The growing interest in EFs is largely attributed to changing food consumption patterns, which are increasingly focused on selecting healthier nutritional options. In addition to their aesthetic and organoleptic contribution to various culinary preparations, EFs are now recognized for their nutritional value due to their content of bioactive compounds with multiple health benefits [10].

Floriphagy, defined as the practice of consuming flowers as food, represents an ancient cultural tradition in various regions that continues to grow in popularity today [11]. This practice has long been part of the food culture of Indigenous peoples in the Americas and other parts of the world, who have appreciated and consumed flowers since ancient times. Representative examples of this tradition include the consumption of *Cucurbita maxima* flowers in Mexico, *Calendula officinalis* in Europe, and *Jasminum officinale* in Asia [12].

The EFs from different species provide a wide variety of bioactive compounds that determine their organoleptic characteristics—such as flavor and aroma—and their potential nutritional benefits. These bioactive metabolites, including antioxidants,

vitamins, minerals, and various phytochemicals, confer not only sensory appeal but also nutritional value. Their incorporation into the diet can enhance the overall nutritional profile of food [13].

From a nutritional perspective, flowers can be divided into pollen, nectar, petals, and other parts. Pollen is a source of proteins and carbohydrates, saturated and unsaturated fatty acids, carotenoids, and flavonoids. Nectar contains a balanced mixture of sugars (fructose, glucose, and sucrose), along with free amino acids, proteins, inorganic ions, lipids, organic acids, phenolic compounds, alkaloids, and terpenoids, among others. Petals and other flower parts are rich in vitamins, minerals, and antioxidants [14].

THE GENUS *Viola*: DIVERSITY AND CHARACTERISTICS

The genus *Viola*

The family Violaceae is cosmopolitan and comprises 26 genera and approximately 1,100 species of trees, shrubs, lianas, and herbs [15]. The genus *Viola* is the largest within this family, with 664 species, divided into two subgenera, 31 sections, and 20 subsections [16]. It is characterized by plants that are generally herbaceous and distributed in temperate regions, and it is defined by several apomorphies, with few exceptions, such as non-articulated peduncles (meaning they lack an abscission zone at the level of the bracteoles), solitary flowers, calyx appendages, a clearly spurred lower petal (rarely sacciform or gibbous), and a blade shorter than the lateral and upper petals [16,17].

Importance of the genus

Certain species of the genus *Viola* are cultivated as ornamental plants for their floral display, such as the pansy hybrids *V. × williamsii* and *V. × wittrockiana*, as well as some cultivars of *V. sororia*, *V. palmata*, and *V. prionantha* [16]. Moreover, many more wild species have been introduced as novelties for specialized gardeners. The flowers of *V. odorata*, a commonly cultivated species, along with some wild species, are used for condiments, jellies, syrups, and sweets. The young leaves of several *Viola* species are occasionally consumed as an aromatic herb rich in vitamin C, and the flower syrup has been used for medicinal purposes [17].

The genus *Viola* groups its cultivated varieties, or cultivars, into four main subgroups: B1: pansies; B2: violas; B3: violetes; and B4: cornuta hybrids. Within this classification, modern pansies are distinguished by presenting a well-defined central blotch or “eye” on the flower, a characteristic that differentiates them from the other subgroups. In ornamental horticulture, the term “pansy” is commonly used to refer to annual flowering hybrids with large, multicolored flowers, mainly intended for bed decoration. In contrast, the term “viola” is used to describe smaller varieties, whether annual or perennial, with a more delicate growth habit [18].

General morphological description

The genus *Viola* consists of annual or perennial herbs, rarely suffrutescent, with leaves and stipules of variable morphology. Its flowers, typically zygomorphic and hermaphroditic, appear individually on non-articulated peduncles, generally with

two bracts. The five sepals are slightly differentiated from one another and bear basal appendages of diverse shapes. The petals are unequal, with the lower petal equipped with a spur. The five stamens possess anthers with elongated connectives in the form of membranous appendages, with the two lower stamens being nectariferous. The tricarpellary ovary produces capsules with thickened valves that open by explosive dehiscence. The seeds, usually ovoid, present a conspicuous elaiosome, a straight embryo, and plano-convex cotyledons [19].

