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## Edible flowers as an emerging horticultural product: A review on sensorial properties, mineral and aroma profile

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## ABSTRACT

**Background:** The current consumer needs for functional and healthy foods, as well as for diversified diets that include a variety of food sources have created a market niche for novel horticultural products such as edible flowers and related food formulations.

**Scope and approach:** Considering the increasing interest on this crop production sector during the last few years, this review aims to compile the most relevant data regarding the production and marketing aspects of edible flowers, focusing on pre- and postharvest parameters that should be taken into account to facilitate their successful marketing. Moreover, this review presents the most important flower species that have been traditionally used or suggested for edible uses, while the sensorial attributes and the mineral profile of edible flowers are also presented. A special section is dedicated to the aroma components and the essential oils of several flower species focusing on those reports which refer to species with edible uses, while the bioactivities of these compounds are also cited. Finally, future remarks regarding the next steps that are required for the establishment of this new food segment in the market and the consumer awareness for related products are discussed.

**Key findings and conclusions:** Edible flowers is a promising and challenging horticultural crop which could provide alternative solutions to farmers under the ongoing climate changing, having also in mind the sustainable use of natural resources, the diversification of agroecosystems and the preservation of biodiversity. Moreover, food industry could benefit by covering market demands for functional and healthy foods through the development of novel floral-based foods and food formulations, thus allowing the valorization of species that are unexplored or underexplored so far.

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## 1. Introduction

Currently, there is an increasing consumers' demand for functional and healthy foods of natural origin, while an important market niche refers to edible flowers (Benvenuti & Mazzoncini, 2021). This demand is also driven by the pursuit of adding new colours and flavors in gourmet dishes by chefs that may diversify food products and make dishes and recipes more attractive to consumers (Cunningham, 2015). However, apart from the aesthetic aspects and the visual improvement that edible flowers may confer to food, they are also highly appreciated for their nutritional and bioactive properties (Fernandes, Casal, Pereira, Saraiva, & Ramalhosa, 2017).

Various flowers in nature are classified as edible when they guarantee safe and harmless aspects for consumption and contribute to human health through their numerous metabolites and their nutritional properties. Currently, approximately 180 species with flowers suitable for human consumption are known, many of them being intensively studied worldwide (Purohit, Rana, Idrishi, Sharma, & Ghosh, 2021). In terms of classification, edible flowers can be grouped into three main categories, e.g. fruit flowers, vegetable flowers and medicinal aromatic flowers (Zhao et al., 2019). Regardless of the category, edible flowers are considered valuable functional food ingredients, being responsible for attributing positive visual aspects, unique aromas and exotic flavors, valuable nutrients and medicinal properties in various food products and dishes (Tardivo & Meru, 2018). Apart from their nutritional value and the important health effects, edible flowers can be used as a highly appreciated food source which facilitates the dietary differentiation strategy in the food market (Tardivo & Meru, 2018). However, much of the potential of the edible use of these flowers is still unexplored, mainly because these plant parts are usually pegged and have a high phenolic composition (Rivas-García et al., 2021). The need of valorization of floral parts of plants is becoming more intense, when considering the vast number of wild species whose flowers could be eaten (Demasi et al., 2021). However, before suggesting new wild edible plants as potential food sources special attention should be given, since many of these species may contain anti-nutritional or toxic with adverse or harmful effects on consumers health (Demasi et al., 2021).

From a historical point of view, mankind has a culture of floriphagy, i.e., the habit of eating flowers since ancient times (Kumari, Ujala, & Bhargava, 2021; Lara-Cortés, Osorio-Díaz, Jiménez-Aparicio, & Bautista-Baños, 2013). This habit is still present in several regions of the world, particularly in the tribal civilizations of the American continent, such as in the millenary Mexican cuisine and the Peruvian Inca civilization (Mulík, Hernández-Carrión, Pacheco-Pantoja, Aguilar-Ruiz, & Ozuna, 2022), while it has been recorded in ancient Greece and Rome as ingredient of the Mediterranean diet (Chatzopoulou, Carocho, Di Gioia, & Petropoulos, 2020), in medieval France and the Victorian England (Pires, Barros, Santos-Buelga, & Ferreira, 2019), and mainly in some regions of Asia and the Middle East (Chen & Wei, 2017). The popularization of these plant parts occurred through different sociocultural and religious interventions and passed down through generations, since many modern dishes, drinks and rites are using various flowers as ingredients (Mulík et al., 2022).

The inclusion of edible flowers in food products can contribute directly to the visual aspects of dishes by adding peculiar shades and by enhancing their overall appearance (Fernandes, Casal, Pereira, Saraiva, & Ramalhosa, 2020; Purohit et al., 2021). At the same time, the use of such species may contribute to the valorization of local flora, the diversification of dietary sources and the improvement in the availability of nutrients in modern diets (Kinupp & Lorenzi, 2014). Currently, the consumption of edible flowers is considered as a growing market trend and its use is directly related to the concepts of eating more natural, healthy, and eco-innovative food products (Matyjaszczyk & Śmiechowska, 2019; Rop, Mlcek, Jurikova, Neugebauerova, & Vabkova, 2012). This aspect corroborates the current expectations of consumers, who have become more critical and are searching for more balanced,

healthy, and safe food, followed by numerous changes in their eating habits (Fernandes et al., 2020). In this perspective, edible flowers can bring functionality to different recipes and, thus, help to prevent multiple human pathogenic symptoms and chronic diseases when integrated in diets on a daily basis (Pires et al., 2021).

The edible flowers segment is valuable in the business market, whether for its sale in raw form and the development of new food products and formulations, or even for the extraction of compounds of high interest (Fernandes et al., 2020). This growing market trend is justified by the frequent reference to edible flowers in various media, including culinary TV shows, magazine articles, books, and social networks (Chitrakar, Zhang, & Bhandari, 2019; Fernandes et al., 2020). The scientific community has also shown great interest in edible flowers, as being evidenced by the numerous discoveries of novel bioactive compounds with beneficial health effects (Chitrakar et al., 2019; Fernandes et al., 2020).

The market size of packaged edible flowers is presented in Fig. 1, where an overall increase of 90.5 USD million is expected from 2020 to 2026. There is also a steady annual increase of 4.24% and 4.40% for 2021 and 2022, while the annual growth is expected to raise up to 4.85% for 2026. Moreover, the cumulative annual growth is expected to reach 31.17% in 2026 compared to 2020. Fig. 2 presents the global market share of packaged edible flowers in specific regions of the world.

## 2. Edible flowers: from farm to fork

### 2.1. Production aspects

Currently, there is little information available in the literature regarding the global production and export of edible flowers (Fernandes et al., 2020; Purohit et al., 2021). However, there are particular studies which indicate that specific regions of Asia, especially in the Far East, have higher production and consumption of flowers compared to the Western world (Chen & Wei, 2017). China, India, and Taiwan are identified as the largest producing countries, probably due to cultural aspects, favorable climate conditions, and relatively low labor costs which facilitate the cultivation of specific species for the production of edible flowers (Cunningham, 2015; Fernandes et al., 2020; Purohit et al., 2021). At the macro-market level, Europe is characterized as a promising region for using flowers in the human consumption segment, with countries such as England, France, Spain, Italy, and Portugal showing an exponential increase in the production and consumption of floral-based food products (Fernandes et al., 2020). Recent data demonstrate that within Europe, the Netherlands is considered the largest exporter of flowering bulbs, although not all of them are intended for culinary purposes (Purohit et al., 2021). In the Nordic countries, a shift towards the consumption of wild edible plants has been recorded, including various species with edible flowers (Santos & Reis, 2021). On the other hand, in some parts of Latin and Central America, the habit of flower consumption and production is not evenly spread (Guiné, Florence, Moya, & Anjos, 2020). For example, the production of edible flowers in Mexico is strongly linked to the sociocultural development of rural regions through traditional agriculture (Mulík et al., 2022), while Colombia stands out as one of the largest exporters of carnation roses and chrysanthemums (Purohit et al., 2021). In Brazil, it is not until recently that edible flowers are being produced and commercialized on a large scale (Rodrigues et al., 2017), while in the United States of America, small producers are already producing edible flowers with great market success (Kelley, 2002; Tardivo & Meru, 2018).

Nowadays, with the advent of globalization, the demand for edible flowers has increased as consumer awareness has grown (Rop et al., 2012). Thus, producers of ornamental plants show a growing interest in species with potentially edible flowers, as a new alternative product, aiming to diversify the market, satisfy the needs of customers, contribute to the market demands for more attractive and healthy food and react to recent market crises (Falla, Contu, Demasi, Caser, & Scariot, 2020). In

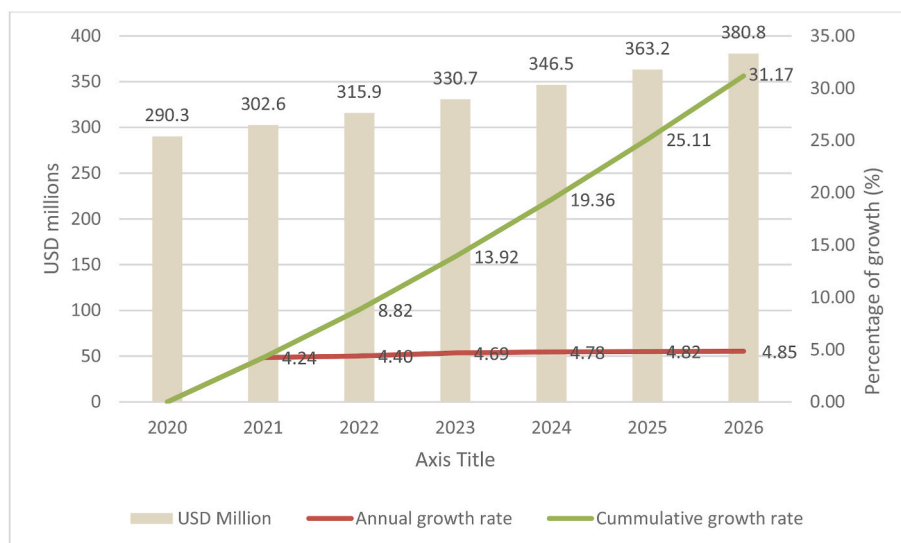


Fig. 1. Market size of packaged edible flowers.

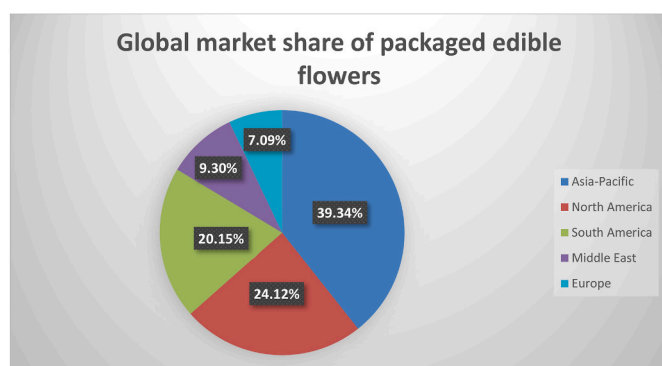


Fig. 2. Global market shares of packaged edible flowers.

this scenario, the environmental aspects of cropping flower species solely for edible uses should be taken into account, especially when considering the differences in agronomic practices and input demands compared to floricultural products for ornamental use (Falla et al., 2020).

In rural regions, the production of edible flowers most often is directly linked to the cultivation of conventional vegetables, being used as alternatives to supplement income for farmers, to expand their product portfolio and encompass the market (Fernandes et al., 2020). Furthermore, the production of many floral species is intended exclusively for decorative and landscaping activities, although they may have interesting edibility characteristics (Pires, Caleja, Garcia, Ferreira, & Barros, 2021 b). Despite being often decentralized, the production of small amounts of edible flowers has promoted great sociocultural achievements, due to its direct impact on local commerce, and the exchange of information between small producers and their customers such as grocery stores, restaurants, and bars (Tardivo & Meru, 2018).

The low-scale production of edible flowers is directly related to the numerous challenges encountered during cultivation and after harvest, since many of these plants are fragile and susceptible to pre- and post-harvest losses, they usually present low yields, and they also are linked with high production and conservation costs due to the particularities of each species (Purohit et al., 2021). Moreover, edible flowers production is also limited by pests and pathogens attacks because they are niche specialty crops and there are no agrochemicals registered to manage such issues; therefore, considering that consumers prefer food

products with no agrochemicals inputs make the production of edible flowers even more challenging (Pereira et al., 2021). In addition, it is worth mentioning that the information about the composition of flowers, food safety and the best practice guides of growing and storing flowers are necessary aspects to be considered by small producers of edible flowers (Fernandes et al., 2020).

One of the current and most suitable alternatives to produce edible flowers is organic cultivation, which, although more demanding in terms of practices and expertise, it can increase the value of the final product and preserve its bioactive properties. Moreover, it can contribute to eco-biodiversity and the protection of the environment by ensuring that no pesticide residues, biological contaminants, and pollutant particles are introduced in the food chain (Fernandes, Casal, Pereira, Ramalhosa, & Saraiva, 2017a, 2017b; Santos & Reis, 2021). However, the production of edible flowers with reduced chemical residues content is indeed a difficult task for their producers, considering the susceptibility of the flower parts to pests and pathogens attacks and the lack of best practice guides regarding their chemical control (Matyjaszczyk & Śmiechowska, 2019). It has to be mentioned that the production of edible flowers must follow the required precautions that are necessary to guarantee food quality and safety, a condition which raises several questions, both from the scientific segment and consumers (Kumari et al., 2021; Matyjaszczyk & Śmiechowska, 2019).

Regarding food safety, some incidences of contamination related to the consumption of edible flowers have already been reported through the European RASFF system (Rapid Alert System for Food and Feed), in which various cases of pathogenic micro-organisms and chemical agents presence in floral specimens were reported (Matyjaszczyk & Śmiechowska, 2019). Despite these incidences, little has been investigated about edible flowers as a contributor to food contamination, although these products are normally consumed raw without adequate hygiene precautions (Santos & Reis, 2021).

