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Health Benefits of Flowers and their Value-Added Products

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Abstract: This paper is aimed to study the health benefits of flowers and their value-added products. Flowers play an essential role in human nutrition and diet. Several studies have shown that flowers are not only edible but also an excellent source of nutrients and medicinal properties. However, it should be noted that not all flowers are edible, and their selection should be done after proper research. This review of the research literature shows the properties and health benefits of flower-based decoctions. According to research, flowers are an excellent source of phytochemicals and have anti-inflammatory, cholesterol-lowering, anti-cancerous, anti-obesity, anti-fungal, anti-diabetes, and anti-bacterial, anti-ulcer, and antitussive properties. Studies have shown that flowers are being used to make decoctions in different parts of the world to cure and treat diseases. This review also discusses several studies carried out on animals to evaluate the effects of different flowers in treating induced conditions such as cancer, diabetes, obesity, liver problem, and inflammation. The results obtained proved that flowers are a promising source in the prevention, curing, and treatment of diseases that are prevalent in most parts of the world. Despite flowers having many health benefits, they should be taken in moderation as they also contain anti-nutritional factors which may interfere with the absorption of nutrients.

Index Terms **- Edible Flowers, Phytochemicals, Decoctions, Health Benefits, Anti-Nutritional Factors**

1.0 Introduction

Flower is the part of a plant that is often brightly colored and has a pleasant smell. Many of the flowers have found their use in food preparations and the edible flowers are defined as nontoxic, innocuous flowers with health benefits (Alasalvar et al., 2013). Like fruits; vegetables, spices, leaves, nuts, flowers are also part of nature's roster of nutrition providers for us. many of the edible flowers have gained popularity as a creative and innovative ingredient in the culinary world, due to their unique flavors, textures and colors,. The edible part varies in different flowers like petals of Tulipa (Tulipa gesneriana L.), Chrysanthemum (Chrysanthemum morifolium), Rosa spp., Marigold spp.; the flower buds of daisies (Bellis perenis), garden nasturtium (T. majus) and the inner petals and bracts of banana blossoms (Musa x paradisiaca). The flowers have been used for food and medicinal purpose since ancient times. Early reports indicate that flowers have been used for cooking since ancient times in the Romans, Chinese, Middle Eastern and Indian cultures. The major edible flowers in India are rose(Rosa hybrida), hibiscus(Hibiscus rosa-sinensis), marigold(Tagetes erecta), banana blossoms(Musa acuminate colla), fennel flowers(Foeniculum vulgare), squash/pumpkin blossoms(Cucurbita pepo), sunflowers(Helianthus annuus), lavender(Lavandula angustifolia), jasmine(Jasminum sambac), violets(Viola indica), dandelions(Taraxacum officinale), chrysanthemums(Chrysanthemum indicum) etc. The flowers add color and aroma to the food and increase their aesthetic appeal and acceptability (Dadlani, 2017). Flowers are often added to beverages as flavorings, or utilized to make beverages like herbal teas and wines. They are put on to spreads such as butter or fruit preserves, and to vinegar, marinades, and dressings. Edible flowers not only add color to our plate but are also a rich source of phytochemicals like flavonoids, carotenoids, anthocyanins, total phenolics etc., present numerous health benefits and are also used for therapeutic purposes. This paper discusses in detail the nutritional and phytochemical composition of flowers ad their health benefits.