HISTORY AND CULTURAL SIGNIFICANCE OF VIOLAS

The earliest records of the use of violas (*Viola* spp.) in Europe date back to Ancient Greece, where they were sold at the Agora of Athens, praised in the poetry of the time, used for medicinal purposes, and played an important role in myths such as that of Persephone. They were also used in garlands, mentioned in the *Odyssey*, and maintained their relevance throughout the Middle Ages and the Renaissance, when they became symbolically associated with the Virgin Mary and humility [16,20].

In the Americas, viola nurseries were established on both coasts, in New England along the Atlantic and in California along the Pacific. However, the locality most closely linked to the history of these flowers in the United States was Rhinebeck, New York, where varieties such as *Viola* ‘Marie Louise’ and *Viola* ‘Lady Hume Campbell’ were widely cultivated [20].

Today, pansy flowers are used as garnishes in salads and desserts; the bluish or purplish petals have been used to prepare syrups and jellies, and the tender leaves of several *Viola* species are cooked as a leafy vegetable [16].

During the first half of the 20th century, nurseries and catalogs across Europe and the Americas documented numerous iconic cultivars of *Viola cornuta* L., such as ‘Admiration’, ‘Alba’, ‘Papilio’, ‘Gelber Triumph’, and ‘Lord Nelson’, which were widely distributed and contributed to consolidating the popularity of this *Viola* species in gardens and green spaces. Today, many of these historical cultivars are still available through specialized markets, demonstrating the enduring ornamental value and potential of *Viola cornuta* for contemporary horticulture [21].

The history of the pansy (*Viola* × *wittrockiana*) is closely linked to that of the European violet (*Viola* spp.). The name pansy comes from the French word pensée, which means “thought” or “remembrance.” During the 19th century, systematic hybridization efforts led by horticulturists such as Lord Gambier and his gardener William Thompson in England resulted in the development of larger flowers with more striking color patterns, giving rise to the modern *Viola* × *wittrockiana*. This achievement stimulated the expansion of pansy cultivation throughout Europe and North America, where they quickly became very popular ornamental flowers, noted for their diversity of colors and their ease of propagation from seed [22].

EDIBLE FLOWERS OF THE GENUS *Viola*

The demand for EFs is growing worldwide, not only for their flavor, color, and aroma, but also for their health benefits. They are a rich source of phytochemicals with potential

health-promoting properties [23]. The use of EFs has been documented for thousands of years; however, they still represent only a small fraction of the market and are currently considered a culinary curiosity [24]. Different *Viola* species are known for their traditional use as medicinal agents with analgesic, antitussive, febrifuge, hypnotic, pain-relieving, and anti-inflammatory properties; moreover, they are considered edible flowers in certain cultures [25]. The species *Viola cornuta*, *V. tricolor*, and *V. × wittrockiana* are currently the three most consumed edible *Viola* species [24].

The growing interest in EFs is driving growers and technicians to seek cultivation methods that ensure high yields and quality production without losing sight of sustainability [26].

***Viola cornuta*: Horned violet**

This species produces one of the most popular EFs cultivated as bedding and potted plants [27]. Violas are short-lived annual or perennial plants that grow 10 to 15 cm tall and produce flowers approximately 2.5 cm in diameter (Figure 1). From 2015 to 2020, sales of *Viola* in the United States increased from approximately 95 to 100 million dollars, and in the same period, the number of *Viola* growers rose from 1,714 to 1,869. These flowers are among the most widely used for aesthetic food decoration. They are commonly used to decorate cakes and desserts and have also gained popularity in the kitchen for their vibrant colors and nutraceutical value [23].

***Viola × wittrockiana*: Pansy**

The pansy, *Viola × wittrockiana*, is another species of this genus with edible flowers. In addition, it is an important and attractive ornamental plant with a wide variety of flower colors (Figure 2) [28]. This species is considered an unconventional food plant (UFP) because it is not currently used in food, even on a seasonal basis, but it has high nutritional potential and is also a source of bioactive compounds such as flavonoids and anthocyanins [29]. It is an herbaceous plant characterized by its remarkable tolerance to low temperatures and its ability to flower early, traits that make it a key species in commercial floriculture. Its versatility has made it a suitable option for residential gardens, urban green areas and public spaces [30].



