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Review

A Comprehensive Review of Edible Flowers with a Focus on Microbiological, Nutritional, and Potential Health Aspects

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Abstract: Edible flowers have been used since ancient times directly as food, flavoring agents, and garnish in food products, and are now reappearing in modern cuisine. Edible flowers have gained popularity due to changing consumer habits focused on healthier food options. In addition to contributing to the esthetics and flavor of various dishes, edible flowers are now recognized for their nutritional value, as they contain bioactive components with different health benefits. However, a significant concern regarding edible flowers is the potential contamination by undesirable microorganisms. Since edible flowers are often consumed fresh or minimally processed, they can pose a microbiological risk. Edible flowers may be susceptible to contamination by various pathogenic microorganisms, particularly *Bacillus* spp., *Enterobacter* spp., *Salmonella* spp., and *Staphylococcus aureus.* In addition, mycotoxin-producing fungi, such as *Aspergillus*, *Penicillium*, *Alternaria*, or *Fusarium*, can be found in various flowers. Good agricultural practices, hygienic handling, and appropriate storage are essential to reduce contamination and guarantee the safe consumption of edible flowers. Since current investigations on the microbiological safety aspects of edible flowers are scarce, this review aims to provide an overview of the consumption of edible flowers and a discussion of their uses, health benefits, and risks, focusing on microbiological aspects.

Keywords: bacteria; pathogens; antioxidants; polyphenols; health benefits; novel ingredients; natural colorants; toxicity

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1. Introduction

Current food trends include the search for products perceived as 'natural' and with certain health-promoting properties [1–3]. In addition, plant-based foods have also become more popular in recent years [1]. Part of these trends can include edible flowers, considered as those flowers that are harmless and safe to eat and that bring positive health effects to the human being [4,5]. Edible flowers have been used since ancient times by different cultures for various purposes, including nutritional value, medicinal properties, sensory qualities, and ornamental value [6,7]. Although these are foods with a long history of use, recent years have seen a resurgence in the consumption of edible flowers [6,8,9]. In some countries, it is possible to purchase edible flowers in various kinds of shops, including supermarkets and health food stores, while in other nations the flower market is still limited to the production of ornamental ones [8,10].

The use of edible flowers in food production allows us to obtain products with distinctive color, appearance, and flavor features, making them interesting ingredients for the preparation of gourmet dishes, where visual perception and esthetics play an important role [1,2,11,12]. In addition, several research topics focus on finding natural alternatives to the use of food additives [13]. In this context, natural pigments present in edible flowers can be considered useful to providing color to beverages, yogurts, baked goods, and desserts [13–16]. As an example, innovative results can be obtained by adding certain flowers to food matrices, such as *Clitoria ternatea* (known as pea flower). This flower can add blue tones to food products and exhibits remarkable color-changing properties depending on the pH of the medium, shifting shades in acidic or alkaline environments [17]. Despite the importance of food appearance in influencing consumer's purchasing decisions, health consciousness plays a role in the consumption of edible flowers, so it is interesting to evaluate the amounts and forms of preparation required for each edible flower to maximize health benefits [12,18].

Edible flowers are recognized for their potential health-promoting properties including high antioxidant capacity, anti-bacterial effects, and a nutritional composition characterized by a wide variety of vitamins and minerals and a low-calorie content [19,20]. However, some of these flowers contain natural compounds that, while beneficial for the plant's defense, may have adverse effects on the human health. Furthermore, these foods can be associated with different biological (e.g., microorganisms, insects, etc.) or chemical risks [2,21]. On the other hand, the diversity of edible flowers can make it challenging to distinguish between toxic and non-toxic species. Regarding the microbiological characteristics of edible flowers, they can be contaminated by different microorganisms, including species belonging to the genera *Salmonella*, *Bacillus*, *Pseudomonas*, and *Enterobacter*, and this contamination can occur before or during harvest or also during the post-harvest handling of the product [18]. To date, scientific research on the microbiological safety aspects of edible flowers is scarce, so further studies are needed to assess the factors that may influence their safety in order to promote their marketing and consumption and extend shelf-life [8].

This review aims to bring together the current knowledge on the different aspects of edible flowers, with a particular focus on their microbiological aspects, nutritional attributes, and health benefits as well as their safety characteristics. The information provided is intended to promote the intake of safe edible flowers while also exploring the most effective methods of preparation.

2. Varieties of Edible Flowers

The flowers that are considered edible include approximately 180 species [22]. This large number comprises a wide variety of flowers, which can be categorized in different ways. One classification of edible flowers can be into fruit flowers (e.g., citrus or banana flowers) and non-fruit (or ornamental) flowers (e.g., hibiscus, begonias, and calendula) [8,23]. Additionally, some foods considered vegetables are actually inflorescences (e.g., artichoke, broccoli, and cauliflower) [3]. Figure 1 shows the different types of edible flowers. In this review, only ornamental flowers will be discussed.

In particular, the best-known species of ornamental edible flowers, their scientific and common names, their color and sensory characteristics, and their applications as food additives or for traditional and culinary uses are summarized in Table 1. As can be seen, most edible flowers are currently used in the preparation of different types of beverages and infusions or are included in salads or soups [8].

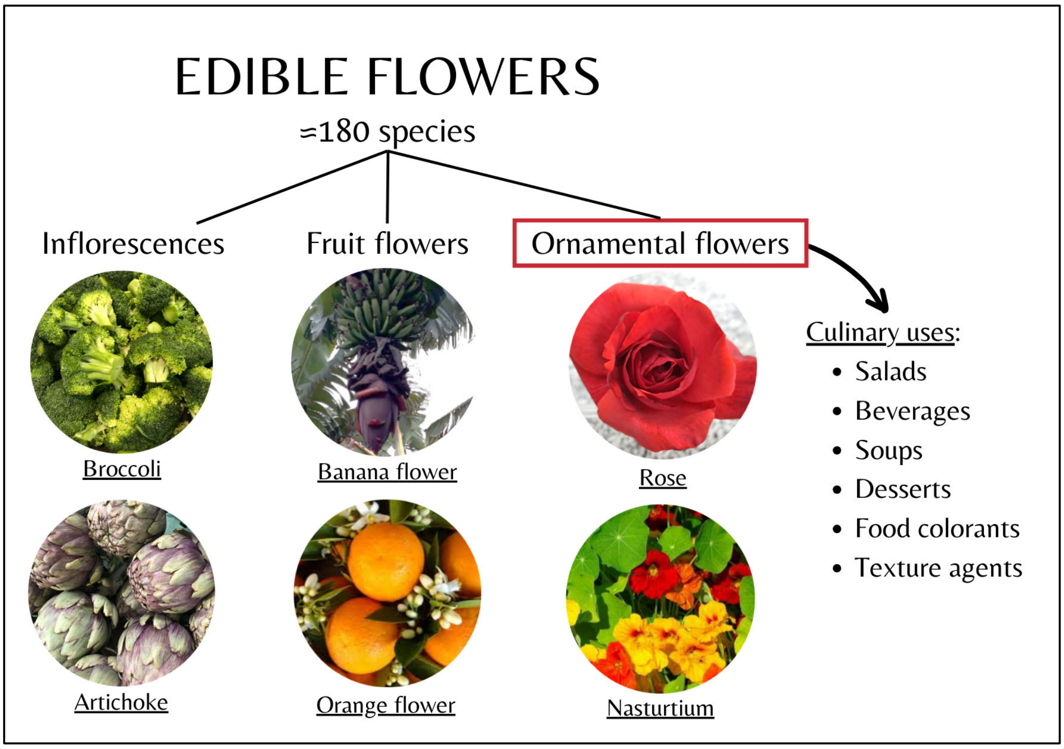

Figure 1. Classification and culinary uses of edible flowers. This review focuses on the use of ornamental flowers as edible flowers.

Chive flowers (*Allium schoenoprasum* L.), for example, are often used in dishes preparation since they offer a mild onion-garlic flavor with a hint of floral notes [3,24]. Species such as *Begonia × tuberhybrida* and *Begonia × semperflorens-cultorum*, *Hibiscus* L., and *Pelargornium hortorum*, are known for their citrus-like sensory taste and vibrant color and are often added to salads or used as garnish for dishes and drinks [3,7,25–31]. Flowers of *Chrysanthemum* spp., *Cichorium intybus* L., *Tagetes erecta*, *Taraxacum officinale* Weber, *Tropaeolum majus* L., and *Viola tricolor* are characterized by a bitter flavor and are widely used in both sweet preparations (pancakes, cookies, and desserts) and savory dishes (salads and omelets), making them a valuable ingredient in various cuisines, mainly Asian [25,26,30,32–37]. Then, there are flowers that have a sweeter, honey-like or intense floral flavor such as *Bougainvillea glabra*, *Lavandula angustifolia*, *Jasminum sambac*, *Malva sylvestris*, *Matricaraia chamomilla*, *Tulip gesneriana* L., or *Viola × wittrockiana*, that are used in the preparation of beverages, dessert, infusions, or syrups [26–28,30,38–41].

In general, edible flowers possess a delicate and non-invasive flavor. However, some have bitter or spicy notes that may not be appreciated by consumers. Some edible flowers may even resemble other foods, which facilitates their acceptance. Benvenuti et al. [42] conducted a sensory panel on this matter. Tasters were asked to associate the flavor of various flowers with foods and the panelists found similarities between certain flowers and fruits (*Begonia* was found like lemon, while *Tagetes erecta* resembled pomegranate) and vegetables (*Borago officinalis* L. was found like cucumber and *Tropaeolum majus* L. to radish). In addition, Cheng et al. [43] found that volatile compounds can differ according to the organ of the flower, with the petals having the highest content of these compounds in some cases.

Despite some studies having addressed this topic, further scientific research on sensory aspects of different flower varieties is needed to better understand their possible acceptance by consumers. An online questionnaire regarding the intake of edible flowers, carried out by Mulik et al. [44], revealed that almost 90% of the participants had a positive experience in consuming these kinds of flowers. This provides further exploration in this field, suggesting that edible flowers have the potential to achieve high levels of approval from the general population.

