Edible species of Boraginales

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Review

Abstract

Background: The order Boraginales comprises numerous species known for their medicinal properties, but their role as food sources remains understudied and largely confined to local traditions. This review aims to systematically document edible species within this order, highlighting their nutritional, cultural and economic significance and advocating for their broader integration into global food systems.

Methods: This study compiles data from diverse botanical and ethnobotanical sources, identifying 107 edible species whitin Boraginales. The analysis includes taxonomic distribution, with the Boraginaceae family contributing the most species (50), followed by Cordiaceae (32), Hydrophyllaceae (10), Ehretiaceae (9), Heliotropiaceae (3), Lennoaceae (2), and Namaceae (1). Preliminary fieldwork in Iran supplements literature-based research to assess local availability and traditional uses.

Results: The findings reveal that edible Boraginales species are widely consumed in various regions, yet their potential remains undervalued in mainstream agriculture and nutrition. Many of these plants play crucial roles in local diets but lack comprehensive scientific evaluation of their cultivation and nutritional benefits.

Conclusions: In addition to identifying edible Boraginales species that are consumed only in a specific region, this review reveals a biogeographic split in organ use: temperate regions favor leafy herbaceous taxa, whereas seasonally dry and wet tropical regions emphasize fleshy fruits, especially within *Cordia* and *Ehretia*. Representative records illustrate this contrast: leafy parts are used in Europe/Turkey/Iran and North America, and fruit are used in Africa, the Neotropics, and South/Southeast Asia.

Keywords: Ethnobotany, Edible plants, Boraginales, Culinary traditions, Traditional knowledge

Background

Since the dawn of human existence on Earth, the pursuit of sustenance has been a paramount concern. Throughout history, wild plants have been indispensable allies in the quest for nourishment. Beyond being a source of food, these botanical wonders have served as medicinal remedies, materials for textile, and fodder for domestic animals (Ahmad-Khan *et al*. 2017, Balick *et al*. 2006, Ghahremaninejad *et al*. 2021). The vital role of edible wild plants in ensuring food sovereignty and sustaining countless families and communities worldwide is undeniable. In an era marked by the rapid globalization of food markets and advances in nutritional science, the potential of wild plants for both sustenance and healing has gained renewed attention (Manohar *et al*. 2023). However, it remains apparent that not all the secrets of edible plants have been uncovered, as some traditional uses have been documented in languages such as Chinese, still await translation (Taoerdahong *et al*. 2023). The convergence of food and health further fuels this interest, exemplified by research into oral vaccines delivered through plants (Yip *et al*. 2023). In the wake of growing interest in vegetarianism and plant-based diets, the significance of edible plants has increased. Authors have provided guidelines and recommendations tailored for this dietary shift (Lightowler *et al*. 1998, Mangels *et al*. 2003, Messina *et al*. 2003, Mutch 1988). However, the science and practice of plant use, encompassed whitin ethnobotany, are far from uniform across the globe. Native edible species vary widely; with some regions, such as the Americas (e.g. Diago & Garcia 2021, Gori *et al*. 2022, Mapes & Basurto 2016), boast a wealth of such plants, while others, such as Iceland, possess a more limited repertoire (Svanberg & Aegisson 2012). Throughout this mosaic, the introduction and appreciation of local species remain pivotal, an endeavor championed by researchers (Cavender 2002, Duke 1999, Funk *et al*. 2007, Heywood & Zohary 1973, Khodayari *et al*. 2015). The interdependence between local communities and forest and pasture plants is a undeniable thread woven into the fabric of their livelihoods and the management of natural resources (Eshaghi Milasi & Mahmoudi 2016).

Ethnobotany preserves vital traditional knowledge that connects culture, biodiversity, and sustainability. Plant-based traditions are crucial for food, medicine, and rituals in many societies. Studies show plant use in Bhutanese Buddhist ceremonies (Dorji & Thinley 2023), tribal ethnomedicine in India (Sahu *et al*. 2020), and diverse plant uses in Yemen (Al-Fatimi 2024). Ethnobotany contributes to biodiversity, food security, and climate resilience, supporting global sustainability goals (Cámara-Leret & Bascompte 2021).

Boraginales comprises approximately 125 genera and 2700 species of herbs, shrubs, trees, and lianas (Luebert *et al*. 2016). The classification of Boraginales has undergone profound changes, a transformation catalyzed by molecular insights and phylogenetic studies (Hilger *et al*. 2019). The order now includes 11 families: Boraginaceae, Codonaceae, Coldeniaceae, Cordiaceae, Ehretiaceae, Heliotropiaceae, Hoplestigmataceae, Hydrophyllaceae, Lennoaceae, Namaceae and Wellstediaceae (Hilger *et al*. 2019). While botanists and evolutionary researchers have explored the phylogenetic intricacies of borages in numerous studies (Diane *et al*. 2002, Gottschling *et al*. 2001, Gottschling *et al*. 2004, Gottschling *et al*. 2014, Hilger & Weigend 2016, Hilger *et al*. 2018, Hunt 1969, Luebert *et al*. 2016, Moore & Jansen 2006, Taylor 2012, Thulin & Johansson 1996, Weigend *et al*. 2014), this paper focuses on the edible plants within this order. Although families such as Ehretiaceae (Nazari & Ghahremaninejad 2025a), Cordiaceae (Nazari & Ghahremaninejad 2025b), and Heliotropiaceae (Nazari & Ghahremaninejad 2024) typically possess distinctive trichomes, many of their species have edible plants. Despite their importance and nutritional value, some species remain little-known in certain regions, while in others, particularly in North and Central America, they hold a cherished place in culinary traditions (Ali-Shtayeh *et al*. 2008).

Furthermore, extreme climate change events can reshape landscapes, affecting millions of people globally and potentially eroding the traditional knowledge of those residing in these regions held by local natural resources (Lima *et al*. 2023). As global warming disrupts ecosystems and traditional cultivation patterns, the use of diverse and adaptable food sources becomes essential to mitigate the potential consequences of crop failures and food scarcity (Godfray *et al*. 2010). These ecological transformations can drastically affect crop production, making it essential to identify and secure alternative food sources, including edible Boraginales species (Battisti & Naylor 2009). Exploring the nutritional value of these plants and conserving their genetic diversity in gene banks, we can take steps toward ensuring food sovereignty for future generations. Although our focus is on Boraginales, it is important to acknowledge that numerous other lesser-known plants hold significant food value and research in this field is ongoing (e.g. Caetano *et al*. 2023, Chamorro & Ladio 2020, Chamorro & Ladio 2021, Navia *et al*. 2019). As the interconnected challenges of global warming, population growth, and the dwindling suitable cultivation regions, the risks of plant species extinction and widespread human starvation becomes starkly apparent (Myers *et al*. 2017). To address this concerning scenario, it is necessary to embrace the exploration of novel edible resources and consider expanding our culinary repertoire to secure our future food supply.

Material and Methods

A comprehensive dataset of edible Boraginales species was compiled from botanical literature, ethnobotanical studies, and herbarium collections (W, T), supplemented by searches in databases such as Scopus and GBIF. Cross-referencing of sources ensured geographical representativeness and taxonomic validity. Cultural uses of edible plants were gathered from Spanish, Persian, and Chinese. Translations of these sources captured traditional culinary and medicinal practices, providing a holistic view of their ethnobotanical significance. Visual documentation included botanical illustrations based on herbarium specimens, digital repositories, and in-situ photographs, which aided in accurate taxonomic classification and species identification. Detailed illustrations by the first author, based on actual plant samples, were used to ensure precise identification of edible species, distinguishing them from non-edible counterparts. In Iran, the authors surveyed 30 medicinal and edible plant stores across Tehran, Hamedan, and Abadan, and compiling a comprehensive list of the plants offered for further identification and study.

Results

Based on a comprehensive review of reports and documented sources, a total of 107 edible species were identified spanning seven of the 11 families recognized within Boraginales (Table 1). The preeminent contributor to this culinary diversity is the family Boraginaceae, which accounts for an impressive 50 edible species. It is followed by Cordiaceae (32 species), Hydrophyllaceae (10), Ehretiaceae (9), Heliotropiaceae (3), Lennoaceae (2), and Namaceae, which is represented by a single edible species. However, no comprehensive reports surfaced for the four remaining families—Codonaceae, Coldeniaceae, Hoplestigmataceae, and Wellstediaceae—signaling a potential avenue for future exploration.

A preliminary field survey was conducted in three Iranian cities, where 30 medicinal and edible plant stores were randomly selected (20 stores in Tehran, 5 stores in Hamedan, and 5 stores in Abadan). We prepared a list of all plants offered in these stores and subsequently extracted the species belonging to the order Boraginales. In all these stores, only two species from this order were available: *Cordia myxa* and *Echium amoenum* (Figure 1). *Cordia myxa* was available both fresh and dried. Its dried fruits are used to make and are also sometimes soaked. Jam and pickles are made from the fresh fruits; these producs hold a special place in Iranian culture and are consumed either as a condiment or alongside other foods. Although *Borago officinalis* was also available in one store as a processed bagged drink, Iranians typically use *Echium amoenum* as a substitute. It is sold under the name "Borago" (Gav Zaban, meaning "cow tongue") and is consumed as tea or, sometimes, in powdered form in foods and salads. Despite this divergence, both plants are enriched with therapeutic properties and nutritional value, and they continue to hold a cherished place in traditional medicine and nutrition (Ghassemi *et al*. 2003, Mitra *et al*. 2005, Maghsudi & Parsapajouh 2022).

Figure 1. Edible species of Boraginales in traditional herbal markets of Iran. A) Iranian Borago (*Echium amoenum*) in Tehran, B) *Cordia myxa*, in Hamedan, and C) *Cordia myxa* pickle from Abadan.

The edible species of Boraginales have several documented uses. They may be consumed raw, cooked, or both. They can be eaten alone as food, a snack, or in salads. They are also used as additions to other foods, as side dishes, or processed into drinks and desserts. A summary of the uses and plant parts consumed is provided in Table 1. Here we discuss each of these species along with its distribution range. Specifying the geographical range of these plants, we aim not only to identify them as potential future food sources but also to provide a clear reference for experts and farmers interested in cultivating them in similar geographic regions.

Ⅰ. Boraginaceae s.str. Family

1. *Adelinia grandis* (Douglas ex Lehm.) J.I.Cohen

This perennial plant usually grows in temperate regions, with a distribution range from western Canada to western United States of America. The roots of this plant (Fig. 2.M) have a long history of use as food in America for a long time. Today, the roots are used in sauces, and the powdered roots is used as a seasonings (Yanovsky 1936).

2. *Alkanna froedinii* Rech.f.

This plant grows in eastern Turkey in humid areas. Since ancient times, people in Turkey have consumed the aerial parts of this plant, especially its leaves. The leaves (Fig. 3.19) are cooked in stews and are sometimes eaten with rice. They have potential for use in other soups and stews due to their oily texture and unique flavor and aroma (Kaval *et al*. 2015).

3. *Alkanna tinctoria* (L.) Tausch

This perennial species grows in temperate regions accros much of Europe, from the Mediterranean to Turkey, as well as in North Africa. In Spain, the leaves and stems have been used as vegetables or in salads for many years. However, the most important edible part is the root. These roots (Fig. 2.n) have a distinctive aroma and taste, and are consequently used as a seasonings or spices (Benítez *et al*. 2023).

4. *Amsinckia lycopsoides* Lindl. ex Lehm.

This annual plant is native to western Canada and the western United States of America but has also been introduced to parts of Western Europe and Southeast Asia. The edible parts are branches, which are crispy and juicy. For decades, people in western America have used them as a vegetable or salad. These branches (Fig. 2.G) are also used as a garnish in cocktails and other drinks (Yanovsky 1936).