Currently, there are a few legislations and legal requirements related to the cultivation, production, marketing, and storage of edible flowers, thus indicating the extremely important demand for strategic regulation and legislation to ensure the safe use of edible flowers (Lara-Cortés et al., 2013; Purohit et al., 2021). To date, no food authority has ruled on the maximum daily intake for each edible flower species, especially in the case of wild edible species where the presence of toxic compounds and antinutritional factors is possible (Demasi et al., 2021). So far, only the European Regulation N° 258/97 (EC) refers to the safety aspects of flowers in relation to the development of novel foods and ingredients (Barani, Zhang, Mujumdar, & Chang, 2022). Therefore, various studies

have reported that one of the most prudent strategies to introduce such species to consumers should be their gradual integration into the diet by means of small quantities (Lauderdale & Bradley, 2014).

Despite the current challenges, many projects have been striving to stimulate the production of edible flowers on a larger scale (Fernandes et al., 2020). A reference example could be the project ANTEA, which spread the knowledge about the edible flower use and accelerated their production through the strategies for the improvement of several floral matrices (Lazarova, Pastorino, Pedrelli, Bisio, & Giacomini, 2019). Through all these scenarios, it can be noted that the edible flowers present themselves as a potent food alternative for the future, being able to contribute directly to the well-being of new generations and shift dietary habits either to direct consumption of edible flowers or to the development of new healthy and functional products based on edible flowers (Purohit et al., 2021). Moreover, it is certain that edible flowers are gaining space in nutraceutical and functional products research which focus their efforts on new agronomic and economic perspectives (Guiné, Santos, & Correia, 2017).

## 2.2. Pre- and post-harvesting aspects

Even before harvesting, intensive care is required for edible flowers, as they are extremely sensitive and susceptible to various contaminants of physical, chemical, and biological origin throughout the food chain (Matyjaszczyk & Śmiechowska, 2019). Among these contaminants, the most important ones are pesticide residues, undesirable chemical agents, natural toxic substances, environmental pollution residues and pathogenic micro-organisms (Matyjaszczyk & Śmiechowska, 2019). However, there are many other points of contamination in the flower production chain, starting from the field and including irrigation with poor-quality water, air and soil pollution, or the use of agrochemicals within the broader region of the cultivation area, as well as during the post-harvest stages of handling, cleaning, and packaging of the final product (Kaiser & Ernst, 2021; Matyjaszczyk & Śmiechowska, 2019). Moreover, although they are similar in plant physiology aspects, edible flowers differ from ornamental flowers in terms of crop production practices and marketing, since their handling from planting to harvesting and processing needs extra care so as to avoid using agrochemicals that can be harmful to human health (Pires et al., 2019; Santos & Reis, 2021). In addition, other relevant aspects for the edible flower producer are the identification of any toxicological properties of the final product, especially in the case of wild edible flowers, since the floral parts of many species are similar and could be confused with non-edible flowers due to the presence of toxic compounds (Guiné et al., 2017; Santos & Reis, 2021).

In this context, special care is needed to ensure the safety and quality of the flowers during the pre-harvest period, including pest and disease control, the removal of dead, damaged and unmarketable flowers, the quality control of irrigation water, the taxonomic identification of the species grown, the preservation of soil quality and the use of proper fertilizers (Kaiser & Ernst, 2021; Santos & Reis, 2021). In addition, good cultivation practices, such as crop rotation or mixed cropping could be good alternatives for pest and disease control, since the use of pesticides is not a viable alternative for edible flowers production due to the lack of registered products (Kaiser & Ernst, 2021). Weed control, on the other hand is pivotal because it can increase labor costs, damage the final product, and increase processing time at harvesting (Kaiser & Ernst, 2021).

It is also recommended to carefully select locations and farms destined exclusively for edible flowers cultivation, with known records of agrochemical use (Kelley, 2002; Santos & Reis, 2021). The origin of harvested flowers is pivotal, since flowers intended for ornamental use are often sprayed with pesticides or treated after harvest with additives and preservatives which are extremely harmful to human health, thus highlighting the importance of acquiring products from farms specialized in edible flower production (Guiné et al., 2017; Santos & Reis,

2021). In the case of wild edible flowers, it is not recommended to collect them by the roadsides or in open places with access to pets, due to the possibility of residual contamination from feces and urine, while collection from arable lands should also be avoided due to possible residues from agrochemicals (Nicolau & Gostin, 2016; Santos & Reis, 2021). Moreover, the collection of flowers from wild plants should be performed by persons experienced in the identification of the species or after thorough search in literary tools such as guides and illustrated books, while the required protocols for wild plant collection should be followed to ensure that genetic erosion is avoided (Nicolau & Gostin, 2016).

To preserve the freshness of the product, it is recommended that harvesting takes place in the morning, just after the dew has evaporated and when the flowers are fully open, to ensure the best visual appearance of the final product (Kelley, 2002). However, flower tissues have an innate structural fragility, and improper handling may result to rapid degradation and contamination and reduction of visual quality caused by enzymes and microorganisms due to injuries and bruising (Chitrakar et al., 2019). Immediately after harvest, the flowers should be sanitized, cooled, and stored at an average temperature between 1 and 5 °C degrees to prolong shelf life, which can extend from 2 to 14 days under these conditions, depending on the product (Benvenuti & Mazzoncini, 2021).

After the proper sanitization process, the flowers should be stored in specific packages, namely polyethylene trays, or plastic collection boxes which should be kept under freezing conditions (Benvenuti & Mazzoncini, 2021; Fernandes, Ramalhosa, Pereira, Saraiva, & Casal, 2018). In general, flower storage containers should have small perforations to avoid the condensation of vapors and to reduce wilting and rotting of the petals (Fernandes, Saraiva, Pereira, Casal, & Ramalhosa, 2018), while the low storage temperature should preserve the antioxidant activity of the floral tissues (Benvenuti & Mazzoncini, 2021). During cool storage, some organoleptic alterations could be noted, especially under prolonged storage, since there can be discoloration of the petals, and wilting, dehydration, and darkening of the whole flowers (Benvenuti & Mazzoncini, 2021). In addition, the phytochemical content of flowers tends to vary according to the type of packaging, making the proper choice of packaging material an important aspect in ensuring the quality of the product until consumption (Demasi et al., 2021).

Another issue of extreme relevance that should be taken into consideration at harvesting refers to the particularity of each species, since a great variability between species or varieties of the same species exist in terms of growing period and harvesting stage, e.g. some species produce flowers seasonally, presenting a limited harvesting period, while others produce flowers throughout the year and can be harvested for several months (Fernandes et al., 2020). In fact, the seasonal development of some flowers tends to limit their gastronomic use, as many flowers tend to bear flowers only in periods of favorable weather conditions or under specific day lengths (Martins, Camargo, & Morrellato, 2021); however, the agronomic conversion of ornamental species into food species has proved to be a promising alternative to meet this need, as soon as the proper agronomic practices are followed (Benvenuti & Mazzoncini, 2021). Furthermore, soil and climate conditions can also influence the senescence period of the flowers, including the harvesting stage, although few studies have reported this phenomenon for edible flowers (Cavaiuolo, Cocetta, & Ferrante, 2013). Therefore, further knowledge about the specific requirements of each species is necessary to understand the harvesting period of flowers, in order to obtain the highest yield, as well as to define the best storage conditions (Shantamma et al., 2021). In this context, preventive measures are of extreme necessity to preserve the properties of edible flowers and reduce the impacts of post-harvest degradation. Among these measures, the methods of conservation stand out, namely: the dehydration of the flowers by freeze-drying, hot-air drying, osmotic drying, sun-drying, shade-drying, as well as conservation by cold, canning in sugars and preservation in distillates among others (Kumari et al., 2021; Pires et al.,

2019). It has to be noted, that inadequate implementation of drying methodologies can lead to phytochemical degradation of flower components, as their bioactive compounds are prone to alterations under diverse conditions, such as extreme cold and heat, pH changes, water removal, photodegradation and oxidation (Kumari et al., 2021). Extending the shelf life of edible flowers, and preserving their bioactivities and sensorial characteristics, is still a challenging task which has to take into account the whole value chain, including cultivation, postharvest and processing practices.

### 2.3. Market perspectives

Currently, the global food market has focused its efforts on meeting the demands of consumers who seek the adoption of healthier, safer, and more nutritious dietary habits (McClements & Grossmann, 2021). The segment of edible flowers still presents itself as a complementary or a side-product in relation to the conventional fruit, vegetables, and other horticultural commodities (Holmer, Linwattana, Nath, & Keatinge, 2013). Despite its slow progress and establishment, the market for fresh and processed edible flowers is growing steadily (Barani et al., 2022). In that regard, traders have made efforts to solidify flowers in the market sector, a fact which is proven by the greater availability of edible flowers in supermarkets and retail shops, or even by their increasing use in various gourmet dishes by chefs (Fernandes et al., 2017a).

The sector of edible flowers for human consumption is very diverse and broad since there are many alternative food products with added value that could be integrated in human diet, in particular, drinks, beverages, dishes, preserves, jams, and others (Purohit et al., 2021). This insertion of flowers as edible ingredients or even in the decoration of dishes and drinks, justifies the appearance of an emerging market and its potential demands (Ganesamoorthy Janarny, Gunathilake, & Rana-weera, 2021 b). Flowers by themselves, as well as their derivatives, are already available in specialized outlets such as farmers' markets, grocery stores, street markets, restaurants, and even online sales sites (Fernandes et al., 2020). Furthermore, many of these plants are not only marketed locally, but they are also exported, which indicates their high potential for sale and marketing (Cunningham, 2015; Kaiser & Ernst, 2021; Rop et al., 2012).

Certainly, edible flowers are filling a significant market gap, a trend that could be reinforced by encouraging commercial cultivation of various species, targeting their flowers as the final product (Pires et al., 2021). The growing and constant sale of edible flowers are related to the innumerable benefits, such as its capacity to improve the appearance and enhance the flavor and aesthetic valorization of foods products, aspects that are in accordance with the expectations of consumers (Fernandes, Casal, Pereira, Ramalhosa, & Saraiva, 2017b). The choice of suitable species with prolonged production, is a major market alternative to meet the food sector's need for diverse, flexible and widely available food products (Kelley, 2002). In addition to these parameters, the straightforward introduction of some floral specimens in the food market could be justified by their nutraceutical benefits, especially their antioxidant properties, which can often be compared to the bioactivities of fruit and vegetables commodities (Zheng, Lu, & Xu, 2021).

In fact, edible flowers are appreciated as a profitable alternative for farmers, although the needs of targeted consumers should be considered for the mutual benefit of both parties (Falla et al., 2020; Kaiser & Ernst, 2021). In another perspective, the production of flowers for human use show a great opportunity for the diversification of the agri-food sector, whether they are intended for conventional ornamental use or as a food source (Solarte, Cejudo-Bastante, Hurtado, & Heredia, 2022). Moreover, forecasts estimate that the market for the edible flowers market is likely to increase its annual growth rate by about 4.7% from 2022 to the end of 2032 ("https://www.factmr.com/report/2979/edible-flowers-market," 2022). However, despite the ambitious market growth perspective, there are many obstacles to overcome regarding the trading of edible flower (Guiné et al., 2020). To date, much of the market potential of

edible flowers remains unexploited, although some societies and local communities have a culture of consuming various flowers in traditional cuisine (Stefaniak & Grzeszczuk, 2020). However, although there are numerous flower species available for commercialization, they represent only a small fraction of the wide range of edible flowers present in nature, which need to be valorized and become available on the market (Demasi et al., 2021).

Table 1 summarizes a part of the current potential of edible floral parts, through its frequently food uses and its geographical origins.

Broadening the knowledge about the phytochemical composition and commercialization of edible flowers is a crucial factor to meet the demands of consumers, producers, and retailers (Demasi et al., 2021). The fragile texture of flowers and the high perishability index of the final product make the marketing of fresh flowers very challenging due to the postharvest processes which induce dehydration and oxidation (Guiné et al., 2020). Another challenge to overcome is the all year round availability of some species and varieties of flowers, since many consumers report difficulty in finding non-conventional edible flowers in retail shops (Mazon et al., 2019). Furthermore, the adoption of more appropriate processing and storage methods, the optimization of post-harvest treatments and the development of a globally organized food chain are pivotal factors that must also be considered for the successful marketing of edible flowers (Cavaiuolo et al., 2013). Thus, the last but not least important for the commercial success, is to focus on introducing these new products to the market, since for many consumers the edible flower market is still something new and uncommon (Benvenuti & Mazzoncini, 2021).

### 3. Mineral profile

Despite their low caloric value, edible flowers have aroused interest in the food sector due to their promising profile of health-relevant compounds (Kumari et al., 2021). Nowadays, several studies have reported that in terms of macronutrients, the profile of flowers resembles other more commonly consumed plant organs such as leaves, stems and fruit (Fernandes et al., 2019; Mlcek & Rop, 2011; Rop et al., 2012). The edible products of flowers are generally divided into three main parts: pollen, petals, and nectar, each of which has interesting nutritional particularities (Barani et al., 2022). Pollen, for example, contains high amounts of proteins, carbohydrates, fats and often carotenoids; the petals are a good source of vitamins, antioxidants and minerals; while the nectar has a high concentration in sugars such as fructose, sucrose, and glucose (Barani et al., 2022). However, despite the prolific scientific research during the last years it is believed that the medicinal and nutritional potential of the flowers has not yet been adequately revealed and more research is needed to further valorize these valuable natural matrices (Barani et al., 2022). In more specific terms, minerals are micronutrients that human body is unable to produce, and can be found in various foods, including edible flowers, which are still scarcely explored from the scientific community (Mitra et al., 2022).

Minerals are responsible for numerous important functions in human body, such as bone formation, hormones synthesis, and transmission of nerve impulses (Rop et al., 2012). For these reasons, the regular inclusion of these components in the daily diet is advisable, since their deficit is associated with several severe symptoms (Drago, 2022). From another perspective and in market terms, an increase in consumer interest has been observed for alternative food products richer in micronutrients, such as vitamins and minerals, which indicates the creation of a new market niche for edible flowers (Rop et al., 2012). Previous studies have already suggested that edible flowers have interesting mineral profiles (Kumari et al., 2021), such as phosphorus (P), potassium (K), sodium (Na) and calcium (Ca) which stand out as the most abundant elements, whereas zinc (Zn), iron (Fe), nitrogen (N), magnesium (Mg), copper (Cu), molybdenum (Mo), manganese (Mn), and strontium (Sr) are usually detected in lesser amounts (Cunningham, 2015; Mlcek et al., 2021; Rop et al., 2012).

