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Scientific insights on edible flowers: A comprehensive review on its potential for human nutrition and health

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Abstract

In recent years, edible flowers have surged in popularity as multifunctional ingredients that enhance the colour, taste, and visual allure of culinary dishes. This abstract offers a thorough examination of edible flowers, covering their historical importance, nutritional content, culinary applications, cultivation methods and emerging trends. Traditionally, various cultures worldwide have utilized edible flowers for culinary and medicinal purposes. Ancient societies such as the Greeks, Romans and Chinese acknowledged the significance of flowers as both food and medicine, integrating them into their diets and traditional healing practices. As time progressed, the use of edible flowers transformed, with distinct cultures creating unique culinary customs and recipes that highlight floral elements. Edible flowers comprise various plant species, including herbs, vegetables, and ornamental blooms. Notable examples of edible flowers are *Viola arvensis*, *Hibiscus rosa-sinensis*, *Matricaria chamomilla*, *Tagetes* spp., *Rosa* spp. *Viola odorata* and *Borago officinalis*, each providing unique flavors, fragrances and nutritional benefits. These blooms are rich in vitamins, minerals, antioxidants and other bioactive substances that enhance their health-boosting qualities. In culinary contexts, edible flowers are utilized to garnish salads, soups and main courses, infuse flavors into drinks, adorn cakes and desserts and produce value-added items like infused oils, syrups, and jams.

1. Introduction

Since ancient times, the consumption of edible flowers has been well-documented across various cultures, from ancient Greece and Rome to Europe, Victorian England, the Middle East and Asian nations such as China and Japan, where their use has been recorded for millennia (Gupta *et al.*, 2024). Today, globalization and increased consumer awareness have contributed to a revival of traditional lifestyles, wherein edible flowers play a significant role. These plant parts represent a rich natural resource, with many containing phytochemicals that are believed to offer health benefits, garnering growing interest (Toiba and Naseer, 2022).

Historically, edible flowers have been utilized in folk medicine for treating ailments, and recent studies have validated these traditional health claims. Additionally, research has focused on assessing the

safety of commonly consumed edible flowers to ensure their safe usage and appropriate dosages across various industries (Koike *et al.*, 2015; Wetzal *et al.*, 2010).

Numerous edible flower species exist globally, yet only a fraction has been thoroughly studied. Therefore, more comprehensive research on this natural resource is essential to enhance their acceptance as food ingredients and mitigate potential risks. Not all flowers fulfill the necessary criteria to be classified as edible; they must be non-toxic and possess nutritional benefits. Some species contain harmful or anti-nutritional compounds such as trypsin inhibitors, hemagglutinins, oxalic acid, cyanogenic glycosides or alkaloids. Consequently, these flowers must be considered inedible and excluded from the human diet (Liu *et al.*, 2018).

Nadhila *et al.* (2021) reported that flowers are a rich source of antioxidants, contributing to improved health and a reduced risk of diseases. They emphasized that environmental factors such as UV-B radiation, medium components, and elicitors can enhance the plant cell culture process for commercial anthocyanin production. In today's trend of returning to natural products, the use of edible flowers in the pharmaceutical and food industries is becoming increasingly important. Mia *et al.* (2022) found that cornflowers exhibited the highest levels of ascorbic acid (AsA) and anthocyanins. Additionally,

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African marigold was noted for having the highest content of polyphenolic compounds and carotenoids, while common marigold was found to be the most abundant in chlorophylls. Zucchini flowers showed the lowest antioxidant capacity compared to other studied edible flower species.

Otakat *et al.* (2012) revealed that 12 edible flower species contained higher levels of mineral elements than most fruits and vegetables. The combination of high nutritional value, antioxidant capacity, and appealing appearance positions edible flowers as a promising new food source for enhancing human nutrition. Inmaculada *et al.* (2015) reported that edible flowers are increasingly utilized in human nutrition, with their consumption rising in recent years. This study highlighted that the levels of total phenolic compounds (TPC) and antioxidant capacity were significantly higher in *Tagetes erecta*, followed by *Salsola oleracea* and *Tropaeolum majus*. A total of thirty-nine different phenolic compounds were tentatively identified, with flavonols being the predominant compounds detected across all samples, followed by anthocyanins and hydroxycinnamic acid derivatives. In *Tagetes erecta*, small amounts of gallotannin and ellagic acid were also identified. Flowers are cultivated not only for their ornamental value but also for their nutritional, medicinal, culinary, cosmetic, and aromatic properties. The chemical analysis revealed that *Monarda* and *Mimulus* × *hybridus* flowers had significantly higher contents of macro- and microelements compared to other species. Among the macroelements, potassium was found in the highest amounts (averaging 30.03 g/kg dry matter), while iron was the most abundant microelement (averaging 154.93 mg/kg dry matter). Furthermore, the edible flower species exhibited relatively low concentrations of heavy metals, with averages of 2.297 mg Ni, 1.298 mg Pb, 0.723 mg Co, and 0.342 mg Cd per kg of dry matter. Notably, the lowest concentrations of heavy metals were found in the flowers of *Paeonia officinalis* cultivars (Grzeszczuk *et al.*, 2018).