5. *Amsinckia tessellata* A.Gray

This annual species is native to the western and central United States, northern Mexico and western and southern South America, where it grows in temperate regions. Nutrient-rich seeds of this plant are consumed in many parts of North and South America. They are used as a meat-protein substitute and are also ground into flour (Yanovsky 1936).

6. *Anchusa azurea* Mill.

This species is distributed from Europe to Central Asia and Western Himalayas, and from Arabia to North and South Africa. It has also been introduced to the United States. In many countries, including Spain, all parts of this plant are used for food. The leaf (Fig. 3.33) has been used as a vegetable or in salads for many years. The flowers (Fig. 5.B) are used as a garnish for food or drinks or in salads, or as a flavoring for sweets. The roots (Fig. 2.R) are also edible in some areas (Benítez *et al*. 2023, Eshaghi Milasi & Mahmoudi 2016, Kaval *et al*. 2015, Kunkel 1984, Masoumi 2010, Molero-Mesa & García-Barriuso 2017, Motti *et al*. 2022, Pinela *et al*. 2017).

7. *Anchusa capensis* Thunb.

This annual or biennial plant thrives in the subtropical biomes of southern Africa. It is native to South Africa and Namibia. The leaves (Fig. 3.23) are used in salads and as a cooked vegetable. The flowers (Fig. 5.A) are also used to color and flavor cold drinks (Facciola 1998).

8. *Anchusa riparia* A.DC.

This species is native to South Africa. Local people consume the leaves (Fig. 3.24) and young shoots (Fig. 2.A) cooked. The flowers are also used as a garnish for salads and various dishes (Facciola 1990, Jacke & Toensmeier 2015, Johnson 1906).

9. *Anchusa strigosa* Banks & Sol.

This biennial or perennial species is native to an area from Cyprus and Turkey to Iran, where it grows in temperate regions. The aerial parts of the plant (Fig. 2.B, Figs. 3.36, 5.J) are used to flavor various foods, including cheese and yogurt, due to their distinctive taste (Motti *et al*. 2022).

10. *Anchusa undulata* L. subsp. *granatensis* (Boiss.) Valdés

This biennial or perennial subspecies is native to Spain and Portugal. Since ancient times, people in Andalusia have used the leaves (Fig. 3.11) and shoots (Fig. 2.C) of this plant. They are incorporated into various dishes (Benítez *et al*. 2023, Molero-Mesa & García-Barriuso 2017).

11. *Anchusa hybrida* Ten.

This biennial or perennial plant is native to southern Europe, Turkey, Iraq and North Africa. In Turkey, the leaves and young branches are used as a vegetable or as an addition to other dishes (Ertug 2004, Motti *et al*. 2022).

12. *Borago officinalis* L.

This species is globally known for its medicinal properties. It is native to Europe and North Africa but is also cultivated or has been introduced in many countries. This annual plant grows in temperate biomes and has a chemical profile rich in mucilage, tannins, and volatile oils. Beyond its historical medicinal uses, its leaves (Fig. 3.16), stems (Fig. 2.H), and flowers (Fig. 5.H) are used in salads and as snacks. Additionally, the roots (Fig. 2.Q) are eaten cooked in Italy, Spain, and Lebanon (Benítez *et al*. 2023, Ceccanti *et al*. 2018, Faisal *et al*. 2022, Hasanvand *et al*. 2020, Herrera *et al*. 2020, Kaisoon *et al*. 2012, Molero-Mesa & García-Barriuso 2017, Motti *et al*. 2022, Pinela *et al*. 2017).

13. *Bothriospermum tenellum* (Hornem.) Fisch. & C.A.Mey.

This annual or biennial plant is native to a region from Central Asia to the Philippines and Japan, where it grows in subtropical biomes. It is well known in Laos as an edible species. The leaves and flowers (Fig. 5.C, Fig. 3.9) are used in many traditional Lao dishe (Kosaka *et al*. 2013).

14. *Cerinthe major* L.

This annual plant is native to Mediterranean and North Africa but has is also been introduced to the eastern United States. It grows in the subtropical biome and is cultivated in India. The leaves (Fig. 3.3) are a popular main ingredient in many salads (Ertug 2004, Motti *et al*. 2022).

15. *Cynoglossum lanceolatum* Forssk.

This annual or biennial plant is native to tropical Africa and tropical to subtropical Asia, where it grows primarily in seasonally dry tropical biomes. The leaves (Fig. 3.35) are valued for their taste and aroma and are used as a main ingredient in various soups in some regions (Useful Tropical Plants 2023).

16. *Cynoglossum monophlebium* Baker

This annual or perennial species is native to Madagascar and grows primarily in the seasonally dry tropical biome. Its young leaves (Fig. 3.28) are consumed both raw and cooked and have been recognized for their edible potential in North America (Facciola 1998).

17. *Echium amoenum* Fisch. & C.A.Mey.

This biennial or perennial species is native to Georgia, Armenia, Azerbaijan, and Iran, where it grows mainly in temperate biomes. The plant is well known in Iran for its medicinal properties and has a historical record of use in the region's culture and traditional medicine, where it is called Iranian Borago. The leaves (Fig. 3.30) and flowers (Fig. 5.F) are also used in various dishes, soups, and desserts (Hoeeinpour-Azad *et al*. 2022, Khodayari *et al*. 2015, Torabi *et al*. 2022).

18. *Echium creticum* L.

This biennial plant is native to southern Europe (France, Spain, Portugal) and North Africa (Algeria, Tunisia, Morocco) but has also been introduced to parts of Scandinavia and the eastern United States. In Spain, the leaves (Fig. 3.27) have long been consumed as a snack (Molero-Mesa & García-Barriuso 2017, Motti *et al*. 2022).

19. *Echium creticum* L. subsp. *granatense* (Coincy) Valdés

This subspecies is native to the subtropical biomes of southern Spain. The shoots (Fig. 2.E) were used in many traditional Andalusian dishes and continue to be used in modern dishes in the region today (Benítez *et al*. 2023).

20. *Echium italicum* L.

This biennial species is native from East-Central and Southern Europe to Afghanistan and grows primarily in temperate biomes. In Turkey, the plant's nectar is popular and is used to make syrup or as a flavoring due to its distinctive taste (Motti *et al*. 2022).

21. *Echium plantagineum* L.

This annual or biennial plant is native to an area from Europe to Western Asia and North Africa but has been introduced to Australia, South Africa, and North and South America. It grows primarily in subtropical biomes. The leaves (Fig. 3.5) have been used in Spain and India for many years and hold a special place in the culinary culture of these countries (Molero-Mesa & García-Barriuso 2017, Motti *et al*. 2022).

22. *Echium vulgare* L.

This annual or biennial plant is native to most of Europe and Asia but has been introduced to the Americas, Africa, and Australia. It grows in temperate biomes. In Spain, the leaves (Fig. 3.32) are used in some traditional dishes; their distinctive taste has given them cultural significance (Molero-Mesa & García-Barriuso 2017, Motti *et al*. 2022).

23. *Eritrichium ssp.*

Although the reference does not specify the exact species, the description suggests that a species within this genus has leaves that are underappreciated yet contribute vital flavor. Although rarely used, these leaves have potential as a unique flavoring in soups and other dishes (Kunkel 1984).

24. *Lithodora fruticosa* (L.) Griseb.

This subshrub is native to Algeria, France, Morocco, and Spain. In Spain, the shoots (Fig. 2.F) and leaves (Fig. 3.26) are widely consumed as snacks (Molero-Mesa & García-Barriuso 2017, Motti *et al*. 2022).

25. *Lithospermum incisum* Lehm.

This perennial species is native to North America and northern and western Mexico, where it grows in temperate biomes. The roots (Fig. 2.O) are eaten cooked in some regions of North America (Yanovsky 1936).

26. *Lithospermum officinale* L.

This perennial species is native to most of Europe and Asian, and has also been introduced to the Americas. It grows primarily in the temperate biome. The fruits have both food and medicinal uses and are widely utilized (Molero-Mesa & García-Barriuso 2017).

27. *Mertensia bella* Piper

This plant is native to the western United States (California, Idaho, Montana and Oregon) and grows in temperate biomes. Both the flowers (Fig. 5.I) and leaves (Fig. 3.10) are edible and have been used for food in Alaska for many years (Yanovsky 1936).

28. *Mertensia ciliata* (E.James ex Torr.) G.Don

This perennial species is native to the western and central United States and typically grows in subalpine or subarctic biomes. Both the leaves (Fig. 3.39) and flowers (Fig. 5.M) are edible and are consumed in some parts of Alaska (Yanovsky 1936).

29. *Mertensia longiflora* Greene

This perennial species is native to western Canada and the western United States, where it typically grows in temperate biomes. Both the flowers (Fig. 5.O) and leaves (Fig. 3.2) are used as food in Alaska (Yanovsky 1936).

30. *Mertensia maritima* (L.) Gray

This perennial species is native to North America and northern Europe and grows in temperate biomes. The flowers (Fig. 5.G), leaves (Fig. 3.1), and roots (Fig. 2.P) have been used for food in Alaska and other parts of North America for many years (Facciola 1990, Schofield 1989).

31. *Mertensia oblongifolia* (Nutt.) G.Don

This perennial species is native to the western and central United States and grows in subalpine or subarctic biomes. The flowers (Fig. 5.L) and leaves (Fig. 3.8) are incorporated into many traditional Alaskan dishes (Yanovsky 1936).

32. *Mertensia paniculata* (Aiton.) G.Don

This perennial species is native to an area from Canada to the central United States and typically grows in subalpine or subarctic biomes. Both the flowers (Fig. 5.K) and leaves (Fig. 3.34) are used as food in Alaska (Schofield 1989).

33. *Moltkia coerulea* (Willd.) Lehm.

This perennial species is native to a region from Turkey, Lebanon-Syria, and Transcaucasus to Iran, where it grows in temperate biomes. In Turkey, the flowers (Fig. 5.N) are added to some dishes for their unique taste, aroma, and color, and are also used as a garnish (Motti *et al*. 2022, Ozdemir & Alpınar 2011).

34. *Nonea persica* Boiss.

This perennial species is native to an area from Turkey and the Caucasus to Iran, where it grows in temperate biomes. In Iran, the leaves (Fig. 3.7) have long been used as a vegetable or in soups (Masoumi 2010).

35. *Nonea pulla* (L.) DC.

This annual or perennial plant is native to a vast range from Europe to the Russian Far East and Iran. In Turkey, both the leaves and roots are used to prepare various dishes and stews, giving this plant a special place in Turkish food culture (Kaval *et al*. 2015).

36. *Omphalodes spp*.

The specific species is not mentioned in the reference. Based on the description, the cooked leaves of certain *Omphalodes* species are added to soups and other dishes (Kunkel 1984).

37. *Onosma alborosea* Fisch. & C.A.Mey.

This subshrub is native to Iran, Iraq, Lebanon-Syria, and Turkey, where it grows in temperate biomes. Its aerial parts are widely used as a snack in Turkey and are added to some foods (Motti *et al*. 2022)

38. *Onosma roussaei* DC.

This perennial plant grows in the temperate biomes of a region from Turkey to Syria. The nectar is used in both Turkey and Syria as a flavoring added to some foods (Motti *et al*. 2022).

39. *Pentaglottis sempervirens* (L.) Tausch.

This biennial or perennial species is native to Spain, Portugal, and France but has also been introduced to the United Kingdom and the United States. It grows in temperate biomes. In Spain, the leaves (Fig. 3.29) and flowers (Fig. 5.D) are edible (Facciola 1990).

40. *Plagiobothrys campestris* Greene

This annual plant (syn: *Plagiobothrys fulvus* var. *campestris*) grows in temperate biomes and is native to California and Oregon in the United States. The cooked seeds (Fig. 6.38) are edible and consumed in these areas (Kunkel 1984, Yanovsky 1936).

