Trends in Food Science & Technology 117 (2021) 106–124

Contents lists available at ScienceDirect

Trends in Food Science & Technology

journal homepage: www.elsevier.com/locate/tifs

Current status of genus *Impatiens*: Bioactive compounds and natural pigments with health benefits

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ARTICLE INFO

Keywords:
Edible flowers
Impatiens
Natural pigments
Bioactivities
Phenolic compounds

ABSTRACT

Background: The market for edible flowers has grown exponentially due to consumers demand. This has been motivated by the concern to include healthier foods in the daily diet, leading to a great interest in these natural matrices. However, and although the consumption of this type of matrices are popularly associated with health benefits, scientific studies are still scarce. The industry seeks to satisfy the consumers demands and, at the same time, seeks to launch new challenges in the sector, in order to outline new conservation and production strategies. Although there are several flowers with edible potential in nature, many are still little explored or unnoticed, so this type of study is increasingly sought after.
Scope and approach: The present review intendeds to explore the context of edible flowers as well as their conditions of production and consumption. Then, focusing on the characterization of the genus *Impatiens*, which, although is still little explored, gathers data on its chemical and nutritional characterization, bioactivities, and the possible exploration of natural pigments and industrial application.
Key findings and conclusions: Several studies have been focused on the chemical characterization of flowers, evaluation their edibility, as well as validating their bioactive potential. In particular, the genus *Impatiens* is characterized by presenting perennial and succulent herbs with attractive colors, normally found in tropical forests. There are countless studies on the bioactive activities present in these edible flowers. In addition, its pigmentation has a direct relationship with the presence of several compounds, especially anthocyanins and their derivatives. These bioactive compounds have a great interest to the food industry and consumers, due to their diverse health benefits that are provided by their regular consumption.

1. Introduction

Flowers have been present in human daily life since ancient times (de Morais et al., 2020; Zheng, Meenu, & Xu, 2019). Although flowers are usually associated with decorative purposes, there are reports of the presence of flowers as ingredients of different recipes in different cultures around the world (Fernandes, Casal, Pereira, Saraiva, & Ramalhosa, 2016; Pires, Barros, Santos-Buelga, & Ferreira, 2019). In addition, studies claim that the universe of application of flowers is very wide, in which they can be applied within different areas, namely for the pharmaceutical, cosmetic and even food sectors (Trinh, Choi, & Bae, 2018).

Currently, the production of edible flowers, as well as their consumption is growing due to the advent of media interventions and a greater consumer demand for healthy alternatives for food (Koike, Antonio, Ferreira, & Villavicencio, 2014; Pires et al., 2019). However, from an agronomic point of view, the cultivation for human consumption of these plants still presents challenges, since many flowers, although edible, are produced for the purpose of ornamentation and landscaping (Matyjaszczyk & Śmiechowska, 2019).

In general, flowers are inserted into the human diet *in natura* (Matyjaszczyk & Śmiechowska, 2019). However, several studies have been carried out testing different processes, in order to find effective methodologies in the conservation of their structures without degrading their nutritional composition, and providing the least possible damage in terms of organoleptic characteristics (Pires et al., 2019).

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https://doi.org/10.1016/j.tifs.2021.01.074
Received 7 August 2020; Received in revised form 20 January 2021; Accepted 30 January 2021
Available online 3 February 2021

The scientific community is increasingly committed to deepening studies on edible flowers, namely the identification and characterization of various bioactive compounds (Zheng, Meenu, & Xu, 2019), thus becoming an interesting subject of study as functional food products (Gostin & Waisundara, 2019).

Plants of the genus *Impatiens* are characterized as perennial and succulent plants which are often found in tropical and subtropical humid forests, especially near river slopes (Szewczyk, Bonikowski, Maciąg-Krajewska, Abramek, & Bogucka-Kocka, 2018a). They usually have a simple foliage, medium-sized and have attractive colored flowers. Some cultivars of this genus can be easily found in commercial spaces, being normally associated with landscaping functions, ornamentation activities and, occasionally, for human consumption (Kinupp, 2014). It is known that the genus *Impatiens* is very broad in terms of diversity of species (Yu et al., 2016). Current studies affirm the existence of more than 300 distinct compounds present in several studied species, among them flavonoids, phenolic acids, coumarins, quinones, terpenes, and saponins stand out (Szewczyk, 2018; Li et al., 2017; Kim et al., 2015; Li et al., 20015a; Mitchel, Brescia, Smith & Morgan, 2007; Lobstein et al., 2001). In general, carbohydrates are the main macronutrients present, followed by proteins and lipids (Fernandes et al., 2016). Furthermore, pigments are very common in flower petals, although some species also show colour in their stems, being anthocyanins the main compounds responsible for the colour of these organs. Many of the compounds present in these plants are directly linked to studies related in the prevention and reduction of human pathologies (Imam, Nahar, Akter, & Rana, 2012). In fact, some species such as *Impatiens balsamina* L. (1753) and *Impatiens walleriana* Hook. f. it has been shown a great relevance in the pharmaceutical field (Szewczyk, 2018).

Thus, in this review, some concepts related to the universe of edible flowers will be addressed, such as contextualizing the insertion of these plants in the human diet and reporting the current concepts in relation to the consumption and production of this food segment. Highlighting, in particular, the genus *Impatiens*, which is still little studied and explored despite its immense potential. This work is the first written bibliographic review that gathers information about chemical and nutritional characteristics of flowers of the genus Impatiens as well as the main bioactive compounds currently identified, and the main benefits provided by their consumption. This review allows us to reflect and explore the possible applications of these edible flowers in the food industry, as a natural ingredient with coloring potential.

2. Contextualization of edible flowers

2.1. Edible flowers: history and customs

Literature describes the presence of edible flowers in several civilizations since ancient times (Pires et al., 2019). For example, ancient Greek and Roman civilization used flowers as ingredients in making dishes but also in alternative medicine (Mlcek & Rop, 2011). Then, other studies reported the presence of edible flowers in the medieval era in France, as well as in Victorian England (Liu et al., 2015). While in the Asian continent, flower consumption has been described for thousands of years in countries like China and Japan (Takahashi, Rezende, Moura, Dominguete, & Sande, 2020). On the American continent, as flowers are always present in the daily lives of indigenous peoples, especially the Aztecs (Newman & Kirker, 2016).

Several historical fragments describe the relationship between edible flowers and humans (Takahashi et al., 2020). *Taraxacum*, for example, is quoted in biblical writings as bitter herb used in fresh salads and as an ingredient in bread. Manuscripts in bamboo strips and fragments of silk cited that the *Nelumbo nucifera* Gaertn. Flower as an ingredient in the composition of several recipes in China (Newman & Kirker, 2016). Artifacts found in Greece endowed with the year 1500 b.C., showed the existence of the cultivation of flowers such as *Cynara scolymus* L., *Dianthus caryophyllus* L. and *Papaver rhoeas* L. by the Greek peoples (Takahashi et al., 2020). In one of the expeditions carried out by the Europeans to discover the new world, the Dominican friar Diego Duran described in one of his documents the following sentence: “It would be an understatement to say that the Aztecs liked flowers, they loved them”, also confirming the presence of flowers in the Aztecs routine (Newman & Kirker, 2016).

Edible flowers can be consumed in different ways. They are usually used in typical dishes, as part of rituals and festive events (Takahashi et al., 2020). In India, for example, the consumption of edible flowers from trees was related to the concept of human immortality, just as the Asians believed that ingesting the lotus flowers, would provide a greater balance and longevity throughout life (Newman & Kirker, 2016; Pinakin, Kumar, Suri, Sharma, & Kaushal, 2019).

Several customs relating to flower consumption have been reported in the Americas. Pumpkin flowers were included in the making of stews in North America by the Zuni tribe, and hibiscus flowers in South America (Cunningham, 2015; Newman & Kirker, 2016). In another way, the Aztecs believed that the act of smelling the odor or consuming small fragments of flowers contributed to fight against the sensation of hunger. In Peru, the consumption of two varieties of nasturtium flowers became popular through medicinal application and in salad preparation (Newman & Kirker, 2016).

In the Europe, flowers made up the banquets of the aristocracy, adorning dishes and drinks (Rop, Mlcek, Jurikova, Neugebaurova & Vabkova, 2012). In countries like Portugal and Spain, traditional cheeses based on sheep’s milk are produced with a coagulant based on the *Cynara cardunculus* L. flower (Gomes et al., 2019). While in Switzerland, elderly people mention that they remembered their childhood through the consumption of flowers (Abbet et al., 2014).

The adoption of new eating habits, the modernization of society and urbanization are factors that influence customs regarding the consumption of edible flowers. Thus, resulting in a loss of valuable information regarding the benefits provided by the consumption of these plants parts (Abbet et al., 2014; Harmayani et al., 2019). However, Fernandes, Casal, Pereira, Saraiva, and Ramalhosa (2020) states that the market for edible flowers is growing due to globalization, which can raise awareness and encourage consumers to return to previous lifestyles.

2.2. Current conditions of production and consumption of edible flowers

Edible flowers are an emerging food class, in which producers are trying to satisfy frequent market demands (de Favari Tardivo & Meru, 2018; Fernandes et al., 2020). However, many factors such as seasonality and perishability affect the production of this segment (Fernandes et al., 2020). Although similar in their physiological characteristics, flowers intended for food and landscaping are different in terms of cultivation (Matyjaszczyk & Śmiechowska, 2019). Since, the production of ornamental flowers involves fertilizer applications in dosages that are often harmful to human health, while flowers intended for food are usually the result of organic cultivation (Matyjaszczyk & Śmiechowska, 2019).

The increase in demand for healthier foods, minimally processed and free from harmful effects, justifies an important scenario for the investment in organic flower cultivation, despite the fact that this segment has a higher cost than conventional cultivation (Fernandes et al., 2020; Pires et al., 2019). In addition, paradigms such as shelf life are recurrent in the daily life of edible flower producers, as many of these plants are fragile and suffer many injuries through stern factors such as inadequate transport, high temperatures and pest attack (Pires et al., 2019).

Another relevant aspect is the community to which these plants are intended, as it is believed that this is a very specific market niche, as they are currently found as components of haute cuisine, in addition to often having a high cost (Fernandes et al., 2016, 2020). In addition, the shelf life of these plants is very short, varying on average from 7 to 10 days, which can affect productivity due to their low resistance to storage

(Fernandes et al., 2020).

However, studies involving technologies to increase the useful life of these products are already present. Koike (2015), for example, researched the increase in resistance of the flowers of *Tropaeolum majus* L. submitted to electron beams and gamma radiation, however the results obtained stated that this process allows to increase the useful life of these flowers providing satisfactory improvements for the object of study. It is worth noting that the production of edible flowers requires a lot of effort in terms of labor and prior knowledge. In addition, new technologies regarding transport and conservation must be developed to provide consumers with a higher quality of this product.

Conducting the production of edible flowers is essential to guarantee the safety of its consumers. Odorizzi, Silva Júnior, and Lemos (2014) recommends that the cultivation of these plants should be conducted through organic cultivation or by the restaurant and residence that uses them. Menegaes, dos Santos, and Londero (2014), on the other hand claims, that hydroponic cultivation is a great alternative for this plant segment to produce constant and profitable flowers. In addition, investment in the development of edible flower production is notorious in several locations. Countries like Italy and France have projects for the development of flowers for human consumption (ANTEA, 2019). While in Florida, small producers are seeing good results with flower production, through distribution in local markets, *gourmet* restaurants and bars (de Favari Tardivo & Meru, 2018).

There are several reports about the relationship between food security and the consumption of edible flowers. The European Union Rapid Alert System for Food and Feed (EURASFF) alerted the incidence of external contamination in some species of flowers intended for consumption. Among the contaminating agents present, the following were reported: the presence of *Salmonella*, insect infestations, rat droppings and the presence of unauthorized sulfites. Therefore, precautions must be taken to mitigate certain episodes in order to guarantee the production of safe food (de Favari Tardivo & Meru, 2018).