For centuries, edible flowers have been an essential part of human nutrition. In Central Europe, for example, fried black elder (*Sambucus nigra*) flowers coated in batter are commonly enjoyed, as are dandelion flowers boiled with sugar, which were historically used as a substitute for honey. Dandelion (*Taraxacum officinale*) is referenced in the Bible as one of the bitter herbs consumed in salads and unleavened bread (Ninama *et al.*, 2024). Nowadays, the demand for fresh, high-quality flowers intended for human consumption is increasing globally (Mlcek and Rop, 2011). These flowers can be consumed dried, incorporated into cocktails (often frozen in ice cubes), canned with sugar, or preserved in distillates (Neugebauerova and Vabkova, 2009).

2. Definition of edible flowers

Edible flowers are defined as flowers that are safe for human consumption and have culinary uses. These flowers are generally free from toxins or harmful substances and are specifically cultivated for culinary applications. Edible flowers exhibit a wide variety of flavors, colors, and textures, enhancing the visual appeal, taste, and aroma of numerous dishes and beverages. From delicate petals to aromatic blossoms, edible flowers provide diverse culinary opportunities, contributing both aesthetic and gastronomic value to food creations. It is crucial to accurately identify edible flowers and confirm they have been grown and handled in a manner that ensures food safety before using them in recipes.

Flowers consumed directly are termed ‘edible flowers.’ They are rich in phenolic acids, which exhibit potent antioxidant activity both *in vivo* and *in vitro*. In various cuisines across Asia, the Middle East, and Europe, flowers serve as essential ingredients, providing seasoning or garnishing for dishes. Most research has concentrated on the essential oils and flavors present in these flowers. Studies on edible flowers have demonstrated their low-calorie content alongside high levels of vitamins, minerals, mucilage, amino acids, fibre, carbohydrates, essential oils, and proteins. Furthermore, edible flowers possess significant therapeutic properties, including antidiabetic, anticancer, anti-anxiety, anti-inflammatory, antibacterial, diuretic and immunomodulatory effects. For centuries, the edible parts of plants such as stems, leaves, flowers, roots, seeds and pollen have been utilized in culinary arts for flavoring and garnishing (Soujanya *et al.*, 2023).

3. Types of edible flowers

Edible flowers can be categorized into two primary groups.

3.1 Fruit flowers

Most fruit flowers are not typically consumed raw and require specific cooking methods before they are safe to eat. For instance, in Indonesia, flowers from banana and papaya plants are usually boiled or sautéed before serving.

3.2 Non-fruit flowers

Non-fruit flowers include those that are vegetable-based, medicinal, aromatic or ornamental. These flowers come in a variety of attractive colors, particularly ornamental types, and have been extensively utilized in culinary applications. Examples include roselle, butterfly pea, various rose species, and jasmine, which are often used in beverages, as decorations for salads, and in desserts. They enhance food products with their unique flavors, colors, fragrances, and a range of beneficial nutrients (Table 1).

4. Edibility of flowers in history

Ancient civilizations such as the Greeks, Romans, and Chinese utilized flowers for their medicinal properties and nutritional benefits. In aromatherapy, flowers like rose, lavender, rosemary, and passionflower are commonly employed. Historically, fresh edible flowers were regarded as fine spices and were transported as such. They have been incorporated into a variety of cooked foods, including syrups, jellies, sauces, and desserts. Flowers were also included in products like liquors, vinegar, teas, honey, oils, candied flowers, ice cubes, and salads. Flower petals were most frequently consumed fresh in salads or used as garnishes. Their inclusion in dishes can significantly influence the sensory characteristics of food by enhancing its color, flavor, and aesthetic appeal. Common examples of edible flowers include roses, dandelion, viola, calendula and chamomile.

