

# The edible flowers from woody ornamental plants

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## Abstract

Interreg Alcotra ANTEA (n. 1139) is an international project devoted to the development of the crossborder (IT-FR) the edible flower supply chain, the study of chemical and organoleptic characteristics of the flowers and their production with biological and sustainable methods. The popularity of edible flowers is increasing constantly; more and more restaurants propose these products as dishes garnishment or as real ingredient, improving plating and nutritional benefits of food preparations. Most of the edible flowers are produced by ornamental herbaceous (e.g., viola, nasturtium, marigold) or aromatic plants (e.g., sage, lavender, rosemary, basil, anise hyssop), although the flowers of several ornamental and fruit trees are used to have been eaten in traditional country meal recipes. In Europe, it is possible to list plants belonging to *Fabaceae* (acacia, mimosa, Judas tree, wisteria) and *Malvaceae* (hibiscus and linden) along with fruit species as orange, apple, and pear tree and elder, jasmine, lilac that, having interesting taste, are still source of edible flowers for traditional and innovative food preparations. In other part of the world, several exotic flowers of climbing plants and trees are consumed as supplement in the diet. Among these species *Clitoria ternatea*, *Erythrina americana*, *Erythrina berteroana*, *Sesbania grandiflora* (*Fabaceae*), *Bombax ceiba* (*Malvaceae*), *Arbutus xalapensis* (*Ericaceae*), *Acca sellowiana* (*Mirtaceae*), *Madhuca indica* (*Sapotaceae*), *Moringa oleifera* (*Moringaceae*), *Musa acuminata* (*Musaceae*), *Yucca* sp. (*Asparagaceae*) are an important source of proteins, carbohydrates, vitamins, mineral substances and antioxidants. In the frame of the activities of the project ANTEA, the aim of this mini review is to explore the nutritional characteristics of edible flowers from ornamental trees.

**Keywords:** edible petals, European tree, exotic tree, phenols, flavonoids

## INTRODUCTION

Currently, some flowers or inflorescence such as artichokes, broccoli, cauliflowers, capers, turnip greens and courgetti flowers are commonly eaten by consumers who consider them vegetables. Since time immemorial, edible flowers have been used to decorate dishes, add more colours, flavors or nutrients to poor dishes. Moreover, the use of edible flowers has been presented since the time of Greeks and romans in Europe and in all societies in other part of the World, like Chinese, Indian, African and South American cultures. The differences among the different cultures about the use of flowers in culinary preparations are the flower species used. All over the world the edible flower market is a niche market because the production is difficult, laborious and linked to seasonality, the shelf life of product is limited and the packaging is not easy (Fernandes et al., 2019). Interreg Alcotra ANTEA (n. 1139) is a project about the development of edible flower supply chain, the study of their chemical and organoleptic characteristics, and their production with biological and sustainable methods, including the packaging, the transport of products, information about edible flowers, and the statistical data about edible flower market. Most edible flowers derive from annual or perennial herbaceous plants easily cultivated in pots like calendula, nasturtium, marigold, pansies and violets. Another source of edible flowers are some bulbous species, such as *Hemerocallis* and tulips produce edible flowers; among these, tepals of *Crocus sativus*, generally considered a biological residue from saffron production, can be consumed, improving human diet with several compounds (polyphenols, anthocyanins and flavonoids),

characterized by healthy properties (Marchioni et al., 2019). Among the woody plants the edible flower species belong to the genus *Rosa* (Marchioni et al., 2021) or to aromatic shrub plants such as *Lavandula*, *Rosmarinus* and *Salvia*. Aromatic plants produce many essential oils and volatile organic compounds which add important properties to edible flowers (Najar et al., 2019). These compounds are mainly produced by the glandular trichomes which are present on the leaves and flowers, and in the same species the quantity and quality of these secondary compounds produced varies according to the age of plant, the environmental conditions, the genotype and also the symbiotic microorganisms (Copetta et al., 2006).