41. *Pulmonaria officinalis* L.

This perennial species is native to Europe and has been introduced in the eastern United States. It grows mainly in the temperate biome. The leaves (Fig. 3.17) have been used in salads since ancient times (Guil-Guerrero 2003).

42. *Symphytum asperum* Lepech.

This perennial species is native to Iran, North Caucasus, Transcaucasus, and Turkey, and has been introduced to United States, Europe and parts of Central Asia. It grows mainly in the temperate biome. The leaves (Fig. 3.13) of are consumed as food in Turkey (Hedrick 1972, Launert 1981).

43. *Symphytum kurdicum* Boiss. & Hausskn.

This perennial species is native to Turkey, Iraq, and Iran, where it grows in temperate biomes. The leaves (Fig. 3.15) hold a special place in the food culture of Kurdistan and have been used in this region for a long time (Kaval *et al*. 2015).

44. *Symphytum officinale* L.

This perennial species is native to an area from Europe to western Siberia and northwestern Turkey and grows mainly in temperate biomes. The leaves (Fig. 3.31) and young branches are used for food, medicine, and animal fodder, though some parts may contain toxic compounds (Hedrick 1972, Launert 1981, Tanaka & Nakao 1976).

45. *Symphytum × uplandicum* Nyman

This perennial hybrid species (a cross between *S. asperum* and *S. officinale*) is native to the Caucasus and grows in temperate biomes. The raw or cooked shoots and leaves (Fig. 3.14) are edible (Hedrick 1972, Launert 1981).

46. *Trachystemon orientalis* (L.) D.Don

This rhizomatous geophyte is native to Turkey and Bulgaria but has also been introduced to some regions of Europe and Britain. It grows primarily in temperate biomes. The leaves (Fig. 4.I), flowering branches (Fig. 2.J), and rhizomes are used in some areas (Basher 1997, Baytop 1994, Kibar & Kibar 2016, Yıldırımlı 1994).

47. *Trichodesma indicum* (L.) Sm.

This annual species is native to a broad region from Afghanistan to Thailand, including the Indian subcontinent, Myanmar, the Philippines, and Sri Lanka. It has also been introduced to Cameroon, Kenya, Mauritius, and Tanzania. The leaves (Fig. 3.38) are used as food in some parts of Asia (Useful Tropical Plants 2023).

48. *Trichodesma zeylanicum* (Burm.f.) R.Br.

This subshrub is native to Australia, Southeast Asia, and much of Africa, where it grows in seasonally dry tropical biomes. In Tanzania, the leaves (Fig. 3.22) are consumed for their taste and high nutritional value (Mutie *et al*. 2023).

49. *Trigonotis icumae* (Maxim.) Makino

This perennial plant is native to South Korea and Japan and grows in temperate biomes. The leaves (Fig. 3.18) are cooked and eaten as food in these countries (Plants for a Future 2021).

50. *Trigonotis peduncularis* (Trevir.) Benth. ex Hemsl

This annual or perennial species is native to an area from southern European Russia to Asia and grows in temperate biomes. The leaves (Fig. 3.6) are cooked before consumption (Kunkel 1984, Yang *et al*. 2005).

Ⅱ. Cordiaceae Family

51. *Cordia africana* Lam.

This shrub or tree is native to Africa and Arabia and grows primarily in the seasonally dry tropical biome. Its fruit (Fig. 6.1) is edible and is used in various dishes in Ethiopia (Ashagre *et al*. 2016, Girmay *et al*. 2022, Mutie *et al*. 2023, Shaheen *et al*. 2017).

52. *Cordia alliodora* (Ruiz et Pav.) Oken

This shrub or tree is native to Central and South America and grows primarily in the seasonally dry tropical biome. The fruits (Fig. 6.2), known as *freijó* in Brazil, are commonly consumed fresh but are also processed into jams, chutneys, and balsamic vinegar. They are also used to produce medicine and animal feed (Segura *et al*. 2018).

53. *Cordia boissieri* A.DC.

This shrub or tree is native to Texas and Mexico and grows in desert or dry shrubland biomes. The fruits (Fig. 6.3) are used in Mexican cuisine (Kermath *et al*. 2018, Segura *et al*. 2018).

54. *Cordia collococca* L.

This shrub or tree is native to southern Mexico and tropical America. It grows in the seasonally dry tropical biome. The fruits (Fig. 6.4) are edible and can be used in cocktails and for making marmalades (Kermath *et al*. 2018).

55. *Cordia crenata* Delile

This shrub or tree is native to a broad range across Africa and Asia, including Eritrea, Ethiopia, India, Iran, Kenya, Niger, Oman, Somalia, Sudan, Tanzania, Uganda, and Yemen. It grows primarily in desert or dry shrubland biomes. The fruits (Fig. 6.5) are edible (Mutie *et al*. 2023).

56. *Cordia cymosa* (Donn.Sm.) Standl.

This tree is native to Central America and western South America and grows in wet tropical biomes. The fruits (Fig. 6.6) have a unique taste and are used in Ecuadorian cuisine (de la Torre *et al*. 2008).

57. *Cordia dentata* Poir.

This tree is native to Central America and northern South America and grows in the seasonally dry tropical biome. In addition to its medicinal uses, the fruit (Fig. 6.7) is consumed as food (Miller 1988, Segura *et al*. 2018).

58. *Cordia dichotoma* Forst.f.

This shrub or tree is native to a region from India to Australia and grows in seasonally dry tropical biomes. The fruits (Fig. 6.8) are edible (Khadar *et al*. 2016).

59. *Cordia dodecandra* A.DC.

This shrub or tree is native to Central Mexico, Guatemala, and Cuba, and grows in wet tropical biomes. The fruits (Fig. 6.9) have a unique taste and are used in some Brazilian dishes (Kermath *et al*. 2018, Segura *et al*. 2018).

60. *Cordia ellenbeckii* Gurke

This shrub or tree is native to Ethiopia and Kenya and grows in the seasonally dry tropical biome. The fruits (Fig. 6.10) are edible (Ashagre *et al*. 2016).

61. *Cordia lomatoloba* I.M.Johnst.

This tree is native to countries in North, Central, and South America and grows in wet tropical biomes. The fruits (Fig. 6.11) are edible and are used in Brazilian cuisine (Kermath *et al*. 2018).

62. *Cordia lutea* Lam.

This tree is native to Colombia, Ecuador, the Galapagos Islands, and Peru. It grows in the seasonally dry tropical biome. The fruits (Fig. 6.12) are edible and are used in various foods in South American countries (de la Torre *et al*. 2008).

63. *Cordia macleodii* Hook.f. & Thoms.

This ree is native to India and the western Himalayas and grows in the seasonally dry tropical biome. The fruits (Fig. 6.13) are edible and are used in some Indian foods (Khadar *et al*. 2016).

64. *Cordia monoica* Roxb.

This shrub or tree is native to most African countries, Saudi Arabia, India, Myanmar, Malaysia, and Madagascar. It grows in the seasonally dry tropical biome. The fruits (Fig. 6.14) are edible (Mutie *et al*. 2023, Ruffo *et al*. 2002).

65. *Cordia myxa* L.

This tree is native to a region from Iran to India and parts of China and has been introduced to Australia, Saudi Arabia, and some African countries. It grows in the seasonally dry tropical biome. The fruits (Fig. 6.15) are edible. They are consumed raw, used in various dishes, and processed into jam and pickles in Iran (Aberoumand 2011, Chauhan *et al*. 2014, Khadar *et al*. 2016, Khodayari *et al*. 2015, Meghwal *et al*. 2021).

66. *Cordia nodosa* Lam.

This tree is native to an area from North to central South America and grows in wet tropical biomes. The fruits (Fig. 6.16) are edible (de la Torre *et al*. 2008, Kermath *et al*. 2018).

67. *Cordia panamensis* L.Riley

This tree is native to an area from North to central South America and grows in the seasonally dry tropical biome. The fruits (Fig. 6.17) are edible and are used in various foods from Mexico to Peru (de la Torre *et al*. 2008).

68. *Cordia quercifolia* Klotzsch

This shrub or tree is native to dry tropical Africa, the Arabian Peninsula, India, and Sri Lanka. It grows in desert or dry shrubland biomes. The fruits (Fig. 6.18) are edible (Mutie *et al*. 2023).

69. *Cordia scabrifolia* A.DC.

This tree is native to South Tropical America and grows in wet tropical biomes. The fruits (Fig. 6.19) are edible and are used in some Brazilian foods (Kermath *et al*. 2018).

70. *Cordia sebestena* L.

This shrub or tree is native to the Florida Keys, the Caribbean, Mexico, and Venezuela. It grows in the seasonally dry tropical biome. The fruits (Fig. 6.20) are edible (Kermath *et al*. 2018, Miller 1988, Segura *et al*. 2018).

71. *Cordia seleriana* Fernald

This tree is native to southwestern Mexico and grows in the seasonally dry tropical biome. The fruits (Fig. 6.21) are edible (Segura *et al*. 2018).

72. *Cordia sellowiana* Cham.

This tree is native to an area from Bolivia to Brazil and Paraguay and grows in wet tropical biomes. The fruits (Fig. 6.22) are edible (Kermath *et al*. 2018).

73. *Cordia sinensis* Lam.

This shrub or tree is native to a region from Africa to the Indian Subcontinent and grows in the seasonally dry tropical biome. The fruits (Fig. 6.23) are edible. In Tanzania, they are used as a flavoring in food (Khadar *et al*. 2016, Mutie *et al*. 2023, Ruffo *et al*. 2002).

74. *Cordia somaliensis* Baker

This shrub or tree is native to an area from Somalia to Kenya and grows in the seasonally dry tropical biome. The fruits (Fig. 6.24) are edible and are consumed by local people (Mutie *et al*. 2023).

75. *Cordia sonorae* Rose

This tree is native to northern and western Mexico and grows in desert or dry shrubland biomes. The fruits (Fig. 6.25) are edible and are used in some Mexican foods (Segura *et al*. 2018).

76. *Cordia superba* Cham.

This shrub or tree is native to Brazil and grows in the seasonally dry tropical biome. The fruits (Fig. 6.26) are edible (Kermath *et al*. 2018).

77. *Cordia tetrandra* Aubl.

This tree is native to an area from the Windward Islands to South Tropical America and grows in wet tropical biomes. The fruits (Fig. 6.27) are edible (Kermath *et al*. 2018).

78. *Varronia calocephala* (Cham.) Friesen

This shrub is native to Brazil and grows in wet tropical biomes. The fruits (Fig. 6.28) are edible (Kermath *et al*. 2018).

79. *Varronia crenata* Ruiz & Pav.

This shrub is native to an area from Peru to Bolivia and grows primarily in the subtropical biome. The fruits (Fig. 6.37) are edible and are used in some foods in Ecuador (de la Torre *et al*. 2008).

80. *Varronia grandiflora* Desv.

This shrub is native to Colombia and Brazil and grows primarily in wet tropical biomes. The fruits are edible (Kermath *et al*. 2018).

81. *Varronia macrocephala* Desv.

This shrub is native to Brazil. The plant grows primarily in the seasonally dry tropical biome. Its fruits are edible (de la Torre *et al*. 2008).

82. *Varronia oaxacana* (A.DC.) Friesen

This shrub or tree is native to Mexico. The plant grows primarily in the seasonally dry tropical biome. Its fruits are edible (Segura *et al*. 2018).

Ⅲ. Ehretiaceae family

83. *Bourreria succulenta* Jacq.

This tree is native to Florida, Caribbean, Southern Mexico, and Northern Venezuela. It grows primarily in the seasonally dry tropical biome. In addition to its medicinal uses, the fruits (Fig. 6.36) are edible (Hedrick 1972, Kermath *et al*. 2018).

84. *Ehretia acuminata* R.Br.

