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Blossoming Flavors: Harnessing the Potential of Edible Flowers in the Food Industry

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ABSTRACT

Floriculture and horticulture are now intertwined within the food industry, with flowers emerging as a promising avenue for fulfilling the escalating demand for innovative food options that offer both sensory appeal and health benefits. Flowers, rich in pigmentation, contain numerous phytochemicals that positively impact human health, including antioxidants that combat cellular aging. Edible flowers are widely used to enhance the appearance and flavor of various foods. Flowers like Rose, Hibiscus, Pansy, Nasturtium, and Rhododendron are popular choices for salads, cakes, garnishes, and flavorings. They are not only visually appealing but also offer nutritional benefits. They contain carbohydrates, proteins, fats, vitamins, minerals, and phenolics, which contribute to their functional properties such as antioxidant, anti-inflammatory, antimicrobial, anticancerous, neuroprotective, antidiabetic, uricosuric, and antihaemolytic effects. The demand for functional foods and new tastes is increasing, creating significant opportunities for the commercial use of edible flowers in the food industry. However in India, challenges for edible flowers include limited awareness, lack of standardized cultivation practices, insufficient research on nutritional benefits, seasonal availability, and regulatory hurdles for commercialization, impacting their adoption in culinary and medicinal applications.

Keywords: *Edible Flower, Antioxidant, Food Industry, Antidiabetic, Antimicrobial, Anticancerous, Edible Flower Tea, Squas and Vitamins*

Introduction

Now is the era where consumer demands novelty and variety in flavors. What appeals to our senses is preferred more. So, what could be more visually and otherwise appealing to our senses than flowers which are already known since history adding beauty to our lifes. In this context, a category of flowering plants known as edible flowers is most frequently used to garnish or improve the flavor and look of various cuisines [1]. Their beautiful petals can be candied, served as a dessert, used for garnishing, enriching the taste of various cuisines, and much more. There are several historical evidences of the use of flowers for their edible value. Ancient societies decorated dishes with flowers and used them in the preparation of various meals. In ancient Rome, rose petals were used to flavor omelets, purees, beverages, and sweets. *Viola odorata* was used to tint sugar syrups and other beverages during the 17th century [2, 3]. Floral ingredients can also be used as natural colorants and as natural preservatives in food [4]. Begonia, calendula, carnation, cornflower, chrysanthemum, daylily, gladiolus, hibiscus, honeysuckle, impatiens, pansy, lilac, miniature rose, wild rose, nasturtium, pansy, sweet pea, tuberous begonia and violets are a few of the most common flowers grown to be used as edible flowers. Humans' urge to rediscover traditional lifestyles, explore novel flavors, and fragrances, and attain medicinal benefits has aroused their interest in edible flowers.

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Flowers when used fresh in salads or added to classic foods like meat, fish, soups, wine, beer, sweets, candies, jellies, spices for flavoring or garnishing, used dry, as infusions or confections surely add to their value [5]. They add soothing flavours to our palate satisfying different consumer tastes. For instance, Calendula petals have a mildly bitter or peppery flavor thus they are frequently used to give rice or soups a lovely golden-yellow hue like saffron. Scent geraniums and pansies are the best choices to enrich your salads, desserts, and cool summer soups with strikingly revitalizing mint flavor, and for a lemon flavour undertone lilacs fulfils the purpose. Nasturtiums impart brilliant color, a spicy flavor, and a fresh appearance whereas begonias impart a crisp texture with a slightly sour citrus flavor to many salads. This distinctive balance of flavors and sensations leads to their embellishment. The role of edible flowers is not restricted to flavouring but they lead to body nourishment providing several medicinal benefits to the human body [6, 7, 8]. For instance, they provide antioxidative activities by lowering reactive oxygen species generated during endogenous metabolic processes, acting as cancer-preventive agents [9] and possess a significant antibacterial and polyphenolic action [10]. They can also provide a valuable source of natural fiber for daily consumption [11]. Demand for edible flowers is rising worldwide as people are becoming aware of their nutritive potential. This indicates the potential chances of expansion of the edible flower market internationally.

Current Status, Challenges, and Opportunity

Current status: Restaurant chefs and home cooks are utilizing edible flowers more and more to enhance the appearance as well as the flavor of food.

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An abrupt increase of 32% was observed in a number of food lovers seeking suggestions on the incorporation of pretty flowers in their culinary dishes on Pinterest [12]. According to Package Edible Flower Market - Global Market Share, Trends, Analysis and Forecast 2022-2032 the global market for packaged edible flowers was valued at US$ 265 million in 2018. It has already increased in value by USD 341.78 million between 2018 and 2022 and is anticipated to reach US$ 504 million by 2030, growing at a CAGR of 5%. The top seven regions in the world market for edible flowers are North America, Eastern Europe, Latin America, Western Europe, Asia Pacific (excluding Japan), The Middle East, and Africa.

Challenges: - The usage of edible flowers poses several difficulties:

Safety and Quality: For a flower to be considered suitable for consumption, it must be non-toxic, safe to eat, and contain nutritional properties [13]. The cultivation, preservation, transport, and storage of edible flowers are crucial due to the risks of microbial contamination and chemical residues. Thus, it is advisable to separate those ornamental plants intended for human-use from those grown solely for ornamental purposes [8]. Some plant species have evolved toxicity and poisonousness in order to defend themselves from parasitic or pathogenic organisms [14]. Thus, potential health dangers must be avoided through proper identification by sourcing from reliable vendors and by adhering to food safety rules thereby ensuring safety and quality [15]. The type of flower affects microbial contamination, with daisies and daylilies being most likely to be contaminated with *Staphylococcus aureus*. Some flower species, like calendulas and nasturtiums, may be resistant due to their biologically active compounds. The contamination can be reduced following hygienic harvesting practices [16].

Limited Availability: Flowers have historically only been used in food within a restricted, seasonal window of time when they are mostly found in their natural habitats. The acknowledged admiration for flowers like borage (*Borago officinalis*), acacia (*Robinia pseudoacacia*), and mallow (*Malva sylvestris*) are notable examples of this "season-dependent" culinary floral potential [14].

Standardization: Due to the inherent variability in flower's morphological and physiological properties, it can be challenging to establish standards regarding their quality, size, and appearance.