Furthermore, special attention can be given to the use of these flowers as additives in the food industry, since some of them can act as natural coloring agents (e.g., *Bougainvillea glabra*, *Clitoria ternatea*, and *Hibiscus* L.) or as texture agents (e.g., *Hibiscus* L. and *Malva sylvestris* L.) [45–47]. *Bougainvillea glabra* is known for its vibrant pigments and it is often used as a natural food coloring agent. *Clitoria ternatea*, instead, is rich in anthocyanins, and provides a striking blue or purple color to beverages, desserts, and other foods [47]. Also, *Hibiscus* L. contains anthocyanins and serves as a natural red or pink food dye, commonly used in teas, syrups, jams, and desserts [30]. Flowers like *Hibiscus* L. and *Malva sylvestris* are rich in mucilage which acts as natural thickener in soups, sauces, and desserts [48,49].

Table 1. Sensory aspects and food application of different edible flowers.

Scientific Name	Common Names	Color	Sensory Features	Food Application	Countries of Consume	References
Allium schoenoprasum L.	Chives	Pink, purple	Onion taste, strong flavor, spicy	Dips, soup	Europe, Asia, India	[3,24]
Begonia × tuberhybrida	Tuberous begonia	Pink, red, white, yellow	Citric and sweet flavor, crisp texture	Salads	Unknown	[25,26,28]
Begonia × semperflorens-cultorum	Wax begonia	Red, white	Citric, sour and sweet flavor, crisp texture	Salads	Unknown	[7,25–27]
Borago officinalis L.	Borage, starflower	Blue, purple, white	Similar flavor to cucumber, sweet flavor	Drinks, salads, soups, used as a spice	Denmark, Italy, Spain	[3,42,50,51]
Bougainvillea glabra	Bougainvillea, Bougainville, glory of the garden, paper flower	Orange, pink, violet	Intense color, subtle flavor	Food colorant, infusions, lemonade, salads	Thailand	[30,34,38,45,52]
Calendula officinalis L.	Calendula, pot marigold	Orange, yellow	Slightly bitter, similar flavor to saffron, peppery, easy chewiness	Beverages, food colorant infusions, salads	Bosnia-Herzegovina, Brazil, France, Italy	[3,25,37,42,50]
Centaurea cyanus L.	Centaurea, cornflower, bachelor's buttons	Blue	Spicy, vegetal flavor	Cakes, cookies, desserts, food colorant, infusions, salads	Unknown	[26,27,30]
Chrysanthemum spp.	Chrysanthemum	Pink, purple, white, yellow	Bitter flavor	Desserts, infusions, salads, soups	China	[26,32,53]
Cichorium intybus L.	Chicory	Blue, violet	Bitter flavor, similar flavor to endive	Salads, soups	Unknown	[3,27]
Clitoria ternatea	Asian pigeon wings, blue bell vine, blue pea flower, butterfly pea, Darwin pea	Blue, violet	Color changes with pH	Bio-preservative, bread, cakes, chocolate, food colorant, fermented beverages, infusions, noodles, yogurt	Argentina	[14,15,17,46,47,54–58]

Table 1. *Cont.*

Scientific Name	Common Names	Color	Sensory Features	Food Application	Countries of Consume	References
Cucurbita pepo L.	Zucchini flower	Orange, yellow	Slightly sweet, mild aroma	Dressings, fried, salads, soup, stuffed	Italy, Mexico, Slovenia, Spain, Türkiye	[9,50,59–62]
Dahlia mignon	Dahlia	Pink, white, yellow	N.D.	Food colorant	Mexico	[13,63]
Hibiscus L.	Hibiscus, Jamaica tea flower	Pink, red, orange	Acid and citrus flavor	Beverages, cakes, desserts, food colorant, ice cream, jam, muesli, pickles, salads, sauces, syrup, texture agent	China, Taiwan	[3,29,30]
Jasminum sambac	Arabian jasmine, Asian jasmine	White	Intense and floral aroma	Beverages, desserts, flavor agent, infusions, syrup	Taiwan	[12,30,41,64,65]
Lavandula angustifolia	Lavender	Lavender, purple, violet	Highly perfumed, intense flavor	Beverages, cakes, desserts, dressings, ice-cream, jam, pastry, soups	Argentina, Italy, Spain, Taiwan	[12,30,50]
Malva sylvestris L.	Blue Mallow, blue malva, cheese flower, common mallow	Pink, violet, white	Honey-like, sweet and floral flavor, spicy	Edible coating, food colorant, infusions, salads, soups, thickener	Boznia-Herzegovina, Spain	[30,39,50,66]
Matricaria chamomilla	Chamomile, German chamomile	White, yellow	Floral flavor, sweet scented	Beverages, desserts, baked goods, ice cream, infusions, jam, salads	Unknown	[27,40,67]
Nelumbo nucifera	Lotus	White	Crunchy texture, mild flavor	Infusions, fried, salads, soups	Vietnam	[27,30,34,40]
Pelargonium hortorum	Common geranium, garden geranium, malvon	Orange, pink, red, white	Citric flavor	Beverages, desserts, salads,	Unknown	[31]
Petunia hybrida	Petunia	Blue, pink, purple, red, white, yellow	Mild- tasting	Salads	Unknown	[30]
Rhododendron arboreum	Rhododendron	Pink, red, white	Sweet, sour flavor, bitter	Fermented beverages, food colorant, flavor agent, jam, jellies, juices, yogurt	China	[30,68–72]
Rosa spp.	Rose	Orange, red, pink, white, yellow	Astringent, highly aromatic, slightly bitter, sweet	Beverages, desserts, food colorant, ice cream, infusions, jam, liquors, muesli, preservative in meat products, syrup	Brazil, China, Taiwan, Slovenia	[2,3,12,25,26,28,29,60,73]
Tagetes erecta	Marigol, Mexican marigold	Orange, red, white, yellow	Bitter, similar flavor to pomegranate, strong flavor	Baked goods, beverages, butter, salads, soups	Mexico, Thailand	[3,27,33,34,42]

Table 1. *Cont.*

Scientific Name	Common Names	Color	Sensory Features	Food Application	Countries of Consume	References
Taraxacum officinale Weber	Dandelion, Lion's Tooth	Yellow	Bitter flavor	Desserts, cheese, flavor agent in sweet meals, salads, vegan honey substitute, wine	Unknown	[3,35,36]
Tropaeolum majus L.	Empress of India, nasturtium, monks Cress,	Orange, red, white, yellow	Bitter, peppery, similar flavor to radish, spicy	Beverages, dips, salads, vinegar	Denmark, Croatia	[25,30,37,42,50,51]
Tulip gesneriana L.	Tulip	Red, pink, yellow,	Similar flavor to pea, sweet,	Salads, stuffed, syrup	Unknown	[28,30]
Viola tricolor L.	Heart's ease, wild pansy	Multi-colored, pink, violet, white, yellow	Bitter	Beverages, cookies, desserts, salad, soups	Australia, Denmark, Italy	[3,27,30,50,51]
Viola × wittrockiana	Pansy	Multi-colored, pink, violet, yellow, white	Sweet flavor	Beverages, cookies, desserts, salad, soups	Brazil	[3,26,30,60]

3. Nutritional Composition of Edible Flowers

Edible flowers are increasingly recognized for their nutritional and health-promoting properties, being rich in essential nutrients, bioactive compounds, and phytochemicals that contribute to a balanced diet and provide various functional benefits. The chemical composition and bioactive constituents of edible flowers are shown in Table 2. According to Jadhav et al. [8], water is the major component of edible flowers (about 70–90% of the total weight); so, the dry matter in edible flowers is very low. Therefore, due to their low yield, a significant amount of fresh flowers is required to produce 100 g of dried flowers [34,74].

The proximate composition of edible flowers varies greatly between species, but several general trends can be observed. Edible flowers are a good source of protein and dietary fiber, with protein content typically ranging from 2% to 23%, depending on the species and environmental factors affecting growth [25,75]. The lipid content is generally lower than 10%, while soluble sugars, composed by total or reducing sugars, are present in amounts higher than 15% [10,25,75–77]. These sugars contribute to the sweetness and flavor profile of certain flowers. Crude fiber (CF) content varies from 0.4% to 20.5%, while total dietary fiber (TDF) values range from 17.2% to 75.9% [10,75,78,79]. TDF values are usually more than 50% higher than CF values, because they include non-digestible molecules such as polysaccharides and oligosaccharides (e.g., cellulose, lignin, pectin, mucilage, and gums) that provide low amounts of calories. Finally, the ash content, which represents the total minerals of edible flowers, has been reported to range from 3.8% to 22.0% with some exceptions depending on the specific type of flower [76,78]. Other nutritional components of edible flowers include a variety of phenolic compounds, vitamins, and minerals, as well as flavonoids and carotenoids. Specific characteristics of the major compounds present in edible flowers are detailed below.

3.1. Carbohydrate, Sugar, and Fiber Composition

Carbohydrates are one of the most abundant compounds in edible flowers, with reported values exceeding 90 g/100 g of dry weight (d.w) in species such as *Rosa spp.* [80] or 80 g/100 g in *Hibiscus acetosella* [81]. The total carbohydrate content can vary from 3.3 to 90.0% depending on the flower species.

The composition of soluble sugars in edible flowers is crucial for their taste and nutritional value. Fructose, glucose, and sucrose are the primary sugars present in flowers, with significant variability depending on the species [82]. As reported in Table 2, different authors found high amounts of total sugars in flowers from *Allium* spp., *Borago officinalis*, *Centaurea cyanus*, *Cucurbita moschata* (Butternut squash), and *Fuchsia regia*.

Regarding dietary fiber content of edible flowers, Jakubczyk et al. [83] evaluated different flower varieties. Among them, samples of *Calendula officinalis* L. showed the highest total fiber content (62.3 g/100 g d.w), followed by *Centaurea cyanus* L. (53.1 g/100 g d.w), *Cichorium intybus* L. (32.2 g/100 g d.w), *Taraxacum officinale* (27.0 g/100 g d.w), *Syringa vulgaris* L. (25.9 g/100 g d.w), and *Magnolia* × *soulangeana* (13.2 g/100 g d.w). Most of the fiber present in these samples corresponded to insoluble fiber, with values ranging from 8.7 g/100 g d.w (*Magnolia* × *soulangeana*) to 57.5 g/100 g d.w (*Calendula officinalis* L.).

Table 2. Nutritional composition of different edible flowers (d.w).