This tree is native to Tropical and Subtropical Asia to Eestern Australia and grows primarily in the seasonally dry tropical biome. In addition to its medicinal uses, the fruits (Fig. 6.35) are edible and they have a special place in the food culture of some Asian regions (Cribb & Cribb 1976, Facciola 1990, Gamble 1972, Gupta 1945, Hedrick 1972, Kunkel 1984, Tanaka & Nakao 1976).

85. *Ehretia alba* Retief & A.E.van Wyk

This shrub or tree is native to southern Africa and grows primarily in the desert or dry shrubland biome. The fruits (Fig. 6.34) are edible and are used in local foods (Leffers 2003).

86. *Ehretia anacua* (Tera´n et Berland.) Johnst.

This tree is native to an area from Texas to Mexico and grows primarily in the subtropical biome. The fruits (Fig. 6.33) are edible (Facciola 1990, Kermath *et al*. 2018, Segura *et al*. 2018, Tanaka & Nakao 1976, Vines 1987, Yanovsky 1936).

87. *Ehretia cymosa* Thonn.

This shrub or tree is native to tropical Africa (Eritrea and Uganda), islands in the western Indian Ocean, and the Arabian Peninsula. It grows primarily in the seasonally dry tropical biome. The fruits (Fig. 6.32) are edible (Ashagre *et al*. 2016).

88. *Ehretia dicksonii* Hance

This species is a tree and is native to Nepal to Southeast Asia and Japan. This plant grows primarily in the subtropical biome. Its fruits (Fig. 6.31) are edible (Kunkel 1984, Tanaka & Nakao 1976).

89. *Ehretia janjalle* Verdc.

This tree is native to a region from Nepal to Southeast Asia and Japan and grows primarily in the subtropical biome. The fruits (Fig. 6.31) are edible (Mutie *et al*. 2023).

90. *Ehretia obtusifolia* Hochst. ex A.DC.

This shrub is native to Ethiopia and Kenya and grows primarily in the desert or dry shrubland biome. The fruits (Fig. 6.30) are edible and have a unique taste (Thulin 1993).

91. *Ehretia tinifolia* L.

This tree is native to Mexico to Central America, and Caribbean. It grows primarily in the seasonally dry tropical biome. Its fruits (Fig. 6.29) are edible and used to make beverages, liqueurs, syrups and jams as well as to flavor soups (Kermath *et al*. 2018, Segura *et al*. 2018).

Ⅳ. Heliotropiaceae family

92. *Euploca ovalifolia* (Forssk.) Diane & Hilger

This annual plant or subshrub is native to a vast range including Africa, Turkey, the Arabian Peninsula, the Indian Subcontinent, Indo-China, the Lesser Sunda Islands, and the Solomon Islands. It grows primarily in the seasonally dry tropical biome. The leaves (Fig. 3.4) are edible (Mutie *et al*. 2023).

93. *Heliotropium longiflorum* (A.DC.) Jaub. & Spach

This subshrub is native to Chile and grows primarily in the desert or dry shrubland biome. The leaves (Fig. 3.37) are aromatic and are used to flavor some dishes (Mutie *et al*. 2023).

94. *Heliotropium zeylanicum* (Burm.f.) Lam.

This perennial or subshrub is native to Africa, the Arabian Peninsula, and India, and grows primarily in the seasonally dry tropical biome. The young leaves (Fig. 3.21) have been used in some Indian and Tanzanian dishes for a long time and are integrated into local food cultures (Mutie *et al*. 2023, Ruffo *et al*. 2002).

Ⅴ. Hydrophyllaceae family

95. *Hydrophyllum appendiculatum* Michx.

This biennial species is native to southeastern Canada and the central and eastern United States. It grows primarily in the temperate biome. The leaves (Fig. 4.H) are edible (Kermath *et al*. 2018, Thayer 2006, Yanovsky 1936).

96. *Hydrophyllum canadense* L.

This perennial species is native to eastern Canada and the north-central and eastern United States. It grows primarily in the temperate biome. The leaves (Fig. 4.G) have been consumed for many years (Kermath *et al*. 2018, Thayer 2006, Yanovsky 1936).

97. *Hydrophyllum capitatum* Douglas ex Benth.

This biennial or perennial species is native to western Canada and the western and central United States. It grows primarily in the temperate biome. The leaves (Fig. 4.F) are used as food in some areas (Thayer 2006).

98. *Hydrophyllum fendleri* (A.Gray) A.Heller

This biennial or perennial species is native to the northwestern, western, and central United States. It grows in the temperate biome. The leaves (Fig. 4.E) are consumed in some areas (Thayer 2006).

99. *Hydrophyllum macrophyllum* Nutt.

This perennial species is native to East and Central United States of America and grows in the temperate biome. Its leaves (Fig. 4.D) serve as food or salads (Thayer 2006).

100. *Hydrophyllum occidentale* (S.Watson) A.Gray

This perennial species is native to the eastern and central United States. It grows in the temperate biome. The leaves (Fig. 4.D) are consumed as food or in salads (Kermath *et al*. 2018, Thayer 2006, Yanovsky 1936).

101. *Hydrophyllum tenuipes* A.Heller

This plant is native to an area from southwestern Canada to California in the western United States. It typically grows in temperate biomes. The leaves (Fig. 4.B) are a main ingredient in many local dishes where it is found (Thayer 2006).

102. *Hydrophyllum virginianum* L.

This perennial plant is native to Canada and the central, eastern, northeastern, and southeastern United States. It grows in temperate biomes. The leaves (Fig. 4.A) are highly popular as food in the eastern United States, where they are used in various dishes ranging from salads to sandwich fillings. The unopened flowers are also edible (Edible Wild Food 2011, Facciola 1990, Hedrick 1972, Kermath *et al*. 2018, Thayer 2006, Yanovsky 1936).

103. *Phacelia ramosissima* Dougi.

This annual plant is native to western Canada and the western United States and grows in temperate biomes. The leaves and flowers are known to local people and are commonly consumed. They have been eaten in many areas of North America in salads or as a side dish (Yanovsky 1936).

104. *Romanzoffia californica* Greene

This perennial species is native to Oregon and California in the United States and typically grows in temperate biomes. The leaves (Fig. 4.J) are known to local people and are commonly consumed (Schofield 2003).

Ⅵ. Lennoaceae family

105. *Pholisma arenarium* Nutt.

This plant is native to an area from California to Mexico and grows in dry, desert areas. The stems and roots (Fig. 2.K) are edible and are known to local people (Green Deane 2007-2018, Yanovsky 1936).

106. *Pholisma culiacana* (Dressler & Kuijt) Yatsk.

This species is native to Mexico and grows in dry areas. The stems (Fig. 2.L) are edible and have been consumed by local people for many years (Dressler & Kuijt 1968).

VII. Namaceae family

107. *Eriodictyon californicum* (Hook. & Arn.) Torr.

This shrub is native to Oregon and California in the United States. The leaves (Fig. 3.25) have been used as a vegetables and in salads in this region for many years (The Watershed Nursery 2023).

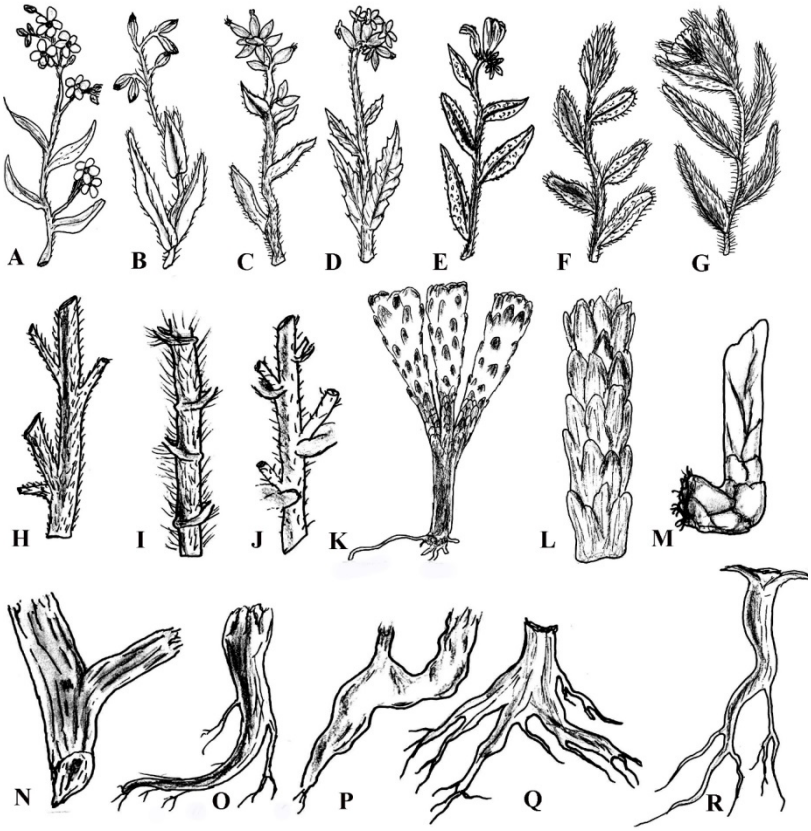

Figure 2. Edible shoots, stems, and roots of some Boraginales species. A) Shoot of *Anchusa riparia*, B) Shoot of *Anchusa strigosa*, C) Shoot of *Anchusa undulata* subsp. *granatensis*, D) Shoot of *Anchusa hybrida*, E) Shoot of *Echium creticum* subsp. *granatense*, F) Shoot of *Lithodora fruticosa*, G) Shoot of *Amsinckia lycopsoides*, H) Stem of *Borago officinalis*, I) Stem of *Alkanna tinctoria*, J) Stem of *Trachystemon orientalis*, K) Stem and root of *Pholisma arenarium*, L) Stem of *Pholisma culiacana*, M) Root of *Adelinia grandis*, N) Root of *Alkanna tinctoria*, O) Root of *Lithospermum incisum*, P) Root of *Mertensia maritime*, Q) Root of *Borago officinalis*, R) Root of *Anchusa azurea*. All are drawn by H. Nazari.

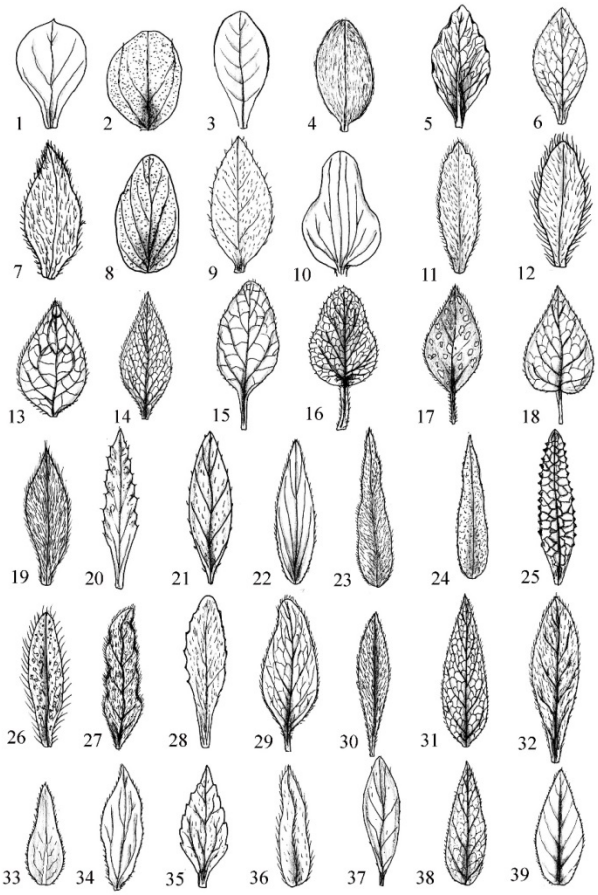

Figure 3. Edible leaves of Boraginales species. 1) *Mertensia maritime*, 2) *Mertensia longiflora*, 3) *Cerinthe major*, 4) *Euploca ovalifolia*, 5) *Echium plantagineum*, 6) *Trigonotis peduncularis*, 7) *Nonea persica*, 8) *Mertensia oblongifolia*, 9) *Bothriospermum tenellum*, 10) *Mertensia bella*, 11) *Anchusa undulata* L. subsp. *granatensis*, 12) *Alkanna tinctoria*, 13) *Symphytum asperum*, 14) *Symphytum × uplandicum*, 15) *Symphytum kurdicum*, 16) *Borago officinalis*, 17) *Pulmonaria officinalis*, 18) *Trigonotis icumae*, 19) *Alkanna froedinii*, 20) *Anchusa hybrida*, 21) *Heliotropium zeylanicum*, 22) *Trichodesma zeylanicum*, 23) *Anchusa capensis*, 24) *Anchusa riparia*, 25) *Eriodictyon californicum*, 26) *Lithodora fruticosa*, 27) *Echium creticum*, 28) *Cynoglossum monophlebium*, 29) *Pentaglottis sempervirens*, 30) *Echium amoenum*, 31) *Symphytum officinale*, 32) *Echium vulgare*, 33) *Anchusa azurea*, 34) *Mertensia paniculata*, 35) *Cynoglossum lanceolatum*, 36) *Anchusa strigosa*, 37) *Heliotropium longiflorum*, 38) *Trichodesma indicum*, 39) *Mertensia ciliata*. All are drawn by H. Nazari.