Regulations and Compliance: It might be difficult to use edible flowers in a way that complies with legal regulations. Various nations and areas may have unique laws limiting the use of flowers in cuisine, including prohibitions on particular species or production methods.

Supply Chain Management: Managing the edible flower supply chain, which includes harvesting, storing, moving, and distributing them is another challenge that can be defied by maintaining their freshness as well as purity following proper handling and storage procedures.

Cost: Because of their scarce availability, fragility, labor-intensive production, and harvesting procedures, edible flowers can be quite pricey compared to other cuisine ingredients thus less affordable to some businesses and consumers.

Consumer Awareness: The popularity of incorporating edible flowers (EF) into culinary practices is on the rise. Nonetheless, there remains a scarcity of information regarding the key factors that significantly contribute to the acceptance of this product [17]. Many consumers are still unaware of how to use them in food preparations and it's quite tricky to spread knowledge of safe usage and offer advice. To address these issues and ensure safe sourcing, farmers, suppliers, regulators, and consumers must work together. Marketers can enhance sales by focussing on the health benefits of edible flowers and by incorporating aroma into their promotional mix, offering products in various forms, including fresh and dried powdered form [5].

Opportunities: The usage of edible flowers presents a number of opportunities:

Product Development: There is a chance to investigate and create novel infused oils, syrups and spreads that are made with edible flowers.

Sustainability: Edible flowers encourage the use of natural products and provide a waste-free alternative to typical food decorations.

Culinary Innovation: By experimenting with edible flowers, chefs and food artisans can develop novel flavor profiles and aesthetically pleasing dishes.

Health and Wellness: By adding vitamins, minerals, and antioxidants to foods, edible flowers can improve their nutritional worth.

Marketing and Aesthetics: Edible flowers can improve the visual appeal of foods and beverages, making them more alluring to consumers from a marketing and aesthetics point of view. They give companies the chance to set their products distinct from the competition and develop a special selling point.

Cultural and Artistic Expression: Edible flowers have been utilized for a very long time in many different culinary cultures all throughout the world. Examining the various ways that different cultures use edible flowers might lead to chances for cross-cultural culinary appreciation and exchange.

Gardening and farming: Growing edible flowers can give farmers and gardeners an additional source of income. It enables them to expand the range of products they sell and take advantage of the rising demand for distinctive and specialty ingredients. By utilizing these opportunities, businesses and individuals may profit from the growing consumer demand for unique flavors, eco-friendly cooking techniques, and culinary innovation, ultimately expanding the market for edible flowers and their varied applications.

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Table: - 1. The most commonly used edible flowers

Sr. No.	Common name	Scientific name	Family	References
1	Anise hyssop	*Agastache Foeniculum*	Rosaceae	[2]
2	Basil	*Ocimum basilicum*	Lamiaceae	[1]
3	Bauhinia	*Bauhinia purpurea*	Fabaceae	[18]
4	Butterfly pea	*Clitoria ternatea*	Fabaceae	[19]
5	Calendula	*Calendula officinalis*	Asteraceae	[20]; [21]
6	Carnation	*Dianthus caryophyllus*	Caryophyllaceae	[20]
7	Chamomile	*Matricaria chamomilla*	Asteraceae	[22]
8	Fennel	*Foeniculum vulgare*	Apiaceae	[1]
9	Hibiscus	*Hibiscus rosa sinensis*	Malvaceae	[23]
10	Honeysuckle	*Lonicera species*	Caprifoliaceae	[24]
11	Jasmine	*Jasminum sambac*	Oleaceae	[1]
12	Lavender	*Lavandula sp.*	Lamiaceae	[24]
13	Marigold	*Tagetes erecta, Tagetes patula*	Asteraceae	[1]
14	Moringa	*Moringa oleifera*	Moringaceae	[1]
15	Nasturtium	*Tropaeolum species*	Tropaeolaceae	[20]
16	Pansy	*Viola tricolor*	Violaceae	[25]
17	Rose	*Rosa odorata*	Rosaceae	[26]
18	Sunflower	*Helianthus annuus L.*	Asteraceae	[1]

Table: - 2. List of some potential wild edible flowers of the Western Himalayas

Scientific name	Common name	Family	Reference
Indigofera cassioides	Neel, Sakina, Hikpi	Fabaceae	[27]
Melia azedarach Linn.	Drek	Meliaceae	[28]
Nyctanthes arbor-tristis Linn.	Night jasmine	Oleaceae	[29]
Phlogacanthus thyrsiflorus (Roxb.) Nees	Lalbahuk, Kaldona	Acanthaceae	[29]
Rhododendron anthopogon D. Don	Nacahani	Ericaceae	[30]
Saussurea simpsoniana Lipschitz	Ucha	Asteraceae	[31]
Viola serpens	Banpash	Violaceae	[27]
Woodfordia fruticosa Kurz.	Dhavi, Gulbaha	Lythraceae	[28]

***Table: - 3. List of potential wild edible flowers** [21]*

Allium ursinum L.	Amaryllidaceae
Bellis perennis L.	Asteraceae
Centaurea cyanus L.	Asteraceae
Cichorium intybus L.	Asteraceae
Dianthus carthusianorum L.	Caryophyllaceae
Dianthus pavonius Tausch	Caryophyllaceae
Erythronium dens-canis L.	Liliaceae
Geranium sylvaticum L.	Geraniaceae
Lavandula angustifolia Mill.	Lamiaceae
Leucanthemum vulgare Lam.	Asteraceae
Mentha aquatica L.	Lamiaceae
Paeonia officinalis L.	Paeoniaceae
Primula veris L.	Primulaceae
Primula vulgaris Huds.	Primulaceae
Robinia pseudoacacia L.	Fabaceae
Rosa canina L.	Rosaceae
Rosa pendulina L.	Rosaceae
Salvia pratensis L.	Lamiaceae
Sambucus nigra L.	Adoxaceae
Taraxacum officinale Weber	Asteraceae
Trifolium alpinum L.	Fabaceae
Viola odorata L.	Violaceae
Borago officinalis L.	Boraginaceae
Calendula officinalis L.	Asteraceae