Fornefeld et al. (2017), mentioned that the conditions of different crops and processing, can enable the attack of microorganisms in flowers. The inadequate use of fertilizers and pesticides, the poor quality of irrigation water and contaminated soil are some of the external factors prior to flower harvesting, while poor sanitary conditions of handling, transport, distribution and storage are the main problems of post-harvest contamination (Matyjaszczyk & Śmiechowska, 2019). In addition, many flowers are used fresh to ornament dishes, and even if not ingested, they can cause problems related to cross-contamination with other foods that make up the meal (Matyjaszczyk & Śmiechowska, 2019).

Currently, the consumption of edible flowers can be observed both in gastronomy, through the composition of dishes and beverages, as well as in industry, through processes of dehydration, crystallization, in obtaining food additives or even in the composition of foods, such as jellies and pastry products (Chen & Wei, 2017; Fernandes et al., 2020). On the other hand, Rodrigues et al. (2017) points out in his research, that the consumption of edible flowers is currently limited to sophisticated establishments of gastronomy, however it reinforces that the potential of these plants is substantially greater due to their properties. While Pires et al. (2019) states that the flowers are generally consumed in their entirety, but in many cases, only some parts such as petals and buds are ingested, due to the presence of bitterness and inedible parts.

Since, cultural differences and consumption patterns can determine the acceptability of these food classes as "new food" or "unknown food" (Rodrigues et al., 2017). However, studies aim to measure the main factors that drive the consumption of flowers in the human diet (Chen & Wei, 2017; Rodrigues et al., 2017). In this way, Chen and Wei (2017) states that the aroma and relation to a "healthy food", are some of the decisive factors for flower consumption. Furthermore, the same authors report that floral foods, endowed with proven health benefits, have great potential for exploitation for the food industry.

Carvalho (2018), states that marketing strategies similar to those used for aromatic herbs can be adopted to boost the consumption of edible flowers, as lovers of the aromatic herbs segment have similar characteristics when related to the consumption of edible flowers. In addition, Chen and Wei (2017) state, that the aroma of floral foods, is an aspect that can encourage the consumer to purchase certain products, so it is noted that this aroma provides an emotional appeal of great relevance when it comes to the addition of edible flowers in food matrices. Other studies, on the other hand, report that colour, price and packaging are very important attributes for the purchase of edible flowers and that packages made up of different cultivars and species tend to be more attractive to the consumer (Kelley, Behe, Biernbaum, & Poff, 2002; Kelley et al., 2001a, 2001b).

As for the current scenario, one can observe the emergence of a new market trend regarding the consumption of edible flowers. This is due to the increase in scientific research, the relationship between flower consumption as a "healthier" diet, greater exposure in media such as social networks and greater insertion in the market, through small producers and chefs (Fernandes et al., 2020). However, Kelley, Cameron, Biernbaum, and Poff (2003) also stated in their study, that although there is no statistical data regarding the consumption of edible flowers, it is evident that this segment is heated due to the increase in the number of cookbook publications and website articles related to the theme, as well as a the growing investigation by the scientific community about the nutritional and chemical composition present in these flowers.

3. Characterization of *impatiens* genus

Impatiens are plants belonging to the balsaminaceae family that are subdivided into approximately 500 species identified (Grey-Wilson, 1980; Morgan, 2007; Szewczyk, 2018). Its name is given due to the "impatient" and explosive behavior of its pods, which when mature hatch due to external mechanical actions and disperse its seeds throughout the environment (Britannica Academic, 2017). They are characterized as perennial, erect herbs, provided with succulent-fleshy stems, they can reach an average of 20–40 cm in length and are generally found in tropical and subtropical forests, mainly near the river slopes (Kinupp, 2014). They arouse interest due to their colorful and attractive flowers that can change between the white, pink, orange and purple colors (Kinupp, 2014). And despite being made up of thick stems, they have fragility in their petals and leaves that are easily damaged (Britannica Academic, 2017; Grey-Wilson, 1980). Currently, some species are found in the trade selected for landscaping, ornamentation or even for human consumption (Kinupp, 2014). In addition, some studies denote the use of the genus *Impatiens* by Asian people as an ingredient for alternative medicine, attacks and combating pathologies such as rheumatism, inflammation of nails and treatment of fractures (Wang, Li, & Bi, 2018).

Some studies point to historical facts about *Impatiens* specimens. The *I. walleriana*, for example, have been grown as ornamental plants since the 19th century (CABI, 2020b). Studies also point to the appearance of *I. balsamina* in India and its spread through Southeast Asia, while in Europe its ornamental use has been dated since the 16th century (CABI, 2020a). *I. glandulifera* Royle, conquered the European continent from the United Kingdom, spreading due to its use by beekeepers and through the dispersion of its seeds along the course of rivers (CABI, 2020c). In addition, the vast spread of these species has led to their naturalization in countries such as Finland, Czech Republic, Switzerland and Germany (CABI, 2020c). Meanwhile, the first reports about *I. parviflora* DC. in the wild were present in the year 1831, in the botanical garden of Genfe, Switzerland (CABI, 2020d). However, nowadays many species of *Impatiens* can be considered weeds in some regions of Europe (Britannica Academic, 2017). According to Grey-Wilson (1980), the genus *Impatiens* is present mainly in the flora of the Old World, in the most diverse places, such as in territories of tropical Africa and in Southeast Asia, in addition to propagating in temperate regions of Europe, Russia, China

Table 1
Characteristics present in species of the genus *Impatiens*.

Scientific Name	Synonyms	Native Range	Habitat	Flowers	Height (m)	Edible Parts	Uses
Impatiens arguta Hooker and Thomson (1859).	*Impatiens arguta var. bulleyana* Hook. f.; *Impatiens gagei* Hook.f.; *Impatiens namchabarwensis* R.J. Morgan, YM Yuan e XJ Ge; *Impatiens taliensis* Lingelsh. & Borza (The Plant List, 2013).	Native to parts of Asia (China, Bhutan, north east India, Myanmar and Nepal) (Matthews et al., 2015).	In damp shady places along the path (Matthews et al., 2015).	The inflorescences have one or two flowers with very short peduncles. The large or medium flowers are pink or purple red (Matthews et al., 2015).	0.7	Leaves (PFAF, 2020).	Boiled or cooked with meat (PFAF, 2020).
Impatiens aurella Rydb.	*No synonyms are recorded.*	North America (British Columbia) and the northwest United States (Batten, 2015; Klinkenberg, 2013).	Damp thickets and springy places (PFAF, 2020; Useful Tropical Plants, 2016).	Flowers yellow to orange, with or without spots, spur strongly curved (Washington State, 2020a).	0.5 to 1.0	Leaves and seed (PFAF, 2020).	Cooked (young shoots), Medicinal (Antidote, parasiticide, stings and warts) (PFAF, 2020).
Impatiens balfourii Hook.f.	*No synonyms are recorded.*	Native to Himalaya (India, Nepal and Pakistan) (Matthews et al., 2015)	Locality with a high incidence of light, invading abandoned places and with waste disposal, can also be found in humid places, clearings and meadows (Matthews et al., 2015).	They are composed of five petals, in which the lower two are fused, forming two compound flanges. Its coloration can vary from white, pink to shades of red (Matthews et al., 2015).	0.4 to 0.8	_	_
Impatiens balsamina L. (1753).	*Balsamina angustifolia* Blum; *Balsamina coccinea* (Sims) DC.; *Balsamina cornuta* (L.) DC.; *Balsamina foeminea* Gaertn.; *Balsamina hortensis* Desp.; *Balsamina lacca* Medik.; *Balsamina minutiflora* Span.; *Balsamina mollis* G. Don; *Impatiens balsamina var. corymbosa* Santapau; *Impatiens coccinea* Sims; *Impatiens cornuta* L.; *Impatiens eriocarpa* Launert; *Impatiens stapfiana* Gilg (The Plant List, 2013).	India (Matthews et al., 2015).	Gardens, roads, dumps, fields, forest edges, grasslands, riverbeds, vacant lots, homes and cemeteries (PFAF, 2020; Useful Tropical Plants, 2016).	Its inflorescence can be of a single flower or with two or three flowers. The flowers are usually white, pink or purple and have single and double petals (CABI, 2020).	0.6 to 1	Leaves, oil and seed (PFAF, 2020).	Dyestuffs, Ornamental, Medicinal (Tradicional/ Folklore) (CABI, 2020).
Impatiens bicolor Royle	*Impatiens amphorata* Edgew.; *Impatiens amphorata* Edgew. var. umbrosa (Edgew.) Hook. f.; *Impatiens pallens* Edgew.; *Impatiens picta* Knowl. & Westc; *Impatiens roylei* Klotzsch; *Impatiens umbrosa* Edgew (Ganeshaiah et al., 2020).	Western Himalayas (Ganeshaiah et al., 2020).	Shaded slopes (Ganeshaiah et al., 2020).	An inflorescence with several flowers in the upper parts of the plant. Pink and yellow flowers (Ganeshaiah et al., 2020).	0.3 to 1.0	_	_
Impatiens capensis Meerb	*Balsamina capensis* (Meerb.) DC.; *Balsamina fulva* Ser.; *Impatiens capensis f. capensis; Chrysaea biflora* (Walter) Nieuwl. & Lunell; *Impatiens biflora* Walter (The Plant List, 2013).	Eastern North America (Zika, 2006).	Banks of rivers and canals, low-lying moist woodlands, avoiding acid soils (PFAF, 2020; Useful Tropical Plants, 2016).	It has spots on its petals (although there is a rare immaculate shape); Typically, orange, however, may vary in colors, such as cream or pale yellow (Washington State, 2020a).	1.2	Leaves, seed and stem (PFAF, 2020).	Cooked (young leaves and shoots), Medicinal (Antidotes, poutice, stings and warts) (PFAF, 2020).
Impatiens edgeworthii Hook.f.	*Impatiens chrysantha* Hook. F. (The Plant List, 2013).	Indian sub-continent and north-western Himalaya (Matthews et al., 2015).	Forest openings, ditches near water drains (PFAF, 2020; Useful Tropical Plants, 2016).	They are generally yellowish in color with red stripes, have an average size of 2.5–3.6 cm and their colors vary between shades of violet, yellow and white (Matthews et al., 2015).	0.6	_	Essential oil (PFAF, 2020).
Impatiens flanaganae Hemsl.	*No synonyms are recorded.* (The Plant List, 2013).	South African (Pondoland, Eastern Cape province and Kwazulu-Natal province) (Matthews et al., 2015).	It grows in wooded areas, floodplains with partial shade, along the banks of rivers and gullies (Matthews et al., 2015).	Inflorescence of pink color composed between 6 and 15 flowers and supported by a pendulum of 17–39 cm (Matthews et al., 2015).	1.0 to 2.0	_	_
	Balsamina glandulifera (Royle) Ser.; *Balsamina*	Himalays, north-west Pakistan and	Riverbanks, moist natural forests, forest	They have 5 petals (2 fused, 3 sepals). Their	0.5 to 2.5	Leaves, oil and	Garden ornamental; honey plant and Bach

(continued on next page)

Table 1 (*continued*)