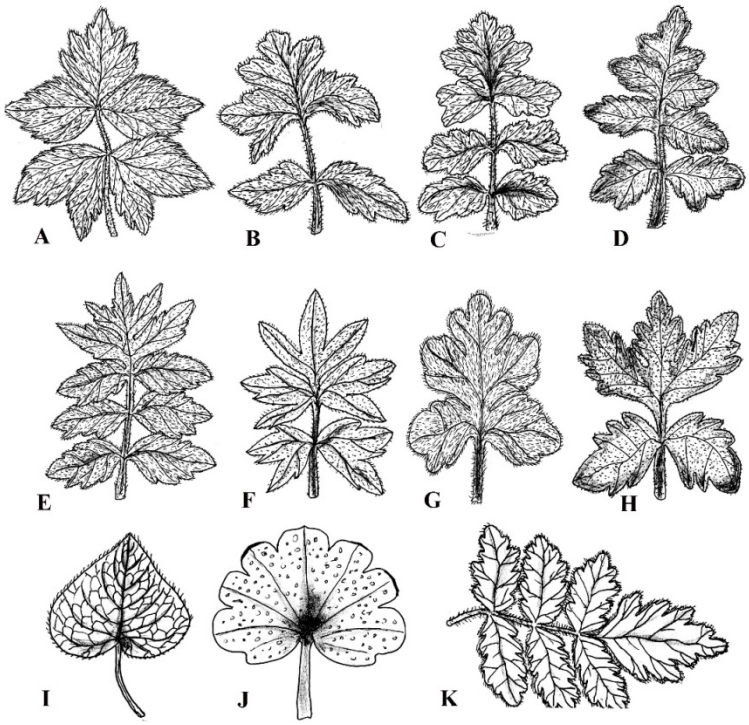

Figure 4. Edible leaves of Boraginales species. A) *Hydrophyllum virginianum*, B) *Hydrophyllum tenuipes*, C) *Hydrophyllum occidentale*, D) *Hydrophyllum macrophyllum*, E) *Hydrophyllum fendleri*, F) *Hydrophyllum capitatum*, G) *Hydrophyllum canadense*, H) *Hydrophyllum appendiculatum*, I) *Trachystemon orientalis*, J) *Romanzoffia californica*, K) *Phacelia ramosissima*. All are drawn by H. Nazari.

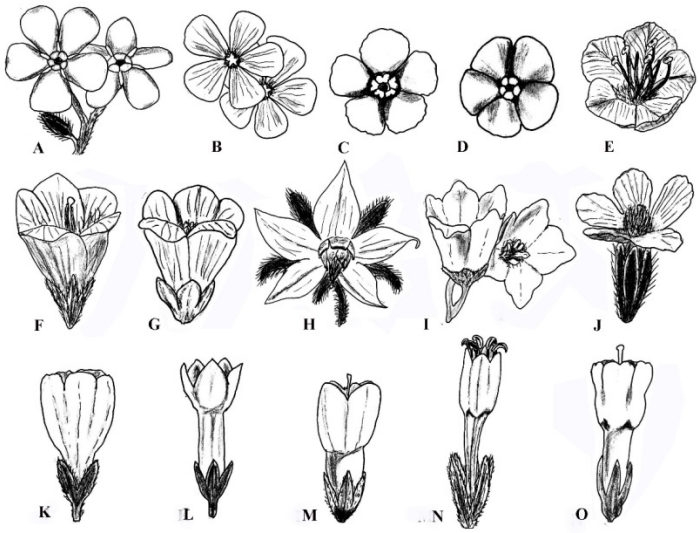

Figure 5. Edible flowers of Boraginales species. A) *Anchusa capensis*, B) *Anchusa azurea*, C) *Bothriospermum tenellum*, D) *Pentaglottis sempervirens*, E) *Phacelia ramosissima*, F) *Echium amoenum*, G) *Mertensia maritime*, H) *Borago officinalis*, I) *Mertensia bella*, J) *Anchusa strigosa*, K) *Mertensia paniculata*, L) *Mertensia oblongifolia*, M) *Mertensia ciliata*, N) *Moltkia coerulea*, O) *Mertensia longiflora*. All are drawn by H. Nazari.

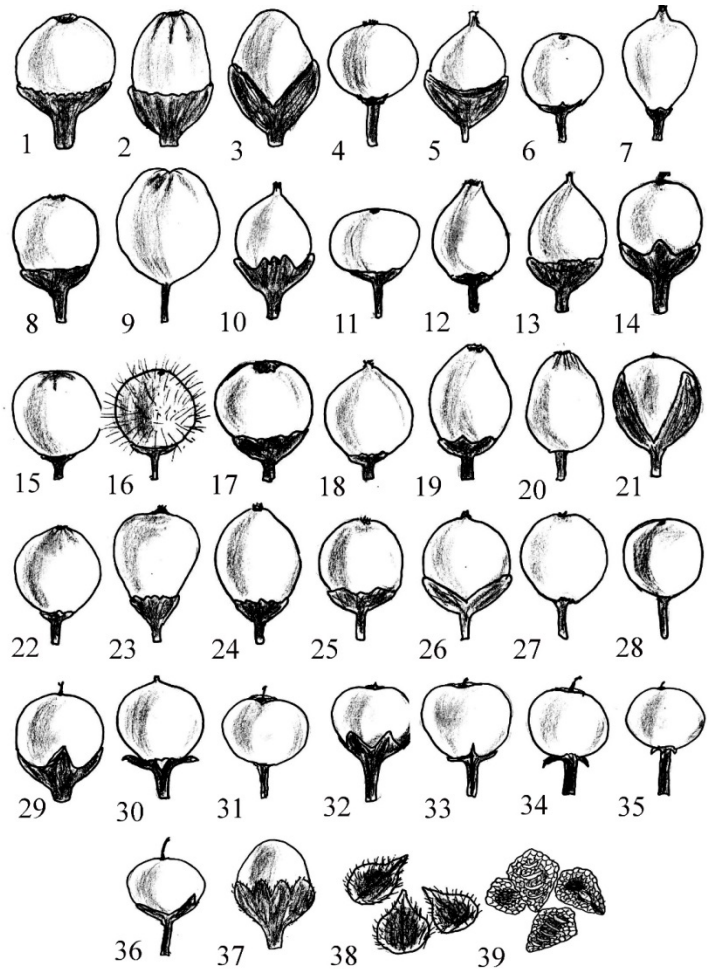

Figure 6. Edible fruits and seeds of Boraginales species. 1) *Cordia africana*, 2) *Cordia alliodora*, 3) *Cordia boissieri*, 4) *Cordia collococca*, 5) *Cordia crenata*, 6) *Cordia cymosa*, 7) *Cordia dentate*, 8) *Cordia dichotoma*, 9) *Cordia dodecandra*, 10) *Cordia ellenbeckii*, 11) *Cordia lomatoloba*, 12) *Cordia lutea*, 13) *Cordia macleodii*, 14) *Cordia monoica*, 15) *Cordia Myxa*, 16) *Cordia nodosa*, 17) *Cordia panamensis*, 18) *Cordia quercifolia*, 19) *Cordia scabrifolia*, 20) *Cordia sebestena*, 21) *Cordia seleriana*, 22) *Cordia sellowiana*, 23) *Cordia sinensis*, 24) *Cordia somaliensis*, 25) *Cordia sonorae*, 26) *Cordia superba*, 27) *Cordia tetrandra*, 28) *Ehretia tinifolia*, 29) *Ehretia obtusifolia*, 30) *Ehretia janjalle*, 31) *Ehretia dicksonii*, 32) *Ehretia cymosa*, 33) *Ehretia anacua*, 34) *Ehretia alba*, 35) *Ehretia acuminate*, 36) *Bourreria succulent*, 37) Seeds of *Varronia crenata*, 38) Seeds of *Plagiobothrys fulvus* var. *campestris*. All are drawn by H. Nazari.

In Table 1, the list of edible species of Borages (Boraginales) is arranged according to family. The edible parts of the species can also be seen.

Table 1. The list of edible species in Boraginales.

Family	Taxon	Edible part	Type of using	References
Boraginaceae	*Adelinia grandis* (Douglas ex Lehm.) J.I.Cohen	Root	Cooked	Yanovsky 1936
Boraginaceae	*Alkanna froedinii* Rech.f.	Leave, shoot, flower	Raw or cooked	Kaval *et al*. 2015
Boraginaceae	*Alkanna tinctoria* Tausch	Leaf, stem, root	Raw or cooked	Benítez *et al*. 2023
Boraginaceae	*Amsinckia lycopsoides* Lindl. ex Lehm.	Shoot	Raw	Kunkel 1984, Moerman 1998, Yanovsky 1936
Boraginaceae	*Amsinckia tessellata* A.Gray	Seed	Raw	Kunkel 1984, Moerman 1998, Yanovsky 1936