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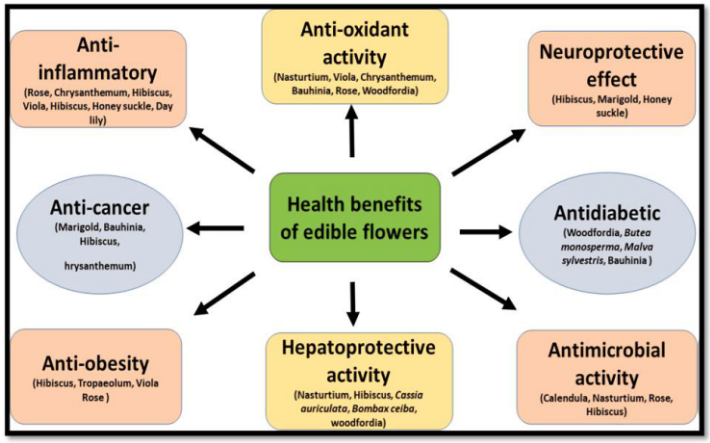
The Potential of Edible Flowers

• **High market value due to appealing colors and shapes**: Due to their vivid and appealing colors, edible flowers are much sought after for garnishing and decorating a variety of food and beverage products. For instance, pansies when sugared and covered with egg white add to the beauty of cakes. Brightly colored flowers like nasturtium and borage are used to beautify salads. To generate ice cubes for summertime beverages, little and medium-sized edible flowers like pansies, roses, lavender, and viola can be frozen.



• **Fulfils demand for more attractive meals**: As humans' desires change with time, there is a need to substitute existing ingredients of various dishes without compromising their nutrition which can be met by various edible flowers.

• **Increases the price of meals:** In various five-star hotels, the price of the same dishes being sold at the roadside increases many folds just because of the beautiful presentation with edible flowers.

• **Medicinal use of edible flowers**

Several flowers taste very nice and also have health benefits along with their lovely appearance and scent. The majority of edible flowers are rich in vitamin C and each one has a long list of advantages that make it essential to include them in our diet. [32]

Table: - 4. Medicinal properties in edible flower

Medicinal properties	Flowers
Antibacterial	Rose, Hibiscus, Nasturtium, Honeysuckle
Anti-inflammatory	Rose, Marigold, Nasturtium, Chamomile, Bauhinia, Clitoria
Antiseptic	Rose, Jasmine, lavender, Pansy, Marigold, Nasturtium, Chamomile, Wild indigo
Antidepressant	Rose, Jasmine, lavender, Marigold, Chamomile,
Cures diarrhea	Rose, Jasmine, Hibiscus, Honeysuckle, Rhododendron, Chamomile
Anti-cancerous	Jasmine, Hibiscus, Chamomile, Honeysuckle, Bauhinia, Clitoria
Aphrodisiac	Jasmine, rose
Antioxidant	Marigold, Rhododendron
Regulates Blood Pressure	Hibiscus, Pansy, Clitoria
Antidiabetic	Chamomile, Rhododendron, Bauhinia, Clitoria
Cures heavy menstrual bleeding	Hibiscus, Lavender
Cold and flu	Pansy, Nasturtium, Chamomile, Honeysuckle, Wild indigo, Marigold
Cures Liver diseases	Jasmine, Hibiscus, Wild indigo
Sore throat and mouth ulcers	Marigold, Chamomile
Bleeding Piles	Chamomile, Hibiscus

Sources of Phytochemicals: A prospective source of phytochemicals with a number of medicinal properties and health-promoting benefits, edible flowers include flavonoids, anthocyanins, carotenoids, terpenoids, and phenolics compounds [32, 6]. Edible flowers also have the potential to prevent or ameliorate skin aging, immune senescence, and neurodegeneration, and extend lifespan by inhibiting oxidative stress, inflammation, and apoptosis [33]. Freeze-dried calendula and cornflower can prove to be a rich source of fiber and protein [11].

Immunity Boosters: Additionally, they are an excellent source of important nutrients, including macro and microelements, proteins, lipids, carbohydrates antioxidants, and vitamins [11, 34]. Vitamins C, E, and A are found in edible flowers [7, 26, 35]. They strengthen the immune system's defenses against contagious microorganisms like bacteria, viruses, and parasites [36]. Rose hips are rich in flavonols, antioxidant activity, and bioactive substances, especially ascorbic acid (6.0 to 8.2 mg g^{-1} fresh weight) [37]. Thus, edible flowers along with their beauty can be exploited for their nutraceutical composition.

Exploring the Relationship Between Edible Flowers and Neurological Disorders

The World Health Organisation defines neurological disorders as conditions that affect both the central and peripheral nervous systems. These include disorders such as epilepsy, migraine, multiple sclerosis, Parkinson's disease, neuroinfectious, brain tumors, Alzheimer's disease (AD), and other dementias. Neurological illnesses affect hundreds of millions of people worldwide. Every year, there are nearly 10 million new cases [38]. Edible flowers offer promising raw materials for the amelioration of the age-related neurodegeneration that causes disorders like AD. Inhibiting cholinesterase, which stops ACh from being broken down, is now the most well-established method of treating AD [39]. Methanolic extracts of some edible flowers, such as *Nymphaea pubescent* [40], *Helichrysum stoechas* [41] or *C. cyanus* and ethanolic extracts of *Tagetes erecta* [42] and *V. wittrockiana* [43] flowers exhibited acetylcholinesterase (AChE) inhibitory property. Some floral extracts were also discovered to have an inhibitory impact on butyrylcholinesterase (BuChE), but this effect was stronger against AChE than BuChE [44].