**Table 1**  
Potentially edible flowers, their origins and food applications around the world.

Scientific Name	Synonyms	Common name	Native/Range	Food Uses	References
<i>Abelmoschus manihot</i> (L.) Medik		Aibika; sunset muskmallow; sunset hibiscus; hibiscus manihot	India, China and Malaysia	The juice of the flowers is used to treat chronic bronchitis and toothache	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Abutilon indicum</i> (L.) Sweet		Indian abutilon; Indian mallow	Africa, Asia (tropical and subtropical region)	The flowers are commonly used to treat fever, colic and to clean wounds and ulcers	("https://powo.science.kew.org/," 2022; "PlantUse English," 2022)
<i>Acacia aneura</i> F. Muell. ex Benth.		Mulga; true mulga	Australia	Cooked flowers, and pollen grains are often used in fritters	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Acacia dealbata</i> Link.		Silver wattle; blue wattle; mimosa	Australia	Human consumption and beverages	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Acacia retinodes</i> Schltldl.		Retinodes water wattle; swamp wattle; wirilda; ever-blooming wattle; silver wattle	South Australia	Cooked flowers	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Acca sellowiana</i> (O. Berg) Burret	<i>Feijoa sellowiana</i> (O.Berg) O.Berg	Feijoa; pineapple guava; guavasteen	Brazil, Uruguay, and Argentina	The flowers have a sweet flavor and can be eaten raw, with fruit, salads or to decorate cakes	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Achyranthes aspera</i> L.		Chaff-flower; prickly chaff flower; devil's horsewhip	Old world (tropical and subtropical region)	Used for human consumption	("https://powo.science.kew.org/," 2022)
<i>Adansonia digitata</i> L.		African baobab; monkey-bread tree; upside-down tree; cream of tartar tree	Africa	The flowers are generally eaten in times of drought	("http://pza.sanbi.org," n.d; "https://powo.science.kew.org/," 2022)
<i>Agastache foeniculum</i> (Pursh) Kuntze		Anise hyssop; blue giant hyssop; Fragrant giant hyssop; lavender giant hyssop	Canada and United States of America (North America)	The flowers are eaten, raw or cooked, usually as seasoning in dishes such as salads and meat	("https://pfaf.org," 2022)
<i>Agastache rugosa</i> (Fisch. & C.A. Mey.) Kuntze		Wrinkled giant hyssop; Korean mint; purple giant hyssop; Indian mint; Chinese patchouli	<i>Agastache rugosa</i> (Fisch. & C.A.Mey.) Kuntze	Used for food	("https://powo.science.kew.org/," 2022)
<i>Agave americana</i> L.		Century plant; maguey; American aloe	United States of America and Mexico	The stems of the flowers can be consumed roasted, and their sap is used for the preparation of syrup	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Agave parryi</i> Engelm.		Parry's agave; mescal agave	Southwest of North America	The flowers are used to make syrup	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Ageratum houstonianum</i> Mill.		Flossflower, bluemink; blueweed; pussy foot; Mexican paintbrush	Mexico to Central America	The flowers are used cooked and in salads	("https://powo.science.kew.org/," 2022)
<i>Albizia julibrissin</i> Durazz.		Persian silk tree; pink silk tree; mimosa tree	Japan	The flowers are used cooked	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Alcea rosea</i> L.		Common hollyhock	Turkey	The flowers and flower buds are used in salads	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Alliaria petiolata</i> (M. Bieb.) Cavara & Grande		Garlic mustard	Europe, Central Asia and Africa	The flowers and pods are eaten raw	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Allium cernuum</i> Roth.		Nodding onion; lady's leek	North America, Canada and Mexico	The flowers are eaten raw or cooked, have a strong flavor and are often used in salads	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Allium moly</i> L.		Yellow garlic; golden garlic; lily leek	Mediterranean Europe and North of Africa	The flowers are eaten raw in salads	("https://pfaf.org," 2022)
<i>Allium neapolitanum</i> Cirillo		Neapolitan garlic; Naples garlic; daffodil garlic; false garlic; flowering onion; Naples onion; Guernsey star-of-Bethlehem star; white garlic; wood garlic	Mediterranean Europe, Africa, and West of Asia	Flowers are eaten raw or cooked, usually in salads	("https://pfaf.org," 2022)
<i>Allium sacculiferum</i> Maxim.		Northern plain chive; triangular chive	China, Japan, Korea and Russia	Raw flowers, are used as a garnish in salads	("https://garden.org," 2022; "https://pfaf.org," 2022; "https://www.gbif.org/pt/," 2022)
<i>Allium tuberosum</i> Rottler ex Spreng.		Garlic chives; Oriental garlic; Asian chives; Chinese chives; Chinese leek	Himalaya, China, Mongolia and North America	Flowers and flower buds are eaten raw or cooked	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)

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Table 1 (continued)

Scientific Name	Synonyms	Common name	Native/Range	Food Uses	References
<i>Allium ursinum</i> L.		Wild garlic; Ramsons; Cowleekes; cows' leek; cowleek; buckrams; broad-leaved garlic; wood garlic; bear leek; Eurasian wild garlic; bear's garlic	Europe and West of Asia	Flowers and flower buds are eaten raw or cooked	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Aloe vera</i> (L.) Burm. f.		Aloe	Europe Mediterranean	Used in medicinal formulations and in drinks when properly prepared	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Alpinia galanga</i> (L.) Willd.		Greater galangal; lengkuas; blue ginger	South China to West and Central of Malaysia	The edible yellow-white flowers are often eaten as vegetable	("https://powo.science.kew.org/," 2022; "https://www.nparks.gov.sg," 2022)
<i>Alpinia zerumbet</i> (Pers.) B.L.Burt & R.M.Sm.		Shell ginger; pink porcelain lily; variegated ginger; butterfly ginger	Japan, Taiwan, China, and Malaysia	The flowers are popularly used for expectoration	("https://powo.science.kew.org/," 2022; INaturalist, 2022)
<i>Alternanthera sessilis</i> (L.) R.Br. ex DC.		Sissoo spinach; Brazilian spinach; sessile joyweed; dwarf copperleaf; mukunuwenna	Tropical and Subtropical Asia, Australia, Mexico, and Tropical America	Human food and beverages	("https://powo.science.kew.org/," 2022; INaturalist, 2022)
<i>Althaea officinalis</i> L.		Marsh mallow; marshmallow	Europe to Central, Siberia, West of Pakistan, and Northwest of Africa	The flowers are used in the preparation of infusions	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Anchusa azurea</i> Mill.		Garden anchusa; Italian bugloss; bugloss	Europe and Western Asia	Salads, soups and fries	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Anchusa capensis</i> Thunb.		Bugloss; Cape Forget-Me Not; Summer Forget-Me Not; Vergeet-My-Nietjie; Ystergras; Koringblom; Ossetongblaar; Petlekheme; Alkanet	South Africa	Salads, soups and fried	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Anchusa officinalis</i> L.		Common bugloss; alkanet	Europe to Caucasus	The flowers can be cooked or used as a garnish	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Anthemis tinctoria</i> L.	<i>Cota tinctoria</i> (L.) J.Gay	Golden marguerite; yellow chamomile; oxeeye chamomile; yer's chamomile; Boston daisy; Paris daisy	Europe (Mediterranean region)	The flower can be used for infusions	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Anthriscus cerefolium</i> (L.) Hoffm.		Chervil; French parsley; garden chervil	East Central Europe to Northwest and North Iran	The flowers are used as a seasoning	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Antigonon leptopus</i> Hook. & Arn.		Coral vine; queen's wreath	Mexico to Central America and Thailand	The flower can be used to make omelets and salads	("https://powo.science.kew.org/," 2022)
<i>Aponogeton distachyos</i> L.f.		Waterblommetjie; Cape-pondweed; water hawthorn; vleiikos; Cape pond weed	South Africa, and occasionally naturalized in Britain	The flowers are used as a flavoring	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Aquilegia canadensis</i> L.		Canadian or Canada columbine; eastern red columbine; wild columbine	Central East Canada to North East Mexico	The flowers are eaten raw and have a sweet taste	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Aquilegia vulgaris</i> L.		European columbine; common columbine; granny's nightcap; granny's bonnet	Europe, North Africa, and China	The flowers are eaten raw and have a sweet taste	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Arabis alpina</i> L.		Alpine rock-cress	North and Central Europe to West Central Siberia, North and East Canada to Greenland	Flowers are used raw or cooked	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Arctium lappa</i> L.		Greater burdock; gobō; edible burdock; lappa; beggar's buttons; thorny burr; happy major	Temperate Eurasia	The flowers can be eaten raw or cooked, in salads	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Artemisia ludoviciana</i> Nutt.		Silver wormwood; western mugwort; Louisiana wormwood; white sagebrush; lobed cud-weed; prairie sage; gray sawewort	Western North America and Mexico	The flowers are used as a flavoring, garnish, in sauces, and in infusions	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Artocarpus heterophyllus</i> Lam.		Jackfruit; jack tree	Southwest India	The flowers can be used raw or cooked, in garnishes, sauces and salads	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)

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Table 1 (continued)

Scientific Name	Synonyms	Common name	Native/Range	Food Uses	References
<i>Asarum canadense</i> L.		Canada wild ginger; Canadian snakeroot; broad-leaved asarabacca	South Central and Southeast Canada to Central and East United States of America	The flowers are used as a substitute of ginger	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Asclepias incarnata</i> L.		Swamp milkweed; rose milkweed; rose milkflower; swamp silkweed; white Indian hemp	Central and East of Canada to West Central and East of United States of America	Unopened flower buds are cooked; they can also be dried and stored for later use; the flower clusters can be boiled down to make a sugary syrup	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Asclepias speciosa</i> Torr.		Showy milkweed	West and Central Canada to West and Central United States of America	The flower buds are eaten raw or boiled, they can be used to thicken soups and the flower clusters can be boiled to make a sugary syrup	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Asclepias syriaca</i> L.		Common milkweed; butterfly flower; silkweed; silky swallow-wort; Virginia silkweed	Central and East Canada to Central and East of United States of America	Flowers and young flower buds cooked	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Asclepias tuberosa</i> L.		Butterfly weed	Southeast of Canada, United States of America to North Mexico	The flowers are used to make sugary syrup	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Asphodeline lutea</i> (L.) Rchb.		King's spear; yellow asphodel	Mediterranean in Southern and Eastern Europe, North Africa and east to the Caucasus	Flowers can be eaten raw, can decorate dishes or compose salads, have a sweet taste and are very sensitive	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Averrhoa carambola</i> L.		Carambola; star fruit; five-corner	Central and East Java to Maluku	The flowers are eaten raw, have an acidic flavor, are added to salads, and can also be made into preserves	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Bacopa monnieri</i> (L.) Wettst.		Water hyssop; waterhyssop; brahmi; thyme-leafed gratiola; herb of grace; Indian pennywort	Tropics and Subtropics	The flowers are eaten in times of food shortage	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Balsamita major</i> Desf.	<i>Tanacetum balsamita</i> L.	Costmary; alecost; balsam herb; bible leaf; mint geranium	Eastern Mediterranean to Krym and Iran	The flower petals are used for conserves	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Bauhinia acuminata</i> L.		Dwarf white bauhinia; white orchid-tree; snowy orchid-tree	South China to Tropical Asia and North Australia	The flowers are eaten cooked, and flower buds are eaten pickled or used in curry	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Bauhinia purpurea</i> L.		Orchid tree; purple bauhinia; camel's foot; butterfly tree; Hawaiian orchid tree	Indian Subcontinent to Myanmar	The flowers are cooked and eaten as a vegetable and flower buds are often pickled or used in curries	( <a href="https://garden.org">https://garden.org</a> ," 2022; <a href="https://pfaf.org">https://pfaf.org</a> ," 2022)
<i>Bauhinia racemosa</i> Vahl	<i>Phanera vahlii</i> (Wight & Arn.) Benth.	Bidi leaf tree	Indian Subcontinent	The flower buds are eaten as a vegetable	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Bauhinia variegata</i> L.		Orchid tree; mountain ebony	Indian Subcontinent to China	The flower can be used as vegetable	( <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022; Kumari et al., 2021)
<i>Bellis perennis</i> L.		Daisy; common daisy; lawn daisy; English daisy	Europe to West of Asia	The flowers have a sour taste; they can be used in sandwiches, soups and salads	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Benincasa hispida</i> (Thunb.) Cogn.		Wax gourd; ash gourd; white gourd; winter gourd; winter melon; tallow gourd; ash pumpkin; Chinese preserving melon	Central and South Malaysia to Southwest of Pacific	Flowers are steamed and eaten as vegetables, or added as a flavoring in soups	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Bergenia ciliata</i> (Haw.) Sternb.		Fringed elephant's ears; winter begonia; hairy bergenia	West Himalaya to Southwest of Nepal	The flowers are boiled and then pickled	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Betula nana</i> L.		Dwarf birch	Europe (Subarctic and Mountains) and East of America (Subarctic)	The buds and twigs are used as a flavoring in stews	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)

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Table 1 (continued)