Flower		Carbohydrates	Proteins	Fat	Ash	Moisture	Reference	Total Phenols		Total Flavanoids	Reference
Rose flower (***Rosa x grandiflora***)		9.41 %	1.88 ±0.042	_	0.72± 0.008	84.56 ±0.122	Franzen et al, 2019	***Rosa kordesii*** petal Extract	mg GAE/g	mg catechin/g	Belal et al., 2016
								Aqueous	461.93 ±3.24	78.11±2.00	
								methanolic	349.59 ±3.62	168.22±2.29	
								n-hexane	42.42± 1.71	45±2.00	
Marigold	***(Tagetes erecta)***	14.15 ± 1.24	1.32 ± 0.01	0.32 ± 0.02	0.80 ± 0.05	83.39 ± 0.17	González et al., 2015	***Tagetes erecta*** Extract	(mg GAE/g extract)	(mg GAE/g extract)	Siddhu and Saxena, 2017
								Chloroform	15.45± 0.44	7.05±0.66	
								Ethyl acetate	44.47± 0.58	13.28±0.66	
								Methanol	49.76± 0.29	13.43±0.43	
	Calendula officinalis	5.62 %	1.20 ±0.014	_	0.93± 0.005	89.34 ±0.100	Franzen et al, 2019	***Calendula officinalis*** Extract	mg GAE g-1	mg GAE g-1	Velikovic et al., 2014
								Water	45.13± 0.0	0.12±0.00	
								Ethanol	31.86± 1.1	0.10±0.00	
								Ethanol-water	29.79± 0.7	0.17±0.00	
Banana blossoms	**Poovan**	95.23±0.77	1.99 ±0.19	0.43 ±0.03	3.21± 0.12	90.1± 1.05	Krishnan and Sinija, 2016	Ethanol extract (% in gm)	1.92±0.02	0.669±0.002	Joseph et al., 2014
	Monthan	95.61±0.98	1.43 ±0.17	0.54 ±0.03	2.42± 0.19	90.23 ±0.67		Methanol extract (% in gm)	1.07±0.01	0.596±0.005	
Lavendar flower (***l. angutifolia***)		40.53%	11.65%	2.77 %	9.22 %	6.40 %	Gharib et al., 2013	1.13-1.14 mg g^{-1} d.m.	0.86-0.91 mg g^{-1} d.m.		Skwiezynska and Dzieciol, 2017
Sunflower (***Helianthus annuus***)		7.57 %	1.75 ±0.011	_	1.25± 0.005	86.45 ±0.377	Franzen et al, 2019	18.2±0.62 (mg (+)-catechin eq/g)	_		Karamac et al., 2012
Hibiscus ***Hibiscus rosa-sinenis***		_	1.54 g/100g	0.35 g/100g	1.40g /100g	83%	Bahuguna et al., 2018	0.25 mgGAE /100g	1.6 mgCE/100g)		Vankar and Srivastav, 2008

Table1. Edible Flowers and Their Bioactive Composition

Edible Flowers	Vitamin c	Calcium	Iron	Zinc	Sodium	Potassium	Reference
Rose	0.2mg	120mg	3.7 mg	-	-	-	Vijayanchali, 2017
Marigold (*Tagetes erecta*)	-	0.110±0.042 m/100g	1.026±0.052mg /100g	0.568 ± 0.093 mg/100g	0.015 ± 0.007 mg/100g	0.215 ± 0.007 mg/100g	González et al., 2015
Hibiscus (*Hibiscus rosa-sinensis*)	7.502mg	4.32 mg	1.48mg	0.82mg	-	236.45mg	Bahuguna et al., 2018
Lavender Flowers	-	-	1767.0 ppm	39.84 ppm	-	-	Gharib et al., 2013
Banana Blossoms	-	687 ± 0.00 mg/100g	158.13 ± 1.84 mg/100g	22.53 ± 0.23 mg/100g	4.7 ± 0.00 Mg/100g	6480 ± 0.01 mg/100g	Florent et al., 2015

Table2. Nutritional Composition of Edible Flowers

2.0 Health Benefits of Edible Flowers:

Many research has proven that the phytochemicals present in edible flowers contribute to health benefits such as antioxidant activity, anti-inflammatory properties, anti-bacterial, immune-stimulatory action, and so on. Edible flowers provide such benefits when used in the human diet as they contain bioactive compounds.

2.1 Anti-Inflammatory Properties:

Many edible flowers exhibit anti-inflammatory activity (Lu et al., 2016). Hajhashemi et al, 2018 studied the analgesic and anti-inflammatory effect of hydroalcoholic extract of Rosa damascena. The hydroalcoholic petal extract was given at a dose of 250, 500, and 1000 mg/kg, and also essential oil at the rate of 100, 200, 400 µl/kg to the male Wister rats and male mice weighing 160-200g and 25-30g, respectively. It was observed in the study that the extract at higher dosage considerably reduced the carrageenan-induced paw edema. However, the essential oils failed to display any analgesic and anti-inflammatory effects. In this study, it was concluded that the hydroalcoholic extract of Rosa damascena exhibits anti-inflammatory activity.

In another study, the floral bioactive sample of *Tagetes erecta* Linn 150µg/ml exhibited a potent anti-inflammatory effect. The anti-inflammatory activity of *Tagetes* can be attributed due to the presence of flavonoids and salicylic acid. Flavonoids and salicylic acid were analyzed for anti-inflammatory effect with RAW 264.7 macrophage cells. Different concentrations of flavonoid and salicylic acid were prepared i.e. 50, 100, and 150 µg/ml, and analyzed for NBT (Nitroblue tetrazolium) reduction at 570 nm. It was reported that NBT reduction increased as the concentration of bioactive compounds increased. The maximum reduction was observed at 150 µg/ml and minimum at 50 µg/ml i.e. 25.26% and 19.6%, respectively. Based on this evidence it was also proposed in this study that the flavonoid would be the anti-inflammatory active drugs shortly (Devika and Koilpillai, 2015).

