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Edible Flowers: A New Source of Minerals

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Abstract: Edible flowers have become very popular in recent years as a potent and natural source of various important minerals, vitamins, flavonoids, enzymes and aromatic compounds. Various anti-bacterial, anti-viral, anti-fungal & anti-inflammatory substances have been found in various edible flowers e.g. Rose, Marigold, Lilac, Chrysanthemum, Chinese hibiscus, Roselle, Tulip, Magnolia, Water lily etc. These flowers are almost calorie-free, high in antioxidants, have inhibitory effects against cancer, obesity and inflammation, prevent neuronal degradation, help to diminish blood pressure, demonstrate gastro-protective and hepato-protective effects. Edible flowers show antioxidant activities, inhibitive activities on free radicals and ROS-scavenging properties due to presence of various phenolic compounds e.g. Quercetin, Rutin, Gallic acid etc. Pollen, nectar and petals are rich source of proteins, carbohydrates, lipids. The colour of flowers is characterized by various carotenoids, anthocyanins etc. Harvesting of edible flowers should be done in cool climate during day time in fully bloomed condition to retain quality and shelf-life. Edible flowers are generally used in salads, soups, beverages, and herbal medicines across the world. People with conditions like hay fever, allergies or asthma must be careful in consuming these flowers. However, in upcoming years, there are immense possibilities of a rapid increase in the consumption of edible flowers when cultivated organically.
Keywords: Edible flowers, anti-inflammatory, antioxidant activities, harvesting, phenolic compounds

I. INTRODUCTION

Nowadays customers prefer attractive, healthy and tasty meals [1, 2]. Edible flowers have all of these characteristics which are used in many restaurants and homemade dishes [3, 2]. Edible flowers are served as an ingredient in soups, salads, desserts and drinks [1, 4, and 5]. They are used in different forms, tastes and colours, so they have high impact on the sensory and nutritional value of food [6]. Edible flowers have been used for many more years to make teas, wines and as supplements of jams, butters and sauces [7]. They are used in food in solid or almost solid forms such as roasts, stews etc. as well as in liquid form such as in alcoholic beverages; or even in the form of flavourings as constituents of olive oils, other oils and vinegars [7]. In recent years, we observed edible flowers have gained interest in the field of nutraceuticals, i.e. functional food which combines nutritional and medicinal values [6, 7]. Edible flowers are rich in many different biologically active compounds such as polyphenols, carotenoids, essential oils, dietary fibre, vitamins, minerals, which play an important role in the prevention of several chronic diseases like cardiovascular diseases and cancer [6].

The aim of the study was to determine the content of macro and micro elements, heavy metals in the flowers of some species and cultivars of ornamental plant flowers and try to understand the knowledge about their habits related to edible flowers.

II. VARIOUS IMPORTANT EDIBLE FLOWERS

TABLE I
Table containing a list of various important edible flowers and their description

Sl. No.	Scientific Name	Description
1	Agastache foeniculum	Anise hyssop is self-seeding, perennial and has a strong flavour [8].
2	Althea rosea	Hollyhock is used as fascinating garnish and has a vegetal flavour [8].
3	Begonia tuberhybrida	Petals are edible with a slightly lemon flavour; generally used in garnish. It has nondescript, ophthalmic, anti-phlogistic, anti-spasmodic effects [9].
4	Bellis perennis	English Daisy is lightly bitter in taste and it should be avoided if one has hay fever, asthma or severe allergies as it can trigger allergic reactions [8].
5	Calendula officinalis	Petal is slightly bitter in taste and helps in digestion, stimulate the immune system, reducing fever, regulates menstruation, have anti-inflammatory effects, aids gastric disturbances, colitis etc. [10].

6	Chrysanthemum spp.	Has a strong flavour and generally the florets are consumed. Only petals of a specific species of Chrysanthemum coronarium should be eaten. It can also be used in the treatment of constipation, hypertensive symptoms, pneumonia, colitis, stomatitis, fever and several infections etc. [3, 9].
7	Dianthus spp.	It has a sweet clove like flavour and narrow base of petals should be removed because of bitter taste. For edible purpose perennial species is generally used [8].
8	Erucavesicaria sativa	Arugula is an annual plant and has a spicy flavour. The leaves become bitter when flowers are formed [8].
9	Hibiscus rosa-sinensis	It has a lightly citrus flavour and used as a showy edible garnish. It contains some antioxidants and prevents cholesterol deposits and liver disorders [8].
10	Lavendula spp.	Lavender has a sweet, perfumed and intense flavour and hence sparingly used. It helps to relieve from stress and works as gentle sleep aids. But lavender oil might be poisonous [8].
11	Monarda didyma	The flowers and leaves of Bee Balm having sweet and minty flavour can be used as garnishes and in tea. This plant plays an important role in preventing digestive problems, nausea, colic, bloated distended stomach etc. [11].
12	Moringa oleifera	Its flower has high medicinal value and can be used as stimulant, aphrodisiac, help to cure inflammation, hysteria, muscle diseases, tumours, and enlargement of spleen, lowers the serum cholesterol etc. [12-14].
13	Passiflora spp.	It is well known as Passion flower. Showy flowers with vegetal flavour are generally used as garnish [8].
14	Rosa spp.	Rose has a luscious and scented flavour and its petals can be sprinkled on salads, used as garnish after removing the white, bitter base of the petal. This flower is rich in vitamin C and exhibits anti-cancer, ophthalmic, diuretic, laxative properties [13].
15	Sesbania grandiflora	Flowers are bitter, cooling, astringent, emollient, anti-pyretic and laxative. The flower juice can be applied to check blindness, sight weakness and also helps to promote vision, cures leucorrhoea, small pox, periodic fever, poisoning cases, healing wrinkles etc. [16, 17].
16	Syringa vulgaris	Lilac has lemony taste and floral or pungent flavour. Petals and blossoms are generally used in salads which help to reduce fever and get rid of internal parasites [15].
17	Tagetes patula	Marigold is slightly bitter in taste, may be harmful in large amounts and hence should be consumed occasionally and in moderation [8].
18	Taraxacum	Young flower of Dandelion has a sweet flavour and it is rich in vitamin A, vitamin C, iron, calcium and phosphorus [8].
19	Tropaeolum majus	Blossoms and leaves of Nasturtium can be used in salad and it has a peppery flavour. It has anti-biotic, disinfectant, wound-healing, expectorant, anti-cancer, anti-scorbutic activities [15].
20	Viola odorata	Violets can be used fresh or candied and it has sweet and perfumed flavour. It possesses anti-inflammatory properties and good for respiratory ailments as well [8].