Scientific Name	Synonyms	Common name	Native/Range	Food Uses	References
<i>Bombax ceiba</i> L.		Cotton tree; Malabar silk-cotton tree; red silk-cotton; red cotton tree; silk-cotton; kapok	Tropical and Subtropical Asia to North Australia	The flowers are dried, crushed and used in the preparation of bread, infusions and vegetable dishes	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; Kumari et al., 2021)
<i>Borago officinalis</i> L.		Borage; starflower	West and Central of Mediterranean	The flowers are eaten raw; used as decorative garnish in salads and drinks, pickles, cakes, infusions, pastries, and desserts	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022; Janarny, Ranaweera, & Gunathilake, 2021 a)
<i>Bougainvillea brasiliensis</i> Lund ex Choisy	<i>Bougainvillea spectabilis</i> Willd.	Great bougainvillea	East and South of Brazil	The flowers are used to make a beverage	( <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022; Williams et al., 2021)
<i>Bougainvillea glabra</i> Choisy		Lesser bougainvillea; paperflower	Thailand and East to South of Brazil	The integral flowers generally used in infusions and salads	( <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022; Janarny et al., 2021)
<i>Brassica juncea</i> (L.) Czern.		Brown mustard; Chinese mustard; Indian mustard; leaf mustard; Oriental mustard; vegetable mustard	North Europe to Central Asia	Flowers and stems are eaten raw or cooked	(( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022; <a href="https://www.gbif.org/pt/">https://www.gbif.org/pt/</a> ," n.d.; Janarny et al., 2021)
<i>Bromelia pinguin</i> L.		Wild pineapple	Mexico and Tropical America	The inflorescences can be eaten fried and used to make porridge	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Bunias orientalis</i> L.		Turkish wartycabbage; warty-cabbage; hill mustard; Turkish rocket	East Central Europe to Northeast of China	Flower buds are consumed raw or cooked, they can be an alternative to broccoli	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Cadaba farinosa</i> Forssk.		Cadaba bush; herd-boy's fruit	Sahara to Tropical Africa, and Arabian Peninsula	Flower buds are stimulant, antiscorbutic, purgative	( <a href="https://garden.org">https://garden.org</a> ," 2022)
<i>Caesalpinia gilliesii</i> (Hook.) D.Dietr.	<i>Caesalpinia gilliesii</i> (Hook.) D.Dietr.	Bird of paradise	Chile to Uruguay	The flowers can be used as food coloring	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Caesalpinia pulcherrima</i> (L.) Sw.		Poinciana; peacock flower; red bird of paradise; Mexican bird of paradise; dwarf Poinciana; pride of Barbados; flos pavonis; flamboyant-de-jardin	Southeast Mexico to Central America	The flowers are claimed to be effective against intestinal worms and cure sores	( <a href="https://flora-on.pt">https://flora-on.pt</a> ," 2012; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Calendula arvensis</i> L.		Field marigold	Macaronesia, Europe to Mediterranean and West Himalaya and Arabian Peninsula	The flowers can be picked, and the petals can be used fresh in salads or dried and used to color cheese or as a substitute for saffron	( <a href="https://aegeanedibles.weebly.com">https://aegeanedibles.weebly.com</a> ," 2022; <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Calendula officinalis</i> L.		Pot marigold; common marigold; ruddles; Mary's gold; Scotch marigold	West of Mediterranean	The petals can be eaten fresh, or dried and they have a high potential as an edible coloring agent	(Amrouche et al., 2022; <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022; Kumari et al., 2021)
<i>Calluna vulgaris</i> (L.) Hull		Common heather, ling; heather	Macaronesia, Europe to Central Siberia, and North of Morocco	The flowers are used in infusions and can replace hops in beer production	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Calotropis gigantea</i> (L.) W.T.Aiton	<i>Calotropis procera</i> (Aiton) W.T.Aiton	Crown flower	South China and Tropical Asia	The central part of flower can be used as candied sweet	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022; Janarny et al., 2021)
<i>Calligonum polygonoides</i> L.		Phog	Central and West of United States of America	Fresh flower buds can be added to salads	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Caltha leptosepala</i> DC.		White marsh marigold; twinflowered marsh marigold; broadleaved marsh marigold	Central Alaska West of United States of America	The flowers can be eaten raw or pickled; however care must be taken regarding toxicity	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Caltha palustris</i> L.		Marsh-marigold; kingcup	Temperate and Subarctic Northern Hemisphere	Buds are edible only when cooked; young flowerbuds can be used as a spice	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)
<i>Camellia japonica</i> L.		Common camellia; Japanese camellia	China, Korea, Central and South Japan to Taiwan	The dried flowers are used in the preparation of infusions, and can also be cooked with rice	( <a href="https://pfaf.org">https://pfaf.org</a> ," 2022; <a href="https://powo.science.kew.org/">https://powo.science.kew.org/</a> ," 2022)

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Table 1 (continued)

Scientific Name	Synonyms	Common name	Native/Range	Food Uses	References
<i>Camellia sinensis</i> (L.) Kuntze	<i>Camellia sinensis assamica</i> - (Masters.) Kitam.	Tea plant; tea shrub; tea tree	East of Asia (China)	The flowers are made into 'tempura' using the edible oil that is obtained from the seed	("https://jb.utad.pt," 2022; "https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Cananga odorata</i> (Lam.) Hook.f. & Thomson		Ylang-ylang; cananga tree	Malaysia to North of Australia	The essential oil of flowers is of great importance to the food industry for the production of flavorings	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Capparis spinosa</i> L.		Caper; caper bush; Flinders rose	Europe, Mediterranean to East Asia to Himalayas	Salad and preserved in vinegar and salt	(Amrouche et al., 2022; "https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022; Janarny et al., 2021)
<i>Capsicum annuum</i> L.		Pepper; bell pepper	South and Central America	Flowers are often used raw or cooked	("https://identify.plantnet.org/pt," 2022; "https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Cardamine hirsuta</i> L.		Hairy bittercress	Temperate Subtropical Northern Hemisphere to Old World Tropical Mountains	Flowers are often used to decorate salads	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Cardamine pentaphyllos</i> (L.) Crantz		Five-leaflet bitter-cress; showy toothwort	France to Slovenia	Flowers are eaten raw and have a bitter taste	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Cardamine pratensis</i> L.		Cuckoo flower; lady's smock; mayflower; milkmaids	Greenland to North Central and Northeast United States of America, Azores Island, Temperate Eurasia, Ethiopia	The flowers are very attractive and often used in salads	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Carica papaya</i> L.		Papaya; papaw; pawpaw	South Mexico to Venezuela	The male flowers cooked can be used as vegetable	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Carlina acanthifolia</i> All.			France to Italy	The flowers are cooked as an artichoke replacement	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Carlina acaulis</i> L.		Stemless carline thistle; dwarf carline thistle; silver thistle	Europe to Caucasus	The flowers are cooked as an artichoke replacement	("https://eol.org/," 2018; "https://pfaf.org," 2022)
<i>Carlina vulgaris</i> L.		Carline thistle	Europe to Iran	The flowers are cooked as an artichoke replacement	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Carthamus tinctorius</i> L.		Safflower	Central and East of Turkey to Iran	Food coloring and flavoring	(Amrouche et al., 2022; "https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Caryota urens</i> L.		Solitary fishtail palm; kitul palm; toddy palm; wine palm; sago palm; jaggery palm	East of Asia, India and Sri Lanka.	A type of brown sugar is obtained from the juice of flowers	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Cassia fistula</i> L.		Golden shower; purging cassia; Indian laburnum; Kani Konna; pudding-pipe tree	India, Thailand, and Sri Lanka	The young leaves and flower buds are cooked as a vegetable	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022; Janarny et al., 2021)
<i>Catalpa ovata</i> G. Don		Yellow catalpa; Chinese catalpa	China	Flowers and young pods are boiled and washed (to remove the bitterness)	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Ceiba pentandra</i> (L.) Gaertn.		Kapok; Java cotton; Java kapok; silk-cotton; samauma	Mexico to Tropical America	Flowers are boiled and added to chili sauce; the stamens are used as colorant	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022; Janarny et al., 2021)
<i>Centaurea cyanus</i> L.		Cornflower; bachelor's button	Mediterranean	The flowers are eaten raw or cooked; generally, they used in salads and garnishes, and an edible blue dye can be obtained from the petals	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022; Janarny et al., 2021)
<i>Cercis canadensis</i> L.		Eastern redbud	Central and East United States of America to Mexico	The flowers can be cooked or eaten raw in salads	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)
<i>Cercis siliquastrum</i> L.		Judas tree; Judas-tree	<i>Cercis siliquastrum</i> L.	Flowers are eaten raw or as a pickle; usually they are added to salads or used as a condiment;	("https://pfaf.org," 2022; "https://powo.science.kew.org/," 2022)

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Table 1 (continued)

Scientific Name	Synonyms	Common name	Native/Range	Food Uses	References
<i>Chamerion angustifolium</i> (L.) Holub	<i>Epilobium angustifolium</i> L.	Fireweed; great willowherb; rosebay willowherb; bombweed	Temperate Northern Hemisphere to Northeast of Mexico, Morocco	flower buds are also used as a substitute for capers The floral buds are eaten raw or cooked; the floral buds are added to salads and have a sweet taste	( <a href="https://garden.org">"https://garden.org,"</a> 2022; ( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Cichorium intybus</i> L.		Common chicory; blue daisy; blue dandelion; blue sailors; blue weed; bunk; coffeeweed; cornflower; hendibeh; horseweed; ragged sailors; succory; wild bachelor's buttons; wild endive	Europe, including Britain, from Scandinavia south and east to North of Africa and West of Asia	The flowers can be used in salads, soups, boiled or and baked	(Amrouche et al., 2022; ( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022); Janarny et al., 2021)
<i>Citrus × aurantium</i> L.	<i>Citrus sinensis</i> (L.) Osbeck.	Bitter orange; sour orange; Seville orange; bigarade orange; marmalade orange	Unknown Range	Flowers are boiled and used as a vegetables, or used to flavor infusions	(Amrouche et al., 2022; ( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Chrysanthemum coronarium</i> L.	<i>Glebionis coronaria</i> (L.) Cass. ex Spach	Garland chrysanthemum; chrysanthemum greens; edible chrysanthemum; crowndaisy chrysanthemum; chop suey greens; crown daisy; Japanese greens	Mediterranean to Central Asia and Arabian Peninsula	Usually, only the flower petals are used raw or lightly blanched	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022; Janarny et al., 2021; Kumari et al., 2021)
<i>Clitoria ternatea</i> L.		Asian pigeonwings; bluebellvine; blue pea; butterfly pea; cordofan pea; Darwin pea	Asia, Africa and Australia	The flowers are used to color cooked rice; they are also used in desserts and drinks	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022; Janarny et al., 2021; Kumari et al., 2021)
<i>Cocos nucifera</i> L.		Coconut	Malaysia Central to Southwest Pacific	Generally, the stems of the inflorescence are used to extract a sugary sap, which is later fermented to obtain an alcoholic beverage. In addition, the cooked inflorescence can be used as a vegetable	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Coriandrum sativum</i> L.		Coriander; cilantro	India, China, Russia, and Europe	The flower are be used in wine and spice preparations	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022; Janarny et al., 2021; Kumari et al., 2021)
<i>Cosmos sulphureus</i> Cav.		Sulfur cosmos; yellow cosmos	Mexico, Europe, and Asia	Infusions are prepared from the flowers	( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022; Janarny et al., 2021)
<i>Crocus sativus</i> L.		Saffron crocus; autumn crocus	Greece	The flowers can be used such as food coloring and flavoring	(Amrouche et al., 2022; ( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://plants.ces.ncsu.edu/">"https://plants.ces.ncsu.edu/,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022; Janarny et al., 2021)
<i>Cucurbita argyrosperma</i> C. Huber.		Cushaw squash; silver-seed gourd	Mexico to Nicaragua	The flowers are eaten cooked	(Amrouche et al., 2022; ( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022); Janarny et al., 2021)
<i>Cucurbita maxima</i> Duchesne		Pumpkin; winter squash	Bolivia to North Argentina	The flowers are eaten cooked	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Cucurbita moschata</i> Duchesne ex Poir.		Squash; pumpkin	Mexico to Guatemala	The flowers are eaten cooked	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Cucurbita pepo</i> L.		Summer squash; pumpkin	Central America	The flowers are used as food ingredient, e.g. salads, dressings, soups, and main dishes such as pasta, French crepes and stuffed zucchini flowers	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Cynara cardunculus</i> subsp. <i>cardunculus</i>		Cardoon; artichoke thistle	South of Europe	The flowers are eaten fresh or processed as delicacies, frozen or even canned, as well as being used as milk coagulants for cheese making	(Amrouche et al., 2022; ( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Dianthus caryophyllus</i> L.		Carnation; clove pink	Europe, West and South of France	The flowers are used as food coloring added to salads, garnishes, creams, vodka, jellies and can be candied	(Amrouche et al., 2022; ( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022; Janarny et al., 2021)
<i>Erica multiflora</i> L.	<i>Erica verticillata</i> P. J. Bergius	Mediterranean heath	West and Central Mediterranean	The flowers are used for infusions	(Amrouche et al., 2022; ( <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022; INaturalist, 2022)

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Table 1 (continued)