2.2 Anti-Cancer Property

Ghellar et al., (2017) anti-mutagenic effect of *Hibiscus sabdariffa* aqueous extract on rats treated with monosodium glutamate. An aqueous extract infusion of the flower was prepared. In this study, according to the procedure of Campos et al (2008), male Wistar rats were subjected to obesity-inducing treatment with monosodium glutamate. The animals were divided into 4 groups (8 animals each). (Group1)- on day 15 control-treated with water and intraperitoneally injected with NaCl (0.9%), (Group 2)- on day 15, cyclophosphamide was treated with water and 25 mg/Kg b.w of intraperitoneal cyclophosphamide , (Group 3) on day 15, treated with *H. sabdariffa* and 25 mg/Kg b.w of intraperitoneal cyclophosphamide, and (Group 4)- on day 15, treated with *H. sabdariffa* and intraperitoneally injected with 0.9% NaCl. The study showed that the group treated with *H. sabdariffa* aqueous extract and cyclophosphamide exhibited 91% ($p < 0.001$) reduction in the frequency of micronuclei in polychromatic erythrocytes of bone marrow when compared to the positive control group. It was also found that *H. sabdariffa* had an impact on the weight of the rats which made them gain less weight in comparison to the other test groups. Based on the results obtained from this study *H. sabdariffa*

L. showed the potential protecting effect to cancer-induced damage to DNA of the animals treated and is a promising chemopreventive agent against carcinogenesis.

2.3 Anti-Diabetes Activity

Afiune et al., (2017) conducted a study on the beneficial effects of *Hibiscus rosa sinensis* flower aqueous extract in pregnant rats along with diabetes. In this study, diabetes was brought on by streptozotocin (STZ, 40 mg/kg) in mature female Wistar rats. Following this, the rats were copulated and divided into four different groups (11 animals in a group) as non-diabetic, non-diabetic treated, diabetic, and diabetic treated. during pregnancy, an aqueous extract of *Hibiscus rosa-sinensis* had been given orally to the rats in the treated groups. It was observed that the non-diabetic treated group showed a decrease in high-density lipoprotein cholesterol, an increase in the atherogenic index (AI) and coronary artery risk index (CRI), in addition a rise in pre-implantation loss rate compared to the non-diabetic group. In the diabetic treated group, it was observed that there was an increased maternal and fetal weight reduction in atherogenic index (AI) and coronary artery risk index (CRI), and reduction in pre-implantation loss rate when compared to the untreated diabetic group. The results given from this study showed that *Hibiscus rosa sinensis* was beneficial to pregnant diabetic rats as well as their offspring but they further concluded that the same treatment could not be used in human beings as it can be dangerous during pregnancy (Lakshmi et al 2014).

Ju et al, (2014) studied the anti-diabetic effects of red rose flowers on streptozotocin-induced diabetic mice. Dried flowers were homogenized and processed both with and without browning for 48–96 hrs at 80 °C with moisture less than 84%. Male mice were induced with streptozotocin (STZ, 70 mg/kg) that destroys the β-cells of the pancreas and causes type 1 diabetes (Goldberg et al., 2004). The mice have been divided into various groups i.e. water control group, non-browned rose extract group, 48 hr browned rose group, 72 hr browned rose group and 96 hr brown rose group. Blood samples were collected from the mice and taken for testing. It was found that the extent of the blood glucose level inhibition after 5 days of the treatment was somewhat lower in the groups treated with browned rose flowers than with fresh rose flowers. After this study, it was concluded that the prepared rose flower extracts had a significant impact on the healing of liver damage in diabetic mice.

2.4 Anti-Obesity Property

Song et al., (2019) studied anti-obesity effects of the *Prunus persica* flower in high-fat diet-induced obese mice. The dried flower extract was first prepared at 100°C for 2 hours in reflux with 20 times (v/w) the volume of distilled water, and then extracted with 15 times (v/w) the volume of distilled water in the same manner. Male C57BL/6 mice (3 weeks old) were chosen for this study and were kept in standard laboratory conditions. Male mice were selected as they're more prone to obesity than female mice (Hong et al., 2009). The animals were divided into four groups comprising of twelve animals each. . Group 1 was given a normal diet, Group 2 was the control group received a high-fat calorie diet with 60% kcal fat, Group 3 was given a high-fat diet + 0.2% *Prunus persica* flower extract and Group 4 received a high-fat diet +0.6% flower extract of *Prunus persica*, corresponding to approximately 200 and 600 mg/kg/day, both. The body weight and amount of food taken were measured twice a week and this last a period of 8 weeks. It was observed that mice fed with a high-fat diet experienced a considerable increase in body weight and weight gain when compared to the normal diet-fed group. In contrast to those in the high-fat diet control community, the groups who obtained a high-fat diet containing 0.2 percent and 0.6 percent Prunus persica flower extract had significantly lower body weight and body weight gain at eight weeks. At the end of the study, it was noted that the control group's abdominal fat weights were nearly four times higher than the usual group's, suggesting that a high-fat diet induced obesity in mice. When compared to the high-fat diet control group, the addition of 0.2 percent and 0.6 percent Prunus persica extract effectively diminished overall and individual (epididymal, perirenal, and mesenteric) fat pad weights, hence it can be concluded that *Prunus persica* has anti-obesity effects.