Flowers of several ornamental and fruit trees are used to have been eaten in traditional country meal recipes, but the studies about these flowers are less frequent compared to those on edible flowers from herbaceous plants. In general, the flowering period of woody plants is shorter than that of some herbaceous plants such as nasturtium, pansies or calendula, and therefore their consumption is more linked to seasonality, if no conservation or transformation processes are implemented. Edible flower trees must be grown in the ground to be fully productive, and therefore their cultivation requires more space than edible flowers from pots or herbaceous plants. Moreover, the collection of edible flowers from tree in nature can be carried out (foraging). These edible flowers are an important source of proteins, carbohydrates, vitamins, mineral substances and antioxidants (polyphenols, anthocyanins, carotenoids and flavonoids).

In the frame of the activities of the project ANTEA, the aim of this mini review is to explore the nutritional characteristics of edible flowers from ornamental trees belonging to very different botanical families: *Fabaceae*, *Malvaceae* and *Rosaceae* are the most represented (Table 1).

## MATERIALS AND METHODS

In the period from July 2019 to January 2020, searches were performed in the bibliographic databases: Google Scholar, PubMed, Web of Science and Scopus, using the keywords “edible flower”, combined with “nutraceutical compounds”, “antioxidant”, “woody plant” or scientific name of tree, and, if relevant, also synonyms. For the preparation of this mini-review, about one hundred and 20 articles concerning the use and nutraceutical characteristics of edible flowers, published among the 1990 and 2020, were taken into consideration.

### *Areaceae*

*Chamaedorea tepejilote* (pacaya) is a tropical forest palm native from Mexico to Colombia, and it is counted among the plants used by the ancient Maya. This species has been domesticated by local populations because it is a food resource. The immature male flowers are used to decorate salads or eaten wrapped in eggs. The immature flowers are a source of fibres and minerals and contain vitamins (A, B2, B3, C) (Cáceres and Cruz, 2019).

### *Asparagaceae*

In Mexico and Central American, the white flowers of *Yucca elephantipes* (giant yucca) are used as ingredients of traditional and regional dishes containing eggs or meat. Various parts of the flower (petals, stigma, style, ovules and ovaries) are edible. They can be used in recipes together or separately because each individual part has a distinctive taste and different chemical and nutritional composition (Juarez-Truillo et al., 2018). The flowers contain 15 fatty acids and 18 phenolic compounds (mainly 4-coumaric acid, rutin, vanillic acid, 4-hydroxybenzoic, ferulic acid and caffeic acid) presents in different quantities depending on the floral part. Other two species of yucca genus are indicated in literature as plants with edible flowers: *Y. filifera* (Sotelo et al., 2007) and *Y. filamentosa* (Newman and O’Conner 2009).

Table 1. List of ornamental woody plants with edible flowers used in the world including nutraceutical compounds present in their flowers.