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Edible Flowers: A Natural Approach for Diabetes Management

Dyslipidaemia, and postprandial blood sugar levels are symptoms of diabetes mellitus, a chronic metabolic condition. This illness gradually harms the heart, blood vessels, eyes, kidneys, and nerves severely. This illness is brought on by flaws in the action or secretion of insulin. Diabetes is a major public health concern in every country on the planet. The illness affected 422 million adults globally in 2014 (8.5% of the adult population). In 2019, diabetes and kidney disease due to diabetes caused an estimated 2 million deaths [45]. *Chrysanthemum morifolium* (yellow) and *Primula juliana* (blue) selectively inhibit the activity of glucosidase in this regard, whereas the ethanolic extracts of miniature (red) and *Dendrobium phalaenopsis* (purple) flowers merely showed inhibition of the activity of -amylase [46]. The intestine-glucosidase enzyme activity was also reduced in rats fed flower methanolic extracts from *Rhododendron arboretum* [47]. Even a single 200 mg/kg dose of *B. monosperma* extract has been proven to lower blood sugar levels [48]. Short-term blood glucose levels in diabetic rats were decreased by 73.6% after treatment with *Rhododendron arboreum* ethyl acetate fraction of ethanolic extract (200 mg/kg, ir). Extract administration (200 and 400 mg/kg once daily for 30 days) caused a significant decrease in blood glucose levels over time by increasing insulin secretion and glycolysis while reducing gluconeogenesis [49]. In mice C57BL/6 fed an insulin-resistant high-fat diet (HFD), treatment (18 weeks) with the chamomile extract (200 mg/kg bw/d, oral, the final 6 weeks) significantly reduced fasting blood glucose (13%), plasma insulin levels (23%), and insulin resistance (36%) and improved plasma lipid status [50].

Edible Flowers: A Solution for Obesity

The frequency of weight troubles has nearly tripled globally since 1975. Over 650 million human beings were impacted with the aid of weight problems in 2016 and 38 million children under the age of five had been overweight or overweight by way of 2019. obesity is characterized by way of a notable or immoderate buildup of fat, which could have a poor effect on one's fitness. It also appears as one of the foremost characteristics of metabolic syndrome. Adipocyte boom is aided by way of manner of the transcription issue CCAAT element binding protein (C/EBP). The protein tiers of those transcription factors can be decreased through flower extracts from *Hibiscus sabdariffa, Tropaeolum majus, Edgeworthia gardneri,* and *Citrus aurantium* [51].

Edible Flowers: Protecting Liver Health

All of the metabolic and detoxifying routes involve the liver. Oxidative stress, environmental pollutants, metals, medications, and tobacco can harm the liver's ability to maintain homeostasis. A high alcohol intake may be linked to the rise in injuries caused by hepatopathies. Natural compounds made from plants might be a viable solution to safeguard the liver from these changes. Due to its high polyphenol and flavonoid content, *Penthorum chinense* Pursh has been used traditionally to preserve the liver and prevent illnesses [52]. Additionally, many flower extracts have shown the ability to control gene expression in the liver. Accordingly, *Matricaria recutita* enhanced the nuclear PPAR gene expression in hepatic cell lines [50]. Additionally, according to [53], extracts from *Osmanthus fragrans* and *C. morifolium* suppressed the expression of two factors involved in the production of lipid droplets and fatty acid synthesis in the liver, respectively.

Biological potential of edible flowers: Edible flowers have become more popular in recent years due to their attractive appearance and potential health benefits. In addition to their attractive appearance, many edible flowers offer unique flavors, textures, and nutritional properties that make them great additions to a variety of culinary dishes. By providing important nutrients such as vitamins, minerals, and antioxidants, flowers can support a balanced diet. For example, marigolds contain antioxidants lutein and zeaxanthin, while nasturtium is a source of vitamin C and minerals such as calcium and potassium. Borage flowers are a source of gamma-linolenic acid (GLA) [54]. Among these flowers, *Tagetes tenuifolia* (signet marigold) has the highest biologically active compounds, including L-ascorbic acid (vitamin C), total carotenoids, total polyphenols, and the highest antioxidant activity. Flowers usually contain high carbohydrates. For example, Centaurea flower petals (88.39 %), rose petals (86.1%), dahlia leaves (86.0%), and primrose flowers (76.8%) contain more dry matter than other fruits, flowers and vegetables [3]. *Madhuca indica* contains a large amount of fiber, riboflavin, and carbohydrates. *Cassia fistula* contains high levels of lipids, thiamin, niacin, vitamin C, carotene, moisture, and energy. A large amount of calcium and protein is found in *Moringa oleifera* [55].

Table: - 5. Bioactive compounds in different edible flowers

S No.	Common name	Botanical name	Bioactive compounds	Reference
1.	Artichoke	*Cynara scolymus*	Chlorogenic acid, luteolin-7-O-glucoside	[56]
2.	Agave	*Agave salmiana*	Quercetin	[57]
3.	Burans	*Rhododendron arboreum*	Phytosterols, flavonoids, phenols, alkaloids	[58]
4.	Marigold	*Calendula officianlis*	Flavonoids, triterpenes	[59]
5.	Moringa	*Moringa oleifera*	Flavonoids, rutin, kaempferol	[60]
6.	Mallow	*Malva sylerstris*	Vitamins, minerals, fibers	[61]
7.	Hibiscus	*Hibiscus sabdariffa*	Flavonoid, anthocyanin, terpenoids	[62]
8.	Pansies	*Viola wittrockiana*	Quercetin, glycosides, isorhamnetin	[63]
9.	Rose	*Rosa micrantha*	Ellagitannins	[64]

Edible flower products: - Here is a list of products you could find useful if you're seeking things that either include edible flowers in their composition or can be used to create things with edible flower bases:

Garnishing: Use edible flowers as a garnish to give your food a sophisticated feel. Just before serving, sprinkle a few petals or full flowers on top of soups, entrees, or desserts. Pansies, nasturtiums, borage, or even tiny rose petals make excellent garnishes.

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Salads: You may add color and freshness to your salads by using edible flowers. For a colorful and tasty combination, combine them with salad greens, herbs, and other vegetables. The petals of marigolds, bachelor's buttons, chive blossoms, or even dandelion flowers are examples of edible flowers that go nicely with salads.

Cakes: Cakes, cupcakes, and other delicacies can all be adorned with edible flowers. For a magnificent look, place full flowers or individual petals on top of frosted cakes. Use only edible flowers and cut off any non-edible bits when using flowers. Pansies, violets, rose petals, or lavender flowers are typical cake decorations.

Puddings: To add flavor and visual appeal as well as a splash of color, edible flowers can also be used in puddings or custards. Before cooking, drain the flowers from the liquid portion of your custard mixture. Your dessert will gain a faint flowery flavor from this. Chamomile, jasmine, or hibiscus are a few flowers to take into account for custard infusions.

Flower extracts: To give sweets, drinks, and other products a flowery flavor, concentrated extracts made from edible flowers can be and utilized.