Scientific Name	Synonyms	Native Range	Habitat	Flowers	Height (m)	Edible Parts	Uses
Impatiens glandulifera Royle	*macrochila* (Lindl.) Ser.; *Balsamina roylei* (Walp.) Ser.; *Impatiens macrochila* Lindl.; *Impatiens roylei* Walp. (The Plant List, 2013).	north India and Nepal (Matthews et al., 2015).	plantations, forest clearings, railway landfills, landfills, urban areas and wet meadows (PFAF, 2020; Useful Tropical Plants, 2016).	colors can vary from purple, pink or white (Washington State, 2020a).		seed (PFAF, 2020).	flower remedies (CABI, 2020).
Impatiens noli-tangere L.	*Balsamina lutea* Delarbre; *Balsamina noli-tangere* (L.) Scop.; *Impatiens komarovii* Pobed. (The Plant List, 2013).	United Kingdom (Lake District) and Wales (Hatcher, Wilkinson, Albani, & Hebbern, 2004).	Streams, wet ground, woods (PFAF, 2020; Useful Tropical Plants, 2016).		0.4 to 0.8	Leaves and seed (PFAF, 2020).	Cooked (young shoots), Medicinal (Antidote, parasiticide, stings and warts), Other uses (yellow colorant, hair rinse for itchy scalps) (PFAF, 2020).
Impatiens pallida Nuttal	*Impatiens pallida f. pallida* (The Plant List, 2013).	North America (eastern USA and Canada) (Barto, Friese, & Cipollini, 2010).	Moist woodland and wet meadows, usually on calcareous soils (PFAF, 2020; Useful Tropical Plants, 2016).	The size of the flowers can vary from 2.5 to 4 cm, they are composed of 5 petals with cream colors, or less often yellow (Matthews et al., 2015).	1.0 to 1.2	Leaves and seed (PFAF, 2020).	Oriental dishes, Medicinal (Skin and Stings) (PFAF, 2020).
Impatiens parviflora DC.	*Balsamina parviflora* (DC.) Ser. (The Plant List, 2013).	Native to parts of Asia (China, Kazakhstan, Mongolia, Russian Federation, and Afghanistan) (Washington State, 2020b).	Forests, forest edges, moist and humid forests, beech forests, settlements (PFAF, 2020; Useful Tropical Plants, 2016).	Two types of flowers can be found in the species (closed and open for cross-pollination), with a pale-yellow color, and usually also have reddish spots (Washington State, 2020a).	0.2 to 1.5	Leaves and seed (PFAF, 2020).	Botanical garden/zoo; Emergency (famine) food (CABI, 2020).
Impatiens sulcata Wall	*Impatiens gigantea* Edgew. (The Plant List, 2013).	Temperate Himalayas, China, Kashmir, Nepal and Bhutan (Matthews et al., 2015).	Soils rich in humus in forests, shrubs and cultivated areas, along canals, humid places in the shade (PFAF, 2020; Useful Tropical Plants, 2016).	Inflorescence with several flowers, with pendulum between 3.5 and 9 cm in length. In addition to presenting colors between shades of pink, red and purple (Matthews et al., 2015).	1.5	Leaves, oil and seed (PFAF, 2020).	Essential oil (PFAF, 2020).
Impatiens textori Miq.	*Impatiens japonica Franch. & Sav.* (The Plant List, 2013).	Japan (NYBG, 2010).	At open and moist place along a small stream, in light shade (NYBG, 2010).		0.4 to 0.8	Leaves (PFAF, 2020).	Cooked (young shoots) (PFAF, 2020).
Impatiens walleriana Hook. f.	*Impatiens giorgii* De Wild.; *Impatiens holstii* Engl. & Warb.; *Impatiens lujai* De Wild.; *Impatiens sultani* Hook.f.; *Impatiens sultanii* Hook. f. (The Plant List, 2013).	East Africa (Kenya, Tanzania, Malawi and Mozambique) (CABI, 2020).	Gardens, greenhouses, clearings, roads, secondary forests, coastal forests, riverbanks, wet pastures, tropical and subtropical forests (PFAF, 2020; Useful Tropical Plants, 2016).	Inflorescence usually with two flowers, rarely solitary. Variable coloring between pink, purple, violet, orange, red and white (CABI, 2020).	0.3 to 0.8	Flowers (PFAF, 2020).	Enviromental (Amenity), Folk medicine, Pharmaceutical and Ornamental. Garnish in salads or floated in drinks (flowers) (CABI, 2020).

and in North America. Szewczyk, 2018, on the other hand, states that the origin of these plants is not known for sure, but their first specimens were studied in Asia and East Africa.

Regarding the commercialization of these plants, it is believed that currently the species *I. walleriana* and *Impatiens hawkeri* W. Bull together move a market of 250 million dollars annually, in the United States alone (CABI, 2020b). Its uses are the most diverse, for example, the use of *I. glandulifera* for the production of honey (CABI, 2020c); the adoption of *I. balsamina* seed oils for the treatment of inflammation of the throat (CABI, 2020a).

According to the information collected, plants of this genus produced throughout the year, survive sandy and clayey soils, thrive in the presence or low incidence of light, have an affinity for humid environments, and can also show rapid growth (PFAF, 2020). In terms of size, they can vary from 0.4 to 2.5 m in height, are found in the most diverse territories around the world, present several applications in society, among them bioactive characteristics and edibility, these and other characteristics are presented according to the Table 1.

3.1. Nutritional and chemical characterization

Studies generally state that the nutritional content found in edible flowers does not differ from the nutrients found in other plant organs (Fernandes, Casal, Pereira, Saraiva, & Ramalhosa, 2017). These, in turn, appear in different parts of the flowers, such as pollen, nectar and also in the petals according to. Fernandes et al. (2017) states that water is the main component found in flowers, which can vary between 70% and 95%, followed by macronutrients such as carbohydrates, proteins and lipids, respectively. On the other hand, recent research on the chemical composition of flowers indicates the presence of high levels of micronutrients, such as vitamins, minerals, essential oils, mucilages and antioxidant substances (Stefaniak & Grzeszczuk, 2019). However, due to the increased demand for consumption of edible flowers, more research is needed on the nutritional composition and bioactive compounds found in these plants (Cunningham, 2015), since literary studies are minimal regarding the nutrients present in this segment food, even for *Impatiens* L. flowers. However, some studies related to the presence of macro and micro nutrients in other organs of the genus, such as seeds

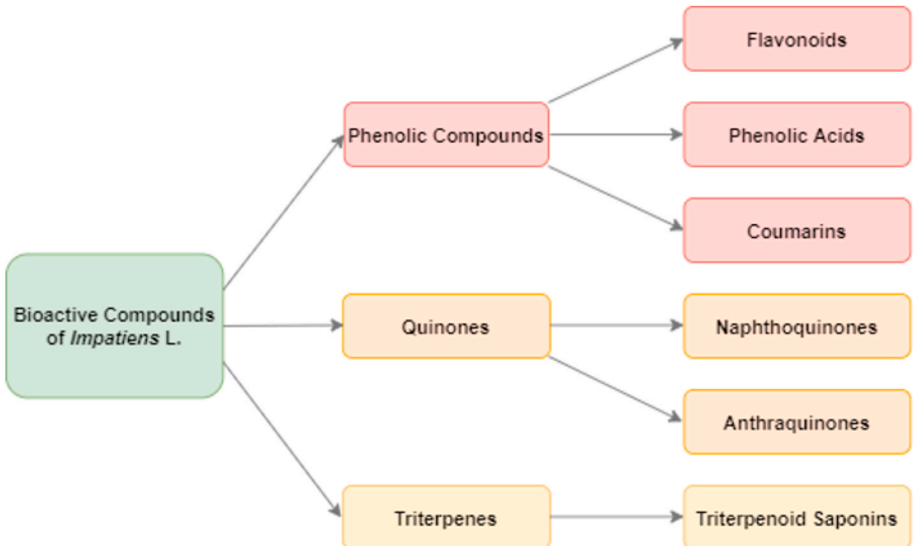

Fig. 1. Main compounds found in the genus Impatiens. (Authorship by the author).

and leaves are presented today.

Invasive plants, such as *Impatiens*, are relevant renewable resources of polysaccharides and phenolic compounds. These, in turn, can be assigned to the most diverse applications, as in cases of alternative medicine practices (Hromádková, Košťálová, Vrchotová, & Ebringerová, 2014). A study regarding the chemical constitution of *I. parviflora* found the presence of several polysaccharide derivatives in its leaves (Hromádková et al., 2014). Among the results obtained, the kiln dried leaves showed high proportions of glucose, which were reduced after the application of pre-extraction techniques. In another way, traces of galactose, arabinose and glucose were discovered in the extractions with cold water, ethylenediamine tetraacetic acid (EDTA) and dimethylsulfoxide (DMSO). Meanwhile, components of monosaccharides, such as xylose, galactose, arabinose and glucose were present in the extractions made with NaOH 1% and NaOH 5% (Hromádková et al., 2014). Szewczyk, Heise, and Piwowarski (2018b), on the other hand, carried out a comparative study about the chemical composition and bioactivities existing in water-soluble polysaccharides, originating from four species of the genus *Impatiens* (*I. parviflora*, *I. balsamina*, *I. glandulifera* and *Impatiens noli-tangere* L.). The studied species showed similarity between their monosaccharide compositions, being identified arabinose, rhamnose, mannose, xylose, glucose, and galactose (which stood out as the major sugar among the samples) (Szewczyk, Heise, & Piwowarski, 2018). However, these sugars differed in terms of proportion between species.

Meanwhile, Szewczyk, Bonikowski, MaciÄ…g-Krajewska, Abramek, and Bogucka-Kocka (2018c), observed the chemical composition of the lipophilic fractions present in the leaves, roots and seeds of the species *I. glandulifera* and *I. noli-tangere*. The first results obtained were related to the percentage of saturated fatty acids (12.2–27.2%), monounsaturated (16.9–34.1%) and polyunsaturated (40.3–55.8%). As for the characterization, α-linolenic, oleic and palmitic acids became predominant, as well as all samples presented constituents of ω-3 and ω-6 (Szewczyk, 2018). However, γ-linolenic acid was also found in large proportions in the roots (5.8%) and leaves (7.9%) of *I. noli-tangere*, while capric acid, was detected only in the roots and seeds of *I. noli-tangere*, and low amounts of arachidonic acid were present in the leaves and seeds of *I. glandulifera* (Szewczyk, 2018). Other reports state that α-parinic acid is the main constituent of *Impatiens* seeds (Bagby, Smith, & Wolff, 1966). In turn, Fachun (2008) stated that *I. balsamina* seed oil is rich in unsaturated fatty acids (70.7%), in which linoleic (16.5%) and α-linolenic (31.5%) acids stand out. While Ortin and Evans (2013), determined the presence of fatty acids from *Impatiens capensis* Meerb seed oil and *Impatiens pallida* Nuttal, where percentages of palmitic, palmitoleic, stearic, oleic, linoleic, α-linolenic and stearidonic acids were found.

There are still few studies that reveal the amounts of proteins present in the genus *Impatiens*. However, some specific studies report the existence of some derivatives, such as peptides and amino acids in the structural organs of these herbs. Through this perspective, Pal and Biswas (1994) discovered a high molecular weight protein from the pericarp of the *I. balsamina* pods. Tailor et al. (1997) identified a new family of small antimicrobial peptides present in *I. balsamina* seeds derived from a precursor protein. The identified peptides were designated as Ib-AMP1, Ib-AMP2, Ib-AMP3 and Ib-AMP4 and attracted their researchers because they are rich in cysteine and for presenting themselves as the smallest antimicrobial peptides derived from plants isolated until the time of their discovery. Patel, Osborn, Rees, and Thornton (1998), stated in his research that the protein variant Ib-AMP4, obtained from the seeds of *I. balsamina*, had greater antifungal activity than Ib-AMP1, particularly in media with high ionic strength. While Thevissen et al. (2005), reported that the peptides Ib-AMPs, from the seeds of *I. balsamina*, show potential in the fight against fungal infections and do not present hemolytic and toxic activity. Fan, Schäfer, Reichling & Wink (2013), in turn, states that the bactericidal activity of the peptides from the seeds of the *I. balsamina* sample (Ib-AMP4) is fast and active against bacteria resistant to multiple drugs and that they can be combined with conventional antibiotics to treat microorganisms resistant.