The culinary tradition of using flowers dates back to ancient times. For instance, the Romans flavored dishes with roses and violets in purees and omelets (Rop *et al.*, 2012). In medieval Europe, calendula flowers were widely consumed in various salads. The documented use of violets in the 17th century highlights their ability to impart sweetness and color to syrups. Overall, the historical use of edible flowers reflects their integral role in enhancing both the taste and presentation of food across different cultures.

Table 1: Some edible flowers with their uses

Botanical name	Uses
<i>Calendula officinalis</i>	The petals are for edible decorative purposes; an alternative for saffron.
<i>Camellia sinensis</i>	As vegetables in the meal.
<i>Clitoria ternatea</i>	The petals as a colorant.
<i>Rosa chinensis</i>	In fruit preserves and infusions.
<i>Tropaeolum majus</i>	Ingredient in salad, drinks, and meals.
<i>Jasminum sambac</i>	In infusions and porridge.
<i>Hibiscus sabdariffa</i>	Ingredient in jams, fermented drinks, herbal drinks, cakes, chocolates, etc.
<i>Bauhinia variegata</i>	Flowers and buds as vegetables and pickles.
<i>Bombax ceiba</i>	Buds and flowers are cooked and pickled.
<i>Butea monosperma</i>	Flowers are used along with milk with sugar to make coolant drink.
<i>Madhuca longifolia</i>	Eaten raw, and used in local drinks. Sun-dried flowers are used as a sweetener.
<i>Rhododendron arboreum</i>	Flowers are used to make chutney with mint.

Source: Poonam Kumari and Bhavya Bhargava (2021).

5. Applications of edible flowers (Tejaswi, 2023)

5.1 Beverage industry

Edible flowers can be utilized to flavor beverages or to create drinks such as tisanes and wines. They are also incorporated into condiments like vinegar, marinades, and sauces, as well as spreads such as butter or fruit preserves.

5.2 Daily meals

Due to their potent and distinctive aromas, textures, and colors, edible flowers have become a popular culinary item. They enhance flavor, scent, and presentation and can be added to salads or featured as part of a main dish.

5.3 Confectionary industry

In the confectionery sector, edible flowers are employed to decorate cookies, cakes, and other sweets for both aesthetic appeal and nutritional benefits (Goel *et al.*, 2022; Kartik Soni *et al.*, 2022).

5.4 Pharmaceutical industry

Some edible flowers possess medicinal properties that make them valuable in the pharmaceutical industry (Hemalatha *et al.*, 2023). The presence of phenolic compounds in flower extracts is associated with significant antioxidant, antimicrobial, and anti-acetylcholinesterase activities, which are beneficial to human health (Table 2).

Table 2: Nutritional information of some popular edible flowers

Flower	Calories	Vitamins	Minerals	Antioxidants	Health benefits
<i>Tropaeolum majus</i>	Low	Vitamin C, A	Iron, calcium	Flavonoids	Supports the immune system, anti-inflammatory
<i>Lavandula aungustifolia</i>	Low	Vitamin A, C	Calcium, magnesium	Polyphenols	Promotes relaxation, aids digestion
<i>Viola arvensis</i> Murray	Low	Vitamin C, A	Potassium, calcium	Antioxidants	Boosts immunity, anti-inflammatory
<i>Hibiscus rosa-sinensis</i>	Low	Vitamin C, A	Iron, calcium	Anthocyanins	Lowers blood pressure, cholesterol
<i>Matricaria chamomilla</i>	Low	Vitamin A, C	Calcium, magnesium	Flavonoids	Reduces anxiety, promotes sleep
<i>Tagetes</i> spp.	Low	Vitamin A, C	Iron, calcium	Carotenoids	Anti-inflammatory, supports eye health
<i>Rosa</i> spp.	Low	Vitamin C, A	Iron, calcium	Polyphenols	Antioxidant, anti-inflammatory
<i>Viola odorata</i>	Low	Vitamin A, C	Potassium, calcium	Anthocyanins	Supports heart health, anti-inflammatory
<i>Borago officinalis</i>	Low	Vitamin C, A	Calcium, magnesium	Omega-3 fatty acids	Reduces inflammation, supports skin health

Source: Poonam Kumari and Bhavya Bhargava (2021).