Boraginaceae	*Anchusa azurea* Mill.	Leaf, shoot, flower, root	Raw or cooked	Benítez *et al*. 2023, Chiej 1984, Eshaghi Milasi & Mahmoudi 2016, Kaval *et al*. 2015, Kunkel 1984, Masoumi 2010, Molero-Mesa and García-Barriuso 2017, Motti *et al*. 2022, Pinela *et al*. 2017
Boraginaceae	*Anchusa capensis* Thunb.	Leaf, flower	Raw or cooked	Elias & Dykeman 1982, Facciola 1998
Boraginaceae	*Anchusa riparia* A.DC.	Leaf, young shoot	Cooked	Facciola 1990, Johnson 1906
Boraginaceae	*Anchusa strigosa* Banks & Sol.	Leaf, shoot, flower	Raw	Motti *et al*. 2022
Boraginaceae	*Anchusa undulata* L. subsp. *granatensis* (Boiss.) Valdés	Leaf, shoot	Raw	Benítez *et al*. 2023, Molero-Mesa and García-Barriuso 2017
Boraginaceae	*Anchusa hybrida* Ten.	Leaf, shoot	Raw	Ertug 2004, Motti *et al*. 2022,
Boraginaceae	*Borago officinalis* L.	Leaf, stem, flower, root	Raw or cooked	Benítez *et al*. 2023, Ceccanti *et al*. 2018, Herrera *et al*. 2020, Molero-Mesa and García-Barriuso 2017, Motti *et al*. 2022, Pinela *et al*. 2017, Faisal *et al*. 2022, Kaisoon *et al*. 2012
Boraginaceae	*Bothriospermum tenellum* (Hornem.) Fisch. & C.A.Mey.	Leaf, flower	Raw	Kosaka *et al*. 2013
Boraginaceae	*Cerinthe major* L.	Leaf	Raw	Ertug 2004, Motti *et al*. 2022
Boraginaceae	*Cynoglossum lanceolatum* Forssk.	Leaf	Cooked	Useful Tropical Plants 2023
Boraginaceae	*Cynoglossum monophlebium* Baker	Leaf	Raw or cooked	Facciola 1998
Boraginaceae	*Echium amoenum* Fisch. & C.A.Mey.	Leaf, flower	Raw	Hoeeinpour-Azad *et al*. 2022, Khodayari *et al*. 2015, Torabi *et al*. 2022
Boraginaceae	*Echium creticum* L.	Leaf	Raw	Molero-Mesa & García-Barriuso 2017, Motti *et al*. 2022
Boraginaceae	*Echium creticum* L. subsp. *granatense* (Coincy) Valdés	Shoot	Raw	Benítez *et al*. 2023
Boraginaceae	*Echium italicum* L.	Nectar		Motti *et al*. 2022
Boraginaceae	*Echium plantagineum* L.	Leaf	Raw	Molero-Mesa & García-Barriuso 2017, Motti *et al*. 2022
Boraginaceae	*Echium vulgare* L.	Leaf	Raw	Molero-Mesa & García-Barriuso 2017, Motti *et al*. 2022
Boraginaceae	*Eritrichium spp.*	Leaf	Raw	Kunkel 1984
Boraginaceae	*Lithodora fruticosa* (L.) Griseb.	Shoot, leaf	Raw	Molero-Mesa & García-Barriuso 2017, Motti *et al*. 2022
Boraginaceae	*Lithospermum incisum* Lehm.	Root	Cooked	Yanovsky 1936

Boraginaceae	*Lithospermum officinale* L.	Leaf, fruit	Cooked	Molero-Mesa & García-Barriuso 2017, Yanovsky 1936
Boraginaceae	*Mertensia bella* Piper	Leaf, flower	Raw	Yanovsky 1936
Boraginaceae	*Mertensia ciliata* (E.James ex Torr.) G.Don	Leaf, flower	Raw	Yanovsky 1936
Boraginaceae	*Mertensia longiflora* Greene	Leaf, flower	Raw	Yanovsky 1936
Boraginaceae	*Mertensia maritima* (L.) Gray	Leaf, flower, root	Raw or cooked	Facciola 1990, Schofield 1989
Boraginaceae	*Mertensia oblongifolia* (Nutt.) G.Don	Leaf, flower	Raw	Yanovsky 1936
Boraginaceae	*Mertensia paniculata* (Aiton.) G.Don	Leaf, flower	Raw	Schofield 1989
Boraginaceae	*Moltkia coerulea* (Willd.) Lehm.	Flower	Raw	Motti *et al*. 2022, Ozdemir & Alpınar 2011
Boraginaceae	*Nonea persica* Boiss.	Young leaf	Raw	Masoumi 2010
Boraginaceae	*Nonea pulla* (L.) DC.	Leaf, root	Raw or cooked	Kaval *et al*. 2015
Boraginaceae	*Omphalodes spp*.	Young leaf	Cooked	Kunkel 1984
Boraginaceae	*Onosma alborosea* Fisch. & C.A.Mey	Nectar		Motti *et al*. 2022
Boraginaceae	*Onosma roussaei* DC.	Nectar		Motti *et al*. 2022
Boraginaceae	*Pentaglottis sempervirens* (L.) Tausch.	Leaf, flower	Raw	Huxley 1992, Facciola 1990, Phillips & Rix 1991
Boraginaceae	*Plagiobothrys campestris* Greene	Seed	Cooked	Yanovsky 1936
Boraginaceae	*Pulmonaria officinalis* L.	Leaf	Raw	Guil-Guerrero, 2003
Boraginaceae	*Symphytum asperum* Lepech.	Leaf	Raw or cooked	Hedrick 1972, Launert 1981
Boraginaceae	*Symphytum kurdicum* Boiss. & Hausskn.	Leaf	Raw	Kaval *et al*. 2015
Boraginaceae	*Symphytum officinale* L.	Leaf, shoot	Raw or cooked	Hedrick 1972, Launert 1981, Tanaka & Nakao 1976
Boraginaceae	*Symphytum × uplandicum* Nyman	Leaf, shoot	Raw or cooked	Hedrick 1972, Launert 1981
Boraginaceae	*Trachystemon orientalis* (L.) G.Don	Leaf, flowering shoots, rhizome, root, petiole, stem	Raw or cooked	Basher1997, Baytop 1994, Kibar & Kibar 2016, Yıldırımlı 1994
Boraginaceae	*Trichodesma indicum* (L.) Sm.	Leaf	Raw	Useful Tropical Plants 2023
Boraginaceae	*Trichodesma zeylanicum* (Burm.f.) R.Br.	Leaf	Raw	Mutie *et al*. 2023
Boraginaceae	*Trigonotis icumae* (Maxim.) Makino	Leaf	Cooked	Plants for a Future 2021
Boraginaceae	*Trigonotis peduncularis* (Trevir.) Benth. ex Hemsl	Leaf	Cooked	Kunkel 1984, Yang *et al*. 2005
Cordiaceae	*Cordia africana* Lam.	Fruit	Raw	Ashagre *et al*. 2016, Girmay *et al*. 2022, Mutie *et al*. 2023, Shaheen *et al*. 2017
Cordiaceae	*Cordia alliodora* (Ruiz et Pav.) Oken	Fruit	Raw	Segura *et al*. 2018
Cordiaceae	*Cordia boissieri* A.DC.	Fruit	Raw	Kermath *et al*. 2018, Segura *et al*. 2018
Cordiaceae	*Cordia collococca* L.	Fruit	Raw	Kermath *et al*. 2018
Cordiaceae	*Cordia crenata* Delile	Fruit	Raw	Mutie *et al*. 2023

Cordiaceae	*Cordia cymosa* (Donn.Sm.) Standl.	Fruit	Raw	de la Torre *et al*. 2008
Cordiaceae	*Cordia dentata* Poir.	Fruit	Raw	Miller 1988, Segura *et al*. 2018
Cordiaceae	*Cordia dichotoma* Forst.f	Fruit	Raw	Khadar *et al*. 2016
Cordiaceae	*Cordia dodecandra* A.DC.	Fruit	Raw	Kermath *et al*. 2018, Segura *et al*. 2018
Cordiaceae	*Cordia ellenbeckii* Gurke	Fruit	Raw	Ashagre *et al*. 2016
Cordiaceae	*Cordia lomatoloba* I.M.Johnst.	Fruit	Raw	Kermath *et al*. 2018
Cordiaceae	*Cordia* lutea Lam.	Fruit	Raw	de la Torre *et al*. 2008
Cordiaceae	*Cordia macleodii* Hook.f. & Thoms.	Fruit	Raw	Khadar *et al*. 2016
Cordiaceae	*Cordia monoica* Roxb.	Fruit	Raw	Mutie *et al*. 2023, Ruffo *et al*. 2002
Cordiaceae	*Cordia Myxa* L.	Fruit	Raw or cooked	Aberoumand 2011, Chauhan *et al*. 2014, Khadar *et al*. 2016, Khodayari *et al*. 2015, Meghwal *et al*. 2021
Cordiaceae	*Cordia nodosa* Lam.	Fruit	Raw	de la Torre *et al*. 2008, Kermath *et al*. 2018
Cordiaceae	*Cordia panamensis* L.Riley	Fruit	Raw	de la Torre *et al*. 2008
Cordiaceae	*Cordia quercifolia* Klotzsch	Fruit	Raw	Mutie *et al*. 2023
Cordiaceae	*Cordia scabrifolia* A.DC.	Fruit	Raw	Kermath *et al*. 2018
Cordiaceae	*Cordia sebestena* L.	Fruit	Raw	Kermath *et al*. 2018, Miller 1988, Segura *et al*. 2018
Cordiaceae	*Cordia seleriana* Fernald	Fruit	Raw	Segura *et al*. 2018
Cordiaceae	*Cordia sellowiana* Cham.	Fruit	Raw	Kermath *et al*. 2018
Cordiaceae	*Cordia sinensis* Lam.	Fruit	Raw	Khadar *et al*. 2016, Mutie *et al*. 2023, Ruffo *et al*. 2002
Cordiaceae	*Cordia somaliensis* Baker	Fruit	Raw	Mutie *et al*. 2023
Cordiaceae	*Cordia sonorae* Rose	Fruit	Raw	Segura *et al*. 2018
Cordiaceae	*Cordia superba* Cham.	Fruit	Raw	Kermath *et al*. 2018
Cordiaceae	*Cordia tetrandra* Aubl.	Fruit	Raw	Kermath *et al*. 2018
Cordiaceae	*Varronia calocephala* (Cham.) Friesen	Fruit	Raw	Kermath *et al*. 2018
Cordiaceae	*Varronia crenata* Ruiz & Pav.	Fruit	Raw	de la Torre *et al*. 2008
Cordiaceae	*Varronia grandiflora* Desv.	Fruit	Raw	Kermath *et al*. 2018
Cordiaceae	*Varronia macrocephala* Desv.	Fruit	Raw	de la Torre *et al*. 2008
Cordiaceae	*Varronia oaxacana* (A.DC.) Friesen	Fruit	Raw	Segura *et al*. 2018
Ehretiaceae	*Bourreria succulenta* Jacq.	Fruit	Raw	Hedrick 1972, Kermath *et al*. 2018
Ehretiaceae	*Ehretia acuminata* R.Br.	Fruit	Raw	Cribb & Cribb 1976, Facciola 1990, Gamble 1972, Gupta 1945, Hedrick 1972, Kunkel 1984, Tanaka & Nakao 1976
Ehretiaceae	*Ehretia alba* Retief & A.E.van Wyk	Fruit	Raw	Leffers 2003
Ehretiaceae	*Ehretia anacua* (Tera´n et Berland.) Johnst.	Fruit	Raw	Facciola 1990, Kermath *et al*. 2018, Segura *et al*. 2018, Tanaka & Nakao 1976, Vines 1987, Yanovsky 1936
Ehretiaceae	*Ehretia cymosa* Thonn.	Fruit	Raw	Ashagre *et al*. 2016