3.2. Bioactive compounds

Food plays an important role in society, which goes beyond obtaining energy and providing nutrients, that is, many of them have different bioactive compounds, which contribute to human health and well-being. These compounds, in turn, act through the prevention and reduction of several pathologies, namely in the treatment of inflammation, in the regulation of immunity and in the delay of the oxidative stress process (Chugh & Kamal-Eldin, 2020). In addition, other studies report that fruits and vegetables stand out for their high content in bioactive compounds, which are capable of preventing chronic and cardiovascular diseases (Gil, Amodio, & Colelli, 2020, pp. 131–146). Zhang, Wen, Zhang, Duan, and Ma (2019) stated, that the active and natural ingredients are instruments of great value for human vitality, due to the biological effects and its wide application in the segment of functional foods and in the treatment of some diseases. While, Essien, Young, and Baroutian (2020), claims that bioactive compounds

Table 2
Phytochemicals found in flowers of *Impatiens* species.

Compound Family	Comoon Name	Compound Name	Extraction Methodology	Species	References
Phenolic acids	Cinnamic acid	(E)-3-Phenylprop-2-enoic acid	The extract was obtained from 10 g of sample, which were placed on filter paper with chloroform and then extracted with 80% aqueous methanol for a period of 72 h.	*I. glandulifera*	Szewczyk and Olech (2017)
	Protocatechuic acid	3,4-Dihydroxybenzoic acid	The extract was obtained from white flowers of *I. balsamina* at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2015)
	Methyl paraben	Methyl 4-hydroxybenzoate	The extract was obtained from white flowers of *I. balsamina* at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2015)
	3-Hydroxycinnamic acid	(E)-3-(3-Hydroxyphenyl)prop-2-enoic acid).	The extract was obtained from 10 g of sample, which were placed on filter paper with chloroform and then extracted with 80% aqueous methanol for a period of 72 h.	*I. glandulifera*	Szewczyk and Olech (2017)
	Vanilic acid	4-Hydroxy-3-methoxybenzoic acid	The extract was obtained from white flowers of *I. balsamina* at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2015)
	m-Hydroxybenzoic acid	3-Hydroxybenzoic acid	The extract was obtained from 10 g of sample, which were placed on filter paper with chloroform and then extracted with 80% aqueous methanol for a period of 72 h.	*I. glandulifera*	Szewczyk and Olech (2017)
	p-Hydroxybenzoic acid	4-Hydroxybenzoic acid	The extract was obtained from white flowers of *I. balsamina* at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2015)
Nitrogen compounds	Balsamitril	2-[(3*S*)-3-hydroxy-2-oxo-1-benzofuran-3-yl]acetonitrile	The extract was obtained from white flowers of *I. balsamina* at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2015)
	Balsamitril-3-O-β-D-glucoside	Balsamitril-3-*O*-β-D-glucoside	The extract was obtained from white flowers of *I. balsamina* at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2015)
Flavonoids	Apigenin	5,7-Dihydroxy-2-(4-hydroxyphenyl)chromen-4-one	The extract was obtained from fresh matter of *I. textori*. The extraction was carried out twice with 35% ethanol for 1 week at room temperature.	*I. textori*	Ueda et al. (2003)
	Kaempferol 3,7-diglucoside	5-Hydroxy-2-(4-hydroxyphenyl)-7-[(2*S*,4*S*,5*S*)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]oxychromen-4-one	The extract was obtained from fresh matter of *I. textori.* The extraction was carried out twice with 35% ethanol for 1 week at room temperature.	*I. textori*	Ueda et al. (2003)
			The extracts were obtained from flowers of *I. balsamina L.*, with the addition of 75% ethanol (3 × 120 L, 2 h each) at 78 °C.	*I. balsamina*	Li, Zhang, et al. (2015)
	6-Hydroxykaempferol 3-Rutinoside -6-glucoside	5,7-di-hidroxi-2- (4-hidroxifenil)-3-[(2 *S*, 3 *R*, 4 *S*, 5 *S*, 6 *R*)-3,4,5-tri-hidroxi-6-(hidroximetil) Oxan-2 -il] oxicromen-4-ona	The extract was obtained from fresh matter of *I. textori.* The extraction was carried out twice with 35% ethanol for 1 week at room temperature.	*I. textori*	Ueda et al. (2003)
			The material was ground, later extracted with pure ethanol (99.9%) and maintained by maceration for 24 h.	*I. glandulifera*	Vieira et al. (2016)
		3,5,7-Trihydroxy-2-(4-hydroxyphenyl)chromen-4-one	The petals (or sepals) were extracted with 1% ethanolic hydrochloric acid.	*I. capensis*	Clevenger (1958)
	Kaempferol		The fresh material of *I. balsamina* was extracted at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2017)
			The extract was obtained from fresh matter of *I. textori.* The extraction was carried out twice with 35% ethanol for 1 week at room temperature.	*I. textori*	Ueda et al. (2003)
			The material was ground, later extracted with pure ethanol (99.9%) and maintained by maceration for 24 h.	*I. glandulifera*	Vieira et al. (2016)
	Balsamiside A, B, C and D		The fresh material of *I. balsamina* was extracted at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2017)
		5,7-Dihydroxy-2-(4-hydroxy-3-methoxyphenyl)chromen-4-one	The extract was obtained from fresh matter of *I. textori.* The extraction was carried out twice with 35% ethanol for 1 week at room temperature.	*I. textori*	Ueda et al. (2003)
		2-(3,4-dihydroxyphenyl)-5-hydroxy-7-[(2*S*,3*R*,4*R*,5*S*,6*R*)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]oxy-2,3-dihydrochromen-4-one	The material was ground, later extracted with pure ethanol (99.9%) and maintained by maceration for 24 h.	*I. glandulifera*	Vieira et al. (2016)
		2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2*S*,3*R*,4*S*,5*R*,6*R*)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]oxychromen-4-one	The material was ground, later extracted with pure ethanol (99.9%) and maintained by maceration for 24 h.	*I. glandulifera*	Vieira et al. (2016)
	Luteolin	2-(3,4-dihydroxyphenyl)-5,7-dihydroxychromen-4-one		*I. textori*	Ueda et al. (2003)

(*continued on next page*)

Table 2 (*continued*)

Compound Family	Comoon Name	Compound Name	Extraction Methodology	Species	References
			The extract was obtained from fresh matter of *I. textori.* The extraction was carried out twice with 35% ethanol for 1 week at room temperature.		
	Myricetin	3,5,7-Trihydroxy-2-(3,4,5-trihydroxyphenyl)chromen-4-one	The extracts were obtained from flowers of *I. balsamina L.*, with the addition of 75% ethanol (3 × 120 L, 2 h each) at 78 °C.	*I. balsamina*	Li, Zhang, et al. (2015)
	Myricetin 3-galactoside	5,7-Dihydroxy-3-[(2*S*,3*R*,4*S*,5*R*,6*R*)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]oxy-2-(3,4,5-trihydroxyphenyl)chromen-4-one	The material was ground, later extracted with pure ethanol (99.9%) and maintained by maceration for 24 h.	*I. glandulifera*	Vieira et al. (2016)
	Nicotiflorin	5,7-Dihydroxy-2-(4-hydroxyphenyl)-3-[(2*S*,3*R*,4*S*,5*S*,6*R*)-3,4,5-trihydroxy-6-[[(2*R*,3*R*,4*R*,5*R*,6*S*)-3,4,5-trihydroxy-6-methyloxan-2-yl]oxymethyl]oxan-2-yl]oxychromen-4-one	The extracts were obtained from flowers of *I. balsamina L.,* with the addition of 75% ethanol (3 × 120 L, 2 h each) at 78 °C.	*I. balsamina*	Li, Zhang, et al. (2015)
	Isoquercitrin	2-(3,4-Dihydroxyphenyl)-5,7-dihydroxy-3-[(2*S*,3*R*,4*S*,5*S*,6*R*)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]oxychromen-4-one	The extract was obtained from fresh matter of *I. textori.* The extraction was carried out twice with 35% ethanol for 1 week at room temperature.	*I. textori*	Ueda et al. (2003)
			The fresh material of *I. balsamina* was extracted at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2017)
		Derivatives of 3,5,7-trihydroxy-2-(4-hydroxyphenyl) chromen-4-one	The fresh material of *I. balsamina* was extracted at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2017)
			The extract was obtained from fresh matter of *I. textori.* The extraction was carried out twice with 35% ethanol for 1 week at room temperature.	*I. textori*	Ueda et al. (2003)
			The fresh material of *I. balsamina* was extracted at room temperature, containing 80% aqueous methanol as solvent.	*I. glandulifera*	Kim et al. (2017)
	Quercetin	2-(3,4-Dihydroxyphenyl)-3,5,7-trihydroxychromen-4-one	The fresh material of *I. balsamina* was extracted at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2017)
			The extract was obtained from fresh matter of *I. textor*i. The extraction was carried out twice with 35% ethanol for 1 week at room temperature.	*I. textori*	Ueda et al. (2003)
			The material was ground, later extracted with pure ethanol (99.9%) and maintained by maceration for 24 h.	*I. glandulifera*	Vieira et al. (2016)
	Quercetin 3-O-Malonylglucoside	3-[[(2R,3S,4S,5R,6S)-6-[2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-4-oxochromen-3-yl]oxy-3,4,5-trihydroxyoxan-2-yl]methoxy]-3-oxopropanoic acid	The material was ground, later extracted with pure ethanol (99.9%) and maintained by maceration for 24 h.	*I. glandulifera*	Vieira et al. (2016)
		2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2*S*,3*R*,4*S*,5*S*,6*R*)-3,4,5-trihydroxy-6-[[(2*R*,3*R*,4*R*,5*R*,6*S*)-3,4,5-trihydroxy-6-methyloxan-2-yl]oxymethyl]oxan-2-yl]oxychromen-4-one	The extracts were obtained from flowers of *I. balsamina L.*, with the addition of 75% ethanol (3 × 120 L, 2 h each) at 78 °C.	*I. balsamina*	Li, Zhang, et al. (2015)
Quinones	2-Methoxy-1,4-Naphthoquinone	2-Methoxynaphthalene-1,4-dione	The extract was obtained from white flowers of *I. balsamina* at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2015)
			The plant material was coarsely macerated and left to infuse in cyclohexane for 24 h. The mixture was decanted and filtered, removing remnants of plant material, and then dried over sodium sulfate.	*I. glandulifera*	Ortin and Evans (2013)
		Balsaminone B, D and E	The dried flowers of *I. balsamina* were extracted with 75% ethanol under reflux at 78 °C. The extract was concentrated in vacuo and suspended in water, then divided with petroleum ether, dichloromethane, ethyl acetate and n-butanol.	*I. balsamina*	Li, Guo, et al. (2015)
Saponins		Balsaminside A, B, C and D	*I. balsamina* flowers were extracted with 75% ethanol under reflux at 78 °C three times. The extract was concentrated in vacuo and suspended in water, then divided with petroleum ether, dichloromethane, ethyl acetate and n-butanol successively.	*I. balsamina*	Li et al. (2017)
Other compounds	Luteolin epoxide	(1*R*,3*S*,6*S*)-6-[(1*E*,3*E*,5*E*,7*E*,9*E*,11*E*,13*E*,15*E*,17*E*)-18-[(1*R*,4*R*)-4-hydroxy-2,6,6-trimethylcyclohex-2-en-1-yl]-3,7,12,16-tetramethyloctadeca-1,3,5,7,9,11,13,15,17-nonaenyl]-1,5,5-trimethyl-7-oxabicyclo[4.1.0]heptan-3-ol	Petal pigments and open flower sepals were extracted.	*I. noli-tangere*	Wrischer, Ljubesic, Prebeg, and e Magnus (1999)
	Tyrosol	4-(2-Hydroxyethyl)phenol		*I. balsamina*	Kim et al. (2015)

(*continued on next page*)