5.5 New food

Due to their non-toxicity and nutraceutical properties, certain edible flowers can be utilized as new food options. These flowers offer unique flavors and potential health benefits, making them an appealing choice for innovative culinary applications.

5.6 Garnishing dishes

Cooked dishes can be beautifully adorned with edible flowers, thanks to their vibrant colors, attractiveness, and visual appeal. Cultivating these flowers requires careful attention to growing conditions, soil quality, and pest management practices. Organic farming methods are often preferred to minimize the risk of chemical contamination and ensure the purity of the flowers.

Innovative approaches such as urban gardening, hydroponic systems, and vertical farming techniques provide effective ways to cultivate edible flowers in urban settings with limited space. Future trends in the edible flower industry indicate a growing consumer demand for sustainably sourced and ethically produced flowers, alongside the development of new value-added products and culinary innovations.

Research into the nutritional and health benefits of edible flowers is ongoing, with potential applications in functional foods and nutraceuticals. Edible flowers represent an intriguing blend of culinary arts, horticulture, and nutrition. Their rich history, diverse culinary uses, and potential health benefits make them a valuable addition to modern gastronomy.

6. Potential uses of edible flowers

Edible flowers have been valued for centuries for their culinary versatility, aesthetic appeal, and potential health benefits. From delicate rose petals to vibrant nasturtium blooms, edible flowers offer a spectrum of colors, flavors, and textures that can enhance a wide range of dishes and beverages.

6.1 Culinary uses

Edible flowers are utilized in cuisines worldwide to add flavor, aroma, and visual interest to dishes. They can be incorporated into salads, soups, main courses, desserts, and beverages, lending their unique characteristics to both sweet and savory creations (Table 3). Whether used fresh as garnishes or infused into oils, syrups, or vinegar, edible flowers provide endless possibilities for culinary creativity.

Table 3: Some popular edible flowers and their culinary uses

Flower	Flavor	Culinary uses
<i>Tropaeolum majus</i>	Spicy, peppery	Salads, garnishes, infused vinegar
<i>Lavandula angustifolia</i>	Sweet, floral	Desserts, teas, savory dishes
<i>Viola arvensis</i> Murray	Mild, sweet	Salads, cake decorations
<i>Hibiscus rosa-sinensis</i>	Tart, cranberry-like	Teas, jams, salads
<i>Matricaria chamomilla</i>	Apple-like	Teas, desserts
<i>Tagetes</i> spp.	Citrus, tangy	Salads, soups, butters
<i>Rosa</i> spp.	Sweet, floral	Syrups, desserts, drinks
<i>Viola odorata</i>	Sweet, perfumed	Salads, candies, jellies
<i>Borago officinalis</i>	Cucumber-like	Salads, drinks, soups

Source: Lu *et al.* (2016).

6.2 Nutritional benefits

Beyond their culinary appeal, edible flowers may also offer nutritional benefits. Many flowers contain vitamins, minerals, antioxidants, and other bioactive compounds that contribute to overall health and well-being. For example, nasturtiums are rich in vitamin C, while lavender may have calming properties. Incorporating a variety of edible flowers into the diet can provide a diverse array of nutrients and phytochemicals.

6.3 Safety considerations

While many flowers are safe to eat, it is essential to exercise caution and ensure proper identification before consuming them. Some flowers are toxic or may have been treated with pesticides or other chemicals. It is crucial to source edible flowers from reputable suppliers and avoid those harvested from roadsides or other potentially contaminated areas. Additionally, individuals with pollen allergies or sensitivities should be cautious when consuming edible flowers.

6.4 Cultural significance

Edible flowers hold cultural significance in many societies, often symbolizing love, celebration, or culinary tradition. For example,

roses are associated with romance and are commonly used in wedding cakes and Valentine's Day desserts. In other cultures, flowers like chrysanthemums and marigolds hold symbolic importance in religious ceremonies and festivals.

Edible flowers offer a delightful fusion of flavor, beauty, and nutrition, making them a versatile ingredient in the culinary world. Whether used to garnish a gourmet dish or infuse a refreshing beverage, they invite exploration and appreciation for the natural bounty of the plant kingdom. With proper knowledge and care, edible flowers can elevate any culinary experience, offering a feast for the senses and celebrating nature's abundance.