Ehretiaceae	*Ehretia dicksonii* Hance	Fruit	Raw	Kunkel 1984, Tanaka & Nakao 1976
Ehretiaceae	*Ehretia janjalle* Verdc.	Fruit	Raw	Mutie *et al*. 2023
Ehretiaceae	*Ehretia obtusifolia* Hochst. ex A.DC.	Fruit	Raw	Thulin 1993
Ehretiaceae	*Ehretia tinifolia* L.	Fruit	Raw	Kermath *et al*. 2018, Segura *et al*. 2018
Heliotropiaceae	*Euploca ovalifolia* (Forssk.) Diane & Hilger	Leaf	Raw	Mutie *et al*. 2023
Heliotropiaceae	*Heliotropium longiflorum* (A.DC.) Jaub. & Spach	Leaf	Raw or cooked	Mutie *et al*. 2023
Heliotropiaceae	*Heliotropium zeylanicum* (Burm.f.) Lam.	Young leaf	Raw or cooked	Mutie *et al*. 2023, Ruffo *et al*. 2002
Hydrophyllaceae	*Hydrophyllum appendiculatum* Michx.	Leaf	Raw or cooked	Kermath *et al*. 2018, Thayer 2006, Yanovsky 1936
Hydrophyllaceae	*Hydrophyllum canadense* L.	Leaf	Raw or cooked	Kermath *et al*. 2018, Thayer 2006, Yanovsky 1936
Hydrophyllaceae	*Hydrophyllum capitatum* Douglas ex Benth.	Leaf	Raw or cooked	Coffey 1993, Craighead et al. 1963, Thayer 2006
Hydrophyllaceae	*Hydrophyllum fendleri* (A.Gray) A.Heller	Leaf	Raw or cooked	Thayer 2006
Hydrophyllaceae	*Hydrophyllum macrophyllum* Nutt.	Leaf	Raw or cooked	Thayer 2006
Hydrophyllaceae	*Hydrophyllum occidentale* (S.Watson) A.Gray	Leaf	Raw or cooked	Kermath *et al*. 2018, Tanaka & Nakao 1976, Thayer 2006, Yanovsky 1936
Hydrophyllaceae	*Hydrophyllum tenuipes* A.Heller	Leaf	Raw or cooked	Gunther 1981, Kunkel 1984, Moerman Moerman 1998, Thayer 2006
Hydrophyllaceae	*Hydrophyllum virginianum* L.	Leaf	Raw or cooked	Edible Wild Food 2011, Facciola 1990, Hedrick 1972, Kermath *et al*. 2018, McPherson & McPherson 1977, Thayer 2006, Usher 1974, Yanovsky, 1936
Hydrophyllaceae	*Phacelia ramosissima* Dougi.	Leaf, flower	Raw	Craighead et al. 1963, Moerman 1998, Yanovsky 1936
Hydrophyllaceae	*Romanzoffia californica* Greene	Leaf	Raw	Schofield 2003
Lennoaceae	*Pholisma arenarium* Nutt.	Stem, root	Raw or cooked	Green Deane 2007-2018, Yanovsky 1936
Lennoaceae	*Pholisma culiacana* (Dressler & Kuijt) Yatsk.	Stem	Raw or cooked	Dressler & Kuijt 1968
Namaceae	*Eriodictyon californicum* (Hook. & Arn.) Torr.	Leaf	Raw	Facciola 1990, The Watershed Nursery

Based on Figure 7 the most edible part of the borages is the leaves at 38 percent, fallowed by the fruit at 30 percent. Then, flower with 12, shoot with 9, root with 6, stem with 4, and seed with 1 percent. As mentioned before, different parts of this group of plants are used raw or cooked. Some of them are used raw and some are cooked. Some are used in both ways. In Figure 8, the type of use of these plants is compared.

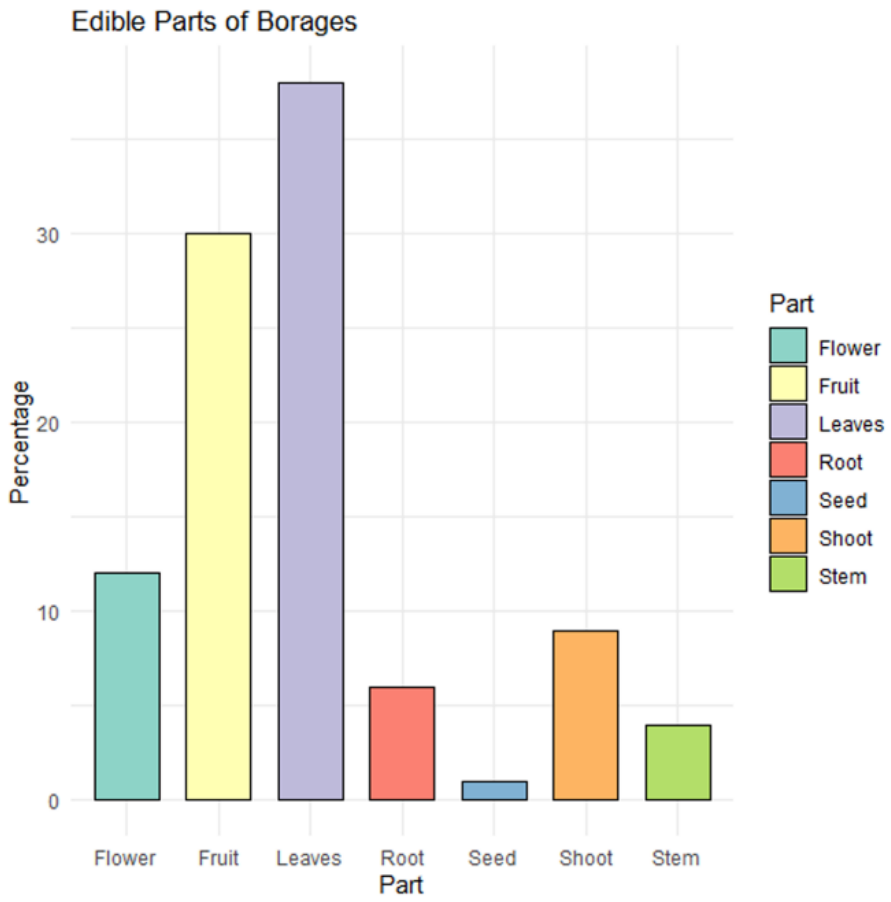

Figure 7. Percent of different edible parts of borages.

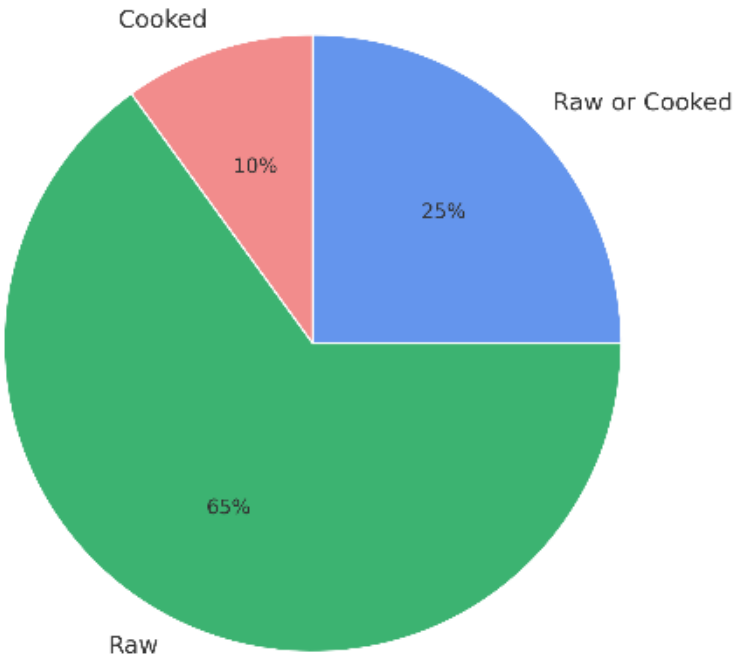

Figure 8. Type of food consumption of edible Boraginales species.

To further contextualise these patterns, we examined cross-cultural and geographical differences in the use of Boraginales species. The data reveal clear regional specializations: temperate areas of Europe, Turkey, and Iran emphasize leafy greens *(*For example *Borago officinalis*, *Anchusa spp*., *Symphytum spp*., *Trachystemon orientalis*) and flower infusions (*Echium amoenum*), whereas subalpine and subarctic North America emphasize on *Mertensia* foliage and flowers as seasonal greens

(Lyashenko *et al*. 2020). In contrast, tropical and subtropical regions—particularly Africa, Central and South America, and South Asia—show a strong reliance on fleshy fruits of *Cordia* and *Ehretia*, often consumed fresh or transformed into jams, pickles, or beverages (Biri *et al*. 2024).

These contrasts suggest that organ use is not random but is mediated by biome, plant life form, and culinary tradition. Indeed, the predominance of tree species in Central and South America and Africa appears to explain the greater reliance on fruits in those regions, whereas the dominance of herbaceous and shrubby taxa in Europe, West Asia, and northern latitudes favours the use of leaves and tender shoots. A synthesis of these regional tendencies is presented in Table 2, which highlights both the taxonomic focus and the dominant culinary practices across major biogeographic zones.

Table 2. Regional patterns of Boraginales consumption (summary of cross-cultural comparisons).

Region / Biome	**Dominant genera used**	**Main organ(s) consumed**	**Common preparation forms**	**Representative example**
Mediterranean & West Asia (temperate)	*Borago*, *Anchusa*, *Symphytum*, *Trachystemon*, *Echium*	Leaves, flowers	Salads, stews, teas	*Borago officinalis* (salads, soups), *Echium amoenum* (teas, desserts), *Trachystemon orientalis* (stews)
Northern latitudes (subalpine/subarctic)	*Mertensia*	Leaves, flowers	Raw greens, garnishes	*Mertensia maritima*, *M. paniculata*
Seasonally dry tropics (Africa, South Asia, Middle East)	*Cordia*, *Ehretia*	Fruits	Fresh fruit, pickles, jams	*Cordia myxa* (pickles, jams), *Ehretia cymosa* (fresh fruit)
Neotropics (Central & South America)	*Cordia*, *Varronia*	Fruits	Fresh fruit, jams, beverages	*Cordia alliodora*, *Varronia crenata*
Southern Africa (temperate to dry tropics)	*Anchusa*, *Ehretia*	Leaves, fruits	Cooked greens, fresh fruits	*Anchusa capensis* (salads), *Ehretia alba* (fruits)

Discussion

Based on the patterns revealed in Figure 9, the edible use profile of the order can be interpreted as follows.

Europe & West Asia

In Europe and West Asia, the edible uses of Boraginales are strongly concentrated in leaves, followed by shoots and stems, with flowers playing a secondary role and fruits and roots of only minor importance. This pattern reflects both the life-form composition of the regional flora and a long culinary tradition. The native Boraginaceae—such as *Borago officinalis*, *Anchusa spp*., *Symphytum officinale*, *Trachystemon orientalis*, and *Echium amoenum*—are predominantly herbaceous or sub-shrubby perennials that produce abundant tender foliage early in the growing season. For centuries, Mediterranean and West-Asian cuisines have celebrated wild greens ("horta") and herbal infusions, integrating these plants into soups, stews and teas. The ready availability of soft, renewable foliage and the deep cultural knowledge of wild vegetable cookery together explain why leaves and young shoots dominate the recorded food uses in this region.

North America

North America shows a broadly similar but distinct pattern: leaves again account for the majority of uses and flowers are comparatively well represented, while fruits remain modest and seeds—though rare—are uniquely documented here. Many native species, notably *Mertensia spp*. and *Hackelia spp*., are short-season perennials of boreal and montane habitats whose early-emerging foliage is easily harvested as spring greens. Indigenous and settler foragers have long valued both the fresh leaves and the showy flowers of these plants and a few western species such as *Amsinckia tessellata* and *Plagiobothrys spp*. also provided edible nutlets, representing one of the very few cases of "grain-like" consumption within the order. The scarcity of fruit-bearing *Cordia* trees in temperate North America reinforces the leaf- and flower-oriented profile.