III. SOURCES OF EDIBLE FLOWERS

Potential sources of edible flowers are involved in flowering plants, fruit plants, vegetables, medicinal plants and ornamental plants [18, 19].

TABLE II

Table containing a list of ornamental plants which are the sources of the most frequently consumed flowers

Scientific name(s)	Common name (s)	Colour(s)	Flavour
Agastache foeniculum	Anise Hyssop	Violet, orange, rosy	Sweet, anise

Calendula officinalis	Pot Marigold	Orange	Slightly sour, slightly pungent
Dianthus	Dianthus	Various (cultivar-dependent)	Slightly bitter
Rosa spp.	Rose	Various (cultivar-dependent)	Sweet and aromatic
Tagetes patula	Marigold	Orange	Bitterish, clove-like
Tulipa spp.	Tulip	Various (cultivar-dependent)	Sweet, pea-like

IV. EDIBLE FLOWERS AS A SOURCE OF BIOACTIVE SUBSTANCE

Pires et al. (2018) [20] defined phenol profiles in flower extracts (*Dahlia mignon, Rosa damascena, Calendula officinalis L. and Centaurea cyanus L.*) and evaluated their bioactive potential, together with antioxidant, ant proliferative and antibacterial capacities. Marigolds contain the highest amount of phenolic compounds. Highest antioxidant activity was found in the infusions and extracts of Rose petals, which could be the result from the presence of quercetin and kaempferol derivatives. Rose oil in several parts of the world, such as Bulgaria, Turkey, India and Iran, is used to acquire essential oil, rose water, liquor, syrup and other products. The most significant properties of rose oil include sedative, diuretic, anti-migraine, antibacterial and antiseptic effects [21].
Research led by Lia et al. (2014) [22] on the total phenolic content and antioxidative abilities of 51 edible and wild flowers indicated that the wrinkled rose (*Rosa rugosa Thunb*.), wavy leaf sea-lavender (*Limonium sinuatum L.*), sweet osmanthus (*Osmanthus fragrans*), stripped pelargonium (*Pelargonium hortorum L.*) and spicy jatropha (*Jatropha integerrima Jacq.*) are characterized by the maximum content of homogentisic acid, protocatechuic acid, cyanidin-3-glucoside, catechin, epicatechin and gallic acid.
In Food and Nutrition, colour plays a vital role and it is an important organoleptic property of any edible flower [23]. The colour of flowers predominantly rests on the content of carotenoids and anthocyanins. In edible flowers, the increased content of anthocyanins is typically completely associated with greater levels of total flavonoids [24]. In addition to the above mentioned bioactive compounds, edible flowers also comprise vitamins and minerals. Vitamins A, C and E were detected in flower petals [9]. The comparatively high content of vitamin C was determined in flower petals of nasturtium, rose and hibiscus [25]. Consecutively, tocopherols were recognised in petals *of Rosa canina L., Dahlia mignon, Calendula officinalis L. and Centaurea cyanus L.* [26]. There are very limited studies on the content of mineral compounds in edible flowers. In tests carried out in Brazil, the content of As, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Na, Ni, P and Zn in rose petals *Rosa* spp. was determined [27].

V. HARVESTING AND POST-HARVESTING

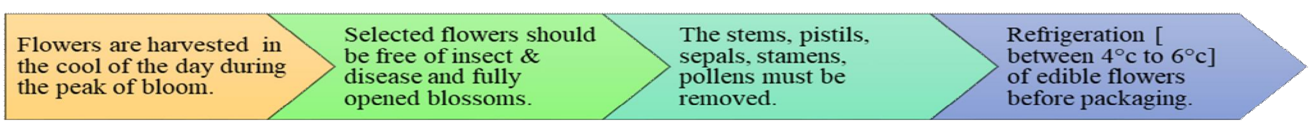

Fig.1 Figure showing harvesting and post-harvesting operations of edible flowers.

Edible flowers should be harvested in cool climate & especially during day-time, when they've bloomed fully & in their best flavour. The flowers are selected only when they're free of insects & diseases; moreover, the unopened, tilted and faded flower should be avoided as they can produce bitter or unappealing flavour [28]. Besides that, flowers that have been sprayed with pesticides or fertilized with untreated manure or that along roadsides must never be collected for consuming purposes as they can be toxic or cause illness due to presence of pathogens [29]. With respect to parts of the flower, stems, sepals, pistil and stamens of most flowers should be removed before using. Pollen must be removed as they may cause allergies in some people and may diminish the taste of the flower. The sepals should be separated from all the flowers as they're sour [30].
As edible flowers are extremely perishable and delicate, after harvesting flowers are susceptible to petal abscission, discolouration, wilting, dehydration and tissue browning. So, refrigeration of edible flowers is done by keeping them in cold storage between 4°C to 6°C before packaging which can increase their shelf life from 2 to 5 days [31].