7. Cultivated edible flowers

Numerous flowers are cultivated specifically for culinary purposes due to their aesthetic appeal, flavor, and versatility in various dishes. Here are some of the most commonly cultivated edible flowers (Figures 1 and 2).

7.1 *Rosa* species (Rose)

Roses have been valued for centuries for their culinary, medicinal, cosmetic, and aromatic properties. The apothecary rose (*Rosa*

gallica) and the Dog rose (*Rosa canina*) are used for making medicinal remedies. It is the hips of the Dog rose that are utilized because they contain high levels of vitamin C, as well as flavonoids, tannins, and vitamins A, B₁, B₂, B₃, and K. In the Middle Ages, the Dog rose was

heralded as a marvelous cure for chest complaints. The Damask rose (*Rosa damascena*) is more commonly used today for its aromatherapy and cosmetic properties; it acts as a sedative and antidepressant and is beneficial for lowering cholesterol.



Rosa species



Hibiscus rosa-sinensis



Chrysanthemum indicum



Calendula officinalis



Tropaeolum majus



Tagetes species

7.2 *Hibiscus rosa-sinensis* (Hibiscus)

The flowers and leaves are known for their ability to check bleeding and soothe irritated tissues. Hibiscus contains a variety of nutrients, including vitamin C, which is a potent antioxidant that supports immune function. Additionally, hibiscus is rich in antioxidants that help protect the body against oxidative stress and may reduce inflammation, supporting healthy aging and preventing chronic diseases.

The flowers and leaves can be incorporated into various dishes and beverages, enhancing flavor and providing health benefits. Hibiscus tea is particularly popular for its tart flavor and vibrant color, and it has been used for thousands of years to help reduce blood pressure and improve digestion. The plant's medicinal properties extend to treating ailments such as high blood pressure and digestive issues, making it a valuable addition to both culinary and medicinal applications.

7.3 *Chrysanthemum indicum* (Chrysanthemum)

Chrysanthemum has a light, sweet flavor. The flower contains vitamins A and B and amino acids. It helps to calm the nerves and relieve cold and flu symptoms. Additionally, chrysanthemum petals are often steeped to make a soothing herbal tea that is enjoyed for its refreshing taste and potential health benefits, including antioxidant properties that support overall wellness.

7.4 *Calendula officinalis* (Calendula)

It also adds a beautiful saffron color to your cooking. The leaves and stems contain carotenoids, primarily lutein (80%) and zeaxanthin (5%), along with beta-carotene. Additionally, calendula petals are often used in herbal remedies for their anti-inflammatory and soothing properties, making them beneficial for skincare as well.

7.5 *Tropaeolum majus* (Nasturtium)

All parts of the nasturtium are edible and nutritious. The flowers have a sweet flavor, while the leaves possess a mustard cress taste. Together, they create an unusual and decorative salad dish, especially when paired with pasta and snow peas. Nasturtium is also a great source of vitamin C, which plays a crucial role in maintaining a healthy immune system. Additionally, it has been noted for its effectiveness in curing and preventing urinary tract infections. Nasturtiums are rich in vitamins A and C, as well as essential minerals like iron and calcium, contributing to overall health and well-being. Their peppery flavor adds a unique twist to various dishes, making them a versatile ingredient in salads, soups, and even garnishes.

7.6 *Tagetes* spp. (Marigold)

The petals of some varieties of marigold are edible. The fresh receptacle is eaten by children. In addition to their culinary uses, marigold petals can add vibrant color to salads and dishes, enhancing both appearance and flavor.



Figure 2: *Nelumbo nucifera*, *Hydrangea anomala*, *Catharanthus roseus* and *Butea monosperma*.

7.7 *Nelumbo nucifera* (Lotus)

Dried carpels of lotus contain approximately 16% protein, 66% carbohydrates, and various minerals. The leaves, carpels, and rhizomes of the lotus plant are known to contain three alkaloids: nuciferine, romaine, and nornuciferine. Research indicates that lotus flower extracts exhibit considerable antioxidant properties, contributing to their potential health benefits. Lotus seeds are also recognized for their nutritional content, including high-quality proteins and essential amino acids. They are rich in minerals such as phosphorus, calcium, and magnesium, which support overall health.