Flower Syrups: - Syrups infused with the essence of edible flowers can be poured over sweets, and breakfast foods like pancakes and waffles or added to drinks. The fresh petals of *Rosa damascena* were found to be a rich source of phytochemicals, including phenolic compounds, anthocyanins, ascorbic acid, and potent antioxidants. The petals also contained significant mineral content. By optimizing the syrup-making process with a 30:70 rose petals to sugars ratio and a temperature of 70°C, a highly desirable and compliant syrup can be achieved [65]. A method for creating 100% natural rose syrup using fresh rose petals and cane sugar was devised by [66]. The production costs were found equivalent to or cheaper than those of synthetic syrups, thus it can be said that the market opportunity in India for natural products without additives is high [66].

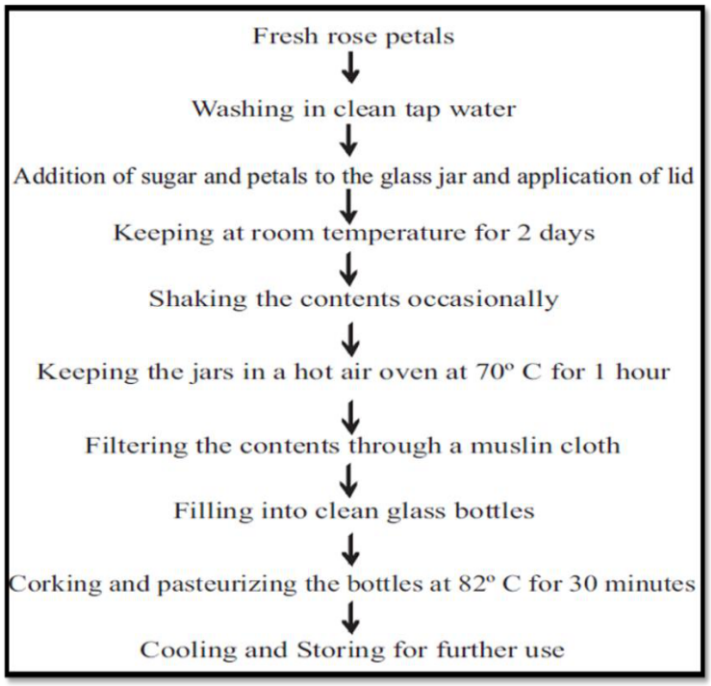

Fig: - Schematic diagram for the production of rose syrup

Edible flower tea: Dried edible flowers can be used to create floral herbal teas.

Rose tea: Rose petals, usually from the *Rosa damascena* or *Rosa centifolia* species, are used to make the popular herbal tea " The rose tea." which is renowned for its delicate flavor and beautiful floral scent. Other than this it is also thought to provide a number of possible health advantages. It is frequently ingested for its calming and relaxing qualities and is said to enhance digestion and improve skin health. It possesses a rich antioxidant value. the total amount of phenolic material 5,24-166,36 mg GAE/200 mL tea, the total amount of flavonoids 2,02-14,83 mg CE/200 mL tea, and the antioxidant capacity values 0.64-10.78 μM trolox /200 mL tea were found in rose tea prepared by steeping the dry rose petals and buds in boiled water at 98°C for 5 minutes [67]. In a study teas brewed from twelve rose cultivars were examined and rose-petal teas were found sensory acceptable, presenting a viable option for consumption either independently or in conjunction with other herbal materials. They displayed significant antioxidant capacity attributed to phenolic compounds, particularly free gallic acid. Cultivars San Francisco, Katharina Zeimet, Mercedes, and *R. damascena,* possessed exceptional antioxidant activity, even surpassing that of green tea [68]. Besides this Rose tea could be a safe and accessible treatment option for dysmenorrhea, offering relief to adolescent girls owing to reduced menstrual pain, distress, anxiety, and improved psychophysiological well-being [69].

Jasmine tea: The odor of Jasmine tea activates the parasympathetic nerve [70] and eases the effects of depression [71]. The root extract of *Jasminum sambac* has anti-inflammatory, analgesic, and antipyretic activities [72]. The polysaccharides of jasmine tea could be a new source of natural antioxidants and hypoglycemics with potential value in healthy food [73]. Jasmine-scented tea is crafted through the blending of tea leaves with fragrant jasmine flowers [74,75] and is predominantly manufactured in the Chinese provinces of Guangxi, Fujian, Sichuan, and Yunnan. This tea boasts a robust, invigorating aroma that is both potent and revitalizing [75]. The potential preventive role of jasmine tea extract makes it a viable treatment for eye problems brought on by UVB exposure [76]. Serving cold-brewed jasmine tea could be considered a potential functional beverage to help prevent obesity and dysbiosis in gut microbiota [77].

Hibiscus tea: Hibiscus tea is a type of herbal medicine made from the dried leaves of the hibiscus plant. It is known for its bright red color and rich, vibrant flavor. Hibiscus tea is a popular beverage all over the world, but it is most commonly used in North Africa, the Middle East, and the Caribbean. The daily consumption of sour tea (*Hibiscus sabdariffa*) was found to effectively lower blood pressure in patients with stage 1 hypertension [78].

Chamomile tea: The calming and soothing effects of chamomile tea, which is produced from chamomile flowers are well recognized. It has been used as a natural cure for millennia to promote sleep, ease anxiety, ease digestion, and provide antioxidant and anti-inflammatory properties. It can be ingested or even applied topically as care for skin and hair. Both chamomile and marigold teas selectively and dose-dependently affected cancer cells, with marigold tea showing higher cytotoxicity [79]. study carried out by [102].

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The cytotoxicity on healthy peripheral blood mononuclear cells (PBMC) was more pronounced for marigold tea. The teas contained flavonoid glycosides and hydroxycinnamic acid derivatives as dominant phenolics. In other studies, Chamomile tea dramatically enhanced the mental health and sleep quality of postpartum mothers who had trouble sleeping [80].

Lavender tea: The dried flowers and leaves of the lavender plant are used to make lavender tea, an herbal beverage. It tastes delicate and faintly sweet and has a distinct flower scent. Because of its well-known calming and soothing effects, lavender tea is a popular beverage for unwinding and encouraging better sleep. Drinking one cup of lavender tea daily for 2 weeks had positive effects on fatigue, sleep quality, and maternal-infant attachment in postpartum women [81]. It is advised to use lavender herbal tea as a supplemental treatment to lessen anxiety and despair since it is affordable and easily accessible and can lower depression and anxiety scores [82].