In this way, it becomes the essential technique in retaining the quality & shelf life of edible flowers. However, there is no specific guideline established for preserving edible flowers. So far only three studies have been done:

1) On the effect of storage temperature [32]
2) By using modified atmosphere packaging (MAP) with controlling the release of 1-methylcyclopropene [31]
3) By using some specific types of packaging, namely PVC, PP with or without modified atmosphere [33]

VI. QUALITY OF EDIBLE FLOWERS

While defining the usefulness of flowers for human nutrition, the growing demand today has been placed above their quality [34]. The medicinal properties of edible flowers depend on the limit of the content of toxic agents [9]. Uses of lesser known or poisonous flowers for humans may be dangerous, e.g.: - Conavallaria majalis [9]. It is definitely recommended not to consume edible flowers of ornamental plants originating from non-tested cultivators or flower shops because they could be affected by herbicides, fertilizers and other types of pesticides [9]. Quality criteria also involve the capability of individual species to be grown on larger areas and the stability of their yields [35]. Edible flowers improve the sensory qualities of food by adding colour, fragrance, flavour and visual appeal to culinary preparations. Edible flowers can also be dried, soused in alcohol or sugar, frozen either directly or in form of ice cubes, added into cocktails etc. [9]. The sublimation drying's method is economically and technically rather demanding but very effective because the original appearance, colour, shape and gloss of the flowers remain preserved [36].

VII. QUALITY ATTRIBUTES

For fresh and processed flowers, the main quality attributes that contribute to sales are aroma, appearance and colour [37]. This attributes are determined by harvesting methods, flower variety, maturity stages and can change rapidly during post-harvest storage and processing [31]. Appearance is the primary quality attribute of processed flowers and fresh flowers. After harvest, the flowers become colourless, dehydrated undergo petal abscission, wilting and browning [38]. In the process of human purchase and selection of flowers the main consideration is the colour, integrity of flower and the size and shape of the petals without defects [39]. Customers do not accept flowers with defective appearance. Their colours are pre-determined by many chemical compounds, among which the contents of flavonoids and carotenoids are most important [24]. Broccoli, cauliflower, cabbage and artichoke are some flowers, which are generally considered as vegetable, but these are inflorescences [38]. In the process of cooking, these flowers need to have a certain firmness, juiciness, toughness and crispness [40]. In flowers, fragrance result from the production and release of various volatile compounds that receive special receptors in the human olfactory system and create the feeling of pleasure [38]. Depending on the mode of biosynthesis, these compounds could be dominatingly divided into three types: terpenes, aliphatic compounds and phenyl propanoids [41].

VIII. COLOUR OF FLOWERS

Colour is a significant organoleptic feature of edible flowers [42]. Although this property is characterized by many chemical compounds such as carotenoids, anthocyanins, it's immensely important as the level of anthocyanin is mostly correlated with higher levels of total flavonoids and it can be said that, it's one of the factors that helps in determining their high antioxidant activity [24] [43].

Garden nasturtium (*Tropaeolum majus*) represents one of the most popular origins of edible flowers. In this species, the colour of edible flower is caused by the anthocyanins and their concentration is near about 720 mg/kg of fresh mass. Besides that, perlargonidin 3-sophoroside comprises more than 90% of whole anthocyanin. Likewise, as in chrysanthemums, lutein is the most important carotene in this instance [44].

Most of the marigold flowers contain 350-450mg/kg of fresh mass [45]. In contrast with yellow or red cultivars of marigold, the maximum amount of lutein can be found in flowers of orange varieties [46]. The consumption of marigold flowers shows a significant effect in reduction of the risk of macular degradation and cataract [47].

In roses, the colour of their petals is caused by cyanidin and pelargonidin, which in conjunction with carotene creates attractive red and rosy colouration of flowers. However brown colouration is mainly caused by delphinine conjunction with carotenoids [48]. As far as anthocyanins are concerned, in roses 3-glucosides and 3-rhamnosides of pelargonidin, cyanidin, delphinidin are identified [49]. In flowers, the occurrence of carotenoids is attached with the presence of phytoene synthase, which is the first significant enzyme of biosynthetic pathway of carotenoids synthesis and this enzyme is coded in the phytoene synthase 1 (PSY1) gene, the transcription of which is most extreme in the later stages of flower development [50] [51].

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IX. NUTRITIONAL, CHEMICAL, & SENSORY COMPOSITION

While talking about nutritional composition, edible flowers can be divided into three major components which plays an important role in human nutrition. The first one is Pollen. Pollen is a very rich source of proteins, amino acids, carbohydrates [52], saturated and unsaturated lipids [53], carotenoids [54] and flavonoids [55] although it is found in very small amount. It also does not give any distinct taste.

The second component is Nectar. Nectar contains sugars (fructose, glucose and sucrose), amino acids (mainly prolin), proteins, inorganic ions, lipids, organic acids, phenolic substances, alkaloids, terpenoids etc. all in a balanced proportion. It also has a sweetish flavour [56].

The last in the list is petals and other parts of flowers. These are an important source of vitamins (yellow flowers are usually a very good source of vitamin A), minerals, antioxidants etc.

The taste of different flowers can be sensed differently by our receptors. The change in taste is mainly due to the presence of varied content of saccharose. The transport of saccharose to opened flowers and petals is in association with synthesis of ethereal oils that are typical to the smell of individual flowers [57]. The content of saccharose may increase during the course of senescence of flowers due to increase in hydrolysis of fructans. This reaction is exhibited by change in osmotic pressure which is visually seen as opening of flowers.

Although edible flowers consist nearly 70 to 95% water but carbohydrate is the most abundantly found macronutrient in majority of the edible flowers. Rose petals often gives a sweet taste to food but its carbohydrate content is much lower than that of petals of centaurea which contains nearly 88.39% (dry matter) [26]. Hibiscus [58] and whole wheat flour (72.7% dry matter) also contains lower amount of carbohydrate than centaurea petals. Since edible flowers are used in relatively small quantity in food preparations, so they can also be incorporated in carbohydrate restricted diets.

While talking about protein content few edible flower shows excellent levels of it like banana flower (*Musa* sp. var. elakki Bale) (12.5% dry matter) [59], sunflower, rose (*Rosa damascena* Mill. 'Alexandria' and *Rosa gallica* L. 'French' draft in *Rosa canina* L.), pot marigold (*C. officinalis*), dahlia (*Dahlia mignon*) and centaurea (*C. cyanus*). The amount of protein present in these may be less than compared to animal protein as for example chicken, but it is much higher than vegetables like broccoli, banana, cauliflower etc.