Joo et al., (2020) studied the anti-obesity effect of fresh and browned *Magnolia denudata* flowers in a high-fat diet murine mode. In this study, flowers of *magnolia* were dried first. then homogenized and are processed for one week at 90°C under 75% humidity, which was maintained under supersaturated conditions along with sodium chloride (Sordo et al., 2019). Both fresh (FMFE) and browned flower (BMFE)samples have been extracted and then lyophilized to create a powdered extract. Male C57BL/6J mice (aged 4 weeks) were chosen and sorted into eight groups of six: Group 1- normal diet control group (ND), Group 2- high-fat diet control group (HDF), Group 3- FMFE 250 mg/kg group, Group 4- FMFE 500 mg/kg group, Group 5- FMFE 750 mg/kg group, Group 6- BMFE 250 mg/kg group, Group 7- BMFE 500 mg/kg group and Group 8- BMFE 750 mg/kg group. It was observed that the bodyweight of mice in the high-fat diet group was higher than that of mice in the regular diet group by week ten, with an average difference of 7.6 g. Besides body weights were remarkably lower in FMFE and BMFE groups than HFD group and the lowest weight gain was recorded in the 750 mg/kg dose than in comparison with 250 and 500 mg/kg doses. The results taken from this study indicate that *Magnolia denudata* has the capacity to be used as a dietary supplement to prevent and reduce obesity and obesity-related disorders. However, more research has to be done to interpret the biological effects of *Magnolia denudata* on obesity-related disorders and to explain its impact on the health of human beings.

2.5 Antitussive Property

Shafei et al., (2003) studied the antitussive effect of *Rosa damascene* in guinea pigs. The researchers prepared two extracts from the flower i.e. ethanolic and aqueous. Male and female guinea pigs weighing between 500g-600g were chosen for this study. Ethanolic extract was administered at concentrations of 5 and 10%, while the aqueous extract was given at a concentrations of 10 and 20%. The number of coughs recorded in the higher concentrations of the extract was less than those recorded at the lower concentrations. In this study, it was concluded that the antitussive effect of *Rosa damascene* was similar to the codeine at the concentrations used.

Boroushaki et al., (2004), studied the antitussive effects of *Portulaca oleracea L.* in guinea pigs. Guinea pigs weighing between 500-600 mg were used for this study. Four different aerosols were prepared using normal saline solution, boiled extract (2.5% w/v), boiled extract (5%w/v), and (0.03g/ml) codeine solution positive control. For seven minutes, the animals were exposed to a 0.1 g/ml citric acid aqueous solution. It was observed that As compared to the normal saline solution, both boiled extract concentrations triggered a decrease in the amount of citric acid induced coughs. There was also a significant difference in cough numbers between

the 5 percent extract and the codeine solution. The effective concentration of extract that caused a 50% reduction in coughs was discovered to be 4.5 percent.

2.6 Anti-Cholesterol Activity

Liyanage et al., (2016) studied the hypocholesterolaemic and hypoglycaemic impact of banana blossom in high cholesterol fed rats. For 4 weeks, Experimental groups were fed with two diets (0.5% cholesterol (CD) and 0.5% cholesterol+ 21% banana blossom powder (CDB)) comparing with casein as the basal diet (CN). Serum total cholesterol was found to be Lower ($P < 0.05$) in CDB fed group, and 21% banana blossom in the CDB showed a decrease in body weight. Both CD and CDB fed groups had lower serum HDL cholesterol levels than the CN fed group. When compared to CD fed groups, serum Non-HDL-C levels were lower (P 0.05) in both CN and CDB fed groups. So in this study, it was found that CDB fed group had lower Serum total cholesterol, non-HDL-cholesterol level, and serum glucose concentrations. Based on this, it was suggested that experimental diets containing banana blossoms could modulate the hypocholesterolaemic and hypoglycemic response.