Figure 1. Floral color diversity of *Viola cornuta* plants.



Figure 2. Diversity of flower colors in the species *Viola* × *wittrockiana*.

Initially, this species was selected as an interspecific hybrid resulting from crosses between species of the *Viola* section *Melanium* Ging. (B1), specifically *V. tricolor*, *V. lutea*, and *V. altaica* [31]. Due to its hybrid origin, the modern variety offers a wide range of flowers in terms of shapes, colors, and sizes. The main types of garden pansies include rayless violas, with single-color flowers lacking dark-colored veins, and luxury pansies characterized by large blotches on the three lower petals [30]. Although pansies are perennial plants in cold climates, in regions of the southeastern United States they are cultivated as cool-season annuals and rarely survive the high summer temperatures [32].

PHYTOCHEMICAL COMPOSITION AND NUTRACEUTICAL VALUE OF *Viola* spp. FLOWERS

To date, approximately 370 compounds have been isolated from flowers of various species within the genus *Viola*, including flavonoids, coumarins, alkaloids, lignans, sesquiterpenes, three types of terpenoids, phytosterols, fatty acids, phenolic acids, cyclotides, and other compounds. Cyclotides and flavonoids are the two most abundant groups of compounds isolated from *Viola* species, with cyclotides also considered characteristic components of these plants [33].

The flowers of *Viola cornuta* represent a significant source of bioactive compounds, particularly polyphenols and flavonoids. In addition, non-anthocyanin phenolic compounds have been identified, with quercetin-3-O-rutinoside ($7.5 \pm 0.1 \text{ mg g}^{-1}$ of extract), chrysin-6,8-di-C-glucoside ($6.52 \pm 0.04 \text{ mg g}^{-1}$ of extract), and quercetin-3-O-(6-O-rhamnosylglucoside)-7-O-rhamnoside ($1.27 \pm 0.01 \text{ mg g}^{-1}$ of extract) representing the main constituents [25]. Other flavonoids, such as luteolin, apigenin, kaempferol, and isorhamnetin, are also present in smaller amounts. This composition supports the potential of *V. cornuta* as a natural source of antioxidants, with a possible contribution of vitamin C and carotenoids as reported by other studies [34]. Additionally, this species is rich in myrcene and α -farnesene [11].

The species *Viola* × *wittrockiana* produces an edible flower exhibiting exceptional nutritional composition and nutraceutical potential. Throughout its floral development, this plant exhibits appreciable levels of proteins, carbohydrates, and beneficial fatty acids, with a high proportion of linoleic acid, accompanied by relevant amounts of palmitic and

linolenic acids. Its phytochemical profile reveals the presence of bioactive compounds such as carotenoids, anthocyanins, tannins, and flavonoids, all of which are associated with notable antioxidant capacity [35].

The petals are rich in polyphenols, especially flavonoids such as rutin, violanthin, vicenin-2, and orientin, as well as various anthocyanosides derived from delphinidin, cyanidin, petunidin, and malvidin. These compounds contribute to a remarkable antioxidant capacity, as demonstrated by ABTS, DPPH, ORAC, and FRAP assays, which confirm a positive correlation between phenolic content and free radical scavenging activity [36].

On a dry weight basis, the flowers contain high amounts of carbohydrates ($80.27 \text{ g } 100 \text{ g}^{-1}$) and proteins ($10.14 \text{ g } 100 \text{ g}^{-1}$), highlighting their nutritional contribution compared to other edible flowers. Their energy value is approximately $376.67 \text{ kcal } 100 \text{ g}^{-1}$. The lipid profile is dominated by saturated fatty acids, mainly palmitic acid, followed by arachidic and myristic acids; among unsaturated fatty acids, the presence of linoleic acid, an essential omega-6 fatty acid, is significant. The petals exhibit considerable levels of phenolic compounds ($73 \text{ to } 1033.5 \text{ mg gallic acid equivalents } 100 \text{ g}^{-1}$), anthocyanins ($0.54 \text{ to } 543.49 \text{ mg } 100 \text{ g}^{-1}$), and flavonoids ($69.38 \text{ to } 824.84 \text{ mg } 100 \text{ g}^{-1}$), with variations depending on petal color [29]. In addition, they contain carotenoids, mainly lutein, zeaxanthin, β -carotene, violaxanthin, and antheraxanthin, which contribute to their bioactive potential [37].