Scientific Name	Synonyms	Common name	Native/Range	Food Uses	References
<i>Eruca vesicaria</i> (L.) Cav.		Arugula; rocket; garden rocket; eruca; ruchetta; rucola; rucoli; rugula; colewort; roquette	China and Arabian Peninsula	Usually the flowers eaten raw	(“https://jb.utad.pt,” 2022; “https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Foeniculum vulgare</i> Mill.		Fennel	South of Europe	Flower heads are usually eaten raw or cooked	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Helianthus annuus</i> L.		Common sunflower	North America	Young flower buds are eaten steamed and served like globe artichokes	(“https://jb.utad.pt,” 2022; “https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Helianthus tuberosus</i> L.		Jerusalem artichoke; sunroot; sunchoke; wild sunflower; topinambur; earth apple	Central and East of Canada to Unites States of America	The flowers are eaten in soups	(“https://jb.utad.pt,” 2022; “https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Helichrysum italicum</i> (Roth) G.Don		Curry plant; Italian strawflower; immortelle	South Europe	The flowers are used in infusions and decoctions	(Amrouche et al., 2022; “https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022; Primitivo et al., 2022; Universidade de Evora, 2022)
<i>Hemerocallis fulva</i> L.		Range day-lily; tawny daylily; corn lily; tiger daylily; fulvous daylily; ditch lily; Fourth of July lily; railroad daylily; roadside daylily; outhouse lily; wash-house lily	Asia (China or Japan)	Salads, vegetables	(Amrouche et al., 2022; “https://pfaf.org,” 2022; “https://plants.ces.ncsu.edu/,” 2022; “https://powo.science.kew.org/,” 2022; Kumari et al., 2021)
<i>Hibiscus diversifolius</i> Jacq.		Swamp hibiscus	Africa	Flowers usually eaten raw or cooked with other foods	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Hibiscus sabdariffa</i> L.		Roselle	West Tropical Africa to Sudan	The flowers are used as a flavoring and coloring agents in hot and cold beverages, fermented drinks, wine, jam, jellies, ice creams, chocolates, puddings, and cakes	(Amrouche et al., 2022; “https://garden.org,” 2022; “https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Hibiscus sinensis</i> L.	<i>Hibiscus mutabilis</i> L.	Chinese hibiscus	South of China, Taiwan	Teas and food supplements	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Hibiscus sinosyrriacus</i> L.H.Bailey.		Chinese rose of Sharon	Southeast of China	The flowers are consumed raw, cooked or in infusions	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Hibiscus syriacus</i> L.		Rose of Sharon; Syrian ketmia; shrub althea; rose mallow	South of China, Taiwan	The flowers are consumed raw, cooked or in infusions	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Hibiscus tiliaceus</i> L.		Sea hibiscus; coast cottonwood	Tropics and Subtropics	Flowers are eaten in powder and batter and fried	(“https://garden.org,” 2022; “https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Jasminum grandiflorum</i> L.		Spanish jasmine; Royal jasmine; Catalan jasmine; Sicilian jasmine	Eritrea to Rwanda, Arabian Peninsula, Pakistan to South Central China	The flowers are consumed dried, as sugary syrup and infusions	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022; “https://www.nparks.gov.sg,” 2022)
<i>Kraunhia floribunda</i> (Willd.) Taub.	<i>Wisteria floribunda</i> (Willd.) DC.	Japanese wisteria	Japan	Flowers are eaten cooked	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Magnolia grandiflora</i> L.		Southern magnolia; bull bay	South-East United States and Europe	The flowers are used to make pickles and as condiments and seasonings	(Amrouche et al., 2022; “https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Malva alcea</i> L.		Greater musk-mallow; cut-leaved mallow; vervain mallow; hollyhock mallow	South Sweden to South and East Europe and North of Turkey	The flowers are eaten raw and usually added to salads	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Malva moschata</i> L.		Musk mallow; musk-mallow	Europe to West of Turkey	Europe to West of Turkey	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Malva sylvestris</i> L.		Common mallow	Most of Europe, including Britain	Infusions, garnish, decoction, syrups, salads	(Amrouche et al., 2022; “https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Matricaria recutita</i> L.	<i>Matricaria chamomilla</i> L.	Chamomile; chamomile; German chamomile; Hungarian chamomile (kamilla); wild chamomile; blue chamomile; scented mayweed	Europe, including Britain, east to West Asia and the Himalayas	Infusion and cakes	(Amrouche et al., 2022; “https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)

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Scientific Name	Synonyms	Common name	Native/Range	Food Uses	References
<i>Mentha canadensis</i> L.		Canada mint; American wild mint; Chinese mint; Sakhalin mint; Japanese mint; East Asian wild mint	Central and East Siberia to China and Japan, North America	Central and East Siberia to China and Japan, North America	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Mentha suaveolens</i> Ehrh.		Apple mint; pineapple mint; woolly mint; round-leaved mint	South and West Europe, north to the Netherlands and east into West Asia	South and West Europe, north to the Netherlands and east into West Asia	(Amrouche et al., 2022; <a href="https://jb.utad.pt">"https://jb.utad.pt,"</a> 2022; ( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Monarda didyma</i> L.		Crimson beebalm; scarlet beebalm; scarlet monarda; Eau-de-Cologne plant; Oswego tea; bergamot	Southeast of Canada to Eastern United States of America	Raw flowers are used as an attractive garnish in salads	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Moringa oleifera</i> Lam.		Moringa; drumstick tree; horseradish tree; ben oil tree; benzolive tree	Northeast of Pakistan to Northwest of India	The flowers are consumed raw, cooked, or powdered, usually added to salads, soups, as a seasoning or in infusions	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Nelumbo nucifera</i> Gaertn.		Sacred lotus; Laxmi lotus; Indian lotus; simply lotus	Asia, Iran, China, Japan, and Australia	Infusions and salads	(Amrouche et al., 2022; <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Ocimum basilicum</i> L.		Basil; great basil; sweet basil; Genovese basil	Africa and Asia	The flowers and the leaves are used to flavor dishes, especially pasta sauces	(Amrouche et al., 2022; <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Origanum vulgare</i> L.		Oregano; wild marjoram	Europe, Britain, and Asia	The inflorescence stem is used to prepare infusions	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Paronychia argentea</i> Lam.		Algerian tea	Mediterranean Region	Infusions	(Amrouche et al., 2022; <a href="http://almargem.org/biodiv/especie/paronychia-argentea/">"http://almargem.org/biodiv/especie/paronychia-argentea/,"</a> 2022; <a href="https://flora-on.pt">"https://flora-on.pt,"</a> 2012; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Perilla frutescens</i> (L.) Britton.		Deulkkae; perilla; Korean perilla	China, Japan, India	Immature flowers are eaten with tofu, while mature flowers are fried	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Phaseolus coccineus</i> L.		Runner bean; scarlet runner bean; multiflora bean; butter bean	Mexico to Central America	The flowers are eaten raw and taste similar to beans	( <a href="https://garden.org">"https://garden.org,"</a> 2022; <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Prosopis juliflora</i> (Sw.) DC.		Mesquite	Mexico to Venezuela, Peru, Caribbean	The flowers have a sweet taste, they are usually roasted for the production of infusions	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Prunus domestica</i> L.		European plum	Turkey	The flowers are used in salads, ice cream and infusions	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Prunus persica</i> (L.) Batsch.		Peach	North and Central China	Flowers can be used in salads, garnish or brewed into infusions	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Raphanus sativus</i> L.	<i>Raphanus raphanistrum</i> subsp. <i>sativus</i> (L.) Domin	Radish	Greece, Italy, and Ex-Yugoslavia	Young flower clusters are used as a substitute for broccoli, they have a spicy flavor and a crispy texture	( <a href="https://garden.org">"https://garden.org,"</a> 2022; <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Rheum x cultorum</i> Thorsrud & Reis.	<i>Rheum x hybridum</i> Murray	Rhubarb	Cosmopolitan	The immature flowers can be cooked like cauliflower	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Ribes odoratum</i> H.L. Wendl.	<i>Ribes aureum</i> var. <i>villosum</i> DC.	Golden currant; clove currant; pruterberry; buffalo currant	West Central and Central United State of America	Flowers can be eaten raw and have a sweet taste	( <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Robinia pseudoacacia</i> L.		Black locust; false acacia	Eastern North of America	The cooked flower are used in liquor, jam, pancakes, honey	(Amrouche et al., 2022; <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; Janarny et al., 2021)
<i>Rosa x centifolia</i> L.		Provence rose; cabbage rose; Rose de Mai	A garden hybrid of uncertain origin	The petals are usually preserved in sugar, they can be used in pastry products, as a fruit flavoring and infusions	(Amrouche et al., 2022; <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Rosa rugosa</i> Thunb		Rugosa rose; beach rose; Japanese rose; Ramanas rose; letchberry	China, Japan, Korea and naturalized in several places in Britain	Pigments, jams, and teas	(Amrouche et al., 2022; <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)
<i>Rosa x damascena</i> Mill.		Damascene rose; Damask rose; Bulgarian rose; Turkish rose; Taif rose; Arab rose; Ispahan rose; Castile rose	Temperate and Subtropical Northern Hemisphere	Pastry uses, garnish, salads, rose water, infusions and rose oil	(Amrouche et al., 2022; <a href="https://garden.org">"https://garden.org,"</a> 2022; <a href="https://pfaf.org">"https://pfaf.org,"</a> 2022; <a href="https://powo.science.kew.org/">"https://powo.science.kew.org/,"</a> 2022)

(continued on next page)

Table 1 (continued)

Scientific Name	Synonyms	Common name	Native/Range	Food Uses	References
<i>Rosmarinus officinalis</i> L.		Rosemary	South Europe to West of Asia	Used in aromatic decoction, or in roast meat, salads, or potatoes	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022; G. Janarny et al., 2021;)
<i>Rubus arcticus</i> L.		Arctic bramble; Arctic raspberry	North America, Europe, and Asia	The flowers are eaten raw and have a sweet taste	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Salvia officinalis</i> L.		Common sage; just sage	Southwest of Germany to South Europe	Flowers can be used to salads to add color and fragrance	(“https://garden.org,” 2022; “https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)]
<i>Sambucus nigra</i> L.		Elder; elderberry; black elder; European elder; European elderberry; European black elderberry; tramman	Europe, including Britain, from Scandinavia south and east to North Africa and West Asia	White salads, infusions, jellies, jams, and sparkling wine	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022; Ganesamoorthy Janarny et al., 2021)
<i>Sesbania sesban</i> (L.) Merr.		Egyptian riverhemp	Tropical and South Africa, Arabian Peninsula, Indian Subcontinent	Flowers are used as decoration of dishes, as vegetables and in omelet preparation	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Sophora japonica</i> L.	<i>Styphnolobium japonicum</i> (L.) Schott	Japanese pagoda tree; Chinese scholar tree; pagoda tree	Japan and China	Young flowers are eaten cooked	(“https://pfaf.org,” 2022; “https://plants.ces.ncsu.edu/,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Sulla coronaria</i> (L.) B. H. Choi & H. Ohashi	<i>Hedysarum coronarium</i> L.	French honeysuckle; cock’s head; Italian sainfoin; sulla; soola	West and Central Mediterranean	Salad and fries with eggs, soups, boiled	(Amrouche et al., 2022; “https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Syzygium aromaticum</i> (L.) Merr. & L.M. Perry		Clove	Asia (Malaysia)	The flower buds are dehydrated and used as a condiment in various recipes, such as cakes, baked apples and minced meat	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Tagetes erecta</i> L.		Aztec marigold; Mexican marigold; big marigold; cempazúchitl; cempasúchil; African marigold	Mexico to Guatemala	Salad and food colorant	(Amrouche et al., 2022; “https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022; Kumari et al., 2021)
<i>Tamarindus indica</i> L.		Tamarind	Tropical Africa	The flowers are usually eaten in salads	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Taraxacum</i> sect. <i>Taraxacum</i> F.H. Wigg.	<i>Taraxacum officinale</i> Webb.	Dandelion; common dandelion	Throughout most of the northern hemisphere, including Britain	The flowers buds can be stored in vinegar, and fritter’s recipes	(“https://powo.science.kew.org/,” 2022; Williams et al., 2021)
<i>Tilia americana</i> L.		American basswood; American linden	North America	The flowers can be added to salads, infusions, or used as substitutes of chocolate	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Thymus vulgaris</i> L.		Common thyme; German thyme; garden thyme; thyme	Southwest of Europe, Southeast of Italy	Infusions, salads	(Amrouche et al., 2022; “https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022))
<i>Tropaeolum majus</i> L.		Garden nasturtium; nasturtium; Indian cress; monks cress	South America and naturalized in parts Europe	Tea, cakes, and flavoring	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Urena lobata</i> L.		Caesarweed; Congo jute	Tropics and Subtropics	They are often used as emergency food	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Viola odorata</i> L.		Wood violet; sweet violet; English violet; common violet; florist’s violet; garden violet	Europe to West and North of Iran	The flowers can be used in salads, infusions, and ice creams	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)
<i>Viola x wittrockiana</i> Gams		Garden pansy; pansy; viola; violet	Hybrid species	The flowers are used in soups, salads, stews, infusions, desserts, and drinks	(“https://pfaf.org,” 2022; “https://plants.ces.ncsu.edu/,” 2022; “https://powo.science.kew.org/,” 2022; Ganesamoorthy Janarny et al., 2021; Kumari et al., 2021)
<i>Zingiber officinale</i> Roscoe.		Ginger; ginger root	Tropical areas	The young flowers can be eaten raw	(“https://pfaf.org,” 2022; “https://powo.science.kew.org/,” 2022)

Despite the low appreciation of floral species, wild plants have a remarkable potential to contribute to improving the quality of human diet, mostly due to their micronutrient content, especially with regard to minerals and vitamins (Fukalova, Martínez, & Raigón, 2021). The mineral content of flowers is very diverse and variable, since the soil conditions, harvesting time, exposure to salinity and abiotic stressors and the genotypic differences are some of the factors that can

differentiate the content of these elements (Chrysargyris, Tzionis, Xylia, & Tzortzakis, 2018).

A study carried out with fourteen different species of edible flowers, popularly used in cooking, found that all of them contained high amounts of minerals, being Mg (542 mg/100 g), Ca (274 mg/100 g), Na (218 mg/100 g) and K (5,9 mg/100 g), the most abundant ones (Araújo, Matos, Correia, & Antunes, 2019). Moreover, another study dedicated to

the analysis of the nutritional profile of the edible flowers of *Helichrysum italicum* (Roth) G. Don through nuclear magnetic resonance (NMR) analysis, showed high contents of Fe, Zn, Ca and K (Primitivo et al., 2022). The mineral content of three edible flower species (*Tropaeolum majus* L., *Tagetes erecta* L. and *Spilanthes oleracea* L.) was investigated by Navarro-González, González-Barrío, García-Valverde, Bautista-Ortín, and Periago (2014), and the detailed characterization revealed that all the tested species had high contents of K followed by Na, while significant amounts of Zn, Fe, Cu, Mn, Sr and K were also detected (Navarro-González et al., 2014).

In a recent review study regarding the presence of health-promoting substances in edible flowers, it was reported that some flowers are endowed with a high mineral profile, as in the case of *Chrysanthemum*, *Dianthus* and *Viola*; in terms of individual elements, Ca and Fe were abundant in *Dianthus* specimens, while Na was frequently present in *Viola* specimens and Zn was mostly detected in the genus *Chrysanthemum* (Rivas-García et al., 2021). The chemical characterization of six distinct genera of edible flowers, namely *Begonia*, *Tropaeolum*, *Calendula*, *Rosa*, *Hemerocallis* and *Tagetes* by atomic absorption spectroscopy, also indicated that the tested species had mineral contents in the following decreasing order: K, Ca, P, Mg, Na, Zn, Mn, Fe, Cu, and Mo (Mlcek et al., 2021).