7.8 *Hydrangea anomala* (Hydrangea)

The young leaves of hydrangea, when dried and rubbed between the hands, become very sweet and are used to make a sweet tea known as “tea of heaven”, which is utilized in Buddhist ceremonies. The leaves contain phelloducin, a very sweet substance that can serve as a sugar substitute; just one small leaf is sufficient to sweeten a cup of tea. In addition to their culinary uses, the leaves, roots, and flowers of hydrangea possess antimalarial and diuretic properties.

7.9 *Catharanthus roseus* (Periwinkle)

Periwinkle is known to increase blood flow and oxygen supply to the brain. Additionally, compounds found in periwinkle, such as vincristine and vinblastine, have been studied for their potential in cancer treatment, highlighting the plant’s medicinal significance.

7.10 *Butea monosperma* (Palash)

The gum, seeds, flowers, bark, and leaves of the Palash tree have great medicinal value. The flowers are useful in treating fever, thirst, and diarrhea. The gum from the Palash tree is known for its effectiveness in managing chronic diarrhea.

8. Flower crops as nutraceuticals

About 2000 years ago, Hippocrates emphasized, “Let food be your medicine and medicine be your food”. A nutraceutical is any substance that may be considered a food or part of a food and provides medical or health benefits, encompassing the prevention and treatment of diseases. The term nutraceutical combines nutrition and pharmaceuticals.

Flower crops are abundant in phytochemicals such as flavonoids, anthocyanins, phenolics, and carotenoids, which provide numerous health benefits, including antioxidant activity, anti-inflammatory effects, anticancer properties, antidiabetic effects, and hepatoprotective qualities. These flowers are successfully utilized by tribal communities in their daily diets as both food and medicine.

9. Advantages of floral nutraceuticals

Floral nutraceuticals offer a complementary approach to conventional nutritional therapy. They can be used alongside traditional treatments to enhance overall health and well-being. Flowers provide a natural and holistic way to support various bodily functions and address specific health concerns. These nutraceuticals typically have no side effects, which makes them safer for regular consumption. They can improve medical conditions in humans and are an economically affordable and easily available source. Additionally, floral nutraceuticals help detoxify the body, prevent vitamin and mineral deficiencies, and restore healthy digestion and dietary habits. (Nagajyothi and Pratheeksha, 2023)

10. Nutritional aspects of edible flowers

Edible flowers can provide a variety of nutrients depending on the specific type consumed. Many edible flowers are rich in vitamins, particularly vitamin C, which acts as an antioxidant and supports the immune system, and vitamin A, essential for vision and skin health. It is important to recognize that the nutrient content can vary based on factors such as the specific species of flower, the conditions in which they are grown, and the methods of preparation. Furthermore, while edible flowers can enhance overall nutrition, they are usually consumed in small amounts and should not be considered a primary source of nutrients. Several researchers have provided investigative insights into various aspects of flowers as nutraceuticals.

Luana *et al.* (2019) demonstrated significant changes in the nutritional and nutraceutical compositions of pansies with varying colors during their flowering stages. In white, yellow, and red pansies, water was identified as the primary macronutrient, followed by carbohydrates, proteins, and ash, making them suitable for low-calorie diets. An increase in protein content was observed in white and yellow pansies during flowering, while the protein levels in red pansies remained stable. Polyunsaturated fatty acids (PUFA) and saturated fatty acids (SFA) were predominant, primarily due to linoleic, linolenic, and palmitic acids. The highest levels of total carotenoids and monomeric anthocyanins were found in red pansies. The total phenolic content (TPC), hydrolyzable tannins, flavonoids, and monomeric anthocyanins increased from the bud stage to fully open flowers in white and yellow pansies.

Edible flowers are a rich source of macro- and microelements, particularly phosphorus, potassium, and iron, while also being characterized by relatively low concentrations of heavy metals. These flowers play an important role in human nutrition due to their richness in antioxidants, anticarcinogenic properties, vitamins, and overall chemical composition. Edible flowers are recognized for their antidiabetic, anti-inflammatory, and antimicrobial properties and are valued for both aesthetic purposes and culinary uses. They are also considered underutilized food sources that may offer higher mineral content than many fruit or vegetable species.