Scientific Name	CarboH (g/100 g)	Sugars (g/100 g)	Proteins (g/100 g)	Lipids (g/100 g)	Fiber (g/100 g)	Ash (g/100 g)	Minerals [1] (mg/100 g)	Vitamin C (mg/100 g)	TPC—CAR	References
Allium spp.	3.3–18.6	6.6–26.2	-	-	-	-	-	35.4–157.8 (f.w)	TPC: 3.6–10.6 CAR: 3.0–23.4	[84]
	-	50.0	15.3	3.4	CF: 6.1	3.8	-	542.1	TPC: 1877.9 CAR: 291.1	[76]
	-	-	-	-	-	-	Potassium (K) Calcium (Ca), Sodium (Na), Iron (Fe), Zinc (Zn)	-	-	[85]
Begonia × *tuberhybrida*	-	-	3.9	-	-	-	K, Ca, Na	-	TPC: 42.3	[25]
Borago officinalis L.	- -	28.8	9.4	4.3	TDF: 40.4	9.3	-	-	-	[10]
	-	16.8	22.7	4.9	TDF: 35.4	15.3	-	-	CAR: 181.4	[75]
	-	20.3	14.4	-	CF: 15.3	14.7	-	196.4	-	[77]
	-	-	-	-	-	-	K, Na, Ca, Fe, Zn, Manganese (Mn)	-	TPC: 16.6 TF: 12.6	[84]
Calendula officinalis L.	3.6 (f.w)	6.2 (f.w)	4.6 (f.w)	-	CF: 1.1 (f.w)	18.4	Fe, Zn, Mn	40.0 (f.w)	TPC [2]: 61.0 (f.w) TF: 37.9 (f.w)	[79]
	-	-	-	-	-	-	K, Na, Ca, Fe, Zn, Mn	-	TPC: 16.3 TF: 9.4	[86]
	-	-	3.9	-	-	-	K, Ca, Na	-	TPC: 40.6	[25]
	-	-	8.7	-	TDF: 62.3	-	-	-	-	[83]
	-	-	-	-	-	-	-	-	TPC: 290.8 CAR: 5745.3	[87]

Table 2. *Cont.*

Scientific Name	CarboH (g/100 g)	Sugars (g/100 g)	Proteins (g/100 g)	Lipids (g/100 g)	Fiber (g/100 g)	Ash (g/100 g)	Minerals [1] (mg/100 g)	Vitamin C (mg/100 g)	TPC—CAR	References
Centaurea cyanus	-	11.9	8.5	4.4	TDF: 75.9	5.7	-	-	-	[10]
	-	20.6	6.9	3.4	TDF: 67.4	5.2	-	-	CAR: 5.8	[75]
	-	-	6.9	-	-	-	K, Ca, Na	-	TPC: 48.9 TF [3]: 18.6	[26]
	-	-	9.6	-	TDF: 53.1	-	-	-	-	[83]
Chrysanthemum frutescens	-	-	7.2	-	-	-	K, Ca, Na	-	TPC: 26.4 TF [3]: 12.9	[26]
Cucurbita pepo	-	-	21.9	5.0	10.5	15.9	-	-	-	[88]
Cucurbita máxima spp.	-	-	-	24.8	41.4	28.1	-	0.4	TPC: 498.3 TF: 304.4	[89]
	25.1	-	14.8	17.0	CF 20.5	22.0	-	149.2	-	[78]
	-	-	-	-	-	-	Ca, K, Na, Fe, Zn	-	-	[85]
	5.3 (f.w)	2.0 (f.w)	2.2 (f.w)	0.2 (f.w)	CF 4.4 (f.w)	3.1 (f.w)	K, Ca, Na, Fe	-	-	[90]
Cucurbita moschata Duchesne	-	-	14.5	-	-	-	Ca, Mn, Fe, Zn	10.7	TPC: 8.4 TF: 3.8 CAR: 8.8	[91]
Dianthus chinensis L.	-	-	9.7	-	-	-	Ca, Fe, Mn, Zn	122.1	TPC: 10.1	[91]
	32.6 (f.w)	12.1 (f.w)	19.5 (f.w)	-	CF: 1.4 (f.w)	6.1	Fe, Mn, Zn	100.0 (f.w)	TPC: 52.5 (f.w)	[79]
	-	-	-	-	-	-	K, Ca, Na, Fe, Zn	-	-	[92]
	-	-	-		-	-	-	-	TPC: 179.6–248.6 CAR: 49.1–75.9	[87]
Fuchsia regia	-	-	6.1	-	-	-	Ca, Fe, Zn, Mn	44.0	TPC: 148.8	[91]
Fuchsia × *hybrida*	-	-	2.8	-	-	-	K, Ca, Na	-	TPC: 41.2 TF [3]: 19.8	[26]
Hibiscus acetosella	83.6	-	-	10.9	-	5.5	-	-	-	[81]
Lavandula angustifolia	-	-	-	-	-	-	-	-	TPC:14.8–32.8 TF:8.5–23.7	[93]
	-	-	-	-	--	-	-	9.0	TPC: 12.7	[37]
		10.9	11.5	-	CF: 17.6	7.3	-	110.3	-	[77]
	-	-	-	-	-	-	K, Ca, Na, Fe, Mn, Zn	-	TPC: 17.3 TF: 18.6	[86]
Nyctanthus arbortristis	-	-	-	-	49.7	-	-	0.7	TPC: 1486.2 TF: 660.2	[89]
Pelargonium hortorum	41.8 (f.w)	5.2 (f.w)	16.3 (f.w)	-	CF: 0.9 (f.w)	7.4	Fe, Zn, Mn	42 (f.w)	TPC: 108.0 (f.w)	[79]
Petunia hybrida	18.4 (f.w)	2.4 (f.w)	15.3 (f.w)	-	CF: 2.10 (f.w)	14.7	Fe, Zn, Mn	28.0 (f.w)	TPC: 50.5 (f.w)	[79]
Rosa odorata	-	-	2.6	-	-	-	K, Ca, Na	- - -	TPC: 49.8 TF [3]: 20.2	[26]

Table 2. *Cont.*

Scientific Name	CarboH (g/100 g)	Sugars (g/100 g)	Proteins (g/100 g)	Lipids (g/100 g)	Fiber (g/100 g)	Ash (g/100 g)	Minerals [1] (mg/100 g)	Vitamin C (mg/100 g)	TPC—CAR	References
Rosa micrantha	90.2	13.1	4.3	1.3	-	4.2	-	295.1	TPC: 424.2 TF: 78.5 CAR: 46.6	[80]
Rosa spp.	-	-	2.0	-	-	-	K, Ca, Na	-	TPC: 30.9	[25]
	-	-	-	-	-	-	K, Ca, Na, Fe, Zn, Mn	-	TPC: 9.9 TF: 2.6	[86]
Syringa vulgaris L.	-	-	12.4	-	TDF: 25.9	-	-	-	-	[83]
Tagetes patula/erecta	-	-	3.2	-	-	-	K, Ca, Na	-	TPC: 51.2	[25]
	-	-	3.0	-	-	-	K, Ca, Na	-	TPC: 47.5 TF [3]: 19.6	[26]
	-	-	-	-	-	-	-	-	TPC: 194.8–303.6 CAR: 500.6–2057.8	[87]
Taraxacum officinale	-	-	13.2	-	TDF: 27.0	-	-	-	-	[83]
Tropaeolum majus	-	-	6.2	-	-	-	K, Ca, Na	-	TPC: 43.8	[25]
	-	-	4.2	-	-	-	K, Ca, Na	-	TPC: 29.3 TF [3]: 45.4	[26]
	-	-	-	-	-	-	K, Ca, Na, Fe, Zn, Mn	-	TPC: 23.0 TF: 5.1	[86]
Viola cornuta L.	-	-	12.9	-	-	-	Ca, Zn, Mn, Fe	248.8	TPC: 33.9	[91]
Viola tricolor L.	-	10.28	13.3	-	CF: 8.4	16.7	-	577.7	-	[77]
	-	-	-	-	-	-	K, Ca, Na, Fe, Zn, Mn	-	TPC: 63.4 TF: 32.8	[86]
Viola wittrockiana	11.8 (f.w)	8.0 (f.w)	2.3 (f.w)	-	CF: 0.4 (f.w)	3.2	Fe, Zn, Mn	32 (f.w)	TPC: 13.9 (f.w)	[79]
	-	27.9-W 8.53-Y 10.4-R	23.3-W 15.3-Y 9.1-R	5.2-W 9.7-Y 4.5-R	TDF: 17.2-w TDF: 32.0-Y TDF: 25.4-R	10.6-W 8.2-Y 6.3-R	-	-	CAR: 21.6-W 58.0-Y 109.2-R	[75]

CarboH: carbohydrates; TDF: total dietary fiber; CF: crude fiber; f.w: fresh weight; Viola W: white; Y: yellow; R: red; TPC: total polyphenol content (mg GAE/g); CAR: carotenoids (mg/100 g); TF: total flavonoids (mg/g). [1] Listed according to amounts, from major to minor. TPC [2]: total polyphenol content expressed as mg catechol/g fw. TF [3]: Total flavonoids expressed as mg rutin/g.

On the other hand, the amounts of soluble fiber are noticeably lower than those of insoluble fiber, with the lowest value of 1.4 g/100 g d.w in *Syringa vulgaris* and the highest of 7.5 g/100 g d.w in *Centaurea cyanus* L.

3.2. Protein Composition

Among the various edible flowers, *Borago officinalis* L. is one of the flowers with the highest reported protein content (approximately 22.7 g/100 g d.w) [75] (Table 2). Other notable protein sources are *Cucurbita pepo* (Zucchini) and *Cucurbita moschata* (Butternut squash), with values ranging from 14.5 to 21.9 g/100 g (d.w) [88,91]. Also, flowers like *Dianthus chinensis*, *Pelargonium hortorum*, *Petunia hybrida*, *Syringa vulgaris* L., *Viola cornuta*, and *Viola wittrockiana* (white variety) have more than 13% protein (d.w) [75,83,91]. In contrast, petals from Rosa species generally have low amounts of proteins, often below

5%. Also, flowers of *Fuchsia regia* (6.1% d.w) and *Fuchsia* × *hybrida* flowers (2.8% d.w) are characterized by low protein levels [26,91].