Other Beverages:

A standardized technique was given to create natural rose preparations and by-products [83]. With the use of 0.5% citric acid, rose extract that displayed enhanced color and smell retention, rose syrup, concentrate, dried residue, and rose water was produced. The products were all high in phenols, anthocyanins, and antioxidants, and had a flavor and appearance that were reminiscent of freshly picked roses. The bioactive components of the rose syrup remained highly desirable for up to six months. The effects of rose syrup and marigold powder on Nutri cereals and a milk-based functional beverage were studied [84]. The best concentrations to be added were found as 10% rose syrup and 0.50% marigold powder. Flower extracts addition increased total phenols, β-carotene, anthocyanins, and antioxidant activity. The rose-flavored beverage had the highest acceptability and storage stability [84]. *Rhododendron arboreum* is used to create a variety of valued food products. Since the blossoms of this plant have a sweet and sourish flavor, numerous food products, such as jam, jelly, juice, preserves, squash, chutney, and local brew, are made from them. A beverage formulated with 35% rhododendron extract, with a total soluble solid (TSS) of 65°B and acidity at 1.50%, was identified as the optimal product based on sensory evaluation and several physicochemical attributes. This beverage demonstrated a safe storage capacity for up to six months under both ambient and refrigerated conditions, regardless of packaging material (glass or PET bottles) [85]. Rhododendron is a popular, reviving, summertime beverage with benefits for headaches, fever, nosebleeds, and stomach [86]. Rhododendron Chutney is made using fresh petals. This chutney has a truly reviving scent and tastes along with numerous health advantages, including being high in antioxidants and vitamin C and being beneficial for heart health, pains, and aches [87]. A Rhododendron squash made with 30% juice and a TSS (Total Soluble Solids) of 45°Brix demonstrated acceptable quality. Its quality remained consistent throughout a six-month storage period [88]. The ginger-blended Rhododendron squash was found to be rich in bioactive compounds, and moderate antioxidant capacity, and the most preferred in terms of appearance (exhibiting appealing red color) and flavor [89]. In the Chamoli District of Uttarakhand, India, a value-chain analysis of *Rhododendron arboreum* squash was carried out [90]. The study emphasized the financial advantages of gathering *R. arboreum* flowers for squash production, supplying local residents with livelihood prospects. The cost of the just-gathered flowers ranged from 30 to 60 Rupees. The research showed that throughout the flowering season, squash can be produced anywhere between 2500 and 7500 liters. In some areas of the Himalayas, the 'Guranse' wine created from flower nectar is frequently consumed and is effective against diarrhea and dysentery [90].

Squash, juice, and edible flower syrup can be combined to make a variety of delectable delights. By combining the syrup, water, and freshly squeezed lemon juice, you can make a revitalizing Edible Flower Syrup Lemonade. Mix the syrup with the squash and sparkling water to make a mocktail without alcohol. Garnish with edible flowers. By blending the syrup with fruit juice and freezing the result, you can create a floral sorbet. For a gorgeous dessert, drizzle the syrup over the ice cream. For a smoothie with floral undertones, blend the syrup, squash, juice, and fruits. These pairings give your culinary masterpieces distinctive flavours and a refined touch.

Flower Liqueurs: Liqueurs created from edible flowers can be added to cocktails or used as a flavouring in sauces and sweets. *Rosa rugosa* petals contain a considerable quantity of secondary metabolites possessing antioxidant properties, rendering them suitable for incorporation into beverages [91]. Similarly, a blend of mahua and guava was identified as having significant potential for entry into the profitable market due to its high antioxidant activity [92].

Ice creams:

Flower ice creams are frozen desserts that capture the essence of various edible flowers, infusing them with both flavor and aroma. These treats often incorporate floral extracts or petals into their base, resulting in distinctive and revitalizing tastes. Research conducted by [93] indicates that Rose Petal Ice Cream received exceptionally positive feedback from participants in Guiuan, Eastern Samar. Moreover, a study by [94] suggests that incorporating 5% roselle extract into ice cream formulations may offer potential health benefits. Respondents described the resulting roselle ice cream as creamy white, sweet, milky, and infused with vanilla flavor. Butterfly Pea, renowned for its vibrant indigo hue, has a long history of use as a memory enhancer, brain booster, stress reliever, and a source of health-promoting antioxidants, flavonoids, and peptides. Incorporating Butterfly Pea as a food flavoring in ice cream resulted in a highly favorable reception among both adults and children [95]. Additionally, (*Echinacea purpurea*) can be transformed into "Ekino Ice," an ice cream enriched with flavonoids, phenols, and cystic acid, which function as beneficial immunomodulators [96].

Flower Candies: Candy or lollipops with actual edible flowers can be eaten as a delightful treat or displayed as decorations. The calyx of the roselle plant (*Hibiscus sabdariffa* L.) can be eaten as a healthier alternative to sweet delights and utilized as a natural colorant in the production of jelly candy [97]. The *Dendrobium officinale* soft candies contain 2.24% flavonoids, protein, carbs, salt, and other nutrients, it is likely safe for the general public to consume [98]. The Mahua candy has a desirable sweet taste, color, and texture and can be an alternative to conventional sore throat remedies [99]. *Clitoria ternatea* extract was used to create blue-colored, hard sweets with strong therapeutic properties (antioxidant activity and total phenol content). The *Clitoria ternatea* flower extract exhibited the greatest percentage of free radical scavenging, at 59.3%. [100].

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The addition of *Clitoria ternatea* flower extract also improved the functional properties of dadah jelly candies (increasing antioxidant activity and total phenol content) [101].