Lastly, different edible flower species contain different levels of fibre. The highest in the list is banana flower which contains nearly 61% (dry weight) of total dietary fibre content [60]. Sunflower disc florets also contain 59% (dry weight) dietary fibre [61]. Both these values are greater than the fibre content present in soybean (18% dry weight) which is considered as an important source of protein. Incorporation of these flowers in the human diet will help in achieving the recommended fibre intake that is 14 g/1000 kcal.

TABLE III

Table containing a list of Protein, Carbohydrate and Total dietary fibre content in edible flowers compared to other foods.

Source (g/100 g dry weight)	Crude Protein	Carbohydrate	Total dietary fibre	References
Soybean	39.3	30.8	18.0	USDA (2018g)[62]
Whole wheat flour	14.6	72.7	10.9	USDA (2018f)[58]
Banana	4.2	86.1	7.6	USDA (2018b)[63]
Chicken breast	87.0	0.0	0.0	USDA (2018a)[64]
Rose	7.6	86.1	-	Pires et al. (2017)[26]
Centaurea	5.8	88.4	-	Pires et al. (2017)[26]
Dahlia	5.9	86.0	-	Pires et al. (2017)[26]
Pot Marigold	6.4	81.3	-	Pires et al. (2017)[26]
Banana flower	12.5	1.2	65.6	Bhaskar et al. (2012)[59]
Sunflower	10.0	12.3	42.9	Liang et al. (2013)[61]
Broccoli	3.0	5.1	2.3	USDA (2018c)[65]
Cauliflower	1.9	5.0	2.0	USDA (2018d)[66]
Hibiscus	2.7	0.9	0.0	USDA (2018e)[67]

X. ANTHOCYANIN COMPOSITION IN EDIBLE FLOWERS

The presence of anthocyanins confers the flowers a boundless variety of colours, touching nearly all the visible spectra, from orange and red to purple and blue hues, making these matrices a probable foundation of these natural pigments, which can offer new colours and flavours, drawing the attention of consumers. Many edible flowers have started to stimulate awareness in the food industry due to the essential amounts of anthocyanins present in their composition. Anthocyanins have been assessed by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) in 1982 and by the EU Scientific Committee for Food (SCF) in 1975 and 1997 [68] and are certified as food colourants in the European Union with the common code E-163 regardless of their origin, showing that, at least from a supervisory point of view, they are looked upon as a group of harmless compounds [69].

The mounting unease about the exchange of artificial colourants for natural counterparts has encouraged the curiosity in the quest for new options, and in this case, edible flowers could be fascinating sources of these natural molecules. It can also be found that the most common anthocyanins present in the bulk of the flowers are cyanidin derivatives, namely cyanidin-3-O-glucoside. Yet, other key compounds can also be found, such as malvidin-3-O-glucoside (202.1 mg/kg fresh weight (FW) and delphinidin-3-O-glucoside (109 mg/kg FW) in Nelumbo nucifera (Gaertn.) [70], delphinidin-3,7-O-diglucoside (3936 µg/g DW) in Crocus sativus L. [71], delphinidin-3-O-(4"p-coumaroyl)-rutinoside-5-O-glucoside (10.2 mg/g DW) in V. tricolour [72] or pelargonidin-3-O sophoroside (591.6 mg/g DW) in Tropaeolum majus L. red variety [73].

Anthocyanins have been defined to deliver an array of health benefits, containing antioxidant, anti-inflammatory and anti-proliferative effects. Many fruits and vegetables have been validated to obstruct the initiation, promotion, and progression of several cancers, such as breast, prostate, liver, colorectal, intestinal, blood, or cervical cancers, which has been associated to their anthocyanin composition [74, 75, and 76]. Anthocyanin rich extracts from Hibiscus have shown to be able to considerably subdue rotenone-induced dopaminergic cell death via interference with microglial activation and amelioration of mitochondrial dysfunction, signifying their neuroprotective activity and capability to improve cognitive, memory and motor performances, which may have prospective application in the deterrence of neurodegenerative disorders, such as Parkinson's and Alzheimer's diseases [76].

Although a number of in-vitro and in-vivo studies have been carried out to try to exhibit the biological activity of anthocyanins, a main downside for their use is their little bioavailability, as they are considered to be poorly absorbed and highly largely metabolised, being found in blood under the form of metabolites [77]. In this respect, the use of nanotechnology can deliver likely tools for resolving the complications of bioavailability [78]. Alternatively, anthocyanin structure may also impact their activity and the molecular mechanisms involved, so that the segregation and purification of specific molecules is mandatory in order to decide their effects [76].

XI. AROMATIC COMPOUNDS OF EDIBLE FLOWERS AND THEIR HEALTH EFFECTS

It has been found that edible flowers of various ornamental plants show antioxidant and Reactive Oxygen Species (ROS) scavenging properties as well as important in exhibiting anti-inflammatory effects within our body. Various anti-bacterial, anti-viral, anti-fungal & anti-inflammatory substances have been found in the flower of rose [79-81]. The principal aromatic components of the ornamental rose flowers are 2-phenylethanol (70-80%), citronellol (7.2%), geraniol (up to 7%), nerol (4.2%), and terpenes linalool (about 3%). According to few research works, 47.5% citronellol and 18% geraniol are found in the rose oil [82, 83].

The oil obtained from marigold flowers is used commonly in America and Africa as a complementary medicine because of its anti-inflammatory activities due to the presence of about 22.5% linalool, 18.3% 2-hexyl-1-decanol, 13.4% piperitone and 7% caryo-phyllene which may exhibit some toxic effects in higher amounts rather [84, 85]. Besides, the flavonoid patuletin is responsible for the anti-bacterial and anti-fungal effects of marigold flower [86].