Table 2 (*continued*)

Compound Family	Comoon Name	Compound Name	Extraction Methodology	Species	References
			The extract was obtained from white flowers of *I. balsamina* at room temperature, containing 80% aqueous methanol as solvent.		
	Violaxanthin	(1*R*,3*S*,6*S*)-6-[(1*E*,3*E*,5*E*,7*E*,9*E*,11*E*,13*E*,15*E*,17*E*)-18-[(1*S*,4*S*,6*R*)-4-hydroxy-2,2,6-trimethyl-7-oxabicyclo[4.1.0]heptan-1-yl]-3,7,12,16-tetramethyloctadeca-1,3,5,7,9,11,13,15,17-nonaenyl]-1,5,5-trimethyl-7-oxabicyclo[4.1.0]heptan-3-ol	Petal pigments and open flower sepals were extracted.	*I. noli-tangere*	Wrischer et al. (1999)
		2-*O*-(4-Hydroxybenzoyl)-4-*O*-*β*-D-glucopyranosyl-6-hydroxyphenylacetic acid	The extracts were obtained from flowers of *I. balsamina L.*, with the addition of 75% ethanol (3 × 120 L, 2 h each) at 78 °C.	*I. balsamina*	Li, Zhang, et al. (2015)
		(3S, 4R)-3,4-dihydroxy-3,4-dihydronapthalen-1(2H)-one	The extract was obtained from white flowers of *I. balsamina* at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2015)
		trans-(3S, 4R)-3,4-dyhydroxy-1-tetralone	The extract was obtained from white flowers of *I. balsamina* at room temperature, containing 80% aqueous methanol as solvent.	*I. balsamina*	Kim et al. (2015)
		β-d-Glucopyranosiduronic acid, (3β)-norolean-3-yl-O-β-d-glucopyranosyl- (1 → 2)-O-[β-d-xylopyranosyl-(1 → 4)]	*I. balsamina* flowers were extracted with 75% ethanol under reflux at 78 °C three times. The extract was concentrated in vacuo and suspended in water, then divided with petroleum ether, dichloromethane, ethyl acetate and n-butanol successively.	*I. balsamina*	Li et al. (2017)
		3-*O*-β-D-Xylopyranosyl-(1 → 2)-β-D-glucopyranosyl-28-*O*-β-D-glucopyranosyl oleanolic acid	*I. balsamina* flowers were extracted with 75% ethanol under reflux at 78 °C three times. The extract was concentrated in vacuo and suspended in water, then divided with petroleum ether, dichloromethane, ethyl acetate and n-butanol successively.	*I. balsamina*	Li et al. (2017)
		α-D-Glucopyranosyl-(1 → 1′)-3′-amino-3′-deoxy-β-d-glucopyranoside	*I. balsamina* flowers were extracted with 75% ethanol under reflux at 78 °C three times. The extract was concentrated in vacuo and suspended in water, then divided with petroleum ether, dichloromethane, ethyl acetate and n-butanol successively.	*I. balsamina*	Li et al. (2017)
		6-*O*-(E)-*p*-Hydroxy-cinnamoyl-β-d-glucose	*I. balsamina* flowers were extracted with 75% ethanol under reflux at 78 °C three times. The extract was concentrated in vacuo and suspended in water, then divided with petroleum ether, dichloromethane, ethyl acetate and n-butanol successively.	*I. balsamina*	Li et al. (2017)
		6-*O*-(*E*)-*p*-Hydroxy-cinnamoyl-α-d-glucose	*I. balsamina* flowers were extracted with 75% ethanol under reflux at 78 °C three times. The extract was concentrated in vacuo and suspended in water, then divided with petroleum ether, dichloromethane, ethyl acetate and n-butanol successively.	*I. balsamina*	Li et al. (2017)
		1,2-*O*-(4-Dihydroxybenzoyl)-2,4,6-trihydroxyphenylacetic acid	The extracts were obtained from flowers of *I. balsamina L.*, with the addition of 75% ethanol (3 × 120 L, 2 h each) at 78 °C.	*I. balsamina*	Li, Zhang, et al. (2015)
		2-*O*-(4-Hydroxybenzoyl)-4-*O*-β-d-glucophyranosyl-6-hydroxyphenylacetic acid	The extracts were obtained from flowers of *I. balsamina L.*, with the addition of 75% ethanol (3 × 120 L, 2 h each) at 78 °C.	*I. balsamina*	Li, Zhang, et al. (2015)
		4-*O*-β-d-Glucopyranosyl-2,6-dihydroxyphenylacetic acid	The extracts were obtained from flowers of *I. balsamina L.*, with the addition of 75% ethanol (3 × 120 L, 2 h each) at 78 °C.	*I. balsamina*	Li, Zhang, et al. (2015)

originating from plants, algae, food and by-products are able to interact with the components of living tissues, in order to provide the most diverse effects.

These compounds are also present in edible flowers. As an example, we can mention some compounds found in greater abundance, such as protocatechuic acid in *Hibiscus sabdariffa* L. that play an antioxidant role, luteolin in *Lonicera japonica* Thunb. that act as anti-inflammatories and quercetin in water lily that can prevent obesity (Lu, Li, & Yin, 2016). Also, Pires, Dias, Barros, and Ferreira (2017), reinforce that edible flowers are responsible for providing many health benefits to those who consume them, due to the presence of bioactive molecules, which posse biological effects.

Phytochemical research carried out with examples of the genus *Impatiens*, affirm the presence of numbers of bioactive molecules in its composition. Among the various bioactive compounds present in the genus *Impatiens*, naphthoquinone, coumarin, phenolic acid, flavonoids, anthocyanins, steroids and peptides are the main ones (Li et al., 2017). A brief summary of the main compounds present in the genus can be found in Fig. 1.

Studies regarding the bioactive compounds present in the genus *Impatiens* stand out, in addition to phenolic compounds, as well as the components present, such as quinones and triterpenes that perform various actions related to human health. However, a current study indicates the presence of approximately 300 distinct phytochemicals in more than twenty-seven species studied by the genus *Impatiens* (Szewczyk, 2018). Some of the main compounds present in *Impatiens* flowers can be seen according to Table 2.

Phenolic compounds make up one of the main groups of non-essential food components synthesized by the secondary metabolism of plants and have a multitude of substances within their class (Rodríguez-Pérez, Segura-Carretero & del Mar Contreras, 2019). They are capable of conferring several benefits to human health, especially in the fight against chronic diseases, such as diabetes and hypertension (Fraga, Croft, Kennedy & Tomás-Barberán, 2019). Over the years, this class of compounds have traditionally been used as food coloring, in addition to some studies showing an inverse relationship between the intake of foods rich in phenolic compounds, and the occurrence of several cardiovascular diseases (Rodríguez-Pérez, Segura-Carretero & del Mar Contreras, 2019). Therefore, these compounds are considered valuable for obtaining functional ingredients.

Over time, the presence of many of these compounds have been confirmed in the various parts that make up the plants of the genus *Impatiens*. The family of flavonoids consists of more than 9000 specimens of individual compounds that are considered potential antioxidants (Hernández, Alegre, Van Breusegem & Munné-Bosch, 2009).

In a study carried out in Poland, concerning the phenolic composition of aerial parts of *I. glandulfera*, the presence of eight distinct flavonoids, two phenolic acids and the compound 2-methoxynaphthalene-1,4-dione (Szewczyk, Sezai Cicek, Zidorn, & Granica, 2019). In a subsequent study, made from *Impatiens hypophylla* Makino, seven flavonoids and a coumarin were also found (Tsushiro, Kurizaki, Watanabe, & Devkota, 2019). Meanwhile, tetrahydronaphthalene was isolated for the first time on stems of *I. balsamina*, along with eleven other distinct compounds by researchers in Korea (Kim, Lee, Subedi, Kim, & Lee, 2019).

Szewczyk, Zidorn, Biernasiuk, Komsta and Granica (2016a), stated in their study, that the extracts (methanol/acetone/water (3/1/1, v/v/v; 3 × 50 ml) of *I. balfourii* Hook.f. (1903)., *I. glandulífera* and *I. parviflora*, have significant amounts of phenolic acids and flavonoids responsible for a multidirectional bioactive activity, as they are capable of presenting antioxidant characteristics and antimicrobial at the same time. In addition to this aspect, Clevenger (1958), found that a subclass of flavonoids, flavonois are constituents of the most diverse parts of *I. balsamina*, so that kaempferol and myricetin present mainly in petals and sepals, while quercetin was only present in sepals (Fukumoto, Ishiguro, Murashima, Yamaki, & Isoi, 1994; Hua, Peng, Chia, Goh, & Tan, 2001; Lim, Kim, & Seo, 2007). Chua (2016), stated that flavonoids are the major compounds in leaf extracts (methanol) of *I. balsamina*. Kim et al. (2017), attested the presence of four biflavonoid glycosides (balasamisides A, B, C and D) in white petals of *I. balsamina*. Vieira, Winterhalter, and Jerz (2016), composed the first report about the composition of flavonoids in the species of *I. glanduliferous*, in which dihydromyricetin, eriodictiol-7-*O*-glucoside, kaempferol-3-*O*-glucoside and kaempferol-3-*O*-6″-malonyl-glucoside were isolated. Hasan and Tahir (2005), characterized nine flavone glycosides from the leaves of *I. bicolor* Royle, three of which were new discoveries.

They are known in the scientific community for promoting the health of some fruits and vegetables, in addition to giving unique flavors to foods and affecting the growth and reproduction of plants (Espín & Tomas-Barberan, 2001). Due to these peculiarities, some researchers strive to quantify and identify this class of acids in the most diverse plants, including *Impatiens*. Szewczyk and Olech (2017) for example, applied several methodologies of solid-liquid extraction with methanol (80:20) in specimens of *I. glandulifera* in order to obtain ultrasound as the best optimized method of extraction. Later on the same authors, found the presence of thirteen phenolic acids (gallic acid; protocatechuic acid; gentisic acid; 4-hydroxybenzoic acid; vanilic acid; *trans*-caffeic acid; syringic acid; *trans*-*p*-coumaric acid; *cis*-*p*-coumaric acid; *trans*--ferulic acid; salicylic acid; *cis*-ferulic acid; 3-hydroxycinnamic acid) from four other species (*I. balsamina*, *I. noli-tangere*, *I. parviflora* and *I. walleriana*), in which the leaves of the species *I. glandulifera* and *I. noli-tangere* highlighted themselves as the organs with the greatest amount of these compounds (Szewczyk & Olech, 2017). In a more remote study Mansell and Kemerer (1970), observed the existence of hydroxycinnamic acid derivatives in the white, red and purple petals of *I. balsamina*. Among the discoveries, *p*-karmaric acid was mostly found in the red petals, while ferulic acid showed a higher concentration in the purple genotype. Bohm and Towers (1962), investigated the presence of ten distinct phenolic acids (gentisic acid, *p*-hydroxybenzoic acid, protocatechuic acid, salicylic acid, syringic acid, vanilic acid, caffeic acid, *p*-coumaric acid, ferulic acid, synaptic acid), in ten species of *Impatiens*.

Another class of compounds widely found in *Impatiens* are coumarins. Which are defined as groupings of benzene rings and pyrones, responsible for conferring a therapeutic potential, especially in the prevention of some cancers (Thakur, Singla, & Jaitak, 2015). The first reports about coumarin isolations in *Impatiens* are dated 1964 and in this study, the leaves of fourteen species of the genus showed traces of scopelithin (Szewczyk, Bonikowski, et al., 2018c). In addition, the presence of isofraxidine and scopelithin from *I. balsamina* roots has been reported (Panjchayupakaranant, Noguchi, De-Eknamkul, & Sankawa, 1995). Chua (2016), in turn, found the presence of scopoletin diacyldipentoside in the stems and leaves of *I. balsamina*.