3.3. Mineral and Vitamin Composition

Edible flowers are also a notable source of essential minerals. The main macroelements identified in flowers are calcium (Ca), sodium (Na), and potassium (K) while among microelements, iron (Fe), manganese (Mn), and zinc (Zn) have been identified (Table 2). Other commonly determined minerals include phosphorous (P), magnesium (Mg), and copper (Cu). Flowers generally contain high amounts of Ca, although concentrations vary between species. For instance, values range from 74 mg/100 g in *Cucurbita pepo* to 9050 mg/100 g in *Fuchsia regia* [88,91]. Regarding microelements, the amount of Fe is remarkably higher than Zn in all the flowers listed in Table 2, except for *Viola cornuta.* Notably, *Dianthus chinensis* and *Petunia hybrida* have high iron contents with 133 mg/100 g and 173 mg/100 g of fresh weight (f.w), respectively [79]. Edible flowers also presented remarkable contents of K, especially in *Calendula officinalis* L., *Lavandula angustifolia*, and *Tropaeolum majus,* with values higher than 4000 mg/100 g (d.w) [86].

3.4. Phenolic Compounds and Other Bioactive Substances

As described before, edible flowers are increasingly recognized for their rich composition in phenolic compounds and other bioactive substances, contributing to their moderate to high antioxidant activity [20]. The information about the total polyphenol content, total flavonoids, and carotenoids in edible flowers is included in Table 2.

Phenolic compounds, as highlighted by Zheng et al. [94], can have numerous health benefits, being characterized by antioxidant, anti-inflammatory, neuroprotective, hepatoprotective, and anti-diabetic properties. Studies have suggested that new compounds such as polysaccharides, lignans, and phenolic glycosides also contribute to these health benefits. Edible flowers, particularly those from the *Allium* family, are increasingly recognized for their nutritional and health benefits [95]. The most commonly cultivated edible flowers of *Allium* species include *Allium schoenoprasum* L. (chive), *Allium sativum* L. (garlic), *Allium cepa L.* (onion), and *Allium ampeloprasum* L. (leek), among others. These plants are recognized for their anti-bacterial, antioxidant, anti-inflammatory, and anti-proliferative properties [96,97]. In a study by Grzeszczuk et al. [76], *Allium* spp. presented a notably high total phenolic content (1877 mg GAE/g d.w). Chetia et al. [89] also demonstrate that *Nyctanthus arbor-tristis* (Night jasmine) and *Cucurbita máxima* (pumpkin) possess an interesting phenolic content (1486 and 498 mg GAE/g d.w, respectively). High antioxidant activity was also recorded in different flowers such as *Tagetes erecta* (70.4 mol $FeSO_4$/100 g f.w), *Fuchsia hybrida* (47.5), *Dianthus barbatus* (38.6), *Viola* × *wittrockiana* (36.5), and *Pelargonium peltatum* (34.7), as reported by Benvenutti et al. [7]. In contrast, lower values of antioxidant activity (below 10 μmol $FeSO_4$/100 g f.w) were observed in *Borago officinalis*, *Calendula officinalis*, white *Dianthus barbatus*, and various cultivars of *Petunia* × *hybrid* and *Viola* × *wittrockiana.*

As reported by dos Santos et al. [81], *Hibiscus acetosella*, a flower widely consumed in Brazil, is rich in several compounds with bioactive functions, including high antioxidant activity. Part of these components comprise substances like different anthocyanins, gallic acid, caffeic acid, and quercetin, among others. Also, other non-common edible flowers such as *Bellis perennis*, *Rumex acetosa*, *Salvia pratensis*, *Sambucus nigra*, *Tragopogon pratensis*, *Trifolium repens*, and *Viola arvensis* are characterized by their high phenolic compound composition and promising antioxidant activity [98].

Despite the high levels of antioxidants present in the different edible flowers, these compounds can be sensitive to environmental conditions, such as light, heat, and oxygen, particularly during post-harvest handling. Therefore, understanding how different storage methods and environmental factors impact their nutrient composition is crucial for maintaining their health benefits and extending their shelf-life.

4. Health Benefits of Edible Flowers

The possible health benefits and risks associated with the consumption of different edible flowers are summarized in Table 3. The evidence supporting these effects is derived from in vitro studies and clinical observations. This distinction should be kept in mind when interpreting the potential health benefits and risks associated with edible flower consumption. The bibliographic reference to each potential benefit was added.

The main health benefits of incorporating edible flowers into diets are related to their antioxidant, anti-proliferative, anti-diabetic, anti-obesity, and cardio-protective properties [99]. The antioxidant activities of edible flowers can be explained by the presence of different amounts of phenolic compounds, and among them, their flavonoid content (See Section 3.4) [18]. By protecting the human body from oxidative stress, these compounds can help to improve immune function, enhance anti-inflammatory effects, and reduce the risk of chronic pathologies [23,100,101].

Other common benefits of flower ingestion include anti-carcinogenic, anti-diabetic, and anti-bacterial properties. Antioxidant, anti-cancer, neuroprotective, hepatoprotective, and anti-diabetic activities can be related to the presence of compounds such as polysaccharides, lignans, phenolic glycosides, and saponins [102]; however, the molecular mechanisms should be elucidated. The less studied effects of flower consumption include anti-diarrheal, anti-depressant, and anti-spasmodic effects, a decrease in pain, protection against the development of gastric ulcers, an increase in the relative abundance of *Firmicutes* present in the gut microbiota, and the inhibition of enzymes involved in the aging process, among others potential benefits [103–109].

Table 3. Potential health benefits and risks associated with the intake of different edible flowers. The evidence supporting these effects is derived from in vitro studies or clinical observations.

Scientific Name	Potential Health Benefits and Risks		Sample Type	References
Allium schoenoprasum L.	Health benefits	Anti-proliferative	Phenolic compounds obtained from methanol extraction of the flower	[110]
	Risks	N.D		
Borago officinalis L.	Health benefits	Anti-bacterial	Aqueous, ethanol, and methanol extracts	[111,112]
		Antioxidant	Aqueous, ethanol and methanol extracts	[20,42,111–113]
		Anti-ulcer activity	Aqueous, methanol, and organic extracts	[103]
		Asthma symptoms reduction	Hydroalcoholic extract	[114]
		Hepatoprotective	Bioactive fractions derived from ethanol extract	[113]
		Pain reduction	Hydroalcoholic extract	[108]
	Risks	Cytotoxicity	Organic extract	[103]
		No information regarding toxic effects in humans	-	[51,115]
		Potential risks due to presence of alkaloids (1,2-unsaturated pyrrolizidine alkaloids)	-	[51]

Table 3. *Cont.*

Scientific Name	Potential Health Benefits and Risks		Sample Type	References
Bougainvillea glabra	Health benefits	Anti-carcinogenic	Aqueous and methanol extract	[34,52]
		Anti-diabetic (by inhibition of α-glucosidase)	Aqueous and methanol extracts	[34,52]
		Anti-obesity (by inhibition of pancreatic lipase)	Aqueous extracts	[34]
		Antioxidant	Dry flowers; hydrophilic and methanol extracts	[20,34,38,45,52]
		Cardioprotective (preventing myocardial necrosis and oxidative stress)	Methanol extract	[116]
	Risks	No mortality of behavioral changes were observed	Methanol extract	[116]
		Non-toxic effects against normal cell lines	Ethanol extract of bracts	[117]
Calendula officinalis L.	Health benefits	Anti-bacterial (against *Klebsiella pneumonia*)	Methanol extract of flowers	[118]
		Hepatoprotective	Ethanol extract	[119]
		Neuroprotective (by increasing locomotor activity and attenuation of hippocampal dam age)	Methanol extract of flowers	[120]
		Anti-spasmodic	Aqueous-ethanol extract of flowers	[109]
	Risks	No information regarding toxic effects in humans	-	[51]
Centaurea cyanus L.	Health benefits	Antioxidant	Aqueous and methanol extract	[26,121]
		Anti-bacterial (against *Escerichia coli*, *Staphylococcus aureus* and *Listeria monocytogenes*)	Aqueous and ethyl acetate extracts of aerial parts	[122]
		Anti-hypertensive (by inhibition of ngiotensin I-converting enzyme—ACE)	Flower extract	[123]
		Antimicrobial (low effect)	Methanol extract of flower	[124]
	Risks	N.D		
Chrysanthemum spp.	Health benefits	Anti-carcinogenic	Methylene chloride fraction of *Chrysanthemum indicum* L.	[125]
		Anti-inflammatory (by suppressing TNF-α, IL-6 and COX-2)	Aqueous extract of *Chrysanthemum × morifolium*	[104]
		Antioxidant	Methanol extracts of *Chrysanthemum frutescens* and *Chrysanthemum parthenium*	[26]
		Anti-obesity (by inhibition of adipogenesis)	Aqueous extract of *Chrysanthemum morifolium* flowers	[126]
		Gut microbiota modulation (by increasing *Firmicutes* content)	Aqueous extract of *Chrysanthemum × morifolium*	[104]
		Hepatoprotective (by mitigation of liver injury)	Flavonoids (luteolin and luteoin 7-*O*-glucoside) extracted from petals of *Chrysanthemum × morifolium* and aqueous extract	[127,128]
		Neuroprotective	Flavonone glycosides derived from *Chrysanthemum morifolium* flowers extract	[129]