Hexanal, 1-hexanol, 2-hexanol, nonanal, benzaldehyde, benzylealcohol, caryophyllene are responsible for the smell of carnation flowers though the terpene caryophyllene is the key anti-inflammatory component [87]. Lilac flowers also show some anti-inflammatory effects due to the presence of various isoprenoids e.g. farnesene, linalool, myrcene, pinene, terpinene etc. [88].

The chrysanthemum flowers also exhibit noticeable anti-inflammatory, anti-microbial and also anti-carcinogenic effects due to the presence of various triterpenes faradiol, arnidiol and heliantriol etc. [89]. They also show marked anti-tubercular activity because of triterpenes (mainly arnidiol) [90].

Terpenoid β-ionone is one of the major aromatic compounds found in violet flowers which show a prominent inhibiting effect on the growth of the malignant cells and it inhibits the apoptosis of gastric adenocarcinoma cells in human [91-93].

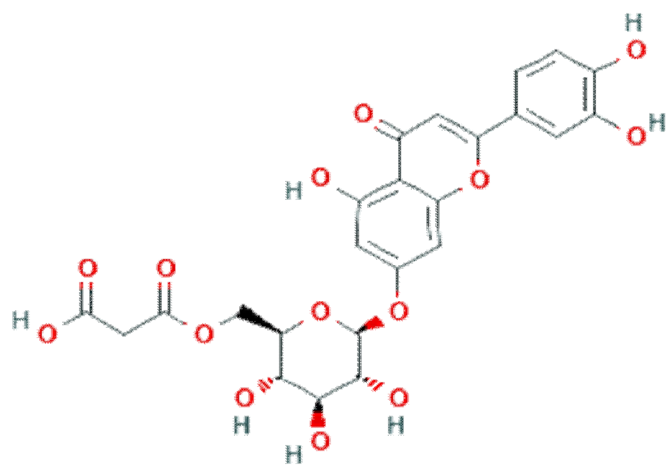
Garden marigold flowers are also mentioned due to their anti-inflammatory effects because of the presence of benzyl isothiocyanate which is biosynthesized from glycoside glucotropeolin by the splitting action of myrosin enzyme [94].

XII. ANTIOXIDANT EFFECT

Edible flowers from different ornamental plants are a potent source of numerous chemical compounds which shows antioxidant activities and inhibitive effect on free radicals [95]. Involvement of various Reactive Oxygen Species (ROS) like hydroxyl radical, nitric oxide or superoxide anion which are produced in human body under conditions of stress, high load conditions or due to various diseases are observed [96]. These species attack the molecules of DNA, protein and enzymes thereby damaging the biomembranes [97]. They also cause reaction of ROS with fatty acid chains that leads to lipid peroxidation [98]. The most important plant compounds are the ones with antioxidant effect and they consist of various phenolic compounds [99]. In edible flowers the correlation coefficient between the level of phenolic substances and the antioxidant activity is quite high [100]. Antioxidant activity plays an important role in the inhibition process of senescence of edible flowers due to the action of ROS on biomembranes which in turn results in disturbances in the semi-permeability, loss of ions and changes in the osmotic pressure of flower cells [101].

Rose flowers show significantly high antioxidant activity [102]. The species *Rosa rugosa* and *R. davurica* are very important as they strongly inhibit the effect on ROS [103]. Edible flowers contain Gallic acid- one of the essential antioxidant which helps them to retain their antioxidant content after one week of cold storage also. Other important antioxidants found are flavonols such as kaempferol and quercetin which are also found in rose petals. In chrysanthemum the antioxidant that shows significant effect against radical scavenging activity is Luteolin 7-O-(6” O-malonyl)-glucoside, which is also one of the most important flavonoid present in edible plants [104].

The antioxidant content and activity is highest in the full bloom stage, i.e. at the beginning of flowering.



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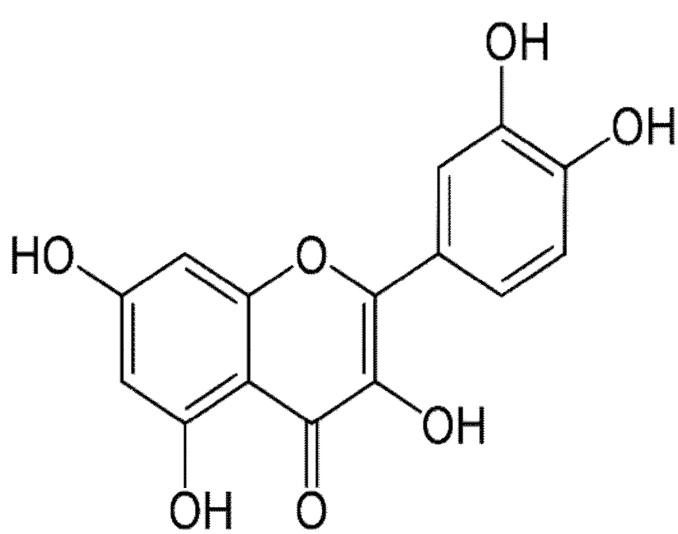

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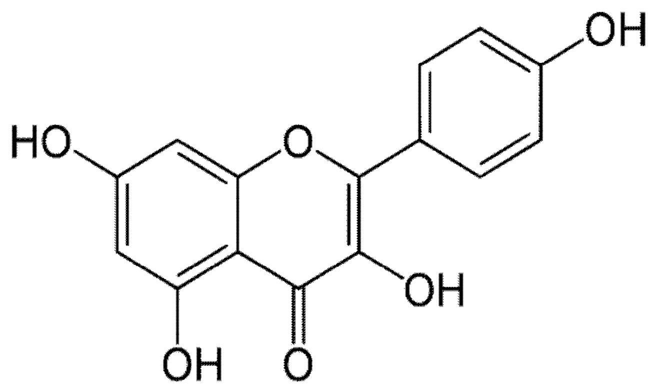

(c)

Fig.2 Figure showing Chemical Structure of Luteolin 7-O-(6” O-malonyl)-glucoside (a), Quercetin (b), and Kaempferol (c).