3.3. Natural pigments

Colored additives or food colors are chemicals, pigments or other coloring substances that can add colour to foods, beverages or non-food applications (including pharmaceuticals) and classified as natural, semi-synthetic and synthetic (Amchova, Kotolova, & Ruda-Kucerova, 2015). The natural pigments are extracted from food or edible natural materials, through physical-chemical processes, being used in the most diverse forms (Coultate & Blackburn, 2018). Semi-synthetic colorants are similar to natural colorant, but their methods of synthesis are carried out by chemical processes, whereas synthetic colour are produced by chemical processes, however they are not found in nature (Amchova et al., 2015).

Nowadays, the food industry is raising several questions about the health risks caused by the inappropriate use of synthetic colour in the composition of industrialized foods, since the possible exaggeration of the use of these substances can confer risk to human health (Albuquerque et al., 2017; Anastácio, Oliveira, Delmaschio, Antunes & Checker, 2016; Jimenez-Gonzalez et al., 2018).

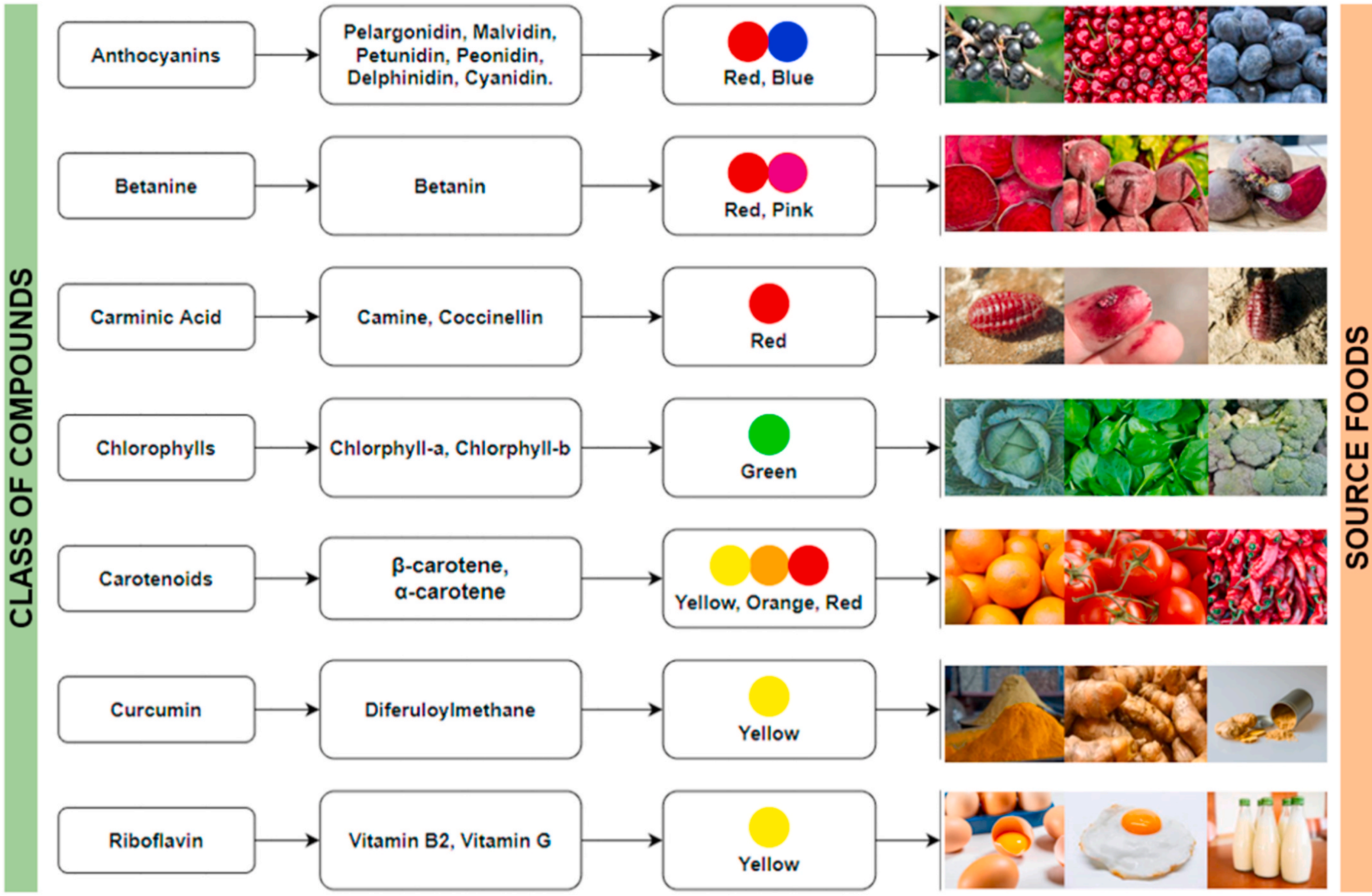

Fig. 2. Classification of natural colorants. (Authorship by the author).

On the other hand, natural colorants attract several scholars, due to the existence of functional and nutraceutical properties in their compositions (López et al., 2018; Rodriguez-Amaya, 2016; Rowles III & Erdman, 2020). In addition, the segments of natural colour consist of numerous substances, but among them, the anthocyanins, betalains, carminic acid, chlorophyll, carotenoids, curcumins and riboflavin stand out as some of the most important (Schiozer & Barata, 2013), as shown in Fig. 2.

As for a more specific definition, it can be said that anthocyanins, are flavonoids originating from the secondary metabolism of plants, have solubility in water, attract attention by colour, which varies from red to blue and are generally found in various plant organs, such as fruits, roots, leaves and flowers (López et al., 2018; Santos-Buelga & González-Paramás, 2019). In addition, studies report the existence of twenty-two main anthocyanin compounds, in which only six of them are relevant to the food industry, namely: cyanidin, delfinidine, malvidin, pelargonidine, peonidine and petunidine (Santos-Buelga & González-Paramás, 2019; Schiozer & Barata, 2013).

Currently, anthocyanin compounds have aroused interest not only for the scientific community (Benvenuti, Bortolotti, & Maggini, 2016; Khoo, Azlan, Tang, & Lim, 2017), but also for the industrial sector, due to their bioactive properties and their advantages as food colors (Bleve et al., 2008; Puértolas, Cregenzán, Luengo, Álvarez, & Raso, 2013), However, obtaining raw chemical substances and stable dyes are the biggest current challenges, when compared to the best conservation conditions by synthetic chemical substances (Anastácio, Oliveira, Delmaschio, Antunes & Checker, 2016; Schiozer & Barata, 2013; Tarone, Cazarin, & Junior, 2020).

In the universe of edible flowers, anthocyanins are compounds that are of remarkable importance in terms of colour assignment (Goto & Kondo, 1991; Lawrence, Price, Robinson & Robison, 1939). Some studies have stated the presence of these flavonoids in the flowers of *Lilium* spp. (Yamagishi, Uchiyama, & Handa, 2018), *Hibiscus sabdariffa* (Grajeda-Iglesias, Salas, Barouh, Barea and Figueroa-Espinoza, 2017), *Ramat chrysanthemum morifolium* (Liu, Xiang, Yin, Grierson & Chen, 2015) and *Paeonia suffruticosa* (Zhang et al., 2014), in addition to being present in the genus *Impatiens* (Aras, Cevahir, Yentür, Eryılmaz, Sarsağ et al., 2007; Klein & Hagen, 1961).

Studies related to the presence of anthocyanin compounds in the genus *Impatiens* are scarce and need to be updated. Because its flowers have great attractiveness in terms of coloring molecules, being a possible natural source, in addition to conferring health benefits due to the bioactive properties of these compounds. However, Aras et al. (2007), investigated the location of anthocyanins in different parts of *I. balsamina*, stating that the pigment production capacity of this species is directly related to everyday factors, such as environmental and nutritional conditions.

Initial studies carried out with nineteen species of the genus *Impatiens* reported the predominance of cyanidin widely distributed in flower petals and sepals, while malvidin was the most common pigment in petals (Clevenger, 1971). In addition, it was also stated that the petals had more elaborate combinations of pigments when compared to the stems that have fewer complex pigmentations (Clevenger, 1971). Other studies have indicated that the anthocyanin compounds most present in the genus *Impatiens* are pelargonidin and peonidine, isolated a priori in flowers of *I. balsamina*, and that other anthocyanins derived from the classes of malvidins, delfinidine and cyanidin can also be found in specimens of the gender (Szewczyk, 2018). Leucoanthocyanidins, on the other hand, present themselves as the main responsible for the attribution of the reddish coloration of the roots and mature roots in several

Table 3
Anthocyanic compounds found in several species of the genus *Impatiens*.

Compound Name	Molecular Formula	IUPAC Name	Extraction Methodology	Species	References
Cyanidin	$C_{15}H_{11}O_6+$	2-(3,4-dihydroxyphenyl)chromenylium-3,5,7-triol	Extraction at room temperature with 1% hydrochloric acid in 95% ethyl alcohol (v/v).	*I. balsamina*	Klein and Hagen (1961)
			Extraction with 50% ethanol and then introduced in a sonication bath, at a frequency of 35 kHz.	*I. noli-tangere*	Paun et al. (2018)
			Anthocyanins were extracted from fresh material (flowers, capsules, pollen and sepals) with methanolic hydrochloric acid (1% solution).	*I. holstii*	Klozová & Rokosová, 1961
			The petal extract was obtained using 1% ethanolic hydrochloric acid.	*I. capensis*	Clevenger (1958)
Cyanidin 3-*O*-glucoside	$C_{21}H_{21}O_{11}+$	(2S,3R,4S,5S,6R)-2-[2-(3,4-dihydroxyphenyl)-5,7-dihydroxychromenylium-3-yl]oxy-6-(hydroxymethyl)oxane-3,4,5-trio	Extraction with 70% ethanol containing 0.4% hydrochloric acid (v/v).	*I. balsamina*	Hagen, 1966
			Extraction with methanol with 1% hydrochloric acid.	*I. platypetala*	Thakur and Nozzolillo. (1978)
Delphinidin	$C_{15}H_{11}C_1O_7$	2-(3,4,5-trihydroxyphenyl)chromenylium-3,5,7-triol; chloride	Extraction at room temperature with 1% hydrochloric acid in 95% ethyl alcohol (v/v).	*I. balsamina*	Alston and Hagen (1958)
Malvidin	$C_{17}H_{15}O_7+$	2-(4-hydroxy-3,5-dimethoxyphenyl)chromenylium-3,5,7-triol	Anthocins were extracted from fresh material (flowers, capsules, pollen and sepals) with methanolic hydrochloric acid (1% solution).	*I.hostii*	Klozová & Rokosová, 1961
			Extraction with 50% ethanol and then introduced in a sonication bath, at a frequency of 35 kHz.	*I.noli-tangere*	Paun et al. (2018)
			The plant parts were extracted in 1% hydrochloric acid in 95% ethanol.	*I.schlecteri./I. hawkeri*	Clevenger (1958)
Malvidin 3-*O*-glucoside	$C_{23}H_{25}O_{12}+$	(*2S*, *3R*, *4S*, *5S*, *6R*) -2- [5,7-di-hidroxi-2- (4-hidroxi-3,5-dimetoxifenil) cromenilio-3-il] oxi-6-(hidroximetil) oxano-3,4,5-triol	Extraction was performed by immersing fresh petals in 2% methanolic hydrochloric acid immediately after harvest.	*I. textori*	Ueno et al. (1969)
Malvidin 3-*O*-(6″-malonyl) glucoside			The dried flowers were immersed in 5% ethanolic acid at room temperature and extracted overnight.	*I. textori*	Tatsuzawa et al. (2009)
Malvidin 3,5-di-*O*-glucoside	$C_{29}H_{35}O_{17}+$	(2*S*,3*R*,4*S*,5*S*,6*R*)-2-[7-hydroxy-2-(4-hydroxy-3,5-dimethoxyphenyl)-3-[(2*S*,3*R*,4*S*,5*S*,6*R*)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl] oxychromenylium-5-yl]oxy-6-(hydroxymethyl) oxane-3,4,5-triol	Extraction was performed by immersing fresh petals in 2% methanolic hydrochloric acid immediately after harvest.	*I. textori*	Ueno et al. (1969)
Malvidin 3-*O*-[6″-*O*-(3-hydroxy-3-methylglutaryl)-β-glucopyranoside]			The dried flowers were immersed in 5% ethanolic acid at room temperature and extracted overnight.	*I. textori*	Tatsuzawa et al. (2009)
Pelargonidin	$C_{15}H_{11}O_5+$	2-(4-hydroxyphenyl)chromenylium-3,5,7-triol	The extraction was performed with material macerated in 70% ethanol containing 0.4% hydrochloric acid (v/v).	*I. balsamina*	Alston and Hagen (1958)
Pelargonidin 3-*O*-glucoside	$C_{21}H_{21}O_{10}+$	(2*S*,3*R*,4*S*,5*S*,6*R*)-2-[5,7-dihydroxy-2-(4-hydroxyphenyl)chromenylium-3-yl]oxy-6-(hydroxymethyl)oxane-3,4,5-triol	The extraction was performed with material macerated in 70% ethanol containing 0.4% hydrochloric acid (v/v).	*I. balsamina*	Klein and Hagen (1961)
Pelargonidin 3,5-*O*-diglucoside	$C_{27}H_{31}ClO_{15}$	(2S,3R,4S,5S,6R)-2-[7-hydroxy-2-(4-hydroxyphenyl)-3-[(2S,3R,4S,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl] oxychromenylium-5-yl]oxy-6-(hydroxymethyl) oxane-3,4,5-triol; chloride	The extraction was performed with material macerated in 70% ethanol containing 0.4% hydrochloric acid (v/v).	*I. balsamina*	Hagen (1966)
Pelargonidin 3-*O*-glucoside-5-*O*-acetylglucoside			The extraction was performed with material macerated in 70% ethanol containing 0.4% hydrochloric acid (v/v).	*I. balsamina*	Hagen (1966)
Peonidin	$C_{16}H_{13}O_6+$	2-(4-hydroxy-3-methoxyphenyl)chromenylium-3,5,7-triol	The pigments were extracted at room temperature with 1% hydrochloric acid in 95% ethyl alcohol (v/v).	*I. balsamina*	Klein and Hagen (1961)
Peonidin 3-*O*-glucoside	$C_{22}H_{23}O_{11}+$	2-[5,7-dihydroxy-2-(4-hydroxy-3-methoxyphenyl) chromenylium-3-yl]oxy-6-(hydroxymethyl)oxane-3,4,5-triol	Extraction with 50% ethanol and then introduced in a sonication bath, at a frequency of 35 kHz.	*I. noli-tangere*	Paun et al. (2018)