These characteristics suggest that *V. × wittrockiana* could be used as a functional ingredient to enhance the nutritional value of various foods, representing a promising option within the edible flower market due to its potential health benefits [35].

PROSPECTS AND CHALLENGES IN THE PRODUCTION OF *Viola* spp.

Potential of Mexican floriculture

Floriculture in Mexico represents a strategic component within the agricultural sector, resulting in high profitability and employment generation capacity, surpassing even several conventional crops. This activity has shown remarkable growth in recent decades, driven mainly by geographic, edaphoclimatic, and biodiversity advantages that position the country as a territory with high potential to become a leader in the production and export of traditional ornamental species [38].

At the territorial level, flower production is concentrated in states such as Jalisco, State of Mexico, Morelos, Puebla, and Michoacán, regions that offer optimal agroecological conditions and a constantly modernizing production infrastructure [39]. A representative example is Mexico City, where over 100 varieties of ornamental plants are cultivated, mainly under intensive potted and greenhouse production systems. Among the most relevant crops of the autumn-winter season is the Dutch tulip, which in 2019 occupied an area of 2.2 hectares, generating approximately 326,700 plants, with a market value reaching 9,088,794 Mexican pesos [40].

However, despite the implementation of public policies and support programs to promote this subsector, the dynamics of foreign trade have faced structural challenges. Imports of floricultural products have increased at a faster rate than exports, generating a

persistent trade balance deficit [38]. This imbalance demonstrates that, although Mexico possesses considerable productive and biological potential, it is essential to strengthen competitiveness, biosecurity, innovation, and integration with international markets in order to fully capitalize on the opportunities in this sector.

Consumption trends of *Viola cornuta* and *Viola* × *wittrockiana*

Species of the genus *Viola*, particularly *Viola cornuta* and *Viola* × *wittrockiana*, occupy a prominent place within the edible flowers segment due to their long-standing tradition of use and their growing popularity today. These ornamental flowers are highly valued for their morphological and organoleptic characteristics: they display a wide range of vibrant colors, single-color or multicolor presentations, diverse floral shapes with varying diameters, and a velvety texture that complements their sweet and refreshing flavor. These attributes make them a versatile resource for gourmet cuisine and functional foods [11].

The interest in incorporating *Viola* spp. and other edible flowers into the human diet has intensified in response to the increasing prevalence of inadequate eating habits, which are associated with the development of various metabolic and chronic degenerative diseases. This situation has boosted the search for novel foods that improve the nutritional profile of the diet and provide bioactive compounds with potential health benefits [41].

Although the use of flowers in gastronomy dates back to ancient times, there is currently a sustained trend toward their use as functional ingredients, driven by growing consumer awareness of the link between food and well-being. This trend is further reinforced by lifestyles that prioritize the consumption of fresh, local, and healthy foods, as well as by increasing scientific evidence documenting the nutritional, antioxidant, and nutraceutical properties of edible flowers. All these factors have positioned *Viola cornuta* and *Viola* × *wittrockiana* as species with high added value for the food industry, responding to the demand for differentiated and functional products [42].

To fully capitalize on this emerging trend, it is essential that *V. cornuta* and *V.* × *wittrockiana* production systems incorporate sustainable agronomic practices that ensure the phytosanitary quality and food safety of flowers intended for human consumption. The adoption of greenhouse cultivation technologies, integrated pest management, and biofortification strategies can contribute to maximizing the content of bioactive compounds and optimizing shelf life. Likewise, the certification of good agricultural practices and the generation of added value through product traceability and differentiation will enable access to gourmet and functional food market niches, meeting the demands of increasingly informed and discerning consumers. This synergy between agronomic innovation, biological quality, and commercial strategies will strengthen the competitiveness of the national floriculture sector and consolidate various *Viola* species as benchmarks in the high-value edible flower market.

