Editorial: Edible flowers: Understanding the effect of genotype, preharvest, and postharvest on quality, safety, and consumption

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Biodiversity of edible flowers

The use of flowers as food is very ancient, since the times of the Greeks and Romans, when flowers were used to decorate various dishes and improve their aesthetic impact. They were part of the diet and improved the sensory quality of the dishes, thanks to their aromas, colors, texture, and taste. Edible flowers have always been widely used in the traditional cuisine in Asia and particularly in China, India, Thailand, and Japan. Today, the use of edible flowers is becoming more and more popular. Edible flowers can be used raw or fresh, as a garnish or an integral part of a dish. The flowers are consumed both as a conventional food and as a functional or nutraceutical food, thanks to the high and diversified content of bioactive compounds present in the various floral parts depending on the species (Falla et al., 2020).

The biodiversity of edible flowers is very wide. Alongside the commonly known edible flowers (e.g., Rosa hybr., Chrysanthemum × morifolium (Ramat.) Hemsl, Dianthus caryophyllus L., Tagetes L. spp., Hemerocallis L. spp., etc.), ornamental garden plants can be used (e.g., Robinia pseudoacacia L., Acca sellowiana (O. Berg) Burret, Forsythia ×intermedia Zabel, Bougainvillea glabra Choisy) or wild species (e.g., Glebionis segetum Fourr., Borago officinalis L., Malva sylvestris L., Centaurea cyanus L., Papaver rhoes L., etc.). In the list proposed by Lim (2014a,b) in the two books of the series dedicated...
Edible flowers and their potential benefit on human health

The introduction of flowers for consumption has raised questions about the value of edible flowers. Numerous researches have therefore investigated the composition of edible flowers, showing the richness of phytochemicals with bioactive properties, such as vitamins, minerals, and phenolics (Rop et al., 2012; Takahashi et al., 2020; Demasi et al., 2021a). Most studies are focusing on phenolics, a wide group of non-nutritional plant secondary metabolites that possess several beneficial properties and exert a strong antioxidant activity, scavenging reactive oxygen species (Durazzo et al., 2019). Adequate intake of phenolics could confer benefits for human health, by reducing the risk of cardiovascular, dysmetabolic, and neurodegenerative diseases, and cancer (in particular gastrointestinal neoplasms), by playing anti-inflammatory effects, and by favorably modulating the gut microbiota composition (Devecchi et al., 2021).

Edible flowers rich in health protective phenolic compounds could therefore provide novel opportunities as ingredient and nutraceutical sources to combat the increasing prevalence of diet and lifestyle-influenced non-communicable chronic diseases (NCDs), such as type 2 diabetes (T2D) (Devecchi et al., 2021).

Among edible flowers, roselle (Hibiscus sabdariffa L.) red calyces - already consumed as part of traditional cuisines and processed foods in several countries of Asia and Africa—are rich in phenolic compounds, which potentially have high antioxidant and anti-hyperglycemic properties. In vitro assays of four different organic solvents (chloroform, hexane, ethyl acetate, and initial crude extraction in 100% methanol) extracted fractions of calyces of roselle indicated that calyces of roselle are excellent sources of health protective phenolic compounds with high antioxidant and anti-hyperglycemic functions and organic solvent (ethyl acetate and methanol) extracted fractions of this edible flower can be strategically utilized to design functional food ingredients and nutraceuticals (Banwo et al.).

However, the phenolic composition of edible flowers as well as the presence and concentration of other botanicals vary widely between different tissues, plant parts, different species and cultivars, and based on the growing condition and environment (Demasi et al., 2021a; Falla et al., 2021).

Additionally, phenolics can interact with other nutritional components leading to the formation of soluble or insoluble complexes that can affect overall bioavailability, bioaccessibility, and health relevant functional properties of phenolics and can alter the health protective functional qualities of plant foods and food ingredients (Banwo et al.). At present, the contribution of edible flowers to human metabolism in vivo is almost unexplored. A first human pilot study, analyzing the relationship between the dietary content of phenolics from edible roses and the urinary phenolic excretion in healthy volunteers, found a direct relationship between the increasing rose phenolic content and the phenolic excretion, meaning that phenolics have been absorbed and metabolized by the body (Devecchi et al., 2021).

Thus, in vivo and human studies are needed to define and confirm the potential role of edible flowers on human health.

Postharvest handling and preservation of edible flowers

The postharvest chain of edible flowers must be carefully defined to ensure the highest quality to the consumer. Since the edible part is represented by the flower these must be characterized for their senescence process (Demasi et al., 2021b). Especially wild flowers are highly perishable, compared with the flowers from ornamental garden plants, because their stems are cut very short and they are usually dry stored (Toscano et al., 2021). Flowers are the most perishable organ...
of the plants. They are genetically programmed to be short-lived organ, in some flower the life span is limited to 1 day such as ephemeral flowers (Hemerocallis, Hibiscus, etc.). The metabolism of flowers is usually higher than other organs and characterized by higher respiration rates. Therefore, the primary strategy for preserving the edible flowers is to store and transport them at low temperature, such as below 5°C (Demasi et al., 2020). Low temperature reduces respiration and ethylene biosynthesis. Ethylene is a key regulator of flower senescence, especially in ethylene sensitive flowers (Reid and Wu, 1992). The preservation of the quality of edible flowers must be obtained by the identification of their ethylene production level and sensitivity to this plant hormone. Many flowers are very sensitive to ethylene, and they can senesce at concentration of 0.5 µL⁻¹. This concentration can be very often found in different step of the distribution chain or in the packaging. Flowers that are highly sensitive to ethylene must be protected from the ethylene action using specific inhibitor such as 1-methylciclopropene (1-MCP) or reducing its biosynthesis (Scariot et al., 2014).

As above describe the most used edible flowers are rich in antioxidant compounds that can help the flowers to counteract the senescence. Therefore, some of these antioxidant compounds can transiently increase and ensure a longer shelf life (Cavaiuolo et al., 2013).

In a study focused on four edible flower species, Ageratum houstonianum Mill, Tagetes lemmonii A. Gray, Salvia dorisiona Standl, and Pelargonium odoratissumum (L.) L’Hér ‘Lemon’ showed different behavior during storage highlighting the different attitude of edible flowers to preserve the quality. These flowers stored at 4°C up to 6 days showed an increase of lipid peroxidation where the antioxidant capacity was retained in three species except P. odoratissumum (Marchioni et al.). This species also showed a significant reduction of carbohydrates during storage. Among the different edible flower species, T. lemmonii is very interesting because retains the total ASA concentration during storage and has a shelf-life.

**Conclusion**

In conclusion, the biodiversity of edible flowers can become an important resource for gastronomic innovation, also for offering new flavors, colors (sensorial quality), and products with a high nutraceutical potential. Particularly, the wild edible flowers could be an important resource to obtain new food of interesting nutritional value; it is important, however, to investigate in view to better define which flowers can be used without problem on human health. Appropriate strategies of harvesting, cultivation, transport and storage must be used considering the postharvest physiology of edible flowers, their metabolism, composition in term of antioxidant compounds, ethylene production and sensitivity.

**Author contributions**

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

**Conflict of interest**

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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