(*continued on next page*)

Table 3 (*continued*)

Compound Name	Molecular Formula	IUPAC Name	Extraction Methodology	Species	References
Leucocyanidin	$C_{15}H_{14}O_7$	2-(3,4-dihydroxyphenyl)-3,4-dihydro-2H-chromene-3,4,5,7-tetrol	The pigments were extracted from petals (or sepals) with 1% ethanolic hydrochloric acid.	*I. capensis*	Clevenger (1958)
			Extraction made with hydrochloric acid, in addition to leaf tissue in test tubes, containing 5g of sample and 5 ml of hydrochloric acid.	*I.glandulifera./ I. parviflora*	Bathe-Smith, 1962
Leucodelphinidin	$C_{15}H_{14}O_8$	(2*S*,3*S*,4*R*)-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2*H*-chromene-3,4,5,7-tetrol	Extraction made with hydrochloric acid, in addition to leaf tissue in test tubes, containing 5g of sample and 5 ml of hydrochloric acid.	*I. parviflora*	Bathe-Smith, 1962

studied species (*Impatiens balfourii* Hook.f., *I. balsamina*, *Impatiens capensis* Meerb., *Impatiens flaccida* Arn., *Impatiens linearifolia* Warb., *Impatiens platypetala* Lindl, *Impatiens schlechteri* Warb, *I. walleriana*, *Impatiens uguenensis* Warb and several hybrid cultivars) (Thakur & Nozzolillo, 1978).

Numerous studies conducted with the genus *Impatiens* have reported the existence of anthocyanin compounds, such as cyanidin fragments in the species *I. canpensis*, *I. noli-tangere* (Szewczyk, 2018). While the leucocyanidin traces were pointed out by Clevenger (1958) and Bathe--Smith (1962), respectively in the species *I. glandulifera*, *I. parflivora* and *I. canpensis* and leucodelfinidin were present in *I. parflivora*. More specifically, Ueno, Takemura, and Hayashi (1969) and Tatsuzawa et al. (2009), identified the compounds malvidin-3-*O*-glucoside, malvadin-3-*O*-(6 ''-malonyl) glucoside and malvidin-3, 5-di-*O*-glucoside in samples of *Impatiens textori* Miq., While peonidin-3-*O*-glucoside was identified by Paun et al. (2018) in extracts of *I. noli-tangere*. These and more other compounds were identified, as shown in Table 3.

3.4. Health benefits associated with consumption of impatiens genus

The genus *Impatiens* have a great relevance in the Asian traditional medicine, mainly in countries such as China, India, Korea and Taiwan (Delgado-Rodriguez, Hidalgo, Loría-Guitiérrez & Weng-Huang, 2017). Different parts of this plant are used in various treatments, such as occasional wounds from thorns, perforations made by glass, abscesses, scrofulose, carbuncles, diarrhea, rheumatism, fractures, superficial infections and even inflammation of the nails (Kang et al., 2013). In the Eastern tradition, infusions of this plant are applied to the skin, in order to relieve bacterial and fungal infections (Kang et al., 2013). In some areas of China, however, beliefs are widespread regarding the relationship between the use of this genus in the treatment of cancers, although there is no confirmation about the efficiency of this practice (Ding, Jiang, Chen, Ly, Zhu, 2008).

Delgado-Rodriguez, Hidalgo, Loría-Gutiérrez, and Weng-Huang (2017) claims that several plants of this genus have the potential to reduce infectious and inflammatory diseases. Otherwise, several studies have already claimed the presence of relevant pharmacological effects present (Ju, Kong, & Li, 2007). Among these effects, antimicrobial (Delgado-Rodriguez et al., 2017; Manikandan, Rajendran, Abirami, & Kongarasi, 2016; Su et al., 2012), antioxidant (Mushtaq et al., 2013; Paun et al., 2018; Szewczyk, Kalemba, Komsta, & Nowak, 2016b) and anti-inflammatory (Delgado-Rodriguez et al., 2017; Sun et al., 2015) activities stand out. Thus other activities such as anti-rheumatic (Kang et al., 2013), anti-pruritic (Kang et al., 2013), antifungal (Nisar et al., 2010), anti-allergic (Kang et al., 2013), anti-tumor (Cimmino et al., 2016), anti-dermatitic (Motz et al., 2015), anti-platelet (Ueda, Oku, Iinuma, & Ishiguro, 2003), anti-anaphylactic (Fukumoto, Yamaki, Isoi, & Ishiguro, 1996; Ishiguro et al., 1992; Ueda, Oku, Iinuma, & Ishiguro, 2005),anti-neurodegenerative (Kim, Bae, Subedi, Suh, Choi & Lee, 2017) and antinociceptive (Imam et al., 2012) have also been reported. This and other bioactivities can be seen according to Table 4.

Gunawardana and e Jayasuriya (2019), pointed out several attributes referring to the health benefits provided by the use of *I. balsamina* as a medicinal plant in Sri Lanka. Its freshness, demulcent, tonic, anti-anaphylactic and anti-hypotensive properties stand out, while its methanolic extract manages to directly combat some fungi and pathogenic bacteria, as well as its methanolic extracts which revealed anti-tumor and anti-nociceptive activities.

Szewczyk, Zidorn, Biernasiuk, Komsta, and Granica (2016b), studied the antibacterial and antioxidant activities of the extracts (methanol/acetone/water (3/1/1, v/v/v; 3 × 50 ml) of aerial parts of six species of the genus *Impatiens*, among the results, as species *I. balsamina* and *I. glandulifera* demonstrated a greater spectrum of antibacterial activity, but all species greater performance against Gram-positive bacteria.

Ethanol extracts from leaves of *I. balsamina* were effective in eliminating radicals and combating microorganisms when evaluated by the Free Radical Scavenging Activity on DPPH method and by antimicrobial assays, the same authors mention that the delay in the harvest time provided an increase in the total phenolic content and in the ability to inhibit the formation of free radicals (Kang et al., 2013). While, John and Koperuncholan (2012), observed the antibacterial activity of *I. balsamina* hexane, petroleum ether, acetone, methanol and water extracts, using the disk diffusion method. The tests were performed against bacterial pathogens namely *Shigella boydii*, *Salmonella paratyphii*, *Proteus vulgaris*, *Staphylococcus aureus*, *Candida albicans* and *Cryptococcus neoformans*. Among the conclusions, *I. balsamina* presented unique characteristics against these microorganisms, having a high potential in the development of new drugs.

Zheng, Hu, et al. (2019) tested the therapeutic effects of *I. balsamina* against androgenic alopecia in mice, where hair growth was observed in dorsal lesions of rodents, due to a reduction in androgen content. Similarly, Imam et al. (2012) obtained good results in relation to the antinociceptive activity of the methanolic extract of flowers of *I. balsamina* applied in rodents, who had less perception of pain in different conditions, in order to prove the efficiency of the extract used by medicine traditional treatment for burns, low back pain, neuralgia and burns.

Li et al. (2017), states that all organs of *Impatiens* can be applied not only for medicinal applications, but also as an alternative functional food. In addition, it reinforces that the bioactivity of saponins present in this plant can confer positive results regarding anti-hepatic fibrosis, in order to arouse interest in its use as a functional food.

3.5. Applications in the food industry

Nowadays, there is a demand for healthier and more natural foods, as many consumers have raised concerns about possible health hazards, especially with the adoption of synthetic additives in the composition of foods (Carocho, Morales, & Ferreira, 2015; Lachno, Dutra, Severo, dos Santos Oliveira, & de Oliveira, 2019). Many food industries are looking more frequently for healthy alternatives of ingredients and additives

Table 4
Bioactivities discovered in the genus *Impatiens*.