Production and sustainability challenges in *Viola cornuta* and *Viola* × *wittrockiana*

The species *Viola cornuta* and *V.* × *wittrockiana* have been established as key ornamental crops thanks to physiological attributes such as their high tolerance to low temperatures and their early flowering capacity, making them strategic in seasonal floriculture. Traditionally,

breeding programs in *V. × wittrockiana* have focused on maximizing vegetative vigor, promoting rapid establishment, and ensuring continuous and abundant flowering. However, specific morphological traits are now also prioritized, such as plant compactness, the development of larger, round-shaped flowers, and the presence of straight petals held on short peduncles, all of which directly influence ornamental quality and commercial acceptance.

One of the main challenges during the nursery stage is controlling excessive seedling elongation, a phenomenon that compromises the uniformity and final plant quality [30]. In addition, floriculture faces limitations associated with the postharvest phase: crops are often exposed to high thermal fluctuations and inadequate irrigation practices along the retail chain, increasing the incidence of water stress. It is estimated that such conditions can cause up to 15% yield loss during commercialization by directly affecting the aesthetic quality of the flowers. Consequently, studies aimed at strengthening *V. cornuta* tolerance to water deficit stress [43] and *V. × wittrockiana* frost resistance under different irrigation regimes [44] have been constantly increasing in recent years.

From a reproductive perspective, since the propagation of these species is primarily carried out through sexual reproduction, another technical challenge lies in optimizing seed quality and viability, an aspect that is currently being actively researched in *V. cornuta* to ensure efficient and uniform production [45].

In terms of food sustainability, the growing consumer interest in innovative and healthy products has driven the development of an emerging industry dedicated to the production and commercialization of edible flowers. In addition to their sensory appeal (unique colors, textures, and flavors), various *Viola* species can provide bioactive compounds with nutraceutical properties, expanding their potential as functional food.

However, this market faces significant challenges related to food safety, since not all ornamental flowers are suitable for human consumption, as some may contain toxic secondary metabolites or antinutritional compounds [37].

Furthermore, given that edible flowers are often consumed fresh or minimally processed, there is a considerable microbiological risk. Therefore, it is essential to guarantee proper agricultural practices, strict phytosanitary controls, and hygienic postharvest handling to reduce microbial load. The implementation of effective preservation, packaging, and storage methods not only helps minimize contamination but also preserves the nutritional quality and stability of the bioactive compounds present in the flowers [10].

Summing up, the comprehensive challenge for producers, researchers, and marketers is to adopt sustainable production systems that integrate genetic improvement, efficient agronomic management, food safety, and value-added strategies, thereby ensuring the competitiveness of *Viola cornuta* and *V. × wittrockiana* as high-value ornamental and edible crops.

CONCLUSIONS

The genus *Viola*, and specifically the species *Viola cornuta* and *V. × wittrockiana*, represents a valuable resource with great potential for diversification within both the floriculture and functional food industries. In addition to their undeniable ornamental value, these species

produce edible flowers rich in bioactive compounds, including polyphenols, flavonoids, anthocyanins, and carotenoids, which contribute to their antioxidant capacity and potential health benefits.

The increasing demand for edible flowers, driven by consumer preferences for innovative, healthy, and visually appealing products, highlights the need to develop sustainable production systems that ensure product quality, safety, and added value. To achieve this, it is essential to integrate agronomic innovation, genetic improvement, efficient postharvest management, and rigid food safety protocols.

Although *Viola cornuta* and *V. × wittrockiana* are already consolidated as important ornamental crops, their emerging role as functional food ingredients presents significant opportunities for the Mexican floriculture and food sectors. However, the challenges related to seed viability, postharvest preservation, food safety, and market differentiation must be addressed to fully exploit their potential.

In conclusion, promoting sustainable production, scientific research and innovation focused on these species will be key to strengthening their competitiveness as high-value edible and ornamental flowers, positioning them as a strategic alternative for responding to market trends and consumer demands for differentiated and health-promoting products.