In the future, it is crucial to evaluate exact values for the edibility of all flower species. Public education and the promotion of edible flowers as a potential source for the food industry are essential, along with their recognition as a promising element of human nutrition. Standardizing recipes and food products that incorporate edible flowers, as well as conducting research to enhance their nutritional value, quality, and size, are necessary. The high nutritional value, antioxidant capacity, and appealing appearance of edible flowers position them as a new and promising food source for broader use in human nutrition moving forward. The results obtained from various scientific studies should aid in popularizing edible flowers as a viable source for the food industry and gastronomy, as well as highlighting their potential benefits for human nutrition.

11. Breeding edible commercial flowers

Breeding edible commercial flowers involves the intentional crossbreeding and selection of plant varieties that exhibit desirable traits for culinary applications. Here is an overview of the steps involved in this process:

11.1 Identification of desired traits

Breeders start by identifying specific traits they wish to enhance or develop in edible flowers, such as color, flavor, fragrance, size, yield, disease resistance, and shelf-life.

11.2 Selection of parent plants

Parent plants with the desired traits are chosen to serve as breeding stock. These may include existing commercial varieties or wild species that possess valuable characteristics.

11.3 Cross breeding

Controlled pollination is performed between the selected parent plants to create new hybrid varieties. This involves transferring pollen from one plant's flower to the stigma of another.

11.4 Generation of genetic variation

The offspring from crossbreeding exhibit genetic variation due to the combination of traits from both parent plants. This genetic diversity provides the basis for selecting desirable traits in future generations.

11.5 Evaluation and selection

Breeders evaluate the offspring for desired traits through field trials, taste tests, and other analyses. Plants that demonstrate the desired characteristics are selected for further breeding.

11.6 Backcrossing and line development

Backcrossing techniques may be employed to reintroduce specific traits from one parent plant into the genetic background of another. This helps stabilize desirable traits while eliminating undesirable ones. Through multiple generations of selection and backcrossing, consistent breeding lines are developed.

11.7 Testing and commercialization

Promising breeding lines undergo rigorous testing for performance, adaptability, and market acceptance. Successful varieties are then commercialized and introduced to growers and consumers.

11.8 Continued improvement

Breeding efforts for edible commercial flowers are ongoing, with breeders continually working to enhance existing varieties and develop new ones with improved traits. This includes incorporating modern breeding techniques such as molecular markers and genetic engineering to expedite the process and address emerging challenges. Overall, breeding edible commercial flowers requires a blend of traditional methods, scientific knowledge, and an understanding of market demands to create varieties that meet the needs of growers, retailers, and consumers.

12. Problems of edible flowers

While edible flowers can enhance culinary creations with beauty and flavor, there are several potential problems associated with their use: Not all flowers are safe for consumption. Some may contain toxins or have been treated with pesticides and other chemicals that render them unsafe to eat. It is crucial to accurately identify flowers and ensure they are sourced from reputable suppliers. Individuals with pollen allergies or sensitivities to certain plants may experience allergic reactions when consuming edible flowers. Symptoms can include itching, swelling, and respiratory issues. Awareness of any known allergies is essential when trying new flowers.

Edible flowers can become contaminated with bacteria, fungi, or other pathogens if not handled and stored properly. Thorough washing of flowers before consumption is important, and flowers that have come into contact with soil or other contaminants should be avoided. Mistakenly identifying edible flowers can lead to the accidental ingestion of toxic species. Knowledge about the specific flowers being used is vital, and cross-referencing with reliable sources can help prevent misidentification.

Finding high-quality edible flowers can be challenging, particularly outside specialty markets or gourmet food stores. Additionally, concerns about sustainable and ethical sourcing arise, especially when flowers are harvested from the wild. While many edible flowers have appealing flavors and textures, some may possess bitter or unpleasant tastes. It is important to consider how the flavor and texture of edible flowers will complement other ingredients in a dish. In some regions, regulations may govern the sale and use of edible flowers, especially for commercial production. Being aware of applicable regulations and ensuring compliance with food safety standards is necessary. Certain edible flowers may only be available seasonally or in specific regions, which can limit their use in culinary applications. Despite these potential issues, many people enjoy incorporating edible flowers into their cooking and baking. With proper knowledge, sourcing, and handling practices, edible flowers can be a delightful addition to a variety of dishes.

13. Future scope for edible flowers

The future scope for edible flowers is promising, with several potential avenues for growth and innovation:

13.1 Increased culinary use

As interest in gourmet cooking and culinary experimentation continues to rise, the demand for unique and exotic ingredients like edible flowers is likely to grow. Chefs and home cooks may explore new ways to incorporate edible flowers into a variety of dishes, including desserts, cocktails, savory entrees, and more.