TABLE IV
Table containing antioxidant content of edible flowers

Edible Flowers	Main Phenolic Compounds	Content	Reference
Hemerocallis fulva L.	Quercetin Ellagic acid Chlorogenic acid	273 mg/g DW 205 mg/g DW 175 mg/g DW	Wu et al., 2018 [105]
Paeonia suffruticosa Andrews	Rutin Gallic acid Quercetin	18.1 mg/g DW 7.99 mg/g DW 7.24 mg/g DW	Xiong et al., 2014 [106]
Rosa chinensis Jacq.	Gallic acid Chlorogenic acid 3-Hydroxy-4-	6.87 mg/g DW 2.66 mg/g DW 1.09 mg/g DW	Xiong et al., 2014 [106]
Rosa rugosa Thunb.	Ellagitannin (+)-Catechin Sanguine H-2	1072 mg/100 g FW 178 mg/100 g FW 166 mg/100 g FW	Cendrowski, Scibisz, Kieliszek, Kolniak-Ostek, & Mitek, 2017 [107]
Lavandula pedunculata Mill.	Salvianolic acid B Rosmarinic acid Luteolin-7-O-glucuronide	582 mg/g DW 550 mg/g DW 84.1 mg/g DW	Lopes et al., 2018 [108]

*DW- Dry Weight; FW- Fresh Weight

XIII. CONSUMPTION OF EDIBLE FLOWERS AND ITS EFFECT

Interest in edible flowers is probably continuously growing, because of their potential health effects that are related to their chemical composition [30].

TABLE V
Table containing list of effects of the most common edible flowers.

Flowers name	Scientific name	Effects	Reference
Beach rose	R. rugosa	The hexane fraction is able to inhibit lipid peroxidation and to prevent oxidative damage, as well as, to promote free radicals scavenging.	Park et al., 2009; [109]
Marigold	C. officinalis	Exhibited potent anti-HIV activity in in-vitro MTT based assay.	Muley et al., 2009; [110]
Indian Chrysanthemum	Chrysanthemum indicum	Ethanolic extract showed anti-inflammatory activity in both acute and chronic irritant contact dermatitis in vivo, as the production of IL-1β and TNF-α was inhibited, with the subsequent blockade of leukocyte accumulation.	Lee et al., 2009; [111]
Chives	Allium schoenoprasu m	Phenolic compounds inhibit cell proliferation, useful for the treatment and prevention of tumour diseases.	Lee et al., 2011; López-García et al., 2013; [112] [113]
Roselle	Hibiscus sabdariffa	Effect on weight control in animal and cell models, effects on liver fibrosis	Kim et al., 2007; Liu et al., 2006; Huang et al., 2015; [114] [115] [116]

XIV. GENERAL AND MEDICINAL USES OF EDIBLE FLOWERS

Edible flowers are mainly used to add colour, fragrance and flavour to food products such as soups, salads, drinks etc. Besides these features, different flowers have also been described to possess anti-inflammatory, anti-oedematous, anti-HIV, anti-microbial, immuno-stimulating and immuno-modulating, spasmolytic, spasmogenic, gastro-protective, insecticidal, genotoxic, antioxidant, or anti-tumour activities [117].

The most common form of consuming edible flowers is in fresh salads such as *Bauhinia purpurea L.* which are widely enlisted in these types of meals but it can also be consumed dried or canned in sugar or incorporated in cocktails with ice cubes [118]. However edible flowers can also be preserved in distillate products or as pickles in vinegar and salt. Flowers like, *Carthamus tinctorius*, *Gardenia jasminoides*, *Lonicera japonica*, and *Rosa chinensis* are commonly consumed as infusions and also mixed in cakes. According to research these specific flowers have been reported to present significant bioactive properties, such as promoting blood circulation, restoring menstrual flow, and heat-clearing and detoxifying activities. [119]

Generally, acceptability of edible flowers depends on a number of factors, such as the social group, species of flowers, characteristics, consumers' profile, or presentation. There are some edible flowers which are consumed as a whole, but there are some flower species where only some parts should be consumed such as: [120]

1) Petals of *Tulipa*, *Chrysanthemum*, *Rosa* spp.
2) Flower buds of daisies & garden nasturtium due to their bitterness and other unpleasant flavours.

TABLE VI
Table containing list of medicinal uses of some edible flowers

Scientific Name	Common Name	Origin	Uses as food	Medicinal Properties	Compounds associated to medicinal properties
C. morifolium	Chrysanthemum, Kotobuki	Japan and China	Salad, soup, infusion, tempura, beverages, herbal medicines	Anti-inflammatory, antimicrobial antihuman immunodeficiency virus, antioxidant, antidiabetic	Flavonoids, alkaloids, phenolic compounds, triterpenes, naringenin-7-*O*glucoside, polysaccharides
Camellia sinensis L. Kuntze	Tea flower	Southeast Asia	Drinks, infusion, drinks	anti-cancer	Saponins including triterpenoid saponins
B. variegata	Cow's foot	Asia	Not described	Cytotoxic, antioxidant, anti-inflammatory, hypoglycaemic, cholesterol and triglyceride reducer	Phenolic acids, flavonols
B. perennis	Common daisy	Europe and western Asia	Salads Consumed as vegetables	Anti-inflammatory, anti-hyperglycaemic, antiaging, antibacterial and anti-cancer	Triterpenoids, favan-3-ols, polymeric procyanidins, phenolic acids
Calendula officinalis	Marigold	Mediterranean region, and Central Europe	Salads, soups and stew	Antioxidant, gastro-protective, hepato-protective, anti-inflammatory, sedative, antispasmodic, bactericidal. Treatment of injuries, ulcers and skin's afflictions. Measles, smallpox	Flavonoids, triterpenes, phenolic acids, quinones, coumarins, carotenoids, and coumarines
T. majus	Nasturtium, monks cress	South America (Peru)	Salads, culinary art	Antimicrobial, antiseptic, purgative, depurative, diuretic, expectorant, laxative, stimulant, antitumor, antithrombotic, hypotensive, throat sore, and anti- viral	Carotenoids (lutein), phenolic compounds
Sesbania grandiflora L.	Katuru murumga, Sinhala, pauk	Southeast Asia, India	Consumed as vegetables	Anticancer, antimicrobial, anti-diabetic, hepato-protective, antioxidant	Phenolic acids, hydroxycinnamic acids, flavonoids, aldehydes