Family	Genus or species	Origin	Eaten in	Bearing	Bloom	Nutraceutical compounds
Arecaceae	<i>Chamaedorea tepejilote</i> Liebm.	Central America	America	Palm	Undefined	Vitamins, amino acids
Asparagaceae	<i>Yucca elephantipes</i> Regel	North America	Central America	Shrub	Jun. - Sep.	Phenols, fatty acid
Caprifoliaceae	<i>Sambucus nigra</i> L.	Europe	Europe	Shrub	May - Jul.	Phenols, flavonoids, anthocyanins, carotenoids
Ericaceae	<i>Arbutus xalapensis</i> Kunth	North America	America	Tree	Feb. - Apr.	Amino acids
Fabaceae	<i>Acacia dealbata</i> Link	Tasmania	Europe	Tree	Gen. - Mar.	Phenols
	<i>Cercis siliquastrum</i> L.	Middle East	Asia, Europe	Tree	Apr. - May	Antioxidants
	<i>Clitoria ternatea</i> Linn.	Asia	Asia	Climbing	Jun. - Oct.	Anthocyanins, flavonoids
	<i>Erythrina</i> spp	North America	Mexico	Tree	Apr. - Jun.	Amino acids
	<i>Gliricidia sepium</i> (Jacq.) Kunth	North America	America	Tree	Dry season	Flavonoids, antioxidants, minerals
	<i>Robinia pseudoacacia</i> L.	North America	Asia, Europe	Tree	May - Jul.	Phenols, flavonoids, anthocyanins, carotenoids
	<i>Sesbania grandiflora</i> (L.) Pers.	Asia	Asia	Tree	Dec. - Feb.	Phenols, tannins, flavonoids
	<i>Wisteria floribunda</i> (Willd.) DC.	Asia	Asia, Europe	Climbing	Apr. - May	Phenols
Malvaceae	<i>Bombax ceiba</i> L.	Asia	Asia	Tree	Mar. - Apr.	Phenols, flavonoids, quinone
	<i>Hibiscus</i> spp.	Asia	Asia	Shrub	May - Oct.	Anthocyanins, flavonoids, vitamins, quercitin
	<i>Tilia</i> spp.	Europe, North America	Europe	Tree	May - Jun.	Polyphenols, carotenoids
Mirtaceae	<i>Acca sellowiana</i> (Berg) Burret.	South America	world	Shrub	Apr. - May	Anthocyanins, phenols, vitamin C
Moringaceae	<i>Moringa oleifera</i> Lam.	Asia	Asia, Africa	Tree	Undefined	Phenols, flavonoids
Musaceae	<i>Musa</i> spp.	Asia	Asia, Africa	Palm	Undefined	Amino acids, fatty acids, minerals
Peoniaceae	<i>Peonia</i> spp.	Asia	Asia	Shrub	Apr. - Jun.	Amino acids, fatty acids, polyphenols, flavonoids, minerals
Oleaceae	<i>Jasminum officinale</i> L.	Middle East	world	Climbing	Jun. - Sep.	Flavonoids, polyphenols
	<i>Jasminum Sambac</i> (L) Ait	Middle East	world	Climbing	Jun. - Sep.	Flavonoids, polyphenols
	<i>Osmanthus fragrance</i> (Thunb.) Lour.	Asia	Asia	Shrub	Jun. - Aug	Polyphenols, flavonoids
	<i>Syringa vulgaris</i> L.	Asia	Asia, Europe	Shrub	Apr. - Jun.	Flavonoids, phenols
Rosaceae	<i>Malus</i> spp.	Asia, Europe	Asia	Tree	Apr. - May	Amino acids, fatty acids, minerals
	<i>Prunus</i> spp.	Asia, Europe	Asia	Tree	Mar. - Apr.	Polyphenols, flavonoids
	<i>Pyrus pashia</i> Buch.-Ham.	Asia	Asia	Tree	Feb. - Apr.	Phenols, flavonoids
Rutaceae	<i>Citrus</i> spp.	Asia	Asia, Europe	Tree	Varies	Phenols, flavonoids
Sapotaceae	<i>Madhuca indica</i> L.	Asia	Asia	Tree	Feb. - Apr.	Proteins, flavonoids, tannins

### **Caprifoliaceae**

The white umbel inflorescences of *Sambucus nigra* (elderberry) are used to enrich salads, to prepare jams or to flavor cakes. A study (Loizzo et al., 2016) carried out about the phytochemical, antioxidant and hypoglycemic properties of the floral extracts of this plant reveals that the flowers are rich in phenols (228.5 mg g<sup>-1</sup> of extract), contain high quantity of flavonoids (rutin, quercetin, kaempferol and myricetin), anthocyanins and carotenoids. Moreover, the flower extract has a good antioxidant activity (1.4 µg mL<sup>-1</sup>). Nowicka and Wojdyło (2019) obtained comparable results by analysing dried flowers.