Flower Chocolate: Chocolates with edible flowers added to them or as decorations make for a tasty blend of flavors. Banana blossoms are supposed to provide several health advantages; prevent diabetes, reduce menstrual bleeding, boost nursing mothers' production of milk, improve gastrointestinal health, aid in weight reduction, avoid ulcers and relieve constipation. The banana blossom nut chocolate that was made with 20% banana blossom inclusion was deemed to be very good in a

Table: - 7. Exploring the Medicinal Potential of Rhododendron arboreum Plant

Plant Part	Bioactive Compounds	Medicinal Uses	Remarks	References
Flower	Phenolic compounds (quercetin, rutin, coumaric acid), saponins, xanthoprotein, steroids, tannins, etc.	Anti-diabetic, anti-inflammatory, antimicrobial, hepatoprotective, anti-allergy, etc.	The flower contains the potential for anti-diabetic and medicinal properties.	[102], [103] and [104]
Leaves	Glucoside, ericolin, ursolic acid, α-amyrin, epifriedelinol, Campanulin, quercetin, hyperoside, flavonoids, phenols, epicatechin, catechins, anthocyanidins	Antioxidant, anti-inflammatory, analgesic, anti-allergy, etc.	Leaves are rich in flavonoids and vitamin C and are used for various medicinal purposes.	[102], [103], [105] and [106]
Root	Alkaloids, terpenoids, tannins, reducing sugars, steroids, saponins, anthraquinones	Anticancer, anti-inflammatory, cardiovascular benefits	The root can be used as a therapeutic agent due to the presence of secondary metabolites.	[102] and [107]
Bark	Alkaloids, steroids, terpenoids, tannins, saponins, reducing sugars, taraxerol, betulinic acid, ursolic acid	Cold reliever, antimicrobial, anti-inflammatory, anti-oxidative, anti-carcinogenic, etc.	The bark possesses various beneficial properties due to its bioactive compounds.	[102] and [107], [108] and [109]
Stem	Alkaloids, steroids, terpenoids, anthraquinones, tannins, glycoside saponins, reducing sugars	Hemorrhage, hay fever, bronchial asthma, anticancer, cardiovascular benefits	The stem contains bioactive substances that promote health and are used for medicinal purposes.	[107]

The standardization of the gulkand recipe and evaluated its sensory and physico-chemical characteristics while in storage were examined. Increased sugar content was produced by higher concentrations of sugar, honey, and jaggery as well as by longer storage times. The maximum decreasing sugar level was found in the rose petal and sugar (1:0.75 w/w) treatment, at 44.56% [110]. The effect of Gulkand and rose petal powder on Shrikhand were investigated. Increasing levels of gulkand and rose petal powder resulted in decreased protein and fat content, and increased carbohydrate, ash, and moisture content in Shrikhand. The composition of 2:1.5 gm of gulkand and dried rose petal powder was preferred by panel members. This composition remained acceptable for 21 days under refrigerated conditions based on sensory evaluation and microbial analysis [111]. In another study to improve the usefulness of Rhododendron flowers, Rhododendron powder was integrated into biscuit manufacturing. Their findings suggest that up to 15% Rhododendron powder can be included to produce biscuits of acceptable quality. Mixing Rhododendron powder with wheat flour notably raised the levels of moisture, ash (from 0.75% to 1.20%), protein (from 3.06% to 4.96%), fiber (from 0.07% to 0.67%), and iron (from 3.90 mg/100g to 4.19 mg/100g) [112]. Heartsease and pansy samples possessed antioxidant properties comparable to the well-known antioxidant ginkgo leaf [113]. A significant correlation was found between the flavonoid content and antioxidant capacity, but no correlation was found between antioxidant capacity and anthocyanidin content [113]. Products made from edible flowers, including gulkand cookies infused with rhododendron and rose powder, have shown encouraging results. They provide improved sensory qualities, more antioxidant power, and distinctive flavors. The inclusion of edible flowers changed the Physico-chemical composition of the products, and lowered sugar content while increasing protein and fat levels, for example. These results emphasize the opportunity to improve food quality and consumer appeal by including edible flowers in food formulations.

Packaging materials for edible flowers

A variety of edible materials, including proteins, polysaccharides, lipids, and resins, are used in edible coating in packaging [114]. These materials are biodegradable and ideal for composting and other biological recycling techniques because they are intended to be consumed along with food items [115]. Films, sheets, coatings, and pouches all fall under the category of edible packaging. While coatings are thin layers that are generated directly on the food surface, edible films and sheets are independent structures deposited on or between food components [116]. Edible flowers are becoming more and more popular in gourmet cuisine as restaurants try to go above and beyond the norm. They give food a fresh, exotic aroma, delicate flavor, and eye-catching presentation. Many upscale eateries and catering businesses use flowers as table decorations or as ingredients in salads, soups, entrees, desserts, and beverages. Small, stiff plastic packaging is usually used to store edible flowers. Due to their comparatively low output and more niche market, edible flowers have not garnered the same attention as fresh fruits and vegetables. There are no standards for the preservation of edible flowers and there is no research available that pinpoint the variables that affect their quality. Flowers are prone to petal abscission, discoloration, wilt, dehydration, and tissue browning due to their high surface area-to-volume ratio and numerous delicately linked parts. Since edible flowers must currently be consumed within 2 to 5 days of harvest, air transportation is necessary for them to reach the majority of regions before they lose their shelf life. In addition to making edible flowers a much more enticing option for restaurants, extending shelf life would offer financial advantages including less wasted product and lower transportation costs with the potential of ground delivery, allowing edible flower growers to expand their niche market. Even though there is a growing market for edible flowers, their growth is still constrained by their fragile product's short post-harvest shelf life. After being picked, the delicate floral tissue begins to dry out and lose its aesthetic appeal.

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Research has also shown that an item's nutritional value and antioxidant levels deplete quickly. Eating films are currently only made in laboratories, and they are more expensive than synthetic plastic films. Further study is required to lower costs and scale up production in order to make edible packaging commercially viable. The intricacy of the production process, the cost of the equipment needed for film production, compatibility with current packaging systems, and manufacturer acceptability are all factors that affect feasibility [117]. The use of edible packaging is becoming more widely recognized as an effective way to cut waste and improve the stability, quality, and safety of products. The use of biopolymer-based polymers to transport and release active substances is being investigated. Nanocomposite ideas and improvements to dry thermoplastic methods hold the potential for enhancing barrier characteristics and adding bioactive elements. Regulating bodies, customer acceptance, and scaling up for commercial uses are still issues.