XV. HEALTH BENEFITS OF EDIBLE FLOWERS

1) Edible flowers are almost free of calorie [8].
2) They are a good source of antioxidants [8].
3) Some flowers also possess anti-inflammatory effects [8].
4) They exert potent inhibitory effects against cancer of various organs such as liver, bladder, colon, breast etc. [8].
5) Few species also show inhibitory effect on obesity e.g. Magnolia, Roselle and Water lily [8].
6) Neuronal degradation that is mainly linked with aging can be prevented to some extent by the extract of Hangzhou white chrysanthemum [8].
7) Chinese hibiscus and Roselle of the *Malvaceae* family demonstrate gastro-protective and hepato-protective effects [122, 123].
8) By the in-vivo and clinical trials it has been shown that Roselle exhibit anti-cholesterol, anti-hypertensive properties [124].
9) Chinese hibiscus not only exerts contraceptive and anti-convulsive effects but also promotes wound healing, hair growth and immunity [125].
10) It has been observed that blood pressure can be diminished in acute as well as chronic cases in animal using Rose extract (20 g/kg). Besides, edible rose species also exhibit anti-HIV effects [126].
11) Chamomile ethanolic extract (20-100 mg/kg) has been shown to be effective against diabetes [127].
12) Along with Chamomile; honeysuckle and wild chrysanthemum are also suitable sources of anti-nociceptive drugs [128].
13) It has also been reported that Day Lily exerts some anti-depression effect & Hangzhou white chrysanthemum helps in sleep patterns regulation [129].

XVI. TOXICITY AND SAFETY ISSUES

Most of the edible flowers are absolutely safe to eat which includes the very common culinary herbs, but it is important to maintain proper identification. Edible flowers that we obtain from nurseries, florists or Garden centres have a chance of being treated with pesticides not safe for food crops. People with conditions like hay fever, allergies or asthma should be careful as pollen of specific plants can cause allergic reactions [8].

At present, many studies are not available that discusses about the toxicity of edible flowers, but they have found that the effects of toxicity depend on plant parts [130]. For example, the leaves of *Allium schoenoprasum*, have sulphurous substances present in their composition; but these are absent in the flowers, which is an uncommon plant part consumed [131]. Presence of some compounds like Hydrogen cyanide, Erucic acid, Coumarin and Thujone in plant parts have to follow a guidance value table set by EFSA or JECFA, which considers the Tolerable Daily Intake or Acceptable Daily Intake of these compounds, and determines the toxicity properties of plant parts [130]. For instances, *Tropaeolum majus*, when consumed in amounts higher than 39.5 g of fresh flowers, will go beyond the Tolerable Daily intake in Erucic acid [130], *Achillea millefolium* flower will exceed the Acceptable Daily Intake for Thujone when more than 18 g of it is taken and the consumption of 7 g of *Galium odoratum* flowers will exceed the Tolerable Daily Intake for Coumarin, for adults [130,132].

Impurities in edible flowers registered in the European Union rapid alert system for food and feed (RASFF) in the years 2004–2018.

Flower	Country of origin	Food safety issue	Year
Cornflower blossoms	Albania	*Salmonella*	2018
Magosa flower (*Azadirachta indica*)	Thailand	*Salmonella* Stanley	2017
Chamomile flower	Egypt	Rat droppings	2016
Tilia flowers	Bulgaria	N,N-diethyl-meta-toluamide	2015
Tilia tomentosa flowers	Albania	Dimethoate	2014
Hibiscus flowers	Egypt	Infested with insects and moulds, rodent excrements	2008
Cinnamon and cinnamon tree flowers (*Cinnamomum verum*)	Sri Lanka	Sulphite unauthorised	2005
Fresh edible flower	Thailand	*Salmonella* Mbandaka	2005
Dried marigold flowers/ *Calendula officinalis*	Egypt	*Salmonella* Hadar	2004

Fig.3 Figure showing impurities in edible flowers registered in the European Union rapid alert system for food and feed (RASFF) in the years 2004–2018 [133].

The data from RASFF point out that suitable growing, preservation, transport and storage of edible flowers should be paid attention to. Awareness should be created regarding the safety of these among sellers and consumers. Various kinds of growing as well as harvesting and processing conditions can expose the way for bacteria to get onto and into the plant material, including flowers. It may happen before harvest, but it is more likely to happen afterwards [134, 135]. Edible flowers are most often consumed fresh and served with foods such as salads, cakes and desserts that may constitute a good growth medium for bacteria. So, the risk of microbial impurities is of concern. Considering data regarding vegetables [136], it is somewhat likely that some edible flowers may be able to maintain the growth of pathogenic bacteria (including *Salmonella*) and, subsequently allow a rise in their concentration during their supply phases.

XVII. ROLE OF ANTI-NUTRITIONAL FACTORS IN CONSUMER ACCEPTANCE

Edible flowers, mostly known as ornamental species possess many significant qualities such as various forms, sizes, colours, textures, aromas. These collection of sensorial features prone flower's acceptability as foods although consumer's behaviour regarding acceptance of any type of food is individual and influenced by demographic (age, gender, income), geographical (region/location in which the individual resides), and individual characteristics (chronic diseases, ethnicity, religious beliefs and psychological conditions) [137]. Since mostly gourmet dishes feature edible flowers, personal features of the consumer such as education, income and gender also affect acceptability [138]. In general, beauty and colour of the flowers arose the interest of the consumers while features like biological properties were usually secondary for most of the consumers [139].