### **Ericaceae**

An evergreen plant with edible flowers growing in arid areas is *Arbutus xalapensis* (Texas madrone). Its flowers contain good quantity of proteins and free amino acids and toxic compounds like alkaloids, trypsin inhibitors and molecules with hemagglutinating activity. For this latter reason, the traditional preparation of the flowers requires cooking or boiling for reduce or eliminate the toxic compounds discarding the broth (Sotelo et al., 2007).

### **Fabaceae**

Several ornamental woody plants with edible flowers originating from various continents belong to *Fabaceae* family. The plants of this family produce papilionaceous flowers and are able to form symbiotic associations with nitrogen-fixing *Rhizobium* bacteria that fix atmospheric nitrogen, converting it into reduced forms, which is provided to host plants, improving their growth and development (Massa et al., 2020). For this reason, generally the seeds and flowers of *Fabaceae* plants are a good source of amino acids.

*Acacia dealbata* (mimosa) tree produces fragrant yellow flowers that are traditionally given away during the women's day. In addition to ornamental use, the mimosa flowers are edible, and they can be used to give colour to dishes and salads or fried in tempura. Ethanolic extract of mimosa flowers contains phenols and it shown a high antiradical activity (Casas et al., 2019).

In early spring, when the tree is leafless, *Cercis siliquastrum* (Judas tree) produces many pink flowers along the branches. They are used in Europe and Middle East to enrich salads, fried to produce omelettes or preserved in vinegar. The flowers extract shows antioxidants and antimicrobial activity (Amer et al., 2019)

*Clitoria ternatea* (butterfly pea) is a perennial climbing with plant woody foot originally from South East Asia. The beautiful blue flowers are very famous and are used to decorate recipes or to prepare blue teas and blue coloured dishes. In facts, the flowers contain anthocyanins (Terahara et al., 1996) and flavonoids (Kazuma et al., 2003) with antioxidant and medicinal activity (Morris, 2009).

The flowers of several species of *Erythrina* genus like *E. americana*, *E. berteroana* and *E. caribaea* are red and very showy, have toxic alkaloid compounds; but they are equally consumed by Mexicans who decrease the concentration of alkaloids by washing and boiling the flowers and eliminating the cooking water of the flowers. The flowers are a source of amino acids (Sotelo et al., 2007).

*Gliricidia sepium* (gliciridia) is a medium-sized tree already domesticated by Mayan and Quiche peoples. This tree is used in Mexico as shade for cocoa and coffee plantations and for this reason it is called 'Madrecacao'. The flowers are bright pink to lilac, gathered in racemes and they can be eaten boiled or fried. Cáceres and Cruz (2019) summarize in their review that gliciridia flowers possess anti-inflammatory, antibacterial and antioxidant activities and they are characterized by saponins, several flavonoids such as astragaline, robinine, trifoline, essential oils and minerals.

When *Robinia pseudoacacia* (locust-tree) is in bloom, it gives off a strong perfume that attracts bees which use nectar to produce honey (acacia honey). Its flowers are used in traditional cuisine and medicinal use both in Europe and Asia and can be eaten fresh, fried and dried or processed to produce jams, pancakes and liqueurs. The flowers extract contains flavonoids (rutin, kaempferol and myricetin), phenols, anthocyanins and carotenoids (Loizzo

et al., 2015).

In India, the red flowers of *Sesbania grandiflora* are eaten fresh or cooked while their juice is used as a traditional medicinal remedy. The flowers contain in their tissues high concentration of phenolics, tannins and flavonoids with antioxidant power and potential cytotoxic activity against human cervical cancer cell line Hela (Loganayaki et al., 2012).

*Wisteria floribunda* and *W. sinensis* (wisteria) are beautiful woody climbing ornamental plant that in spring produces a cascade of flowers whose colour can vary from white to blue to purple depending on the variety. In Italy, the flowers are used to decorate and add a floral taste to the salads, or they can be breaded in batter and fried. The edibility of wisteria flowers has not been studied in depth, Oh et al. (2008) shows that flower extracts with different solvents contain phenolic compounds and that the extracts have significant antioxidative activity and protective effect against oxidative DNA damage; while the toxicity of its seeds and pods is known (Rondeau, 1993).