REFERENCES

1. Toscano S, Romano D, Lazzeri V, Leotta L, & Bretzel F. (2025). How can plants used for ornamental purposes contribute to urban biodiversity? *Sustainability*, 17(9). <https://doi.org/10.3390/su17094061>
2. Rihn AL, Knuth MJ, Behe BK, & Hall CR. (2023). Benefit information's impact on ornamental plant value. *Horticulturae*, 9(7). <https://doi.org/10.3390/horticulturae9070740>
3. Gupta J. (2024). Role of ornamental plants in the improvement of environment. *Agriculture Association of Textile Chemical and Critical Reviews Journal*, 12. <https://doi.org/10.58321/AATCCReview.2024.12.01.185>
4. Hall CR, & Knuth MJ. (2019). An update of the literature supporting the well-being benefits of plants: Part 2 Physiological Health Benefits. *Journal of Environmental Horticulture*, 37(2), 63-73. <https://doi.org/10.24266/0738-2898-37.2.63>
5. Hall CR, & Knuth MJ. (2019). An update of the literature supporting the well-being benefits of plants: Part 3 - Social Benefits. *Journal of Environmental Horticulture*, 37(4), 136-142. <https://doi.org/10.24266/0738-2898-37.4.136>
6. Huss E, Yosef KB, & Zaccai M. (2017). The meaning of flowers: A cultural and perceptual exploration of ornamental flowers. *The Open Psychology Journal*, <https://doi.org/10.2174/1874350101710010140>
7. Ghosh P, Devraj L, & Yadav RS. 2024. Edible Flowers: Potential applications for nutritional security. In: *Future Crops and Processing Technologies for Sustainability and Nutritional Security*. CRC Press.
8. Zhang Q, Zhang J, Xu C, Wu X, & Long C. (2025). The diversity of edible flowers and its biocultural role in local food system in Dali, Southwest China. *Diversity*, 17(1). <https://doi.org/10.3390/d17010070>
9. Książkiewicz M, Karczewska M, Nawrot F, Korybalska K, & Studzińska-Sroka E. (2025). Traditionally used edible flowers as a source of neuroactive, antioxidant, and anti-inflammatory extracts and bioactive compounds: A narrative review. *Molecules*, 30(3), 677. <https://doi.org/10.3390/molecules30030677>
10. Carboni AD, Di-Renzo T, Nazzaro S, Marena P, Puppo MC, & Reale A. (2025). A comprehensive review of edible flowers with a focus on microbiological, nutritional, and potential health aspects. *Foods*, 14(10). <https://doi.org/10.3390/foods14101719>
11. Marchioni I, Gabriele M, Carmassi G, Ruffoni B, Pistelli L, Pistelli L, & Najjar B. (2024). Phytochemical, nutritional and mineral content of four edible flowers. *Foods*, 13(6), 939. <https://doi.org/10.3390/foods13060939>
12. Steven Albán M, Domínguez LD, & Echavarría, AP. (2018). Composición nutricional y propiedades funcionales de flores comestibles. *Saber, Universidad de Oriente*, 30, 498-507.
13. Sood Y, Lal M, Kalia A, & Verma S. (2024). Edible flowers: Super foods with potential health benefits. *International Journal of Plant & Soil Science*, 36, 213-221. <https://doi.org/10.9734/ijpss/2024/v36i34417>