13.2 Functional foods

Edible flowers are valued not just for their aesthetic appeal but also for their potential health benefits. Some varieties contain antioxidants, vitamins, and other bioactive compounds that may offer functional properties, such as immune support or anti-inflammatory effects. Research into the nutritional and health-promoting properties of edible flowers could lead to the development of functional food products fortified with flower extracts or powders.

13.3 Urban farming and vertical agriculture

With the increasing popularity of urban farming and vertical agriculture, there is potential to cultivate edible flowers in controlled indoor environments, such as hydroponic or aeroponic systems. This could enhance year-round availability and enable the production of high-quality flowers in urban areas with limited space.

13.4 Value-added products

Edible flowers can be processed into various value-added products, such as extracts, syrups, jams, and infused oils. These products can offer convenience and versatility to consumers looking to incorporate floral flavors into their cooking and baking.

13.5 Sustainable and ethical sourcing

There is a growing consumer demand for sustainably and ethically sourced ingredients, including edible flowers. Producers may explore organic farming practices, fair trade certifications, and traceability measures to meet consumer preferences for environmentally friendly and socially responsible products.

13.6 Cultural and culinary exchange

Edible flowers are used in culinary traditions across the globe, presenting opportunities for cultural exchange and collaboration in exploring different flower varieties and culinary techniques. This cross-cultural interaction could lead to the discovery of new flavors, recipes, and culinary innovations.

13.7 Education and Awareness

Educating consumers about the safe identification, sourcing, and culinary use of edible flowers is crucial for expanding their popularity and acceptance. Cooking classes, culinary workshops, and educational materials can help raise awareness and appreciation for edible flowers among consumers and food enthusiasts.

Edible flowers offer a unique combination of aesthetic appeal and nutritional benefits, making them valuable in various industries. Value addition of edible flowers involves processing them into products like essential oils, infusions, flower waters, dried flowers, flower syrups, and flower powders. These products not only enhance the economic value of the flowers but also provide health benefits due to their phytochemical content. The extraction methods and applications of these value-added products are crucial for maximizing their potential in culinary, cosmetic, and pharmaceutical industries (Badampudi *et al.*, 2021).

The future of edible flowers is bright, with opportunities for innovation, sustainability, and culinary creativity driving growth in this niche market segment. Edible flowers are a rich source of macro and microelements, particularly phosphorus, potassium, and iron, and they are characterized by relatively low concentrations of heavy metals. They play an important role in human nutrition due to their richness in antioxidants, anticarcinogenic properties, vitamins, and other beneficial compounds. Edible flowers are known for their antidiabetic, anti-inflammatory, and antimicrobial effects, making them valuable not only for culinary purposes but also for health benefits. They are often regarded as underexploited food sources that may contain more mineral elements than many fruits or vegetables.

14. Conclusion

Edible flowers can provide a variety of nutrients depending on the specific type consumed. Many edible flowers are rich in vitamins, particularly vitamin C, which acts as an antioxidant and supports the immune system, and vitamin A, essential for vision and skin health. Notable examples of edible flowers are *Viola arvensis* Murray, *Hibiscus rosa-sinensis*, *Matricaria chamomilla*, *Tagetes* spp., *Rosa* spp., *Viola odorata* and *Borago officinalis* each providing unique flavors, fragrances, and nutritional benefits. These blooms are rich in vitamins, minerals, antioxidants, and other bioactive substances that enhance their health-boosting qualities. In the future, it will be essential to evaluate exact values for the edibility of all flower species. Public education and the promotion of edible flowers are crucial for

their popularization as a prospective source for the food industry and as a promising element of human nutrition. Standardizing recipes and food products that incorporate edible flowers, along with conducting studies to enhance their nutritional value and quality, will be necessary. The high nutritional value, antioxidant capacity, and attractive appearance of edible flowers position them as promising foodstuff species for broader use in human nutrition. The results obtained from various scientific investigations should contribute to the popularization of edible flowers as a new and prospective source for the food industry and gastronomy, highlighting their potential benefits for human nutrition. As consumer interest continues to grow, the edible flower market is projected to expand significantly. The increasing demand for visually appealing food items and the health benefits associated with edible flowers will likely drive innovation in this sector.

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Conflict of interest

The author declares no conflict of interest relevant to this article.

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