### **Malvaceae**

*Bombax ceiba* (red silk-cotton tree) is a pantropical large deciduous tree with spiny trunk. The very showy and numerous red flowers begin appearing when the tree is leafless, and they produce copious nectar. The flower buds and the calyx of not fully opened flowers are eaten cooked as a vegetable (Rameshwar et al., 2014). The nutraceutical value of the flowers of this species has not been investigated, but a recent study finds the presence of phenolics, flavonoids and quinone into alcoholic and water extracts (Gulhane and Jadhao, 2016).

*Hibiscus rosa sinensis* is a shrub cultivated in the tropics as ornamental plant and has several forms with flowers of different colours which are used for medicinal purpose and for the preparations of infusions and decoctions. The nutraceutical properties of flowers are highly studied; they contain various anthocyanins, flavonoids, vitamins (riboflavin, ascorbic acid, thiamine) and other compounds like quercetin (Jadhav et al., 2009 and references). *Hibiscus syriacus* has characteristics like *H. rosa-sinensis* because it is also an ornamental shrub whose flowers can be consumed in infusions and decoctions.

Trees of the genus *Tilia* spp. (linden blossom) produce abundant flowers with a heady scent that attracts bees that use its nectar to make honey (linden honey). Linden flowers are used mainly for the preparation of herbal teas or to produce essential oils to add flavor and aroma into sweets and dishes. The linden dried flowers are rich in polyphenols and carotenoids, and the extract from freeze-dried powders shown a good activity in preventing diabetes mellitus (Nowicka and Wojdyło, 2019)

### **Mirtaceae**

*Acca sellowiana* (feijoa) is an ornamental fruit tree. The crisp white-pink fleshy petals of its beautiful flowers are edible and can be added to salads and foods as decoration and are appreciated also raw because in the mouth the soft petals tend to melt, and it seems to taste a blueberry flavored cream. A recent study shows that the non-enzymatic antioxidant defence system, characterized by polyphenols, anthocyanins, and ascorbic acid content into the flowers, shows the highest values in feijoa petals harvested at a precise stage: when the petals are fully open, anthers, filaments, and carpel have a dark reddish colour (Magri et al., 2020).

### **Moringaceae**

*Moringa oleifera* is a plant native of South Asia and all the parts of this plant such as root, bark, leaves, flowers, fruits and seeds have been used for medicine or food purposes. This species is appreciated in all tropical areas from Asia to Mexico. The flowers as the other parts of plants, mixed with curries are used to flavor chicken, fishes and soups. Its flowers are rich in antioxidants like phenolic compounds and flavonoids (Arulmozhi and Wilson, 2015), in addition to amino acids (mainly arginine, glutamate and aspartate) and fatty acids predominantly unsaturated (Sánchez-Machado et al., 2010).

### **Musaceae**

Several species of *Musa* produce edible flowers like *Musa acuminata*, *M. bajoo*, *M. paradisiaca* and many others (Kennedy, 2009). In Asia and Africa, the immature male inflorescences produced in clusters are cooked as vegetables and used as ingredient to prepare traditional dishes. Antioxidant activity of extract flowers is due to high phenolic compounds such as gallic acid, caffeic acid, quercitrin and isoquercitrin (Tai et al., 2014).

### **Peoniaceae**

Peonies are ornamental plants originating in China and now widely distributed all over the world (mainly Asia, Europe and America). In Asia the flowers of *Peonia suffruticosa* and *P. lactiflora* are used like ingredients of traditional food such as cakes, teas and drinks (Voon et al., 2013). The analyzes show that dried flower buds of *P. suffruticosa* are an important source of carbohydrates, crude proteins, essential amino acids, unsaturated fatty acids and minerals (mainly potassium, phosphorus, calcium and magnesium) (Voon et al., 2013). The extracts of *P. lactiflora* and *P. suffruticosa* contain also polyphenols and flavonoids, and have antioxidant activity (Zeng et al., 2014).