14. Fernandes L, Casal S, Pereira JA, Saraiva JA, & Ramalhosa E. (2017). Edible flowers: A review of the nutritional, antioxidant, antimicrobial properties and effects on human health. *Journal of Food Composition and Analysis*, 60, 38-50. <https://doi.org/10.1016/j.jfca.2017.03.017>
15. Fernández-Bobey A, Dias NB, Vieira NC, Zanatta AC, de Souza BM, de Paula-Souza J, da Silva BV, & Palma MS. (2024). Violaceae: Chemical constituents, traditional use and pharmacology. *Phytochemistry Reviews*, 23, 147-227. <https://doi.org/10.1007/s11101-023-09879-8>
16. Marcussen T, Ballard HE, Danihelka J, Flores AR, Nicola MV, & Watson JM. (2022). A revised phylogenetic classification for *Viola* (Violaceae). *Plants*, 11(17), <https://doi.org/10.3390/plants11172224>
17. Ballard HE, de Paula-Souza J, & Wahlert GA. (2014). Violaceae. In: Kubitzki K. (Ed) Flowering Plants. Eudicots. The families and genera of vascular plants, 11, pp. 303-322. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-39417-1_25
18. Kozicka M, & Hallmann E. (2023). Identification and quantification of bioactive compounds in organic and conventional edible pansy flowers (*Viola × wittrockiana*) and their antioxidant activity. *Plants*, 12(6), 1264. <https://doi.org/10.3390/plants12061264>
19. Muñoz GF, Monserrat P, Laínz M, & Aldasoro JJ. (1993). *Viola* L. In: S. Castroviejo (Ed.), Flora Ibérica. Plantas vasculares de la Península Ibérica e Islas Baleares, Real Jardín Botánico, CSIC, pp. 277-317. http://www.floraiberica.es/PHP/familias_lista_.php?familia=Violaceae. (Retrieved: junio 2025)
20. Carvalho LM, de Fernandes FM, Nunes M de F, Brigola J, Casbas N, & Groves C. (2013). History and cultivation of parma violets (*Viola*, Violaceae) in the United Kingdom and France in the Nineteenth Century. *Harvard Papers in Botany*, 18(2), 137-145. <https://doi.org/10.3100/025.018.0207>
21. Guillot-Ortiz D. (2020). Cultivares de violetas cultivados/comercializados en España en la primera mitad del siglo XX. *Bouteloua*, 29, 65-76.
22. Trinklein D. (2012). View MEG Publications on the web. *Missouri Environment and Garden Newsletter*, 18(9), 57-59. <https://ipm.missouri.edu/MEG/archive/2012/v18n12.pdf&>
23. Regmi A, Poudyal S, Singh S, Coldren C, Moustaid-Moussa N, & Simpson C. (2023). Biochar influences phytochemical concentrations of *Viola cornuta* flowers. *Sustainability*, 15(5): 3882. <https://doi.org/10.3390/su15053882>
24. de Oliveira I, Chrysargyris A, Finimundy TC, Carochio M, Santos-Buelga C, Calhella RC, Tzortzakis N, Barros L, & Heleno SA. (2024). Magnesium and manganese induced changes on chemical, nutritional, antioxidant and antimicrobial properties of the pansy and *Viola* edible flowers. *Food Chemistry*, 438, 137976. <https://doi.org/10.1016/j.foodchem.2023.137976>
25. Moliner C, Barros L, Dias MI, Reigada I, Ferreira ICFR, López V, Langa E, & Rincón CG. (2019). *Viola cornuta* and *Viola × wittrockiana*: Phenolic compounds, antioxidant and neuroprotective activities on *Caenorhabditis elegans*. *Journal of Food and Drug Analysis*, 27(4), 849-859. <https://doi.org/10.1016/j.jfda.2019.05.005>
26. Ottoliti F. (2025). Fiori Eduli: Tecniche culturali innovative applicate a *Viola cornuta*. <https://thesis.unipd.it/handle/20.500.12608/49165>
27. Du X, Wang H, Liu J, Zhu X, Mu J, Feng X, & Liu H. (2022). Major gene with polygene inheritance analysis of shoot architecture traits in *Viola cornuta*. *Scientia Horticulturae*, 303, 111204. <https://doi.org/10.1016/j.scienta.2022.111204>
28. Wan W, Jia F, Liu Z, Sun W, Zhang X, Su J, Guan Z, Chen F, Zhang F, & Fang W. (2024). Quantitative evaluation and genome-wide association studies of chrysanthemum flower color. *Scientia Horticulturae*, 338, 113561. <https://doi.org/10.1016/j.scienta.2024.113561>
29. da Silva LA, Fischer SZ, & Zambiasi RC. (2020). Proximal composition, bioactive compounds content and color preference of *Viola × wittrockiana* flowers. *International Journal of Gastronomy and Food Science*, 22, 100236. <https://doi.org/10.1016/j.ijgfs.2020.100236>
30. Desmet S, De Keyser E, Leus L, Van Huylenbroeck J, Geelen D, & Dhooghe E. (2024). Improved compact growth habit of *Viola × wittrockiana* through *Rhizobium rhizogenes* transformation. *Plant Growth Regulation*, 102(3), 515-527. <https://doi.org/10.1007/s10725-023-01073-2>
31. Du X, Wang M, Słomka A, & Liu H. (2018). Karyologic and heterosis studies of the artificial inter- and intraspecific hybrids of *Viola × wittrockiana* and *Viola cornuta*. *HortScience*, 53(9), 1300-1305. <https://doi.org/10.21273/HORTSCI13098-18>
32. Bailey DA. (1998). Commercial pansy production. North California Cooperative Service, New York.
33. Zhang Q, Wang Q, & Chen S. (2023). A comprehensive review of phytochemistry, pharmacology and quality control of plants from the genus *Viola*. *Journal of Pharmacy and Pharmacology*, 75(1), 1-32. <https://doi.org/10.1093/jpp/rgac041>
34. Benvenuti S, Bortolotti E, & Maggini R. (2016). Antioxidant power, anthocyanin content and organoleptic performance of edible flowers. *Scientia Horticulturae*, 199, 170-177. <https://doi.org/10.1016/j.scienta.2015.12.052>