In another report, the nutritional composition of eleven edible flowers from northern Thailand (A. malaccensis, B. flabellifer, C. fistula, D. costatus, D. serrulata, G. jasminoides, G. inodorum, H. benthamiana, P. theta, S. grandiflora and T. indica) was studied and significant contents of minerals were observed in terms of K (101–657 mg/100 g), Ca (27–218 mg/100 g) and Na (0.01–0.04 mg/100 g) (Kantadoung, Rachkeeree, Puangpradab, Sommano, & Suksathan, 2018). Flowers from semi-arid regions of Mexico were investigated for their minerals content, namely Agave salmiana Otto ex Salm-Dyck, Aloe vera L. Burm. f. *Erythrina americana* Mill., and *Myrtillocactus geometrizans* Mart. ex Pfeiff. Console, with K and N contents being detected within the range of 1.60–2.70 g/100 g (Pinedo-Espinoza et al., 2020).

It is worth mentioning that although much effort has been made to identify and characterize the mineral profile of floral species, the current studies do not reflect the actual potential that the edible flower segment possesses, as numerous species with edible flowers still remain unexplored in terms of micronutrients composition (Fernandes et al., 2019). Therefore, the inclusion of edible flowers in human diet could significantly contribute to the overall daily requirements of micronutrients, since despite the small amounts consumed they are highly nutritious and rich not only in minerals but also in other bioactive and health beneficial compounds.

#### 4. Aesthetic aspects and sensorial compounds

Edible flowers possess diverse sensorial attributes, such as size, colour, shape, flavors, aroma and texture, characteristics that guarantee their establishment as an innovative ingredient in the food sector (Fernandes et al., 2017b; Guiné et al., 2020). When included in foods, they are responsible for unique aspects, such as distinctive colour notes, exotic flavors, enhanced visual quality, factors that can influence consumers' purchase choice in the decision-making process (Rop et al., 2012). These floral characteristics are perceived by humans through the senses of taste, vision and smell, which often reveal the quality of the product, such as freshness, edibility, and the overall appearance (Mlcek & Rop, 2011; Shantamma et al., 2021).

Cultural and socio-economic factors can also interfere with the adoption of flowers in dietary patterns, due to objective approaches that affect the acceptance by individuals, such as distrust, curiosity or even neophobia, considering the current status of edible flowers in the market (Kelley, 2002; Kumari et al., 2021; Pires et al., 2019). According to Purohit et al. (2021), both acceptance and preference for consuming edible flowers may be linked to specific conditions for each region, while personal attributes such as the education status, gender and income may

also interfere in the process of choice and adoption (Rodrigues et al., 2017).

The use of edible flowers is not just limited to their sensorial aspects, since several floral species possess innumerable benefits to human health, along with historical, symbolic and religious aspects (Gamata & Alejandro, 2021). However, for some individuals the motivation for using edible flowers is related to the harmonious sensorial combination of colour, flavour and aroma when inserted into recipes and garnish food dishes (Santos & Reis, 2021). In fact, sensory, aesthetic and acceptability aspects are generally subjective and many studies have endeavoured to record and decipher the diversity in consumers behaviour. In this context, some studies involving sensorial aspects of edible flowers could be cited. Among several examples, the fact that consumers generally prefer yellow and orange flowers when compared to other colours should be pointed out (Mlcek & Rop, 2011). Moreover, transparent plastic packaging enhances flowers' shapes, colours and its visual appearance (Benvenuti & Mazzoncin, 2021). The conditioning temperature of flowers can also influence their quality, since it may result in deformation of their shape or discoloration of their petals (Marchioni et al., 2022). Combining different colours of flowers in the same package can make the product more attractive (Benvenuti & Mazzoncin, 2021), while the presence of flowers in salad dressings can make the final products more attractive in terms of taste, texture and aroma (Simoni, Santos, Andrade, Villavicencio, & Silva, 2018).

Phenolic compounds such as anthocyanins and xanthophylls may also affect the sensorial aspects of flowers through the distinct colouration of the petals (Barani et al., 2022). With maturity progress, the sucrose content may vary and consequently change the taste of the flowers depending on the species, while textural changes may also take place with some flowers becoming tender and crunchy, while others become more fragile and silky (Mlcek & Rop, 2011). Moreover, fresh flowers have a higher acceptability rate in terms of the hedonic scale when compared to dried flowers (Marchioni et al., 2022). The preservation process by irradiation can also contribute to enhancing the taste characteristics of the flowers (Simoni et al., 2018). The concentration of volatile compounds is not directly related to the human perception of aroma, since many other factors could be involved in the interaction of particular chemical compounds and odor receptors; thus sensorial analysis is the best methodology for evaluating this characteristic (Aros et al., 2020).

Despite the current promising scenario, there are a few studies regarding the sensory attributes of edible flowers which focus on a restricted group of species. However, scientific efforts in this area are of extreme importance, mainly in what concerns the consumers' behaviour and the floral organoleptic aspects which are fundamental to evaluate the quality of the flowers for culinary use and to guarantee the greater acceptance by the consumers (Fernandes et al., 2017b; Marchioni et al., 2022; Purohit et al., 2021). It is suggested that the deep knowledge in human eating behaviour attitudes should also be considered, since consumers reluctance is still present and greater efforts are needed to spread the knowledge about the nutritional, functional, and health aspects of flowers for edible purposes and contribute to increasing their adherence and acceptability (Kumari et al., 2021).

#### 5. Aromatic components and essential oils

The aroma profile of plants, can be defined as a complex mixture formed by the combination of numerous volatile substances, manifesting itself in a particular and unique manner in each species (El Hadi, Zhang, Wu, Zhou, & Tao, 2013). From a biological point of view, almost all plants are capable of emitting volatile substances, but their profile may differ depending on genotypic and phenotypic aspects, as well as on the growing conditions, while these substances can be released into the atmosphere by the aerial plant parts and into the soil by the roots (López-Hortas et al., 2022). These volatile characteristics are also present in species with edible flowers, since numerous molecules can be

found in floral parts and result in the emission of particular aromas and fragrances (López-Hortas et al., 2022).

In general, volatile organic compounds have a high vapors pressure under normal conditions, they are volatilized easily in atmospheric air, have low molecular weight, high melting points and lipophilic character (Kapoor, Bhardwaj, & Sharma, 2022). Plants are considered to be the largest source of these compounds, since more than 1700 volatile components have been identified so far (Kapoor et al., 2022). In terms of synthesis, plant volatiles can be found in various organs, such as leaves, roots, fruit and mainly flowers, which are considered the richest sources in these compounds (Li, Wu, Wang, Zhang, & Song, 2022).

Floral volatiles play a significant role in the reproduction process of plants through the attraction of pollinators; in the protection against biotic and abiotic stressors or repelling pests; as well as in the determination of flavour characteristics when considered as food sources for human consumption (Fernandes et al., 2019). Therefore, these components may also affect consumer preferences, while they can be used for the determination of product quality (Fernandes et al., 2019). Otherwise, volatile substances are also associated with aspects of health, mood, and appetite, since various bioactive compounds can be found in floral aroma constituents (Kapoor et al., 2022). From a commercial point of view, volatiles are in high demand in the cosmetics and perfume industries, in flavourings and food preservatives, in alternative therapeutic applications, as well as in the phytopesticides sector (López-Hortas et al., 2022). Considering the chemical aspects, as well as those related to origin, function and synthesis, floral flavourings can be classified into three main categories: terpenoids, phenylpropanoids/benzenoids and fatty acid derivatives (Kapoor et al., 2022). However, considering the chemodiversity in volatile compounds, edible flowers and other plant organs may also contain other aromatic derivatives, such as esters, alcohols, carbonyls, alkane compounds, amino acid derivatives, lipids and phenolic agents, which are responsible for the distinct aspects of flavour and aroma (El Hadi et al., 2013).

Terpenoids are compounds that contribute to plant defense and they are synthesized and stored in plant trichomes (secretory glands of plants) which play the role of biofactories, being responsible for the production of various compounds, including terpenoids and essential oils (Guan, Chen, Chen, Chen, & Jiang, 2022). To date, there have been identified approximately 556 terpenoids that comprise the largest class of volatiles found in flowers (Kapoor et al., 2022). In general, terpenoids have a chemical formula  $(C_5H_8)_n$  and can be classified as hemiterpenoids, monoterpenoids, sesquiterpenoids, diterpenoids, triterpenoids, tetraterpenoids and polyterpenoids, among others (Fernandes et al., 2019). Due to this diversity in chemical structures and the numerous described bioactive functions, terpenoids have aroused commercial interest in both the pharmaceutical and nutraceutical sectors (Ludwiczuk, Skalicka-Woźniak, & Georgiev, 2017).

Phenylpropanoid and benzoid compounds are the second most common class of volatiles found in flowers, which can be synthesized by microorganisms and plant parts exclusively from the aromatic amino acid phenylalanine (Kumar et al., 2021). More specifically, based on differences in their carbonic structural arrangement these compounds can be divided into three subclasses, namely phenylpropanoids ( $C_6-C_3$ ), benzenoids ( $C_6-C_1$ ) and phenylpropanoid-related compounds ( $C_6-C_2$ ) (Muhlemann, Klempien, & Dudareva, 2014). Omnipresent in the plant kingdom, these substances are known as predecessors of numerous biopolymers and are considered important agents for floral aroma, they promote the attraction of pollinators through aerial signaling, and act as protective agents against ultraviolet irradiation and pathogen attack (Koeduka et al., 2016). Furthermore, apart from being strongly related to ecological aspects, the phenylpropanoids/benzenoids compounds have attracted the industry's attention since they can be used as phytohormones and as food preservatives (Colquhoun et al., 2012).

Moreover, fatty acids are essential constituents for plants and represent the third class of volatile compounds often found in flowers (Muhlemann et al., 2014). Flowers contain monounsaturated and

polyunsaturated fatty acids, and according to the literature more than 35 different fatty acids have been identified and quantified so far (Fernandes et al., 2018). These components derive mainly from unsaturated compounds, having the C18 structure and are mostly represented by linolenic and linoleic acids (Ramya et al., 2017). However, the vast majority of edible flowers are low in fatty acids, considering the high water content of flora parts (70%–95%) (Fernandes et al., 2018). In addition, fatty acids are constituents of plant cell membranes and serve as precursors for numerous metabolites that trigger plant immunity responses (Muhlemann et al., 2014).

Other important substances that contribute to the aromatic complex of edible flowers are essential oils (Chen, Zhang, Bhandari, & Mujumdar, 2021). These substances are characterised as liquid components of secondary metabolism, being complex mixtures with volatile aromatic compounds often found in plants (Chen et al., 2021). Similarly to volatile aromatic compounds, essential oils also aroused the interest of industrial sectors due to their versatility in terms of applications, since they can be integrated into cosmetic, medicinal and food product formulations, mainly for their pharmacological capacities and their flavoring aspects (Chen et al., 2021). Due to their composition, essential oils have several bioactivities, namely antimicrobial, antioxidant and pest control activities, which justify their potential use as food preservation agents (Chen et al., 2021).

In terms of composition, the floral essential oils can consist of 20–60 components, being mainly represented by the group of terpenes, with linalool,  $\alpha$ -pinene, 1,8-cineol, eugenol, camphor and camphene being the most common individual compounds detected; however, these constituents can vary depending on the species or the ecotypes, since several factors such as the genetic background, the growing location, the stage of development and the plant part may affect the chemical profile of essential oils (Chen et al., 2021). Although there have been several studies on the identification and characterisation of floral essential oils, there are few reports of industrial and commercial applications (Fernandes et al., 2018). In particular, some databases and articles are reporting the presence of aromatic compounds and essential oils in flowers without indicating whether the studied species are intended for edible or other use.

Therefore, Table 2 aims to describe those aroma compounds and their bioactivities that have been described so far in flowers that can be used for human consumption.

## 6. Future trends and conclusions

The current market status is favorable to innovative food products and formulations with enhanced visual and nutritional quality and beneficial to human health properties. In this context, the market niche for edible flowers is very promising and attracting to entrepreneurs of the farming and food industry sector. However, despite the current momentum in the market several aspects have to be considered to facilitate the establishment of edible flowers cropping instead of being considered as an occasional consumer trend. One of the most important issues to be addressed is to determine those cropping practices that allow the production of safe products. The production of edible flowers is a minor farming sector which means that there are no sufficient pesticides registered for commercial use, thus making the cropping practices challenging for the inexperienced farmers. Moreover, a limited number of species with edible flowers has been valorized so far, meaning a high potential for the introduction of more species with diversified uses and health properties. However, before adopting new species for human consumption an exhaustive and detailed analysis of their chemical profile is necessary to confirm the bioactive properties and eliminate the potential health risks due to the presence of antinutritional, allergenic and/or toxic compounds. Apart from the raw floral tissues, the potential of using aroma compounds and essential oils, and coloring and flavoring compounds should be further explored for the increase of the added value of flower crops through the incorporation of by-products in the