### **Oleaceae**

Only two species of jasmine can be ascribed as edible flowers: *Jasminus officinale* and *J. sambac* (jasmine). Both species are climbers with highly fragrant flowers which are mainly used for ornamental purposes or to produce perfumes and essential oils. Precisely for the characteristic fragrance and the presence of abundant nectar, the flowers are used in infusions and teas, and in confectionery industry for cakes and creams. Moreover, jasmine flowers have secondary compounds, with nutraceutical properties. For example, *J. sambac* contain into flowers flavonoids and polyphenols (Zeng et al., 2014).

*Osmanthus fragrance* (fragrant olive) is an Asiatic evergreen shrub used as ornamental plant. Fruit and flowers are edible. The flowers can spice tea, wine, soup and pastries adding an apricot flavor and polyphenol and flavonoid compounds (Zeng et al., 2014).

The scent of *Syringa vulgaris* (lilac) flowers is unforgettable. Its racemes are really ornamentals and can be eaten. The taste of flowers is floral and pungent, and are used to enrich salads, eggs or for flavor the sugar. The extract of lilac flowers shown remarkable antioxidant activity and contain significant amounts of phenylpropanoids, flavonoids and oleuropein (Tóth et al., 2016).

### **Rosaceae**

Many plants belonging to the *Rosaceae* family are fruit species; For this reason, the studies are focused about nutritional aspects of their fruits, and few are those dealing with flowers.

All over the world, *Malus* spp. (apple trees) are grown as plants to produce apples, moreover in China part of the pinkish white flowers of the apple tree are collected and used to prepare tea and decoctions: the flowers are often mixed with rose and orange petals for aromatic and floral tea. These flowers mainly contain carbohydrates and proteins, but they are also an important source of essentials amino acids, unsaturated fatty acids and minerals (mainly potassium, phosphorus, calcium and magnesium) (Voon et al., 2013).

In China, the use of *Prunus persica* (peach trees) flowers to embellish recipes is part of the popular tradition. The flowers are rich in polyphenolic and flavonoid compounds, and the flower extract shown free radical scavenging activities. Other *Prunus* species like *P. mume* are counted as edible flower tree. The analysis of the macerates of the flowers shows the presence of phenolic compounds (Shi et al., 2009).

The flowers of *Pyrus pashia* are cooked with chicken, eggs or meat and they are a valuable source of antioxidants molecules such as phenolics and flavonoids (He et al., 2015).

### **Rutaceae**

The flowers of the genus *Citrus* spp. (for example *C. limon*, *C. sinensis*, *C. medica* – in different varieties) are edible, are consumed both in Europe and in Asia for herbal teas, and

the preparation of sweets and liqueurs. The flowers have a citrus taste with intensity variations depending on the species and variety and an intense, sweet and floral aroma (Newman and O'Conner, 2009). A study focused on *C. medica* cv Diamante showed that flowers are characterized by high phenols and flavonoids content compared to fruits (Menichini et al., 2011).

### **Sapotaceae**

*Madhuca indica* or *M. longifolia* (mahua) is a tropical tree typical of Asia. Its fragrant yellow-cream flowers flowering from March-April as solitary clustered, and they are used to prepare liquor, grinded to powder and mixed with grain flour to prepare the chapatti (a local flat bread) biscuit, cake, laddu, candy, bar, jam jelly, sauces or mahua flowers are cooked to prepare traditional Indian dishes. Fresh flowers of *M. indica* contain bioactive compounds such as carbohydrates, proteins, flavonoids and tannins (Sinha et al., 2017).

### **CONCLUSIONS**

Many woody plants grown for ornamental purposes have edible flowers, and in most cases, they are part of the culinary or medicinal tradition of the country of origin. The nutritional characteristics of edible flowers from ornamental trees are phenols and flavonoids, but in-depth studies on the identification of all compounds are few and limited to some species.

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