2.7 Anti-Bacterial Activity

In a study, it was proved that most of the extracts of *Hibiscus rosa sinensis* showed antibacterial activity against human pathogens such as *E. coli, B. subtillis, P. aeruginosa, S. aureus, streptococcus sp. Salmonella sp*. Cold extraction showed maximum inhibition zone against B. *subtillis*, *E. coli* i.e 17.00 ± 2.91 and 14.50 ± 1.71 mm, followed by hot extraction against *E. coli*, *Salmonella* sp. as 11.66 ± 3.14 and 10.60 ± 3.09 mm. The highest zone of inhibition was found in the methanol extraction against *B. subtillis, E. coli* as 18.86 ± 0.18 and 18.00 ± 1.63 mm. ethanol extraction showed utmost zone of inhibition recorded against *Salmonella* sp. at 20.40 ± 1.54 mm. on this basis it was proposed that flower material may be used as a substituent of antibacterial agent (Ruban and Gajalakshmi, 2012).
Jahan etal., (2010) studied the antimicrobial activity of banana blossom extract against Gram-positive and Gram-negative bacteria (*Bacillus subtilis, Bacillus cereus, and Escherichia coli*). Ethanol, chloroform, and water extracts were used. Results showed that chloroform and water extracts had a negligible bacterial effect but the ethanolic extract showed the best antibacterial activity against bacteria *Bacillus subtalis* and *Bacillus cereus* at 20.0 % (v/v) concentration.

2.8 Antioxidant activity:

Petrova et al., (2016) studied the antioxidant capacity of five different edible flowers i.e *Tagetes erecta* L, *Calendula officinalis* L., *Geranium macrorrhizum* L., Bougainvillea spectabilis Willd, Helinathus tuberous L. For all of the flowers studied, there was a direct correlation between antioxidant activity and total phenolic material. It was reported that the 95% ethanol extract of Geranium macrorrhizum L. has the highest antioxidant activity i.e 242.9 mM TE/g fw (DPPH assay) and 106.3 mM TE/g fw (FRAP assay), and then by Helianthus tuberosus L. 80 % methanol extracts - 151.9 mM TE/g fw (DPPH assay) and 107.5 (FRAP assay), respectively. The third promising source of antioxidant was 95% ethanol extract of Tagetes erecta L with 73.2 mM TE/g fw (DPPH assay) and 76.6 mM TE/g fw (FRAP assay). Water extract of Calendula officinalis L showed the lowest antioxidant capacity i.e – 0.3 and 2.2 mM TE/g fw for both DPPH and FRAP assays. On this basis, it was suggested that the flowers tested could be used as new sources of safe natural antioxidants in the food industry.

Vinokur et al, (2006) studied the antioxidant activity of different rose cultivar. Rose tea was made with dried petals, and green tea was used as a control antioxidant-rich beverage. Rose petal teas showed antioxidant activity that was equivalent to green tea. The scavenging ability of tea from various rose cultivars ranged from 712.7 to 1770.7 μM Trolox equivalents (TE) per g dry petals, compared to 1227.6 M TE/g dry weight in green tea. The varieties San Francisco, Katharina Zeimet, and Mercedes, as well as the essential-oil-bearing rose Rosa damascena, had the highest antioxidant activity values in this study.

Kumaresan et al, (2019) conducted a study on antioxidant activity in flowers of Jasminum multiflorum. Different solvents were used for extracts and found that the maximum reduction of free radicles was found in the ethanolic extract (252.4 ±2.41 μg/ml) and minimum in aqueous extract (556.6 ±1.51 μg/ml) of *Jasminum multiflorum.*

2.9 Hepatoprotective Property

Hepatoprotective property is found in marigold flower (*T.erecta*). Hepatoprotective behaviour in *T. erecta* may be due to the presence of phytochemicals such as flavonoids, terpenoids, and steroids. (Defedius et al., 2003)
Giri et al., (2011) studied the hepatoprotective effect of *Tagetes erecta* against carbon tetrachloride induced liver damage in rats. Fresh tagetes flowers were collected, dried, and ground into a coarse powder which was extracted with 80% ethanol in water following the Soxhlet method. In this study, Wistar albino rats (150-200g) of either sex were used. The rats were then divided into 4 groups (6 animals each). Group one was used as the control and kept on a normal diet and was injected with 0.2mL/kg intraperitoneal injection liquid paraffin one time daily the Group two, three, and four groups were given dosage orally of CCI4 (1875 mg/kg body weight. Further group three and four were given silymarin (100mg/kg by mouth) and extract of *T. erecta* (400mg/kg, by mouth) respectively once daily for seven days, and animals were studied for changes in clinical signs and body weight. It was found that in comparison to normal animals there was a significant ($p<0.0001$) increase in serum ALT, AST, ALP, and bilirubin levels in CCL4 intoxicated groups. *T.erecta*. given orally at 400 mg/kg caused a significant decrease in serum marker enzymes and bilirubin levels almost to the normal levels. The liver of rats treated with 400 mg/kg extract and CCI4 displayed significant recovery except for cytoplasmicity compared to the other groups and is a commonly used model for screening anti-hepatoprotective or hepatoprotective activity of drugs.
Jeong et al., (2013) studied the hepatoprotective effect of *Chrysanthemum indicum* L. water flower extract. 100g of flowers were ground and were decocted with one liter of water then the extract was lyophilized and dissolved in saline solution. In this research, it was reported that liver damage was caused in rats by an oral gavage of a 1:1 (v: v) mixture of CCl4 and olive oil in male Sprague Dawley rats (180-230g)(Miyazawa et al, 1990). The animals were divided into five groups (9 animals each); Group I (untreated)