**Table 2**  
Aromatic components found in edible flowers.

Species	Common name	Compounds Class	Bioactivities	Identified Compounds	References	
<i>Achillea millefolium</i> L./ <i>Achillea tenuifolia</i> L.	Yarrow; common yarrow; old man's pepper; devil's nettle; sanguinary; milfoil; soldier's woundwort; thousand seal	Monoterpene	Anti-spasmodic, Anti-septic, Anti-inflammatory, Allergenic	$\beta$ -pinene	Kumari et al. (2014)	
				1,8-cineole	Kumari et al. (2014)	
				Anti-viral, Anti-staphylococcal, Anti-spasmodic, Anti-septic, Anti-pneumonic, Anti-inflammatory, Anti-bacterial, Anti-acne	$\alpha$ -pinene	Kumari et al. (2014)
				Anti-spasmodic, Anti-septic, Anti-pruritic, <i>Anti-fibrositic</i> , Anti-neuralgic, Anti-diarrheic anti-dysenteric, Anti-acne, Anesthetic, Analgesic, Allelopathic	Camphor	Kumari et al. (2014)
				Sesquiterpene	Chamazulene	Kumari et al. (2014)
<i>Actinidia chinensis</i> Planch.	Golden kiwifruit	Bicyclic sesquiterpene	Pheromone	$\gamma$ -muurolene	Kumari et al. (2014)	
				Sesquiterpenoid	Nerolidol	Muhlemann et al. (2014)
<i>Actinidia deliciosa</i> L.	Fuzzy kiwifruit	Sesquiterpenoids		$\alpha$ -Farnesene, Germacrene D	Muhlemann et al. (2014)	
<i>Antirrhinum majus</i> L.	Common snapdragon; snapdragon	Benzenoids/phenylpropanoids	Monoterpenoids	Benzaldehyde, Methylbenzoate	Muhlemann et al. (2014)	
				Myrcene, E-( $\beta$ )-Ocimene	Muhlemann et al. (2014)	
				Sesquiterpenoid	Nerolidol	Muhlemann et al. (2014)
<i>Arabidopsis thaliana</i> (L.) Heynh.	Thale cress; mouse-ear cress; arabidopsis	Monoterpenoid		Linalool	Muhlemann et al. (2014)	
<i>Artemisia campestris</i> L.	Field wormwood; beach wormwood; northern wormwood; Breckland wormwood; boreal wormwood; Canadian wormwood; field sagewort; field mugwort	Monoterpene	Anti-viral, Anti-staphylococcal, Anti-spasmodic, Anti-septic, Anti-pneumonic, Anti-inflammatory, <i>Anti-feedant</i> , Anti-bacterial, Anti-acne, Allergenic, Allelochemical	$\alpha$ -pinene		
				Sesquiterpene	Germacrene D	
<i>Artemisia vulgaris</i> L.	Common mugwort; riverside wormwood; felon herb; chrysanthemum weed; wild wormwood; old Uncle Henry; sailor's tobacco; naughty man; old man; St. John's plant	Monoterpene	Anti-spasmodic, Anti-septic, Anti-pruritic, <i>Anti-fibrositic</i> anti-neuralgic, <i>Anti-feedant</i> , Anti-emetic, Anti-diarrheic anti-dysenteric, Anti-acne, Anesthetic, Analgesic, Allelopathic	$\delta$ -cadinene		
				Camphor		
				1,8-cineole		
<i>Bidens alba</i> (L.) DC./ <i>Bidens pilosa</i> L.	Shepherd's needles; beggarticks; Spanish needles; butterfly needles/hitch hikers; black-jack; beggarticks; farmer's friends; Spanish needle; cobblers pegs	Monoterpene	Anti-viral, Anti-staphylococcal, Anti-spasmodic, Anti-septic, Anti-pneumonic, Anti-inflammatory, Anti-flu, <i>Anti-feedant</i> , Anti-bacterial, Anti-acne, Allergenic, Allelochemical	Camphor		
				Sesquiterpene	Germacrene D	
<i>Bidens gardneri</i> Baker.	Ridge beggarticks	Sesquiterpene	Pheromone, Insecticide, Anti-microbial	$\beta$ -copaene	Kumari et al. (2014)	
				Germacrene D	Kumari et al. (2014)	
				$\beta$ -caryophyllene	Kumari et al. (2014)	
<i>Bidens sulphurea</i> (Cav.) Sch.Bip./ <i>Cosmos sulphureus</i> Cav.	Sulfur cosmos; yellow cosmos	Sesquiterpene	Pheromone, Insecticide, Anti-microbial	Bicyclogermacrene	Kumari et al. (2014)	
				Germacrene D	Kumari et al. (2014)	
				Bicyclogermacrene	Kumari et al. (2014)	
				$\beta$ -elemene	Kumari et al. (2014)	

(continued on next page)

Table 2 (continued)

Species	Common name	Compounds Class	Bioactivities	Identified Compounds	References
<i>Calendula officinalis</i> L.	Pot marigold; common marigold; ruddles; Mary's gold; Scotch marigold	Essential oil	Antibacterial, Antimicrobial, Antifungal	(E)- $\beta$ -ocimene, 1,8-cineole, A-humulene, $\alpha$ -pinene, $\alpha$ -amorphone, $\alpha$ -Cadinene, $\alpha$ -Copaene, $\alpha$ -Cubebene, $\alpha$ -Gurjunene, $\alpha$ -Muuroolene, $\alpha$ -Thujene, $\alpha$ -Ylangene, $\beta$ -Caryophyllene, $\beta$ -Cubebene, $\beta$ -Pinene, Bornyl Acetate, Cadina-1,4-Diene, $\delta$ -3-Carene, $\delta$ -Cadinene, $\gamma$ -Cadinene, Germacrene D, Limonene, Myrcene, Nerolidol, Nonanal, T-Muurolol	Khan (2018)
<i>Chamaemelum nobile</i> L. All.	Chamomile; Roman chamomile; English chamomile; garden chamomile; ground apple; low chamomile; mother's daisy; whig plant	Essential oil	Antibacterial	$\alpha$ -Pinene, Borneol, Camphene, Isobutyl angelate, Pinocarvone, Trans-Pinocarveol	Khan (2018)
<i>Chamomilla recutita</i> L./ <i>Matricaria recutita</i> L.	German chamomile; Hungarian chamomile (kamilla); wild chamomile; blue chamomile; scented mayweed	Sesquiterpene Sesquiterpene	Anti-microbial  Stomachic, Perfumery, Anti-viral, Anti-ulcer, <i>Anti</i> -rhinoviral, Abortifacient	Spathulenol  (E)- $\beta$ -farnesene  $\beta$ -bisabolene  Chamazulene  $\alpha$ -bisabolol	Kumari et al. (2014) Kumari et al. (2014) Kumari et al. (2014) Kumari et al. (2014) Kumari et al. (2014) Khan (2018)
<i>Chamomilla recutita</i> Prasant	German chamomile; Hungarian chamomile (kamilla); wild chamomile; blue chamomile; scented mayweed	Essential oil		(E)-Nerolidol, 2-heptanone, 2-phenylethanol, 6-Methyl-5-Hepten-2-One, Khusimol, Bicyclovetivenol, $\alpha$ -Cadinene, $\alpha$ -Muuroolene, $\beta$ -Pinene, Epicurzerenone, Dendrolasin, Limonene, Methyl guaiacol, Myrcene, Sabinene, $\alpha$ -Bisabolol	Khan (2018)
<i>Chamomilla recutita</i> Vallary	German chamomile; Hungarian chamomile (kamilla); wild chamomile; blue chamomile; scented mayweed	Essential oil		(E,E)-Farnesene, 2-phenylethanol, Khusimol, Bicyclovetivenol, $\alpha$ -Muuroolene, Bicyclogermacrene, Epicurzerenone, Dendrolasin, Limonene, 2-Octanol, $\beta$ -Pinene, Cineole, Hexanal, Octanal, Sabinene, $\alpha$ -Bisabolol, Epi- $\alpha$ -Bisabolol, (E)- $\beta$ -Ocimene, (E,E)-Farnesene, 1,8-Cineole, $\alpha$ -Pinene, $\alpha$ -Terpinene, $\alpha$ -Terpineol, $\beta$ -Pinene, Borneol, Bornyl Acetate, Camphene, Camphor, $\gamma$ -Terpinene, Germacrene D, Myrcene, Sabinene, Terpinen-4-ol, $\beta$ -Phellandrene, Limonene	Khan (2018)
<i>Chrysanthemum coronarium</i> L.	Garland chrysanthemum; chrysanthemum greens; edible chrysanthemum; crowndaisy chrysanthemum; chop suey greens; crown daisy; Japanese greens	Essential oil	Antimicrobial	(E)- $\beta$ -Ocimene, (E,E)-Farnesene, 1,8-Cineole, $\alpha$ -Pinene, $\alpha$ -Terpinene, $\alpha$ -Terpineol, $\beta$ -Pinene, Borneol, Bornyl Acetate, Camphene, Camphor, $\gamma$ -Terpinene, Germacrene D, Myrcene, Sabinene, Terpinen-4-ol, $\beta$ -Phellandrene, Limonene	Khan (2018)
<i>Chrysanthemum indicum</i> L. Des Moul.	Indian chrysanthemum	Essential oil		(E)- $\beta$ -Ocimene, (E,E)-Farnesene, 1,8-Cineole, $\alpha$ -Pinene, $\alpha$ -Terpinene, $\alpha$ -Terpineol, $\beta$ -Pinene, Borneol, Bornyl Acetate, Camphene, Camphor, $\gamma$ -Terpinene, Germacrene D, Myrcene, Sabinene	Khan (2018)
<i>Citrus aurantium</i> L.	Bitter orange; Sour Orange; Seville orange; bigarade orange; marmalade orange	Monoterpene		Linalyl acetate	Kumari et al. (2014)
<i>Citrus maxima</i> Burm. Merr.	Pomelo	Monoterpene	Anti-viral, Anti-tumor, Anti-spasmodic, Anti-obesity, Anti-septic, Anti-mutagenic, Anti-inflammatory, <i>Anti</i> -feedant, Anti-asthmatic, Anti-bacterial, Anti-Alzheimer, Anti-acetylcholinesterase, Ache-inhibitor	Limonene	Kumari et al. (2014)
<i>Citrus sinensis</i> L. Osbeck.	Sweet oranges	Monoterpene		Sabinene	Kumari et al. (2014)
<i>Citrus unshiu</i> Marc.	Miyagawa mandarin; unshu mikan; cold hardy mandarin; satsuma mandarin; satsuma orange; naartjie; tangerine	Monoterpenoid		1,8-Cineole, E-( $\beta$ )-Ocimene	Muhlemann et al. (2014)
<i>Curcuma longa</i> L.	Turmeric	Monocyclic monoterpene	Pheromone, Pesticide, Perfumery, Fungicide, Flavor, Deodorant, <i>Anti</i> -nitrosaminic, Antioxidant, <i>Anti</i> -feedant, Allelochemical	Terpinolene	Kumari et al. (2014)
<i>Daucus carota</i> L.	Wild carrot; European wild carrot; bird's nest; bishop's lace; Queen Anne's lace	Essential oil		Octanoic Acid, 2-nitroethanol, $\alpha$ -Pinene, $\alpha$ -Terpinene, $\alpha$ -Thujene, $\beta$ -Pinene, Camphene, Caryophyllene	Khan (2018)

(continued on next page)

Table 2 (continued)

Species	Common name	Compounds Class	Bioactivities	Identified Compounds	References
<i>Dictamnus albus</i> L.	Burning bush; dittany; gas plant; fraxinella	Essential oil		Oxide, $\gamma$ -Terpinene, Hexanol, Limonene, Myrcene, P-Cymene, Sabinene	Khan (2018)
		Monoterpene	Anti-viral, Anti-tumor, Anti-spasmodic, Anti-obesity, Anti-septic, Anti-mutagenic, Anti-inflammatory, Anti-feedant, Anti-asthmatic, Anti-bacterial, Anti-Alzheimer, Anti-acetylcholinesterase, Ache-inhibitor	(E)-Methyl Cinnamate, A-Humulene, Bicyclogermacrene, Citronellol, Docosane, $\gamma$ -Terpinene, Geraniol, Germacrene D, Phytol	
<i>Dipteryx odorata</i> (Aubl.) Forsyth f.	Cumaru; kumaru; Brazilian teak	Monoterpene	Ace-inhibitor, Acaricidal, Aldose-reductase-inhibitor, Anti-acetylcholinesterase, Anti-feedant, Antioxidant, Insectifuge, Irritant, Perfumery, Pesticide	$\gamma$ -terpinene	Kumari et al. (2014)
		Monoterpene		Citronellol	Kumari et al. (2014)
		Azulenic sesquiterpenol	Anti-microbial	Spathulenol	Kumari et al. (2014)
		Sesquiterpene	Pheromone, Insecticide, Anti-microbial	Germacrene D Bicyclogermacrene	Kumari et al. (2014) Kumari et al. (2014)
<i>Eucalyptus citriodora</i> Hook.	Lemon-scented gum	Monoterpene	Anti-viral, Anti-staphylococcal, Anti-spasmodic, Anti-septic, Anti-pneumonic, Anti-inflammatory, Anti-flu, Anti-feedant, Anti-bacterial, Anti-acne, Allergenic, Allelochemical	$\alpha$ -pinene	Kumari et al. (2014)
<i>Ferula glauca</i> L.	Giant fennel	Monoterpene	Flammable	Myrcene	Kumari et al. (2014)
			Anti-viral, Anti-staphylococcal, Anti-spasmodic, Anti-septic, Anti-pneumonic, Anti-inflammatory, Anti-flu, Anti-feedant, Anti-bacterial, Anti-acne, Allergenic, Allelochemical	$\alpha$ -pinene	Kumari et al. (2014)
<i>Glucyrrhiza glabra</i> Mulethi	Liquorice; licorice	Sesquiterpene	Pheromone, Insecticide, Anti-microbial	Germacrene D	Kumari et al. (2014)
		Essential oil		2-Propenenitrile, 3-Cyclohexen-1-ol, 4-Pyridinamine, 5-Methyl-furfural, Aspartic acid, Benzene, Benzoic Acid, Diethyltoluamide, Ethylenimine, Hydrochlorothiazide, Iodoquinol, Isoniazid, Linalool, Methacrylonitrile, Piperitone, Prasterone, Pyrazine, 1,4-dioxide, Retinol, Trans-Permethrin, Warfarin	Khan (2018)
<i>Grindelia robusta</i> Nutt.	Grindelia; gumweed	Monoterpene	Anti-viral, Anti-staphylococcal, Anti-spasmodic, Anti-septic, Anti-pneumonic, Anti-inflammatory, Anti-flu, Anti-feedant, Anti-bacterial, Anti-acne, Allergenic, Allelochemical	$\alpha$ -pinene	Kumari et al. (2014)
		Sesquiterpene	Pheromone, Insecticide, Anti-microbial	Germacrene D	Kumari et al. (2014)
<i>Grindelia squarrosa</i> (Pursh.) Dunal.	Curly-top gumweed; curlycup gumweed	Monoterpene	Anti-viral, Anti-staphylococcal, Anti-spasmodic, Anti-septic, Anti-pneumonic, Anti-inflammatory, Anti-flu, Anti-feedant, Anti-bacterial, Anti-acne, Allergenic, Allelochemical	$\alpha$ -pinene	Kumari et al. (2014)
<i>Heliotropium floridum</i> Clos.		Essential oil		(E)- $\beta$ -Ocimene, (Z)- $\beta$ -Ocimene, 2-Methylanisole, $\alpha$ -Pinene, Benzaldehyde, Benzyl Alcohol, $\beta$ -Myrcene, Germacrene D, Limonene, Methyl Benzoate, Methyl Cinnamate, Phenyl Acetaldehyde, Z-3-Hexenyl Acetate, $\beta$ -phellandrene	Khan (2018)
<i>Heteropappus altaicus</i> Willd.		Cyclic monoterpene			Kumari et al. (2014)