Table 3. *Cont.*

Scientific Name	Potential Health Benefits and Risks		Sample Type	References
Chrysanthemum spp.	Risks	Subclinical alterations in heart tissue; No clinical toxicity observed	Homogenates of *Chrysanthemum morifolium*	[130]
		No toxic effects observed	Ethanol extract of *Chrysanthemum morifolium* flowers	[131]
Cichorium intybus L.	Health benefits	Anti-diabetic (by α-amylase and α-glucosidase inhibition)	Ethanol extract of flowers	[66]
		Anti-diarrheal effect	Infusion of flowers	[132]
		Antioxidant	Ethanol extract of flowers	[66]
	Risks	N.D		
Clitoria ternatea	Health benefits	Antioxidant	Aqueous, ethanol and methanol extracts	[11,47,121,133,134]
		Antidiabetic (by pancreatic regeneration potential and anti-hyperglycemic effects)	Ethanol extract of flower and other aerial parts	[134]
		Anti-endocrine disrupting agent	Aqueous extract	[11]
		Anti-hemolysis	Aqueous extract	[133]
		Memory deficit attenuation	Ethanol extract of flower and other aerial parts	[135]
	Risks	Low toxicity (no mortality, but loss of mobility occurred)	Ethanol extract of flower and other aerial parts	[134]
		Lethargia, decreased locomotor activity and ptosis (dropping of upper eyelids)	Ethanol extract of flower and other aerial parts	[135]
Cucurbita pepo L.	Health benefits	Antidiabetic (by inhibition of α-glucosidase)	Ethanol extract of flowers	[136]
		Cholesterol reduction	Ethanol extract of flowers	[136]
	Risks	Presence of trypsin inhibitors was detected. No alkaloids, cyanogenic glycosides or hemolytic activity were identified	Sundried commercial flowers	[88]
Hibiscus L.	Health benefits	Anti-inflammatory	Aqueous extract and anthocyanin isolated from *Hibiscus sabdariffa* L.	[137,138]
		Anti-hypertensive	Infusion of dried calyces of *Hibiscus sabdariffa* L.	[139,140]
		Anti-obesity (by inhibition of adipogenesis)	Aqueous extract of *Hibiscus sabdariffa* L.	[141]
		Antioxidant	Aqueous extract of red flowers	[20]
	Risks	Diarrhea, hepatotoxicity, possible death	Aqueous and ethanol extracts of *Hibiscus sabdariffa* L.	[142]
		Toxic effects	*Hibiscus sabdariffa* Calyx extract	[143]
		Possible liver and heart injury when using for long periods	Methanol extract of red calyces of *Hibiscus sabdariffa* L.	[144]
		Interference with drugs (Acetaminophen)	Aqueous extract of red calyces of *Hibiscus sabdariffa* L.	[145]
Jasminum sambac	Health benefits	Ant carcinogenic	Methanol extract	[146]
		Antimicrobial (against *S. aureus*, *E. coli*, *Candida albicans*)	Ethanol extract	[147]
		Antioxidant (low effect)	Methanol extract	[148]
	Risk	No toxicity	Ethanol extract	[149]

Table 3. *Cont.*

Scientific Name	Potential Health Benefits and Risks		Sample Type	References
Lavandula angustifolia	Health benefits	Anti-aging (by inhibition of acetylcholinesterase)	Methanol extract	[150]
		Anti-Hyperglycemic (by inhibition of α-amylase)	Methanol extract	[150]
		Anti-depressant	-	[151]
	Risks	Safe to use as a flavor agent	-	[152]
Malva sylvestris L.	Health benefits	Anti-bacterial (against *Bordetella bronchiseptica*, *Erwinia carotovora*, *S. aureus*, *Streptoccocus agalactiae*, and *Enterococcus faecalis*). Bacteriostatic (against *S. aureus*)	Methanol extract	[153–155]
		Antidiabetic (by inhibition of α-amylase and α-glucosidase)	Ethanol extract	[66]
		Antifungal activity (modest) (against *Sclerotinia sclerotiorum*, *Candida kefyr*, *C. albicans*)	Methanol extract	[153]
		Antioxidant	Ethanol extract	[74,121,156]
		Skin elasticity increase	Aqueous extract	[157]
		Triglycerides reduction	Aqueous extract	[157]
	Risks	N.D		
Matricaria chamomilla	Health benefits	Anti-depressant (by increasing mobility)	Hydroalcoholic extract of flowers	[105]
		Anti-diabetic (by lowering glucose and protection of pancreatic islet cells)	Hydroalcoholic extract of aerial parts	[158]
		Antioxidant	Subcritical water extract (210 °C) of flowers	[159]
		Anti-spasmodic	Hydroalcoholic extract	[106]
		Anti-ulcerative colitis (by reducing inflammation, oxidative stress and immune response biomarkers)	Hydroalcoholic extract	[160]
		Cytotoxicity to malign cells	Subcritical water extract (115 °C) of flowers	[159]
		Memory improvement (by modulating cholinergic activity and neuroinflammation)	Hydroalcoholic extract of flowers	[161]
		Reduction in lung damage (by reduction in pulmonary fibrosis)	Hydroalcoholic extract of flowers	[162]
		Wound-curing (by increasing the production of growth factors)	Hydroalcoholic extract	[163]
	Risks	No signs of toxicity observed	Hydroalcoholic extract of flowers	[161]
Nelumbo nucifera	Health benefits	Anti-obesity (by inhibition of the differentiation of preadipocytes to adipocytes)	Methanol extract	[164]
		Hypolipidemic and hypoglycemic	Dry flowers	[165]
	Risks	Genotoxicity when reacting with nitrite (consumers should avoid any nitrite-containing food items)	Methanol extract	[166]
Rhododendron arboreum	Health benefits	Antioxidant	Ethanol extract	[69]
		Cardioprotective	Ethanol extract of petals	[167]

Table 3. *Cont.*

Scientific Name	Potential Health Benefits and Risks		Sample Type	References
Rhododendron arboreum	Risks	Possible presence of grayanotoxins which can lead to intoxication. Authors state that *Rhododendron* plants are poisonous	-	[168]
		Rhododendron honey, flowers or medicinal preparations can lead to intoxication	-	[169]
		Toxic effects (convulsions, hypotension, paralysis, vomits)	All parts of rhododendron	[130]
Rosa spp.	Health benefits	Anti-aging (by Inhibition of skin aging-related enzymes)	Ethanol extract	[107]
		Anti-bacterial (against *Staphylococcus epidermidis*, *S. aureus*, *Bacillus subtilis*, *Micrococcus luteus*, *E. coli*, *K. pneumoniae*, *Pseudomonas aeruginosa*, *Proteus mirabilis*)	Aqueous and methanol extracts	[170]
		Anti-carcinogenic	Aqueous and methanol extracts	[170]
		Anti-diabetic (by Inhibition of α-glucosidase)	Methanol extract of flower	[171]
		Anti-inflammatory on skin tissues	Ethanol extract	[172]
		Antioxidant	Aqueous, ethanol and methanol extracts. Dry petals	[107,173,174]
		Anti-Parkinson’s and neuroprotection (by protection of nerve cells and improvement of motor symptoms and balance disorders)	Ethanol extract	[175]
	Risks	Low cytotoxicity on kidney epithelium; cytotoxic to blood leukocytes	Ethanol and methanol extract	[176]
Tagetes erecta	Health benefits	Anti-carcinogenic	Aqueous extract	[34]
		Anti-diabetic (by inhibition of α-glucosidase)	Aqueous extract	[34]
		Anti-inflammatory	Hydroalcoholic extract	[177]
		Anti-obesity (by Inhibition of pancreatic lipase)	Aqueous extract	[34]
		Antioxidant (strong effect)	Ethanol, hydrophilic, and hydroethanolic extracts	[21,34,178]
		Anti-parasite	Aqueous extract	[179]
	Risks	No lethality or toxic effects	Aqueous extract	[179]
Taraxacum officinale Weber	Health benefits	Anti-angiogenic	Ethanol extract of aerial parts	[180]
		Anti-bacterial (against *Helicobacter pylori*)	Aqueous and ethanol extracts	[181]
		Anti-carcinogenic (against human colon colorectal adenocarcinoma)	Aqueous and ethyl acetate extracts	[182]
		Anti-diabetic (by serum glucose reduction)	Aqueous and ethanol extracts	[183]
		Anti-inflammatory	Aqueous and ethanol extracts	[180,181]
		Anti-nociceptive	Ethanol extracts	[180]
		Antioxidant	Aqueous, ethanol, and ethyl acetate extracts	[182,184]
		Gastroprotective	Ethanol extract	[181]
		LDL-cholesterol and triglycerides reduction, HDL-cholesterol increase	Aqueous extract	[183]

Table 3. *Cont.*

Scientific Name	Potential Health Benefits and Risks		Sample Type	References
Taraxacum officinale Weber	Risks	Allergic reaction.to pollen	-	[185]
		No lethality	-	[186]
Tropaeolum majus L.	Health benefits	Antiarthritic (low effect)	Methanol extracts of aerial parts	[187]
		Antimicrobial (against *Bacillus cereus*, *Pseudomonas* spp., *Acinetobacter* spp., *Staphylococcus* spp., *Enterococcus* spp., and *Klebsiella* spp.)	Methanol extract of flowers	[188]
		Anti-obesity (anti-adipogenic effect and (by inhibition of pancreatic lipase)	Ethanol and methanol extracts	[187,189]
		Antioxidant	Aqueous extract of flower	[20]
		Hepatoprotective (by preservation of hepatic tissues)	Methanol extract of flowers and leaves	[190]
	Risks	High doses (>39.5 g) can exceed the daily intake of erucic acid	-	[8,51]
		Mortality	Aqueous, hydro-ethanol, and methanol extract of flowers and leaves	[190]
Tulipa gesneriana	Health benefits	Antimicrobial (against *S. aureus*, *Enterobacter cloasea*, *Salmonella typhimurium*, *E. coli*, *Yersinia enterocolitica*, *L. monocytogenes*, *B.cereus*, and *B. subtilis)*	Anthocyanin-based extracts of red tulips	[42]
	Risks	Only petals are edible	-	[28]
		Red tulip consume can be questioned	-	[42]
		Yellow and clared red tulip flowers can be toxic	-	[191]
Viola tricolor	Health benefits	Antioxidant	Fresh flowers irradiated	[192]
	Risks	Possible health issues for individuals with sensitivity to salicylic acid due to Methyl salicylate presence	-	[51]
Viola × wittrockiana	Health benefits	Antioxidant	Methanol extract	[42,193]
		Neuroprotection (by inhibition of neurodegenerative enzymes)	Ethanol extract of flower	[194]
	Risks	N.D		

N.D: no data; b.w: body weight.

As can be seen in Table 3, studies on the health properties of raw flowers are scarce. Most of the research on this topic has been carried out using aqueous, ethanolic, and methanolic extracts derived from petals or other aerial parts of the plant. The proven properties of ethanolic extracts of edible flowers include benefits for the liver, heart, and brain [113,119,135,167,194].