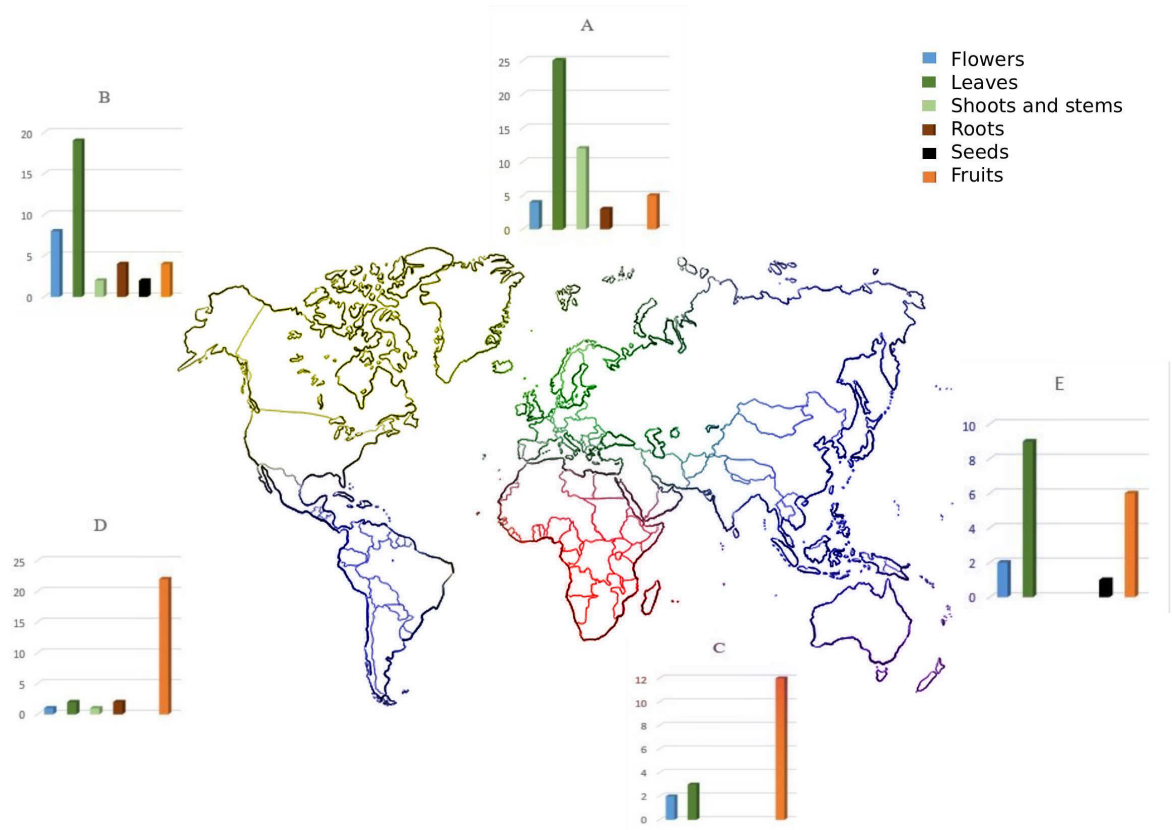

Figure 9. The use of different parts of edible Boraginales species in five different regions: A) Europe and West Asia, B) North America, C) Africa, D) Central and South America, E) East and South Asia.

Africa

Across Africa, the data reveal a striking emphasis on fruits, with only scattered records of leaves, flowers or roots. This reflects the dominance of woody Cordiaceae and Ehretiaceae—particularly *Cordia africana* and *Ehretia cymosa*—in savannah and semi-arid ecosystems. These trees set fleshy drupes reliably even under variable rainfall and have long supplied rural diets with seasonal sources of sugar and vitamins, whether eaten fresh or processed into jams and pickles. Herbaceous Boraginaceae are comparatively sparse in these landscapes, so the European-style tradition of wild leafy vegetables is far less prominent. The African pattern therefore highlights how the prevalence of fruiting tree species directs human food use toward fruits rather than leaves.

Central & South America

In Central and South America, fruit use overwhelmingly predominates, and all other plant parts are only rarely consumed. The Neotropics harbour exceptional diversity of arboreal *Cordia* and *Varronia* species whose sweet, mucilaginous drupes are eaten fresh, fermented into beverages or transformed into jams and sweets. Indigenous and rural communities have a long history of incorporating these fruits into everyday diets, while the relative scarcity of herbaceous Boraginaceae leaves little scope for the leafy-green traditions seen in temperate zones. The overwhelming focus on fruits in this region is therefore a direct consequence of the abundance of fruiting tree species and the cultural importance of their fleshy drupes.

East & Southeast Asia

East and Southeast Asia present a more balanced picture: leaves remain the most frequently used organ, but fruits are also significant and other parts such as flowers, roots and seeds are represented in smaller numbers. This mixed pattern mirrors the coexistence of tropical *Cordia* species, valued for their edible fruits (for example *Cordia dichotoma* and *C. obliqua*), with a suite of temperate or subtropical Boraginaceae herbs traditionally harvested for their greens. South and Southeast Asian cuisines integrate wild leafy vegetables into curries and soups, while pickled or fresh *Cordia* fruits provide seasonal delicacies. The region thus combines the temperate world's heritage of leafy-green cookery with the tropical emphasis on fruit consumption, illustrating how local floristic composition shapes the spectrum of edible plant parts.

Our records indicate regional specializations that align with both flora and foodways:
- Mediterranean-West Asian complex (Europe/Turkey/Iran): leaf-forward cuisines incorporating *Borago*, *Anchusa*, *Symphytum*, and *Trachystemon* as salads, potherbs, or stews; *Echium amoenum* flowers/leaves widely prepared as infusions in Iran.
- Northern latitudes (Europe/North America): repeated use of *Mertensia spp*. foliage and flowers, especially in subalpine/subarctic contexts where brief growing seasons favor rapid, leafy harvests.
- Tropical and subtropical belts (Africa, the Neotropics, South and Southeast Asia): a marked shift toward fleshy fruits of *Cordia* and *Ehretia*—often eaten fresh or processed (jams, pickles)—consistent with seasonally dry/wet tropical biomes where woody Cordiaceae/Ehretiaceae are diverse and locally abundant.
These contrasts suggest that organ use tracks both plant life form and biome, and that culinary traditions have adapted to the dominant edible opportunities provided by local floras.

Socio-ecological mechanisms behind variation
Several mechanisms plausibly explain who uses Boraginales, where, and why:
1. Biome filtering and life-form availability: Temperate floras host numerous herbaceous Boraginaceae suitable for leaf harvest, whereas tropical floras feature arborescent *Cordia* or *Ehretia* with reliable fruiting, a classic resource switch shaped by regional species pools. Examples span *Trachystemon* in temperate Europe, Turkey and *Cordia* across seasonally dry tropics in Africa and Latin America.
2. Culinary technology and processing: Our inventory notes preparation as raw, cooked, or both (Fig. 8), indicating that boiling orstewing blanches bitterness and mucilage and integrates leaves into soups and stews, techniques ubiquitous in Mediterranean and West Asian cuisines.
3. Market access and vernacular taxonomy: Fieldwork in three Iranian cities found only two Boraginales in trade, *Cordia myxa* and *Echium amoenum*, despite additional edible taxa occurring regionally, suggesting that commercial channels and name equivalences (e.g., *Borago* applied to *E. amoenum*) shape visibility and uptake.
4. Risk management and cultural screening: Awareness of plant pyrrolizidine alkaloids (PAs) in several Boraginaceae likely constrains which species/parts are normalized as foods, favoring species with a lower PA load, parts with lower concentrations, or preparations perceived to lower exposure; regulatory concerns are reflected in risk assessments.

Case studies that illustrate the framework
- Iran: *Echium amoenum* (as *Borago*) is sold primarily as an herbal tea; *Cordia myxa* is sold fresh/dried and processed (jams, pickles). This pairing reflects a leaf/flower infusion tradition alongside a fruit-processing economy in seasonally dry regions.
- Turkish and Mediterranean cuisines: repeated records of *Anchusa*, *Borago*, *Symphytum*, and *Trachystemon* as potherbs/greens; a culinary niche for tender leaves and shoots that harmonizes with local cooking methods (boil/sauté/stew).
- Subalpine/subarctic North America: *Mertensia* foliage and flowers used as seasonal greens and garnishes, short seasons, rapid leaf availability, and foraging traditions.

Conclusions

This review documents 107 edible species in the order Boraginales, spanning seven families, with Boraginaceae (50 spp.) and Cordiaceae (32 spp.) as the main contributors to human food use. Leaves dominate (38% of records), followed by fruits (30%), with flowers (12%), shoots (9%), roots (6%), stems (4%) and seeds (1%) (Fig. 7). Organ use shows a biogeographic split: temperate regions favour leafy herbaceous taxa such as *Borago officinalis*, *Anchusa* spp., *Mertensia* spp., *Symphytum* spp., *Trachystemon orientalis*, whereas tropical zones emphasise fleshy fruits of Cordia and Ehretia (e.g. *Cordia africana*, *C. lutea*, *C. myxa*, *Ehretia cymosa*).

The predominance of leaves reflects both ecological availability and culinary tradition. Herbaceous Boraginaceae produce abundant, renewable foliage easily incorporated into salads, stews and potherbs (Leporatti & Pavesi 1993, Şekeroğlu *et al*. 2015). Roots and seeds are rare (6 % and 1 %) owing to low starch allocation and modest seed set; flowers, used as infusions or garnishes (Albert *et al*. 2014, Gil *et al*. 2017), occupy an intermediate niche.

Edible Boraginales also provide notable phytochemicals, phenolic acids, saponins and alkaloids with antimicrobial, hepatoprotective and anti-inflammatory activity (Salehi *et al*. 2020, Korkmaz *et al*. 2019). *Borago officinalis* contains γ-linolenic acid, flavonoids, mucilage and vitamin C (Albert *et al*. 2014, Gil *et al*. 2017); *Symphytum* spp. are rich in rosmarinic

acid and allantoin (Barnes *et al*. 2007, Zaki *et al*. 2022). Several species offer high calcium, potassium, magnesium and fibre (Guarrera & Savo 2016, Łuczaj *et al*. 2012).

Ethnobotanical surveys across Italy, Turkey, Iran and the Balkans confirm their cultural importance (Rigat *et al*. 2009, Bartha *et al*. 2015, Sõukand & Pieroni 2016, Pieroni *et al*. 2013), yet these plants remain largely absent from mainstream agriculture and dietary guidelines, limited by low commercial cultivation and concerns over pyrrolizidine alkaloids (EFSA Panel 2011). Our market snapshot detected only *Cordia myxa* and *Echium amoenum* in trade, the latter sold as "*Borago*", showing how vernacular naming and market access shape visibility.

The leaf-fruit axis has clear implications: temperate leafy taxa can diversify micronutrient sources, while *Cordia*/*Ehretia* fruits can extend tropical fruit availability and support value-added products (jams, pickles, beverages). Food-safety demands species- and organ-specific PA profiling and regulatory guidance (EFSA Panel 2011).

Given rising food insecurity and climate stress, underutilised edible plants are vital for climate-resilient, nutritionally secure food systems (Hunter *et al*. 2019, Mabhaudhi *et al*. 2017). To realise this potential, further toxicological and agronomic studies should identify safe species and promote their inclusion in sustainable food policies (Schulz et al. 2015, Tuso *et al*. 2013). Controlled cultivation, value-chain development and nutritional profiling could mainstream Boraginales into functional foods and nutraceuticals, especially where food systems face biodiversity loss (Padulosi *et al*. 2014, Chivenge *et al*. 2015).

In summary, edible Boraginales represent an under-recognised but valuable resource for nutrition, culture and biodiversity conservation. Their distinct regional patterns of leaf and fruit use demonstrate how human food traditions track local floras; integrating these taxa into food-security strategies while ensuring rigorous safety assessments can diversify diets and support sustainable biodiversity use.

Declarations

List of abbreviations: Fig - Figure; C. - Central; E - Eastern; N - Northern; S - Southern; W - Western; NE - Northeast; NW - Northwest; SW - Southwest; U.S.A. - United States of America.
Ethics approval and consent to participate: The development of the study followed the ethical and legal guidelines for the development of research on traditional knowledge.
Consent for publication: Not applicable
Availability of data and materials: Not applicable
Competing interests: Not applicable
Funding: Not applicable
Author contributions: H.N. collected the data, analyzed, and wrote the text. F.Gh. participated in the theoretical background, monitoring data collection and analysis, helping with discussions, and wrote the final version of the text.

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