rats were given olive oil (1 mL/kg body weight), Group II (control) rats were given CCl4; olive oil (1 mL/kg body weight), Group III (positive control) rats were given silymarin (50 mg/kg body weight), and Group IV&V rats were given Chrysanthemum indicum L. flower extract were given daily at 50 or 100 mg/kg BW dosage by oral gavage for 7 days prior to treatment with CCl4:olive oil. It was observed that rats that received 50 mg/kg bodyweight treatment experienced a reduction in the serum levels of GOT levels when compared with the control group. On the fore, it can be concluded that *Chrysanthemum indicum* flower has hepatoprotective properties.

2.10 Immuno-Stimulatory Action

In a study immunomodulatory activity of hydro-alcoholic flower extract of *Hibiscus rosa sinensis Linn* was investigated. It was found that the Primary and Secondary Antibody titer was observed when rats have been treated with *Hibiscus rosa sinensis* (Hydroalcoholic extract) (75, 150, and 300 mg/kg, p.o.). humoral immune response was evidenced by an increase in the antibody titer in the blood of rats. It was also concluded that hydroalcoholic extract of *Hibiscus rosa sinensis* is a potent immune stimulant and can be used as a complementary therapeutic agent (Gaur et al., 2009).

3.0 All the Edible Flowers and Their Parts of Health Significance

FLOWER	PARTS USED/ CONSUMED	PHYTOCHEMICALS	HEALTH BENEFITS	REFERENCES
Hibiscus Sabdariffa	Calyxes, leaves and flowers	Flavonoids, Thiamin, Riboflavin, Ascorbic Acid	Helps in making lower blood pressure, Boost liver health, Packed with antioxidants, could promote weight loss also	(ikram, 2008)
Roses *(Rosa spp.)*	Leaves. Root barks, Petals, Essential oil	Flavonoids, Carotenoids, Organic acids, Galactolipids	Acts as a natural coolant, Fights depression, Promotes healthy heart, Anticancer, As a cooling and digested aid	(yang, 2017)
Jasmine Flowers *(Jasmine officinale, Jasmine Nudiflorum*)	Petals	Coumarins, cardiac glycosides, phenolics, flavonoids, saponins, essential oils, the steroids	Used in eye diseases, ulcers, Acts as antioxidants in body, protects cell against free radical damage, skin related diseases and itching, anti inflammatory, antiseptic properties used in treatment of depression, good for teeth related diseases also	(Lu, 2015)
Sunflower *(Helianthus annus)*	Seeds, flowers and tender leaf petioles	Vitamins, minerals, polyunsaturated oils and other nutrients	Helps improve cholesterol levels, Support bone health, Promotes healthy detoxification, Support the health of skin, Can assist cancer prevention	(Putt, 1997)
Pumpkin flowers *(Cucurbita pepo)*	Flowers, leaves, seeds, stems and pumpkin skin	Vitamins, minerals, Terpenoids, tannins, lignans, flavonoids, iso flavonoids	Treatment of common cold, Male infertility, Ensure healthy eyes, Production of reactive oxygen species that fights pathogens, helps to enhance the immune system of the body, protects us from cold and cough	(Tlili, 2020)
Mint Flowers	Leaves, roots, interior of flower stalks	Alkaloids, flavonoids, polysaccharides, lectins, chlorophyll, polyacetylenes	Treats dizziness, nausea, helps in improving brain function, relieves breastfeeding pains, improves dental health	(Lawrence, 2006)
Marigolds *(Calendula officinalis)*	Petals, leaves	Alkaloids, tannins, flavonoids, saponin, terpenoids, glycosides, carbohydrates, phenolic compounds, lipids, steroids, tocopherols, terpenoids, quinones, carotenoids	It supports skin healing, contains anti- inflammatory properties, helpful in soothing the mucus membranes of throat, shows diverse pharmacological activities, cures the mouth ulcers	(Chitrakar, 2019)