Colour is a critical factor in the choice of edible flowers [140] after which comes; shape, appearance and size of the flower hold the most value. Roses, for example, are used in salads and for preparation of jellies, while marigold in savoury dishes; chrysanthemum is commonly consumed as infusions [141] and as ingredient for food products, like yogurts [140].

Aroma is also an essential aspect, since the fragrance fascinates consumers, spurs interest and encourages intake and flowers bring an unusual aroma and flavour to preparations [142]. Roses and pansy for example, have sweet and perfumed essence while orange calendula and chrysanthemum are bitter. Nasturtium, which can be of various colours, has peppery and spicy flavour [9].

In total, it is clear that there are two factors which are most vital in defining consumption of edible flowers. The first one is the visual perception, with colour being the first sensory trait perceived by the consumers. As flowers are much pigmented, colours arise interest, the second deciding aspect. Only after eating, the consumer abides by the other sensory traits such as taste, texture and aroma. Therefore, a pleasing sensory experience joined with the search of health makes edible flowers good alternatives and potential foods that can be introduced into a balanced diet.

XVIII. CONCLUSION

It is clear that in the upcoming years, there are immense possibilities of a rapid increase in the consumption of edible flowers. These flowers have been attributed to possess a sound nutritional profile, being a rich source of fibres or even proteins, with very meagre lipid content, thus meeting several dietary demands including vegetarian and vegan. Moreover, the visual appeal due to the varied colours and shapes associated with the relevant antioxidant activity of most edible flowers fit well into the current trend of yearning after natural and healthy foods. Besides adding colours to our plate, edible flowers have several health benefits. Many underutilized plant species can be used in innumerable ways apart from their mere consumption. It's well-nigh essential to identify such plant species and find suitable measures to identify their properties. Researches should be conducted as much as possible to fully utilize edible flowers. This will ultimately lead to the acceptability of edible flowers as potential food ingredients and also help in avoiding the potential hazards. However, edible flowers should not have any kind of toxicity or chemical treatment, such as the use of pesticides, fertilizer with untreated manure, and hence they must be cultivated in an entirely organic way.

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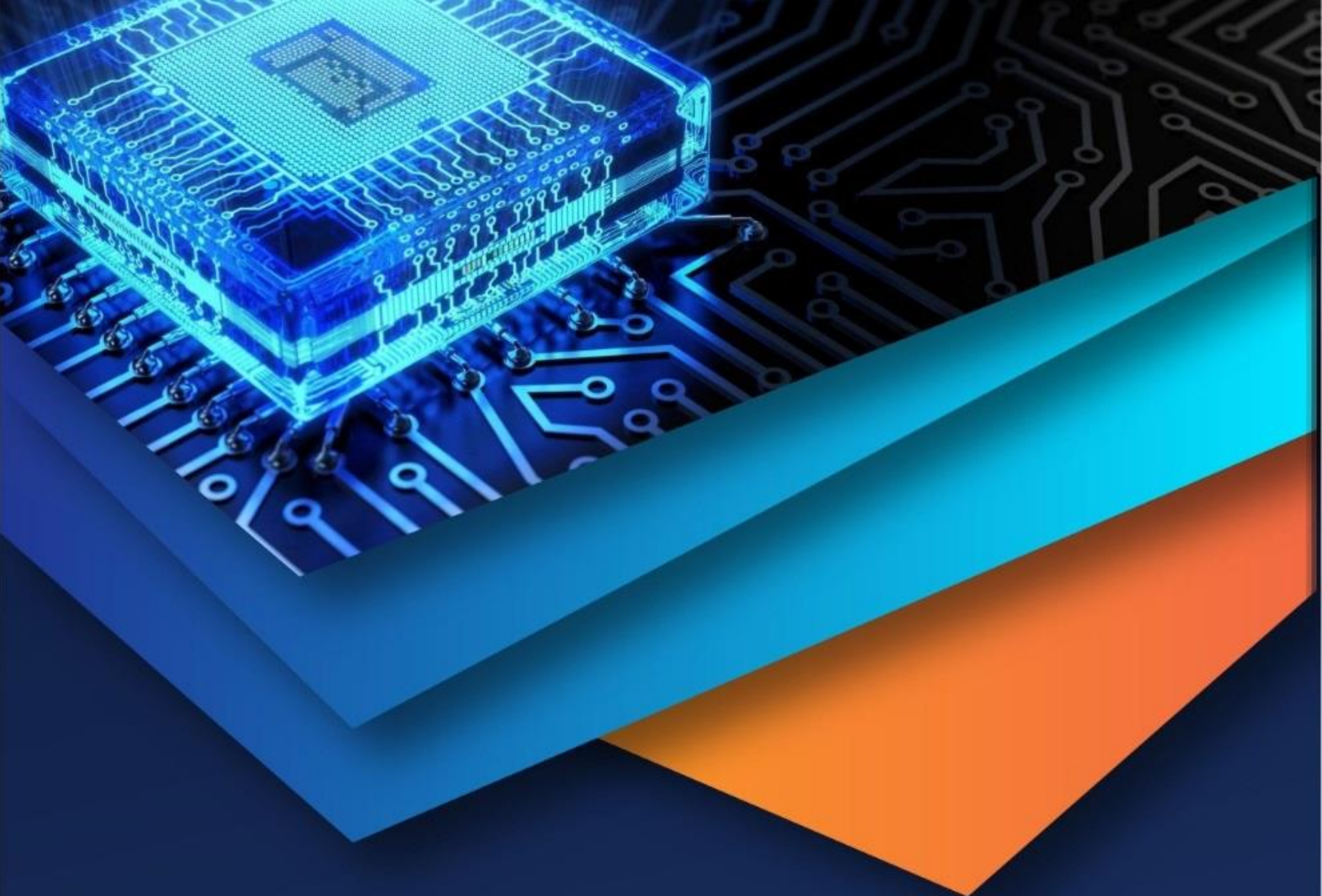

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