Furthermore, infusions made using some edible flowers may be an interesting alternative for patients that seek to reduce body weight, since the anti-obesity properties of aqueous extracts of *Bougainvillea glabra*, *Chrysanthemum morifolium*, *Hibiscus sabdariffa* L., and *Tagetes erecta* have shown effects in inhibiting adipogenesis and enzymes involved in lipid digestion [34,126,141]. In addition, the consumption of aqueous extracts of edible flowers like *Bougainvillea glabra*, *Tagetes erecta*, and *Taraxacum officinale* has been shown to reduce the incidence of diabetes [34,183].

Many of the commonly studied flowers show properties against the proliferation of several types of microorganisms. Among edible flowers, *Borago officinalis* L., *Calendula* *officinalis* L., *Centaurea cyanus* L., *Malva sylvestris* L., *Rosa* spp., *Taraxacum officinale* Weber, *Tropaeolum majus* L., and *Tulipa gesneriana* showed the potential to inhibit the growth of different species of *Bacillus*, *Staphylococcus*, *Escherichia*, *Enterococcus*, and *Salmonella*, as well as some fungal species [42,111,118,122,153–155,170,181,188].

Figure 2 summarizes the most relevant benefits for human health related to edible flower intake, as well as their main nutritional components.

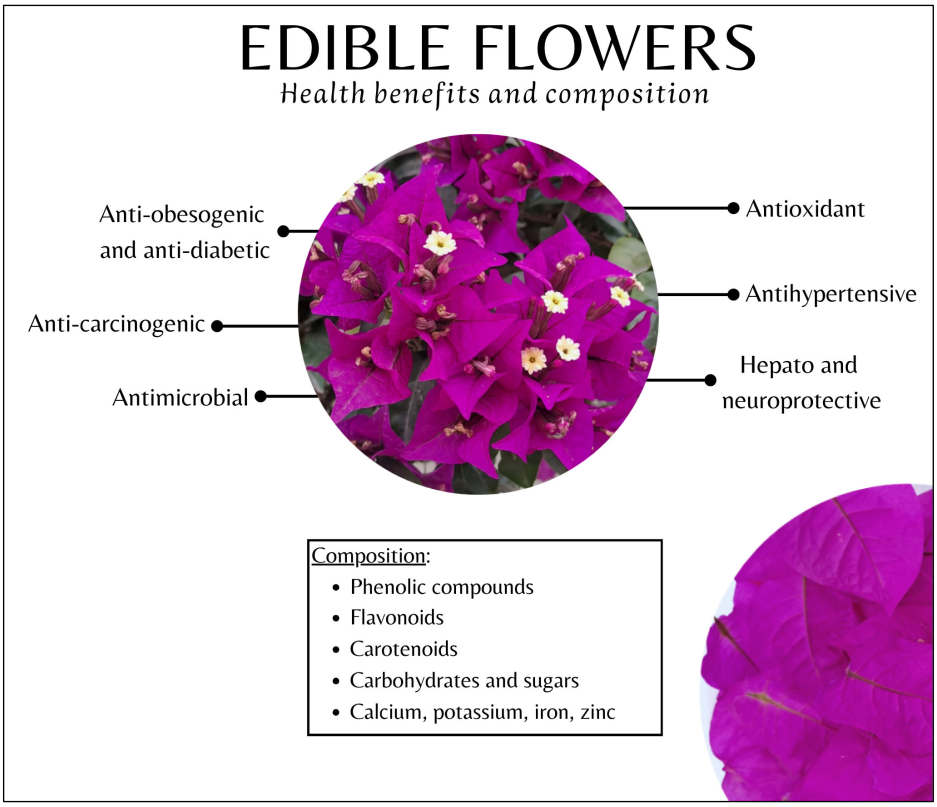

Figure 2. Main health benefits and nutritional composition of edible flowers.

Despite the benefits mentioned, many edible flowers are still under study to understand how best to consume them and maximize health benefits while avoiding risks. In this sense, there is still a long way to go before they are included in the list of foods that can be consumed. Different toxicological studies on cells and animal models have shown that most edible flower extracts are probably safe and non-toxic (Table 3). Nevertheless, some investigations have found possible toxic effects associated with extracts from *Borago officinalis* L., *Chrysanthemum* spp., *Clitoria ternatea*, *Rhododendron arboretum*, and *Rosa* spp. and other species [51,130,135,168,169,176]. A detailed discussion on the general safety aspects regarding the consumption of edible flowers can be found in Section 6.

5. Safety Aspects of Edible Flower Consumption

Several authors highlighted safety issues related to the consumption of edible flowers [1,7,8,169,195]. A review article written by Egebjerg et al. [51] summarizes some of the edible flowers with potentially toxic substances. Although there is insufficient information to determine the toxicity of some of the species studied, these authors have indicated the presence of possibly toxic compounds in *Borago officinalis* L., *Tropaeolum majus* L., *Viola tricolor* L., *Achillea millefolium* L., *Echium vulgare* L., and *Syringa vulgaris* L. In a survey carried out by Guiné et al. [60], among 559 adults from three countries, less than half of them were aware of the risk of consuming edible flowers, with most individuals concerned about the presence of pesticides. Studies regarding the risk of edible flower consumption are summarized in Table 3.

Edible flowers may contain toxic or poisonous substances, including alkaloids, cyanogenic glucosides, oxalic acid, saponins, terpenes, and erucic acid [7,8]. Alkaloids can exert stimulant or psychotropic effects. These substances are usually bitter and act as a defense mechanism for the plant [3,7,8,41]. In addition, some flower species contain anti-nutritional factors like saponins, trypsin inhibitory enzymes, and hemagglutinating activity [7] that may interfere with the absorption or metabolism of certain nutrients. In addition, there is currently a lack of scientific information on the use and safe doses of different flowers [1], and as previously stated, pathogenic microorganisms can be found in edible flowers.

Besides this, confusion can occur between toxic and non-toxic species that are visually similar. Some flowers of the same family can be toxic or edible, such as the flowers of *Pisum sativum* (common pea, edible) and *Lathyrus odoratus* (sweet pea, toxic). In this case, both flowers can have similar colors and some morphological characteristics [3,51].

Allergies to edible flowers can occur in susceptible individuals. Some parts of the flowers (specifically the reproductive organs) can induce allergies [3] and pollen found in flowers may cause various reactions in people allergic to them. Finally, a possible interaction between active principles of flowers and drugs could occur, as in the case documented by Kolawole et al. [145] in samples of *Hibiscus sabdariffa.*

Some flowers mentioned in this article can be helpful to preventing or delaying the onset of diverse health conditions, as well as improving some of their signs and symptoms. However, it is important to consider whether these flowers can be used safely as part of 'alternative medicine' or not. According to González-Castejón et al. [36], edible flowers should not be considered medicinal products, especially for individuals with severe health disorders. In cases where a plant is consumed in its totality, such as dandelion, the information about the safe amount of leaves or roots is already available [36]. According to a review carried out by González-Castejón et al. [36], the amounts usually consumed are below 50 g/day of fresh roots or leaves, and less than 10 g/day of dried roots or leaves. However, information regarding the safe intake of the flowers is not so widespread. There are many missing points regarding the available information of the safety of these kinds of flowers, including their toxicological profile and adequate taxonomy identification in order to determine the species that are genuinely edible [7,196]. In this sense, public and reliable access to information on safe edible flower species and their optimal doses would be an important way to take care of consumers [196]. Moreover, it would be important to have a legal regulation label regarding edible flowers and a government commitment to spread knowledge on this topic. As with other foods that are considered "unconventional", it is important for consumers to be cautious with the edible flowers available, knowing their origin, acquiring them through reliable stores, and evaluating individual tolerance over time.

6. Microbiological Aspects of Edible Flowers

Despite their health benefits, edible flowers are highly perishable and can cause significant safety concerns. Due to their chemical composition and high water content, fresh flowers are exposed to microbial spoilage during storage. Some flowers can be toxic or cause allergic reactions if consumed raw or improperly processed. Furthermore, some blooms are harmful especially due to the presence of pathogens that contaminate them at any stage of their lifecycle (soil, water, post-harvesting, handling, and packaging), as highlighted by the Rapid Alert System for Food and Feed (RASFF), even more so because edible flowers are usually consumed fresh without prior heat treatment [197].

Many of the species isolated and identified from edible flower samples are potentially pathogenic for humans, including *Salmonella* spp., *Enterobacter* spp., *Bacillus* spp., and *S. aureus* that raise potential food safety concerns, emphasizing the importance of proper cultivation and processing practices to ensure consumer safety [198]. Molds and yeasts are also considered undesirable microorganisms, as they compromise both the nutritional and sensory characteristics of flowers, posing risks to product quality and consumer health. Fungi can produce volatile compounds that cause off-flavors and texture alterations, negatively affecting the sensory appeal of edible flowers. Furthermore, they accelerate aging and spoilage during storage, degrading plant tissues through enzymatic activity, thereby reducing shelf-life and marketability [199]. Some molds, such as *Aspergillus*, *Penicillium*, *Alternaria*, or *Fusarium*, can produce mycotoxins, while others, such as *Cladosporium* and *Alternaria*, can cause allergies [200–202]. Table 4 summarizes the main microorganisms identified in different species of edible flowers by culture-dependent and independent methods.

Table 4. Microbiological aspects of edible flowers by culture-dependent and -independent methods.