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Table 2 (continued)

Species	Common name	Compounds Class	Bioactivities	Identified Compounds	References
<i>Hypericum perforatum</i> L.	St. John's wort	Monoterpene	Flammable	Myrcene	Kumari et al. (2014)
			Anti-viral, Anti-staphylococcal, Anti-spasmodic, Anti-septic, Anti-pneumonic, Anti-inflammatory, Anti-flu, <i>Anti-feedant</i> , Anti-bacterial, Anti-acne, Allergenic, Allelochemical	$\alpha$ -pinene	Kumari et al. (2014)
			Insect attractant	(E)- $\beta$ -ocimene	Kumari et al. (2014)
		Sesquiterpene	Pheromone, Insecticide, Anti-microbial	Germacrene D	Kumari et al. (2014)
<i>Hyssopus officinalis</i> L.	Hyssop	Monoterpene	Anti-viral, Anti-staphylococcal, Anti-spasmodic, Anti-septic, Anti-pneumonic, Anti-inflammatory, Anti-flu, <i>Anti-feedant</i> , Anti-bacterial, Anti-acne, Allergenic, Allelochemical	$\alpha$ -pinene	Kumari et al. (2014)
		Sesquiterpene		$\beta$ -caryophyllene	Kumari et al. (2014)
		Monoterpene	Anti-viral, Anti-tumor, Anti-spasmodic, Anti-obesity, Anti-septic, Anti-mutagenic, Anti-inflammatory, <i>Anti-feedant</i> , Anti-asthmatic, Anti-bacterial, <i>Anti-Alzheimeran</i> , Anti-acetylcholinesterase, Ache-inhibitor	Limonene	Kumari et al. (2014)
<i>Jasminum sambac</i> L.	Arabian jasmine; Sambac jasmine	Monoterpene	Transdermal, Spasmogenic, Perfumery pesticide, Irritant, Insectifuge, Herbicide, Flavor, Candidicide, Anti-spasmodic, Anti-septic, Anti-inflammatory	$\beta$ -pinene	Kumari et al. (2014)
		Essential oil	Antimicrobial, Antibacterial	1,8-cineole	Kumari et al. (2014)
<i>Lavandula angustifolia</i> Mill.	Lavender; true lavender; English lavender; garden lavender; common lavender; narrow-leaved lavender	Essential oil		Benzyl Alcohol, E-E- $\alpha$ -Farnesene, Indole, Linalool, 2-Methyldocosane, 2-Methyloctadecane, 6,10,14-Trimethylpentadecan-2-ol, $\alpha$ -Linolenic Acid, Benzene, 1,1'-(1,5-Hexadiene-1,6-Diyl)Bis, $\beta$ -Methylionone, Diethylene glycol dibenzoate, Henicosane, Octacosane, Octadecanal, Palmitic Acid, Pentadecane, Phytol	Khan (2018)
		Essential oil	Antifungal	(22)-(6E)-Farnesol, (E)- $\beta$ -Ocimene, (E)-Nerolidol, (Z)- $\beta$ -Ocimene, (Z)-Nerolidol, 1,8-Cineole, 1-Octen-3-Yl Acetate, 3-Octenylacetate, $\alpha$ -Cedrene, $\alpha$ -Copaene, $\alpha$ -Pinene, $\alpha$ -Terpineol, $\alpha$ -Thujene, $\beta$ -Caryophyllene, Bornyl Acetate, Butyl Isobutyrate, Camphene, Camphor, Caryophyllene Oxide, <i>cis</i> -Linalooloxide (Furanoid), <i>cis</i> -Pinenehydrate, Citronellyl Acetate, $\delta$ -3-Carene, $\delta$ -Elemene, $\gamma$ -Cadinene, $\gamma$ -Terpinene, Geraniol, Germacrene D, Hexadecane, Hexyl Acetate, Hexyl Butyrate, Lavandulyl Acetate, Limonene, Linalool, Linalyl Acetate, Linalyl Propionate, Methyl Thymol, Myrcene, Neryl Acetate, Octadecane, Octyl Acetate, P-Cymene, P-Cymenene, Sabinene, Tau-Cadinol, Terpinen-4-Ol, Terpinolene, Tetradecane, Thymol, <i>Trans</i> - $\alpha$ -Bergamotene	Khan (2018)
<i>Lavandula angustifolia</i> Mill.	Lavender; true lavender; English lavender; garden lavender;	Monoterpene		Linalyl acetate	Kumari et al. (2014)
			Anti-inflammatory	Myrcene	Kumari et al. (2014)
			Anti-viral, Anti-staphylococcal, Anti-spasmodic, Anti-septic, Anti-pneumonic, Anti-inflammatory, Anti-flu, <i>Anti-feedant</i> , Anti-bacterial, Anti-acne, Allergenic, Allelochemical	$\alpha$ -pinene	Kumari et al. (2014)
<i>Lavandula angustifolia</i> Mill.	Lavender; true lavender; English lavender; garden lavender;	Monoterpene	Anti-viral, Anti-tumor, Anti-spasmodic, Anti-obesity, Anti-septic,	Limonene	Kumari et al. (2014)

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Table 2 (continued)

Species	Common name	Compounds Class	Bioactivities	Identified Compounds	References	
	common lavender; narrow-leaved lavender		Anti-mutagenic, Anti-inflammatory, Anti-feedant, Anti-asthmatic, Anti-bacterial, Anti-alzheimeran, Anti-acetylcholinesterase, Ache-inhibitor, Acaricide			
<i>Lavandula dentata</i> L.	Fringed lavender; French lavender	Monoterpene		1,8-cineole	Kumari et al. (2014)	
<i>Lavandula latifolia</i> Medik.	Broadleaved lavender; spike lavender; aspic lavender; Portuguese lavender	Essential oil	Anti-Inflammatory	(E)- $\beta$ -Farnesene, (E)- $\beta$ -Ocimene, (Z)- $\beta$ -Ocimene, 1, 8-Cineole, 1-octen-3-01, A-Bisabolol, $\alpha$ - Pinene, $\alpha$ -Phellandrene, $\alpha$ -Terpinene, $\alpha$ -Terpineol, $\alpha$ -Thujene, $\beta$ -Caryophyllene, $\beta$ -Pinene, Borneol, Camphene, Camphor, $\delta$ -3-Carene, $\gamma$ -Terpinene, Hexyl Acetate, Hexyl Butyrate, Lavandulol, Lavandulyl Acetate, Linalool, Linalyl Acetate, Myrcene, P-Cymene, Sabinene, Terpinen-4-01, Terpinolene, Trans-Sabinene Hydrate Acetate		Khan (2018)
		Monoterpene		1,8-cineole	Kumari et al. (2014)	
<i>Magnolia grandiflora</i> L.	Southern magnolia; bull bay	Essential oil	Antioxidant, Antimicrobial	(E)- $\beta$ -Farnesene, (Z)- $\beta$ -Farnesene, A-Cubebene, $\alpha$ -Humulene, $\alpha$ -Pinene, $\beta$ -Caryophyllene, $\beta$ -cedrene, $\beta$ -Elemene, $\beta$ -Pinene, Caryophyllene Oxide, $\delta$ -Elemene, Farnesol, Germacrene D		Khan (2018)
<i>Matricaria recutita</i> L.	German chamomile; Hungarian chamomile (kamilla); wild chamomile; blue chamomile; scented mayweed	Essential oil		(E)-Nerolidol, (Z)-3-Hexenol, 3-Octanol, 6-Methyl-5-Hepten-2-One, Khusimol, Bicyclovetivenol, $\alpha$ -Cadinene, $\alpha$ -Muurolool, $\alpha$ -Pinene, $\alpha$ -Ylangene, Epicurzerenone, Dendrolasin, Ethyl hexanoate, Ethyl isovalerate, Limonene		Khan (2018)
<i>Melissa officinalis</i> L.	Lemon balm	Monoterpene	Transdermal, Spasmogenic, Perfumery pesticide, Irritant, Insectifuge, Herbicide, Flavor, Candidicide, Anti-spasmodic, Anti-septic, Anti-inflammatory	$\beta$ -pinene	(S. Kumari et al., 2014)	
		Sesquiterpene		$\beta$ -caryophyllene	Kumari et al. (2014)	
<i>Mentha longifolia</i> L. Huds.	Horse mint; fillymint; St. John's horsemint	Monoterpene		Piperitone	Kumari et al. (2014)	
				Carvone	Kumari et al. (2014)	
				1,8-cineole	Kumari et al. (2014)	
<i>Monarda didyma</i> L.	Crimson beebalm; scarlet beebalm; scarlet monarda; Eau-de-Cologne plant; Oswego tea; bergamot	Essential oil	Antifungal	1-Octen-3-0l, $\alpha$ -Pinene, $\alpha$ -Copaene, $\alpha$ -Phellandrene, $\alpha$ -Terpineol, $\beta$ -Bourbonene, $\beta$ -Phellandrene, $\beta$ -Terpineol, Borneol, Camphene, d-3-Carene, $\gamma$ -Terpinene, Germacrene D, Limonene, Linalool, Methyl Thymol, Myrcene, P-Cymene, Thymol, $\gamma$ -terpinene		Kumari et al. (2014)
		Monoterpene	Ace-inhibitor acaricide aldose-reductase-inhibitor - anti-acetylcholinesterase - anti-feedant antioxidant insectifuge irritant perfumery pesticide			
<i>Myrtus communis</i> L.	Common myrtle; true myrtle	Monoterpene	Anti-viral, Anti-tumor, Anti-spasmodic, Anti-obesity, Anti-septic, Anti-mutagenic, Anti-inflammatory, Anti-feedant, Anti-asthmatic, Anti-bacterial, Anti-alzheimeran, Anti-acetylcholinesterase, Ache-inhibitor	Limonene	Kumari et al. (2014)	
			Anti-viral, Anti-staphylococcic, Anti-spasmodic, Anti-septic, Anti-pneumonic, Anti-inflammatory, Anti-flu, Anti-feedant, Anti-bacterial, Anti-acne, Allergenic, Allelochemic	$\alpha$ -pinene	Kumari et al. (2014)	
				1,8-cineole	(S. Kumari et al., 2014)	
<i>Origanum dictamnus</i> L.	Dittany of Crete; Cretan dittany; hop marjoram	Monoterpene		Carvacrol	(S. Kumari et al., 2014)	

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Table 2 (continued)

Species	Common name	Compounds Class	Bioactivities	Identified Compounds	References
<i>Origanum majorana</i> L.	Marjoram; sweet marjoram; knotted marjoram; pot marjoram	Monoterpene		Linalyl acetate	Kumari et al. (2014)

food, pharmaceuticals, nutraceuticals and cosmetics industries within the circular economy context.

Another essential pillar for the establishment of edible flowers, is the valorization of wild edible flowers which possess a great potential for introducing new functionalities in the food industry. In order to eliminate the risk of genetic erosion from the irrational harvesting of wild species, intensive research is needed to allow the commercial production of wild edible flowers and facilitate the all year round availability that will further make easier the access of consumers to such products. For this purpose, plant breeding programs will be useful to identify genotypes that are suitable for edible flower production focusing on higher yields of marketable products, resistance to pest and pathogens, as well as on better availability of flowers throughout the year and the improvement of quality traits in terms of visual appearance, aroma profile, nutritional value and bioactive phytochemicals content. However, as mentioned before the analysis of the edible products is necessary to ensure consumers safety. The evidence-based reports through clinical and cohort studies would further substantiate the health benefits of floral foods and increase consumers' appreciation for edible flowers. The next step forward would be the constitution of an updated list of flowering species suitable for human consumption, along with the necessary legislation for proper agronomic practices and safe marketing.

Considering the great diversity in consumers' preference among the regions of the world and the versatile nature of decision making process when buying food products, a great deal of effort has to be put in the assessment of those parameters that are attractive to consumers, as well as in the identification of those drivers that affect consumer buying process. Before new products are developed and become available in the market, special marketing campaigns should be carried out to introduce the new products to consumers and increase their awareness to healthy and ecofriendly diets, as well to reduce their resistance in buying novel products. In this context, the adoption of novel packages that promote the visual parameters of edible flowers, while at the same time protect them under variable post-harvest conditions is also necessary. Moreover, the post-harvest requirements in terms of the appropriate handling and storage conditions should be better defined, considering the high number of candidate species and the diversity in storage condition requirements, while special storage shelves in retail-shops would be helpful towards eliminating the losses of these perishable products.

Apart from commercial cultivation in the field or in greenhouses, edible flower production is suitable for urban horticulture, especially in domestic level, since most of the consumers are familiar with growing ornamental plants for aesthetic purposes. Therefore, the promotion of edible flowers could amplify domestic cultivation with significant benefits in the mentality and the overall health of consumers.

In conclusion, edible flowers production is a promising and challenging sector which could provide alternative solutions to farmers under the ongoing climate change, having also in mind the sustainable use of natural resources, the diversification of agroecosystems and the preservation of biodiversity. Moreover, food industry could be benefited from fulfilling market demands for functional and healthy foods through the development of novel floral based foods and food formulations, thus allowing the valorization of so far unexplored or underexplored species.

#### Author contributions

Conceptualization: L.B. and S.A.P. writing—original draft preparation, E.O.P.Jr., C.C., F.D.G., P.G.C., N.T. and Y.R.; writing-review and editing, I.C.F.R., L.B. and S.A.P.; Funding acquisition: L.B. and S.A.P. All

authors have read and agreed to the published version of the manuscript.

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#### Declaration of competing interest

None.

#### Data availability

No data was used for the research described in the article.

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#### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.tifs.2023.05.007>.

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