Day lily *(Hemerocallis)*	Petals, flower bud, shoots	Phenolic acid, flavonoids	Flower extract used as blood purifier, Tea made up of rhizomes is used as diuretic, treats common cold and coughing	(Saraiva, 2017)
Rosemary *(Salvia Rosmarinus)*	Leaves	Tannic acid, terpeniol, borneol, cineole, flavonoids, rosmarinic acid, limonene	Oil of rosemary used to promote hair growth, used to prevent baldness and treat dandruff, rich source of antioxidants, helps to improve immunity system, used in digestive system including appetite, blood circulation	(Aljabri, 2020)
Fennel flowers *(Foeniculum Vulgare)*	Strongly flavored leaves, leaves, fruits, fruits of fennel parts	Phenylpropanoids, high in plant compounds and antioxidants, flavonoids, quercetin, limonene	Decrease inflammation, relieve menstrual pain, may help in stomach or gut disorders,	(Hanif, 2020)
Radish flowers *(Raphanus Sativus)*	Leaves, flowers, roots	Amino acid, terpenoids, tannins, saponin, alkaloid, sterols, aromatic acids,	Treats problems like jaundice, piles, urinary problems and helps in prevent cancer	(Singh, 2020)
Lavender flowers *(Lavandula)*	Leaves, flowers, stems, buds	Terpenoids, saponins, tannins, hydroxycinnamic acids, chlorogenic acids	Improves mood, promote restful sleep, reduce inflammation, eliminate dandruff, soothe stomach bloating, lower skin irradiation	(Fernandes, 2020)

Table3. Health Benefits of Edible Flowers

Parts of edible flowers contain many phytochemicals and they are having lots of health benefits. The consumption of edible flowers is increasing day by day. They contributed to many health benefits like anti-inflammatory, anti-oxidant, anti-cancer, anti-obesity, and neuroprotective effects (Lu, 2015). Some newly found phytochemicals are beneficial to human health such as polysaccharides. The consumption of edible flowers in the world is taken as a part of traditional cuisine. Flowers are used as ornaments also. The species of edible flowers are considered very important as they contain high nutritional value as a source of protein and flowers contain essential amino acids. There are many modern methods for the extraction of bioactive compounds from flowers. (Takahashi, 2020)

4.0 Flower Based Decoctions

4.1 *Shatavari*

Shatavari (*Asparagus racemosus)* originated in Kashmir India, rarely used in making decoctions and it can be made by dring the flower petals and drying into powder. It is usually consumed along with milk and honey. once or twice a day is recommended. one teaspoon of dried flowers is mixed into milk and add some honey. This decoction aids in the supply among many female hormones and is particularly beneficial to women who have had hysterectomies. It also aids in the maintenance of the urinary tract, the strengthening of the immune system, and the purification of the blood. (Pandey et al, 2013).

4.2 *Ehongwa*

Ehongwa (*Bidens grantii)* – Ehongwa decoction made by *Bidens grantii* flower and it is originated in Uganda. To make this decoction, Flower petals and their leaves are dried. 1:1 ratio of both dried flowers and leaves are taken boiled with 500ml water for 20 – 30 mins. This decoction can be used as 120ml ones a day. Ehongwa helps to Boosts immunity, to prevent pregnancy disorders, and prehepatic jaundice(Okello and Kang, 2019).

4.3 *Anar*

Anar (*Punica granatum)* – Anar decoction is originated in Andra Pradesh, Karnataka, Maharashtra, and Tamilnadu, India. The Crushed Anar seeds and Flowers can be consumed directly or prepared by adding dried Anar flower in boiled water and kept for 30 mins. This helps to increases peripheral glucose utilization or inhibits glucose reabsorption, Lowers blood pressure level, and various heart diseases (Modak et al, 2007).

4.4 *Palasa*

Palasa (*Butea monosperma)* - *Butea monosperma* is only grown in tropical and sub-tropical areas of the India and Southeast Asia. Palasa can be made by its flower petals. Flowers are crushed gently and made into paste with rock sugar and milk. take 1 tsp of paste and dissolve it in 1 cup of water. It is beneficial for Anorexia, Celiac, Sprue, fever, Hemorrhoids, skin disorders, Edema, eye diseases, Rheumatism, Dyspepsia, and diarrhea (Somani et al, 2006).

4.5 *Ranawara*

Ranawara (*Senna auriculata)* – Ranawara is a popular drink originated in southern region of Sri Lanka. It is made by dried flowers. Dried Ranawara flowers are boiled in the water for 20-30 minutes and jaggery is added into it for sweet taste. This drink is free

from caffeine and it is a natural drink which helps to hydrate your body. It helps detoxifying the body naturally. It can promotes blood circulation. Well known for its ability to control sugar levels and purifies the blood and popular as herbal tea that promotes clear skin (Chandrasekara and Shahidi, 2018).

4.6 *Straw Flower Herbal Tea*

Straw Flower Herbal Tea (*helichrysum plicatum*) - Straw Flower herbal tea is a very popular tea in Turkey. This tea is made with 1:1 ratio dried flowers and leaves and boiled for 15 – 20 mins. consume 1 to 2 times per day. This herbal tea has Antihyperglycemic and it is rich in antioxidants (Aslan et al, 2007).