Scientific Name	Microorganisms Present in Flower	Origins of Flowers	References
Acacia decurrens	Aerobic bacteria, *S. aureus*, *Listeria* spp.	Republic of Korea	[203]
Azadirachta indica	*Salmonella* spp.	Thailand	[204]
Bellis	*S. aureus*, yeasts and molds, *E. coli*	Poland	[198,205]
Borago officinalis	Aerobic Mesophilic bacteria, psychotropic bacteria, yeasts and molds, total coliforms	Portugal	[99,206]
Bougainvillea glabra	Aerobic bacteria, yeasts and molds; *Fusarium oxysporum*	Malesia	[117,207]
Calendula officinalis	*S. aureus*, yeasts and molds, *E. coli*	Poland	[198,203]
Camellia japonica	Aerobic Mesophilic bacteria, yeasts and molds, total coliforms, psychotropic bacteria	Portugal	[99]
Centaurea cyanus L.	*Salmonella* spp. Aerobic Mesophilic bacteria, yeasts and molds, total coliforms, psychotropic bacteria	Albania, Portugal	[99,204]
Chrysanthemum morifolium	*Aerobic bacteria*	Republic of Korea	[203]
Cucurbita pepo L.	*Bacillus flexus*, *Bacillus gibsonii*, *Bacillus indicus*, *Bacillus firmus*, *B. subtilis*, *Pseudomonas viridiflava*, *Pseudomonas syringae*, *Plectosphaerella cucumerina*, *Phoma herbarum*, *Oidiodendron* spp., *Capnobotryella* spp., *Pleosporaceae* spp.; *Erwinia tracheiphila*; Mesophilic aerobic bacteria, yeasts and molds, *Acinetobacter* spp., *Staphylococcus* spp., *Arthrobacter* spp., *Serratia* *marcescens*, *Enterobacter* spp., *Pantoea* spp., *Weissella* spp., *Klebsiella* spp., *Erwinia* spp., *Pseudoclavibacter* spp., *Bacillus* spp., *Pseudomonas* spp. (cold storage)	Austria, USA, Italy	[208–210]
Dahlia spp.	*Pantoea vagans*	Mexico	[211]
Dianthus caryophyllus L.	*S. aureus*, yeasts and molds, *E. coli*	Poland	[198]
Hemerocallis L.	*S. aureus*, yeasts and molds, *E. coli*	Poland	[198]
Hibiscus rosa-sinensis L.	*C hoanephora infundibulifera*	Republic of Korea	[212]
Jasminum sambac L.	Aerobic bacteria, *S. aureus*, *Listeria* spp.	China	[203]
Kalanchoe blossfeldiana	Aerobic Mesophilic bacteria, psychotropic bacteria, Yeasts	Portugal	[206]
Lavandula angustifolia	Aerobic bacteria, yeasts and molds, *Enterobacteriaceae*	Poland	[213]
Magnolia kobus A. P. DC.	Aerobic bacteria, *S. aureus*, *Listeria* spp.	Republic of Korea	[203]
Matricaria recutita L.	Aerobic bacteria, *S. aureus*, *Listeria* spp.	Republic of Korea	[203]

Table 4. *Cont.*

Scientific Name	Microorganisms Present in Flower	Origins of Flowers	References
Nelumbo Nucifera	*S. marcescens; Erwinia* spp., *Sphingomonas* spp., *Dickeya* spp., *Escherichia-Shigella* spp., *Pantoea* spp., *Serratia* spp., *Raoultella* spp.	China, India	[214,215]
Ocimum basilicum	Aerobic bacteria, Mesophilic bacteria, yeasts and molds; *Enterobacter* spp., *Bacillus pumilus*, *Bacillus stratosphericus*, *P. aeruginosa*, *Salmonella enterica* subsp. *enterica* serovar Typhimurium, *Erwinia* spp., *Klebsiella singaporensis*, *Enterococcus raffinosus*	Spain, Poland, USA	[216,217]
Origanum vulgare	Mesophilic bacteria, *E. coli*, Enterobacteriaceae	Spain, Poland	[216]
Pelargonium hortorum	*Enterobacter* spp., *Bacillus* spp., *P. aeruginosa*, *S. enterica* subsp. *enterica* serovar Typhimurium	USA	[217]
Petunia hybrida	*Phytophthora infestans*, *Phytophthora cryptogea*, *Botrytis cinerea*, *Phytophthora parasitica* Dast. (syn. *Phytophthora nicotianae* Breda de Haan.)	USA, Africa, Chile, Romania	[218,219]
Prunus serrulata var. spontanea	Aerobic bacteria, *Listeria* spp.	Republic of Korea	[203]
Pueraria lobata Ohwi	Aerobic bacteria, *S. aureus*, *Listeria* spp.	Republic of Korea	[203]
Salvia rosmarinus	Aerobic Mesophilic bacteria, *B. cereus*, *L. monocytogenes*, *Clostridium perfringens*	Spain, Poland	[216]
Tagetes erecta	*S. aureus*, yeasts and molds, *Salmonella* spp.	Poland, Egypt	[204,205]
Taraxacum officinale	Yeasts and molds, Aerobic Mesophilic bacteria, psychotropic bacteria	Portugal	[206]
Thymus vulgaris	*L. monocytogenes*, *C. perfringens*, Mesophilic bacteria	Spain, Poland	[216]
Tropaeolum majus L.	*S. aureus*, yeasts and molds, *E. coli* *Enterobacter* spp., *Bacillus* spp., *P. aeruginosa*, *S. enterica* subsp. *enterica* serovar Typhimurium	Poland, USA	[198,217]
Viola tricolor L.	*Enterobacter* spp., *Bacillus* spp., *P. aeruginosa*, *S. enterica* subsp. *enterica* serovar Typhimurium, psychotropic bacteria	USA, Portugal	[206,217]
Viola × wittrockiana White/violet	Aerobic Mesophilic bacteria, *Listeria* spp., *E. coli*, *S. aureus*, yeasts and molds, total coliforms, psychotropic bacteria	Republic of Korea, Poland, Portugal	[99,203,205]

Edible flowers, such as *Centaurea cyanus L.*, *Tagetes erecta*, and *Azadirachta indica* (Margosa flower), have been reported to be contaminated by *Salmonella* spp. [204]. *Tagetes erecta* was also found to be contaminated by *S. aureus*, different yeasts (1.30–2.08 log CFU/g), and molds (2.30–4.76 log CFU/g) despite a decontamination treatment made with ozone [205]. In fact, Wilczyńska A. et al. [205] studied this process as a promising method for microbiological decontamination, particularly for edible plants or flowers. Ozone (O_3) is a powerful oxidant with broad-spectrum antimicrobial properties, capable of eliminating bacteria, fungi, and other microorganisms [220]. However, its effectiveness is influenced by factors such as ozone concentration, exposure time, and the presence of organic matter that can reduce its efficiency.

Shalini et al. [117] focused on the microbiological component of *Bougainvillea glabra* bracts, assessing their safety as an edible flower. Total mesophilic bacteria and *Eumycetes* were below the allowable limit, indicating that the flowers were safe for consumption and not microbially contaminated. Lara-Cortés et al. [211] conducted a study to identify enteric bacteria associated with *Dahlia* spp., focusing on morphological, biochemical, and molecular methods. The research aimed to explore the pathogens occurring on these edible flowers that have a historical significance in food consumption. Preliminary results highlighted the potential presence of *E. coli*, *Salmonella* spp., and *Enterobacter cancerogenus*. The main isolate identified in the study was *Pantoea vagans*, representing the first report of this species isolated from *Dahlia* spp. flowers. *P. vagans* is isolated from a variety of geographic locations and ecological sources, including soil, water, seeds, plants, and people. To ensure the microbiological safety of their products, floriculturists must adhere to appropriate hygiene standards, making use of antimicrobial substitutes that are safe for consumers and do not harm the phytosanitary condition of the flower.

Fürnkranz et al. [208] examined the variety of endophytic microbial communities from *Cucurbita pepo* L. flowers. In detail, several pathogenic species were identified, specifically *B. flexus*, *B. gibsonii*, *B. indicus*, *B. firmus*, *B. subtilis*, *P. viridiflava*, and *P. syringae.* The flowers were also examined for fungal contamination revealing the presence of ascomycetes such as *P. cucumerina*, *P. herbarum*, *Pleosporaceae* spp., *Capnobotryella* spp., and *Oidiodendron* spp.

Baruzzi et al. [210] further studied the microbial dynamics of *Cucurbita pepo L.* stored at low temperature (4 °C). Their study found that the microbial load on the pistils was consistently higher than that on the petals, with total aerobic mesophilic bacteria showing significant differences between these parts. The greater availability of nutrients in the pistils probably contributed to this higher microbial proliferation.

Wilczynska et al. [198] carried out a study on the microbial contamination of several edible flowers, including *Tropaeolum majus* L., *Calendula officinalis* L., *Dianthus caryophyllus* L., *Bellis* (daisy), and *Hemerocallis* L. (daylili). They found that all samples were contaminated with *S. aureus*, with counts ranging from 1.24 to 2.94 log CFU/g. In addition, yeasts and molds were detected in all samples, with contamination levels depending on the type of flower, ranging from 3.72 to 5.85 log CFU/g. *E. coli* was only found in *Tropaeolum majus* L. and *Bellis* samples. Furthermore, daisy flowers exhibited the highest levels of *S. aureus*, while daisy flowers showed the lowest levels of contamination [205]. In another study, Wetzel et al. [217] found pathogens like *Enterobacter* spp., *Bacillus* spp., *P. aeruginosa, S. enterica* subsp. *enterica* serovar Typhimurium.

Lee et al. [203] investigated the food safety of *Chrysanthemum morifolium* RAMAT, *Jasminum sambac* L., *Matricaria recutita* L., *Viola × wittrockiana, Acacia decurrens* (acacia), *Pueraria lobata Ohwi* (kudzu), *Magnolia kobus* A. P. DC. (magnoilia), and *Prunus serrulata var. spontanea* (prunus), *Jasminum sambac* L., *Matricaria recutita* L., *Acacia decurrens,* and *Magnolia kobus A. P. DC* contained aerobic bacteria (2.7–4.48 log CFU/g), *Listeria* spp. (2–2.48 log CFU/g), and *S. aureus (*2–2.3 log CFU/g*)*, while *Viola × wittrockiana* and *Prunus serrulata var. spontanea* contained only aerobic bacteria (2–3.35 log CFU/g) and *Listeria* spp. (1.7–2 log CFU/g). *Chrysanthemum morifolium* RAMAT was the only dried flower showing only aerobic bacterial load (2.6 log CFU/g) without the presence of pathogenic organisms. This highlighted the need to implement strict quality controls in the production of edible dried flowers to ensure food safety, adopting sustainable agricultural practices, regular monitoring of products, and consumer education on the potential risks associated with consuming contaminated dried flowers.

Seidler-Lozykowska et al. [213] examined the organic and conventional cultivation of *Lavandula angustifolia* Mill. in Poland. Various parameters were compared, including the level of microbiological contamination. Depending on the origin of the flowers, the microbiological contamination of the raw materials varied greatly. The organic flowers had the highest levels of aerobic bacteria, yeasts, and molds, compared to conventional flowers. The flowers from the organic production had the highest level of *Enterobacteriaceae*. However, all raw materials examined were below the acceptable contamination levels established by the European Pharmacopoeia standard (2010) [221]. After six months of storage, microbial contamination decreased at varying rates, probably for two main reasons: the fact that bacterial species are more or less susceptible to drying, and the presence of plant compounds with antimicrobial properties, such as essential oils, anthocyanins, and tannins which can affect microbial survival.