Scientific Name	Part of the plant	Extract	Bioactivites	References
Impatiens balfourii Hook.f. (1903)	Aerial parts	The samples were sonicated with a mixture of methanol/acetone/water for 30 min at a controlled temperature.	Antimicrobial and antioxidant	Szewczyk, Zidorn, Biernasiuk, Komsta, and Granica (2016)
Impatiens balsamina L. (1753).	Aerial parts	The samples were sonicated with a mixture of methanol/acetone/water for 30 min at a controlled temperature.	Antimicrobial and antioxidant	Szewczyk, Zidorn, et al. (2016)
	Roots and aerial parts	Firstly, an extraction with hot water by sonication was carried out, and then a second extraction with 2% isoamyl alcohol in chloroform.	Antioxidant	Szewczyk, Heise, and Piwowarski (2018)
	Whole plant material	The material was macerated with 80% (v/v) ethanol, then it was protected from light and temperature.		Delgado-Rodriguez et al. (2017)
	Stems	The plant material was extracted by the ultrasound method, in which several solvents were used (petroleum ether, diethyl ether, chloroform, methanol and water).		Su et al. (2012)
	Whole plant material	The material was macerated with 80% (v/v) ethanol, then it was protected from light and temperature.	Antimicrobial	Delgado-Rodriguez et al. (2017)
	Seeds	The seeds were suspended in haxane and remained in infusion for two days at room temperature with agitation.		Manikandan et al. (2016)
	Stems	The plant material was extracted by the ultrasound method, in which several solvents were used (petroleum ether, diethyl ether, chloroform, methanol and water).		Su et al. (2012)
	Aerial parts	Extract was obtained from 95% ethanol (v/v).		Yang et al. (2001)
	Seeds	The protein was extracted from the seeds and, then, precipitation and dialysis with ammonium sulfate were performed.		Patel et al. (1998)
	Flowers	The extract was obtained from the flowers with 75% ethanol, then suspended in water and then divided with petroleum ether, dichloromethane, ethyl acetate and n-butanol.	Anti-hepatic	Li et al. (2017)
	Leaves	The leaves powder was dissolved with 96% solvent ethanol, stirred, left for five days, then filtered.	Antibacterial	Mahyun, Kusuma, and Anshory (2018)
	Pods, Roots, Stems and Leaves	The sample was put in contact with acetone, followed by stirring and remained at room temperature for 1 h and, afterwards, was centrifuged.		Wang et al. (2011)
	Flowers	The extract was obtained from flowers with 75% ethanol, then concentrated, suspended in water and partitioned with petroleum ether, dichloromethane, ethyl acetate and n-butanol.	Anti-diabetic	Li, Zhang, et al. (2015)
	Flowers	The extract was obtained from flowers with 75% ethanol, then concentrated, suspended in water and partitioned with petroleum ether, dichloromethane, ethyl acetate and n-butanol.	Anti-hepatic	Li, Zhang, et al. (2015)
	Flowers	The dried flowers were macerated in methanol with agitation for 3 days, then the extract was filtered.	Antinoceptive	Imam et al. (2012)
Impatiens bicolor Royle	Aerial parts	The extract was obtained through the solvents n-hexane, dichloromethane, ethyl acetate, n-butanol, aqueous and crude.	Antibacterial and antifungal	Nisar et al. (2010) Nisar et al. (2010)
Impatiens capensis Meerb	Leaves	The leaves were extracted in 50% methanol for one week at room temperature without shaking. The extract was then stirred for 24 h at room temperature and filtered under vacuum.	Anti-dermatitic	Motz et al. (2015)
Impatiens glandulifera Royle	Roots and Aerial parts.	Firstly, an extraction with hot water by sonication was carried out, and then a second extraction with 2% isoamyl alcohol in chloroform.	Cytotoxic	Szewczyk, Heise, and Piwowarski (2018)
	Roots and Aerial parts	Firstly, an extraction with hot water by sonication was carried out, and then a second extraction with 2% isoamyl alcohol in chloroform.	Antioxidant	Szewczyk, Heise, and Piwowarski (2018)
	Leaves, Flowers and Roots	The samples were extracted with sonication in an ethanol/water mixture at a temperature controlled by 30 min.	Antinocepitive and antianxiety	Szewczyk, Orzelska-Gorka, Polakowska, and Biala (2018a) Szewczyk, Orzelska-Gorka, et al. (2018b)
	Aerial parts	The samples were sonicated with a methanol/acetone/water mixture at a controlled temperature for 30 min.	Antimicrobial and antioxidant	Szewczyk, Zidorn, et al. (2016)
	Roots, Stems and Leaves	The plant material was extracted twice with n-hexane, ethyl acetate and methanol under stirring conditions for 4 h.	Anti-tumor	Cimmino et al. (2016)
Impatiens noli-tangere L.	Aerial parts	The samples were sonicated with a methanol/acetone/water mixture at a controlled temperature for 30 min.	Antimicrobial and antioxidant	Szewczyk, Zidorn, et al. (2016)
	Roots and Aerial parts	Firstly, an extraction with hot water by sonication was carried out, and then a second extraction with 2% isoamyl alcohol in chloroform.	Cytotoxic	Szewczyk, Heise, and Piwowarski (2018)
		Firstly, an extraction with hot water by sonication was carried out, and then a second extraction with 2% isoamyl alcohol in chloroform.	Antioxidant	Szewczyk et al., 2018c
	Dry leaves and Stems	The extraction was carried out with 50% ethanol and then introduced in a sonication bath for 90 min.		Paun et al. (2018)
	Leaves, Flowers and Roots	The samples were extracted with sonication in an ethanol/water mixture at a temperature controlled by 30 min.	Antinocepitive and antianxiety	Szewczyk (2018) Szewczyk (2018)
	Dry leaves and Stems	The extraction was carried out with 50% ethanol and then introduced in a sonication bath for 90 min.	Anti-inflammatory	Paun et al. (2018)
Impatiens parviflora DC.	Aerial parts	The samples were sonicated with a methanol/acetone/water mixture at a controlled temperature for 30 min.	Antimicrobial and antioxidant	Szewczyk, Zidorn, et al. (2016)
	Roots and Aerial parts	Firstly, an extraction with hot water by sonication was carried out, and then a second extraction with 2% isoamyl alcohol in chloroform.	Antioxidant	Szewczyk, Heise, and Piwowarski (2018)
	Leaves, Flowers and Roots	The samples were extracted with sonication in an ethanol/water mixture at a temperature controlled by 30 min.	Antinocepitive	Szewczyk, Orzelska-Gorka, et al. (2018b)
			Antianxiety	Szewczyk, Orzelska-Gorka, et al. (2018b)

(*continued on next page*)

Table 4 (*continued*)

Scientific Name	Part of the plant	Extract	Bioactivites	References
Impatiens textori Miq.	Flowers	The extract was obtained from a solution containing 35% ethanol (v/v).	Antipruritic, Antianaphylactic and antiplatelet	Ueda et al. (2005) Ueda et al. (2005) Ueda et al. (2003)
Impatiens walleriana Hook. f.	Aerial parts	The samples were sonicated with a methanol/acetone/water mixture at a controlled temperature for 30 min.	Antimicrobial and antioxidant	Szewczyk, Zidorn, et al. (2016)
	Whole plant material	The material was macerated with 80% (v/v) ethanol, then it was protected from light and temperature.	Antioxidant and antimicrobial	Delgado-Rodriguez et al. (2017) Delgado-Rodriguez et al. (2017)

that offer less impact related to the individual's health. (Pinela et al., 2019). While, research is carried out, in order to identify new food matrices, for the preparation of additives, which provide health benefits through their bioactivities and do not harm the environment, such as, for example, natural green colorants (Vieira, Pérez-Gálvez & Roca, 2019).

Edible flowers are being investigated in order to be applied as possible matrices for the preparation of food additives (Pinela et al., 2019). Martins et al. (2013) for example, incorporated phenolic extracts from the flowers of *Rubus ulmifolius* Schoot, in yogurt formulations, in order to enhance antioxidant activity. Carocho et al. (2016), used the chestnut flower as a functional and preserving agent in a famous *Serra da Estrela* cheese. In its turn, Pontes (2019) incorporated ethanolic extracts from leaves and flowers of *Malvaviscus arboreus* Cav. For the preparation of goat hamburgers, to extend the shelf. Almeida and Schweig (2018), developed and evaluated the sensory characteristics of gluten-free cookies with the addition of *Hibiscus rosa-sinensis* L. while Cielo (2018) developed and sensorially tested yogurts added with rose petal jam.

In general, many plants are used as matrices for the extraction of the most diverse ingredients and additives for the food industry. Chen et al. (2019) reported the presence of a new food dye (Lemon yellow # 15) highly stable and soluble in water, from the ethanolic extract of *Citrus limon.* Patras (2019), tested the interaction of nineteen food additives/ingredients on the stability and colour parameters of the hydroethanolic extract of red cabbage residues, in order to measure its potential as a colorant. Domínguez et al. (2020), stated that by-products from tomatoes can be used as natural additives for meat products, in order to promote their nutritional quality, increase product stability, reduce lipid oxidation and among other benefits. Pinela et al. (2019) in turn, optimized the anthocyanins extraction process present in the *Hibiscus sabdariffa* calyces, with an alternative to obtain a new food coloring.

However, the industrial application of flowers of the genus *Impatiens* is still scarce and little explored. Szewczyk, Zidorn, Biernasiuk, Komsta, and Granica (2016b) argues that the extracts of *I. balfourii*, *I. glandulifera* and *I. parviflora* are considerable sources of natural antioxidants, in which they can be designated for the development of food additives and nutraceuticals. In turn, Su, Cao, Fan, Yang & Zhang (2007) they extracted a natural edible pigment from the garden balsam (*I. balsamina*), in which it was found that both the stems and their pigmented parts have relevant values for use. Sultan (2003), on the other hand, extracted a yellow colorant from *Impatiens* spp, stating that these plants are low-cost sources and easy to extract colorants, and that they can provide added value and economic benefits. According to CABI (2020), the dry stems of the species *I. parviflora* can be used as a food source in situations of scarcity, while the species *I. balsamina* is applied as a colorant for dyeing hair, nails, hands and feet of women in Asia.

In this way, it can be emphasized that this type of plants presents themselves as a possible matrix for the development of food additives, mainly the petals, due to the attractiveness of its colors. However, further studies are necessary to understand the safety of these additives. Finally, it can be seen that many studies prove the existence of several bioactive compounds in many edible flowers, including *Impatiens*. Thus, edible flowers can be an opportunity for innovation in the food segment (Benvenuti et al., 2016). In addition, it can be said that studies on the use of edible flowers as food ingredients are constant in terms of research.

4. Concluding remarks

The present manuscript demonstrates edible flowers as a source of a multitude of bioactive compounds focusing on the genus Impatiens, which, despite the scarce studies available, it reveals to be an interesting matrix, showing different groups of compounds, such flavonoids, coumarins and phenolic acids, justifying the numerous bioactivities described for this genus. In addition, its attractive colors are given by anthocyanin compounds that may be of high interest to the food industry, which seeks to explore alternative colorants.

Currently, consumers demand healthier, natural and health-promoting products and, consequently, there has been a great pressure in different industries to apply natural matrices in the development of innovative products. In this sense, this review brings together studies regarding the nutritional and chemical characterization of flowers of the genus Impatiens, as well as a detailed study of several bioactivities highlighted for each species of this genus. This study also shows itself as a useful tool for various industries, namely, food, pharmaceutical and cosmetics in the future exploration of the genus Impatiens.

5. Future trends and/or challenges

The acceptance of edible flowers in the human diet, as well as the application of its components in the food industry, is still a challenge to be overcome. The exploration of bioactive compounds as natural ingredients and health promoters and their application in innovative products, emerges as a desire of the food industry, but also, of the pharmaceutical and cosmetic industry. However, the stability and bio-stability of this type of compound appears as the biggest challenge and still needs several studies that can guarantee the effectiveness of these compounds for human consumption. The exploitation of matrices used since antiquity with recognized properties by the traditional medicine has aroused a high interest and its industrial exploitation on a large scale is expected, which raises some environmental issues in such a way that the management of its exploitation also becomes a future challenge.

Acknowledgements

The authors are grateful to the Foundation for Science and Technology (FCT, Portugal) for financial support by national funds FCT/MCTES to CIMO (UIDB/00690/2020). L. Barros would like to thank the national funding by FCT, P.I., through the institutional scientific employment program-contract. To the project AllNat for the contract of C. Caleja (Project AllNat POCI-01-0145-FEDER-030463). The authors are also grateful to the project TRANSCoLAB 0612_TRANS_CO_LAB_2_P. This work is funded by the European Regional Development Fund (ERDF) through the Regional Operational Program North 2020, within the scope of Project Mobilizador Norte-01-0247-FEDER-024479: ValorNatural®, Norte-01-0145-FEDER-000042: Project GreenHealth. This work was also financed by ERDF, through the Incentive System to Research and Technological Development, within the Portugal2020 Competitiveness and Internationalization Operational Program, for the project POCI-01-0247-FEDER-046112: BIOMA.

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