Edible flowers Industry

The industry includes a wide variety of edible flowers, such as marigolds, rose, pansy, lavender, hibiscus, nasturtium, violets, chamomile, and much more. To guarantee their safety and quality, these flowers are grown using organic or low-pesticide techniques. Additionally, as customers become more aware of natural and organic elements in their meals, demand for edible flowers has increased. Given that they contain certain vitamins, minerals, antioxidants, and other bioactive components, edible flowers are frequently linked to health advantages. These are just a few examples of industries that are related to edible flowers.

John Worldwide: located at D-192, Eldeco Towne, I.I.M. Road, Hardoi Bypass, Lucknow, Uttar Pradesh, 226013, India, is a company with an annual turnover of Rs 2,00,00,000. They primarily export their products to the Middle East, North America, and Asia. They hold certifications from APEDA and the Phytosanitary Spice Board. With a supply ability of 5 metric tons at a time, their products are packaged in H.D.P.E. bags.

DNS Global Food: Registered in 2018 in Vadodara, Gujarat, is a company with a monthly supply ability of 300 kilograms. They hold certifications from FSSAI and USFDA, ensuring the quality and safety of their products. With their main domestic market being all of India, they also export to various regions including South America, Western Europe, Australia, Africa, the Middle East, Central America, Asia, North America, and Eastern Europe.

Mittal Teas: Located on the Ground Floor, No. 6, New Delhi House, No. 27, Barakhamba Road, New Delhi, India, is a company specializing in teas. You can contact them at 011-41520402 or 41507054, or reach out to them via email at info@mittalteas.com or teasmittal@gmail.com. One of their notable products is Rose Green Tea.

Woods And Petals: Located at D24, Lajpat Nagar, Central Market, Liberty Showroom, New Delhi, India, is a company owned by Pragati Lakra. You can contact them at 08048361262. One of their featured products is Chamomile Rose Tea.

Hill Brew: They offer Lavender Tea in dried form. They are located in Gandhipuram, Coimbatore, Tamil Nadu, and can be contacted at 08047677656.

Sri Kiruthihaashini Export & Import: Managed by Dinesh Kirthi, is situated at 10-4, Avinash Road, Thotta Salai, Punjai Puliampatti, Erode-638459, Tamil Nadu, India. They can be reached at 08068442240. They specialize in Jasmine Tea and also provide dried Hibiscus petals.

The Gourmet Box: Located at 11, Heena Madhu park Society, 1st Floor, Plot 128, 1st Khar Road, Khar West, Mumbai, India. They specialize in Rose Oolong Tea.

Addendum Sales Private Limited: Based in Delhi, they are a supplier of Rose Tea and can be contacted at 08048372751.

Future prospects of edible flower: -

The prospects for edible flowers in the future look optimistic because of a number of characteristics that point to strong growth potential:

Increasing Consumer Demand: Consumer demand is rising as people become more experimental with their food preferences and seek out novel and interesting tastes and experiences. Food lovers and shoppers looking for novel ingredients will like edible flowers because they bring something special and aesthetically pleasing to dishes.

Trends in Health and Wellness: The market for edible flowers is greatly influenced by the emphasis on health and wellness. Consumers are adding functional foods like specific flowers to their diets to improve overall wellness as a result of expanding knowledge of the nutritional advantages and potential medicinal characteristics of certain plants.

Sustainable and Local Sourcing: Customers are increasingly looking for goods that are made locally and sustainably. By encouraging sustainable production methods, lowering food miles, and assisting local farmers, edible flowers can encourage this trend. The market prospects are further improved by the emphasis on ethical sourcing and environmental responsibility.

Culinary and Mixology Innovation: Innovation in culinary and mixological inventions can result from collaboration between chefs, mixologists, and suppliers of edible flowers. Culinary experimentation and increased market potential are sparked by the enormous variety of flavors and smell that may be blended into different dishes, desserts, and cocktails using edible flowers.

Social media and culinary Culture: It is indisputable that social media has a significant influence on culinary trends. With their vivid colors and visually appealing features, edible flowers are very shareable on social media sites like Instagram and TikTok. This exposure has the potential to greatly raise knowledge of and spark interest in edible flowers, fueling industry expansion.

Diversification of Product Offerings: In addition to being used in food, edible flowers may also be used in herbal treatments, organic skin care products, and ornamental goods. By diversifying into these non-food industries, businesses may find new opportunities and reach a larger audience.

Education and Public Awareness: Consumer education on the numerous edible flower varieties, their flavors, health advantages, and safe consumption are crucial for market expansion.

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Cooking classes, workshops, and internet resources that promote awareness can provide customers greater assurance to include edible flowers in their daily lives.

International Market Expansion: Although edible flowers have become more popular in some areas, there is still room to grow their business internationally. Market expansion can be fueled by examining traditional foods from other cultures and marketing the distinctive tastes and applications of edible flowers. Overall, the industry for edible flowers has bright future prospects thanks to rising consumer interest in distinctive culinary experiences, healthy options, sustainability, and the aesthetic appeal of food. The market can grow and prosper in the upcoming years by leveraging these trends and raising awareness.

Conclusion

Edible flowers being a very rich source of nutrition and having medicinal value show great potential for their use in the diet in the coming years. These flowers have been related to a good nutritional profile, being a source of fibers or even proteins, with very low lipid content, therefore meeting several dietary demands including vegetarian and vegan. There is an increasing demand of food with more appealing value which also increases the market value of meals. Hence all the edible flowers with their beautiful colours, shapes, and patterns are being used in the food industry and increase the value of the dish by manifolds. In the era of the COVID-19 pandemic, where the floriculture industry suffered a huge loss and farmers shifted towards other agricultural crops, edible flowers showed a new perspective towards the sustainability of floriculture.

Future scope

The study of edible flowers in India holds promising future scope, driven by increasing interest in sustainable and organic food sources. With a rich biodiversity, India offers a wide variety of native flowers with potential culinary uses. Research can focus on identifying and cataloging these flowers, exploring their nutritional benefits, and understanding their medicinal properties. Integrating edible flowers into traditional and contemporary cuisine can enhance food aesthetics and nutrition. Furthermore, cultivating edible flowers could support eco-friendly farming practices, boost local economies, and offer new opportunities for the agricultural sector. Collaboration between botanists, nutritionists, and chefs can innovate culinary applications, creating niche markets in gastronomy and wellness industries. Additionally, educating the public about safe consumption and potential health benefits will be crucial for the mainstream adoption of edible flowers.

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