35. Fernandes L, Ramalhosa E, Baptista P, Pereira JA, Saraiva JA, & Casal SIP. (2019). Nutritional and nutraceutical composition of pansies (*Viola × wittrockiana*) during flowering. *Journal of Food Science*, *84*(3), 490-498. <https://doi.org/10.1111/1750-3841.14482>
36. Skowrya M, Calvo M, Gallego M, Azman N, & Almajano M. (2014). Characterization of phytochemicals in petals of different colours from *Viola × wittrockiana* Gams. and their correlation with antioxidant activity. *Journal of Agricultural Science*, *6*(9). <https://doi.org/10.5539/jas.v6n9p93>
37. González-Barrío R, Periago MJ, Luna-Recio C, García-Alonso FJ, & Navarro-González I. (2018). Chemical composition of the edible flowers, pansy (*Viola wittrockiana*) and snapdragon (*Antirrhinum majus*) as new sources of bioactive compounds. *Food Chemistry*, *252*, 373-380. <https://doi.org/10.1016/j.foodchem.2018.01.102>
38. Ramírez-Hernández JJ, Avitia-Rodríguez JA, Ramírez Hernández JJ, & Avitia-Rodríguez JA. (2017). Floricultura mexicana en el siglo XXI: Su desempeño en los mercados internacionales. *Revista de Economía*, *34*(88), 99-122.
39. Cabrera DM, Pérez-Ríos SR, & Domínguez-Narváez JA. (2023). Producción de flor ornamental de Lisianthus (*Eustoma grandiflorum*) y Freesia (*Freesia × hybrida*) empleando aguas residuales como alternativa económica y ambiental en el valle del Mezquital. *XAHNI Boletín Científico de la Escuela Preparatoria No. 6*, *1*(1), Article 1.
40. Agricultura Ciudad de México. (2020). La floricultura en la Ciudad de México. [gob.mx. http://www.gob.mx/agricultura|cdmx/articulos/la-floricultura-en-la-ciudad-de-mexico?idiom=es](http://www.gob.mx/agricultura|cdmx/articulos/la-floricultura-en-la-ciudad-de-mexico?idiom=es). (Recuperado: junio, 2025)
41. Loaiza-Figueroa L. (2024). Percepción actitudinal sobre el consumo y beneficios de la diversidad de flores comestibles en Chile. <https://doi.org/10.58011/4hnp-va02>
42. Pires EO, Di Gioia F, Roupheal Y, Ferreira ICFR, Caleja C, Barros L, & Petropoulos SA. (2021). The compositional aspects of edible flowers as an emerging horticultural product. *Molecules*, *26*(22), <https://doi.org/10.3390/molecules26226940>
43. Park S, Moon Y, & Waterland NL. (2020). Treatment with calcium chloride enhances water deficit stress tolerance in viola (*Viola cornuta*). *HortScience*, *55*(6), 882-887. <https://doi.org/10.21273/HORTSCI14835-20>
44. Oraee A, Tehranifar A, Nezami A, & Shoor M. (2020). The effects of three levels of irrigation water on the improvement of cold tolerance of acclimated viola. *Acta Physiologiae Plantarum*, *42*(7), 1-10. <https://doi.org/10.1007/s11738-020-03095-z>
45. Saputra AS, Suprihati S, & Pudjihartati E. (2019). The effect of phosphorus and potassium on the growth and quality of viola (*Viola cornuta* L.) seed production. *Caraka Tani: Journal of Sustainable Agriculture*, *35*(1), <https://doi.org/10.20961/carakatani.v35i1.33618>