Wetzel et al. [217] also examined the microbial biota of edible flowers, specifically *Pelargonium hortorum* and *Viola tricolor* cultivated in organic conditions. Their study revealed the presence of various pathogens, including *Enterobacter* spp., *Bacillus* spp., *P. aeruginosa* and *S. enterica* subsp. *enterica* serovar Typhimurium, with a significant number of isolates belonging to the *Enterobacteriaceae* family. Three main factors can contribute to the microbial presence in these flowers: temperature, selective medium, and native plant-bacteria interactions. Most *Enterobacteriaceae* species arise from fecal contamination during pre- or post-harvest handling processes. The presence of *Enterobacteriaceae* could indicate poor hygienic practices during handling and processing. Furthermore, the packaging of edible flowers can exacerbate the risks of microbial contamination.

Sasu et al. [209] discovered that cucumber beetles could lead to microbial contamination in edible flowers. These beetles feed on cucurbitacin in the flowers' anthers, leaving behind excreta that exposes the petals to pathogens such as *Erwinia tracheilphila*. Once inside the plant, the bacteria multiply in the xylem, producing an exopolysaccharide matrix that stops the water flow and causes wilting symptoms, which typically manifest 7–15 days after infection.

In addition to bacteria, edible flowers can also be contaminated by fungi. This is the case of *Hibiscus rosa-sinensis* for which a fungal disease caused by the fungus *Choanephora infundibulifera* has been reported in Korea in 2013 [212] and previously in other countries, including Japan, Myanmar, and the United States. The initial symptoms of the disease manifested as red-violet spots at the tips of the flowers, which later developed into reddish-brown, water-soaked lesions, leading to rapid decay of the affected flowers. Furthermore, some authors found that petunia can be contaminated by *Phytophthora cryptogea*, a pathogen responsible for the rapid decline of petunias [218] and *Botrytis cinerea* [219], the most common, devastating and pathogenic fungus that causes gray mold in greenhouse-grown petunias.

Ruiz Rodríguez et al. [222] carried out a microbial analysis of various edible flowers in Northern Argentina, including papaya flowers (*Carica papaya* L.). Their findings revealed the presence of total microbial counts, coliforms, and lactic acid bacteria.

Carpena et al. [216] carried out a comprehensive study assessing the chemical and microbiological risks associated with the consumption of wild edible plants (WEPs) and flowers, specifically focusing on *Ocimum basilicum* (basil), *Origanum vulgare* (oregano), *Salvia rosmarinus* (rosemary), and *Thymus vulgaris* (thyme). The research revealed significant contamination by various pathogens, with *Salmonella* spp. being the most frequently reported pathogen, followed by *B. cereus* and *E. coli*. *Ocimum basilicum* was identified as the most contaminated herb, exhibiting high microbial loads. Yeasts and molds were present only in *Ocimum basilicum* with counts ranging from 4.92 to 5.35 log CFU/g; aerobic mesophilic bacteria were found in *Ocimum basilicum*, with counts oscillating from 5.00 to 6.95 log CFU/g. Mesophilic bacteria counts ranging from <10 to 1.2×10^7 CFU/g were found in *Origanum vulgare*; *E. coli* and *Enterobacteriaceae* were present at counts of 1.4–6.5 log CFU/g and 6.47 log CFU/g, respectively. *B. cereus* was present only in *Salvia rosmarinus* with counts ranging from 1 to 5×10^6 CFU/g, while *L. monocytogenes* and *C. perfringens* were found only in *Salvia rosmarinus* and *Thymus vulgaris* with a count of 1.5×10^3–7.9×10^3 CFU/g and 0.8×10^3–2.5×10^3 CFU/g, respectively. In a previous study, Wetzel et al. [215] compared organic and conventional *Ocimum basilicum*, revealing a higher microbial diversity associated with organically grown samples, due to the absence of chemical fertilizers, which can expose plants to multiple sources of environmental contamination, such as animal manure. The results demonstrated the presence of *Enterobacter* spp., *Bacillus* spp., *P. aeruginosa*, *S. enterica* subsp. *enterica* serovar Typhimurium, *E. raffinosus*, *Erwinia* spp. and *K. singaporensis*. In particular, a large number of *Enterobacter* spp. was found in all the samples, indicative of indigenous microbial flora associated with WEPs and edible flowers. This aspect has also been observed in other edible flowers, such as *Pelargonium hortorum.*

Methods to Reduce Microbiological Load in Edible Flowers

Several techniques, including dehydration, drying, vacuum, microwave, and hybrid methods, freezing, and high-pressure processing (HPP) are currently being explored to enhance the microbial safety of edible flowers, extend their shelf-life, and preserve their bioactive compounds. Wilczyńska et al. [205] examined the effects of different packaging methods on microbial quality during cold storage of *Tropaeolum majus* L., *Calendula officinalis* L. and daisy (*Bellis*). Flowers stored in vacuum-sealed PA/PE bags and PET cartons showed minor visual alterations after three days of refrigeration. *Tropaeolum majus* L. and *Calendula officinalis* L. showed minimal changes compared to daisies, which exhibited more wilting. After three days in refrigeration, *Tropaeolum majus* L. was the only flower type still contaminated with *E. coli*. *Calendula officinalis* L. flowers had a *S. aureus* count of 1.89 log CFU/g, while daisies had a substantially higher count of 2.72 log CFU/g, but *S. aureus* was present in all of the samples. Yeasts and molds counts remained relatively stable across the different flower types during refrigeration, with only a slight decrease observed in *Tropaeolum majus* L. The findings highlight the importance of proper handling and storage conditions to mitigate the risk of microbial contamination in edible flowers. Packaging plays a critical role in preventing desiccation, maintaining the delicate structure of flowers and reducing their exposure to microbial decontamination and other pollutants [223]. Even with precautions, some bacteria and fungi can still develop and damage edible flowers due to their unpredictable nature [199]. One of the simplest and most straightforward techniques for preserving edible flowers is low-temperature storage. Depending on the species, edible flowers might be satisfactorily preserved at 4 °C for 7–14 days [224]. Hence, combining low-temperature storage with appropriate packaging is crucial to preserve the microbial integrity of edible flowers over time.

In a study conducted by Fernandes et al. [206], the effect of freezing on the microbial quality of edible flowers, specifically *Viola tricolor* together with *Taraxacum officinale*, *Borago officinalis*, and *K. blossfeldiana* (Yellow kalanchoe) was assessed for the first time. The research focused on how the storage at −18 °C for three months influenced the microbial counts, examining both fresh flowers and those frozen in ice cubes. Fresh flowers had different microbial levels, with *Borago officinalis* showing the lowest counts and *K. blossfeldiana* the highest. The average number of molds and yeasts in fresh edible flowers was approximately 2 log CFU/g. Although freezing led to a reduction or maintenance of microbial growth, *Taraxacum officinale* showed an increase in molds and aerobic mesophilic bacteria post-freezing. In addition, the fresh flowers had levels of *E. coli* and total coliforms below 1 log CFU/g, indicating good hygiene practices during manufacturing. Flowers frozen in ice cubes had lower microbial counts than those frozen individually, likely due to better protection from external contaminations. For optimal safety, thawing of flowers should be carried out in the refrigerator rather than at room temperature, and refreezing should be avoided. Fernandes et al. [99] also explored the shelf life of four edible flowers: *Borago officinalis*, *Centaurea cyanus*, *Viola wittrockiana*, and *Camellia japonica* (rose camelias) focusing on the effects of different high hydrostatic pressure (HHP) treatments. Total mesophilic bacteria, yeasts, molds, and total coliforms were analyzed in both untreated and HHP-treated flowers. Untreated flowers showed significantly higher microbial loads (total aerobic mesophilic and molds) with varying post-harvest behaviors: *Borago officinalis* deteriorated rapidly within 1 day; *Centaurea cyanus* had the longest shelf-life at 12 days; *Viola wittrockiana* and *Camellia japonica* had intermediate shelf life of about 6 days.

7. Conclusions

Edible flowers have been consumed since ancient times in several dishes including beverages, salads, soups, and desserts, and they are becoming an important ingredient in modern cuisine and in food technology applications due to their sensory characteristics such as particular taste, aroma, and texture. In addition, health benefits associated with edible flowers are many and diverse, and include antioxidant, anti-obesogenic, anti-diabetic, and antimicrobial properties, as well as neuro- and hepatoprotective functions.

Despite the many advantages of edible flower consumption, there is still a lack of information about their safe intake, the identification of species, and the risks and contaminants associated with their ingestion. In this context, empirical and ancient knowledge may still be highly relevant. Due to their delicate nature, edible flowers are susceptible to contamination by different undesirable microorganisms, necessitating effective microbial control measures. The most common types of microbial contamination in flowers are usually caused by bacteria and fungi. *Bacillus* spp., *Enterobacte*r spp., *Salmonella* spp., and *Staphylococcus aureus* are among the more frequent bacteria in edible flowers. In this sense, several methods to reduce the microbiological load are being evaluated. Proper agricultural practice and hygienic handling are essential to ensure that the product is harvested with the lowest possible load. On the other hand, appropriate storage conditions and packaging are useful to minimize microbial contamination, ensure the safe consumption of edible flowers, prolong their shelf-life, and preserve their bioactive compounds.

Looking ahead, it is important to assess how best to meet current and future demand for edible flowers. As the consumption of the flowers increases, it will become increasingly important to ensure their safety. Beyond the scientific literature currently available and discussed in the present review, there is still a long way to go in promoting the consumption of flowers as food and ensuring their microbiological safety remains imperative. Public access to accurate, consistent, and trustworthy information on the safety, proper use, and handling of edible flowers will be key to promoting responsible consumption.

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Abbreviations

The following abbreviations are used in this manuscript:

b.w	Body weight
CAR	Carotenoids
CarboH	Carbohydrates
CF	Crude fiber
CFU	Colony forming unit

d.w	Dry weight
FDA	Food and Drug Administration
f.w	Fresh weight
N.D	No data
RASFF	Rapid Alert System for Food and Feed
TDF	Total dietary fiber
TF	Total flavonoids
TPC	Total polyphenol content

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