4.7 *Pawatta*

Pawatta (*Adhatoda Vasica)* – Pawatta plant is originated in Sri Lanka. Generally, every part of this plant can be used to make decoctions. It is made with Flowers, Leaves, and roots and boiled with water for 15 – 20 mins. Consumption can be 2 to 3 tbs two times a day. The flowers are antiseptic, insecticidal, and expectorant used to treat cough, chronic bronchitis, and asthma. The fresh flowers are used for ophthalmia. Flowers are given as an infusion to treat fever and are used in the treatment of gonorrhea, jaundice, rheumatism, and abdominal tumor (Rajamanna, 2000).

4.8 *Dandelion*

Dandelion (*Taraxacum)* – Dandelion is originated in China, North America. To make this decoction, combine 1 to 3 teaspoons chopped dandelion dried flowers and root per cup of water, and season to taste. Bring to a boil, then reduce to a low heat and cook for 10 to 20 minutes in a covered saucepan. As a general tonic, drink 1 to 2 cups per day. Dandelion is beneficial for preventing Urinary Tract Infections, its Could Promote Liver Health, Can Act As a Natural Coffee Substitute and may Soothe Digestive Ailments (Moemin and Aboraya, 2014; Yarnell and Abscal, 2009).

4.9 *Rosemary*

Rosemary flower tonic (*Salvia rosarinus)* – Rosemary is very popular in Europe. Rosemary flower tonic is used as a general tonic in Europe. This tonic is made by boiling the Rosemary flowers in clean water until the liquid reduces by half. This is consumed as tea 2 times a day. Rosemary is a supreme digestive aid. It is a simple solution for headaches. Its ability to thicken and often regrow hair. Can be a helpful strategy in coping with stress and anxiety 9 Combs, 2016).

4.10 *Ashok*

Ashok (*Sarasa asoca)* – Ashok is originated in E. Asia - India, Sri Lanka, Bangladesh, and Myanmar. This decoction is prepared by drying *Sarasa asoca* flowers and leaves. The mix of Dried Powdered Flower and leaves is used as tea with warm water. The flowers are diuretic. It is a flower extract that is effective in the treatment of haemorrhoids and dysentery. The flowers can also be used to treat scabies in children and a variety of other skin conditions (Kauser et al, 2016; Kapoor, 2001).

4.11 *Nageswar*

Nageswar (*Mesua ferrea)* – Nageswar is originated in India, Sri Lanka, Nepal, Burma, and Thailand. The flowers are used for making this decoction. First, flower petals are dried and 1 – 3 g of powdered flower mixed with water or with warm water. This decoction is useful in skin decease like leprosy, itching, erysipelas, scabies, wounds, and excessive sweating as it provides fragility and transparency to the skin (Chauhan, 2019).

Product	Region	Recipe	Claimed health benefit	Reference
Shatavari (*Asparagus racemosus)*	Kashmir, India	Mix one teaspoon of the powder in a glass of milk along with honey.	It is a strong Ayurvedic rejuvenative. This decoction aids in the supply among many female hormones and is particularly beneficial to women who have had hysterectomies. It also aids in the maintenance of the urinary tract, the strengthening of the immune system, and the purification of the blood.	Pandey et al, 2013
Ehongwa(*Bidens grantii)*	Uganda	Add 1:1 ratio of dried flowers and leaves for 500ml of water and boil it for 20 – 30 mins and drink 120ml per day.	Boosts immunity, Pregnancy disorders, prehepatic jaundice	Okello and Kang, 2019
Anar (*Punica) granatum)*	AndhraPradesh, Karnataka, Maharashtra and Tamil Nadu, India.	Direct consumption of Crushed anar seeds and flowers Or put dried anar flower in to boiled water and keep it for 30 mins.	Hypoglycemic, increases peripheral glucose utilization or inhibits glucose reabsorption, lowers blood pressure level, prevent various heart diseases.	Modak et al, 2007

Palasa (*Butea monosperma)*	Tropical and sub-tropical region of the India and Southeast Asia	200 g herbal paste prepared from flower taken with 400 g rock sugar and milk. take 1 tsp of paste and dissolve it 1 cup of water .	Beneficial for Anorexia, Celiac, Sprue, fever, Hemorrhoids, skin disorders, Edema, eye diseases, Rheumatism, Dyspepsia and diarrhea	Somani et al, 2006
Ranawara (*Senna auriculata)*	southern region of Sri Lanka	Dried Ranawara flowers are boiled in the water for 20-30 minutes and jaggery is added into it for sweet taste	Free from caffeine. It is a natural drink which helps to hydrate your body.Helps detoxifying the body naturally.Promotes blood circulation.Well known for its ability to control sugar levels.Purifies the blood and popular as herbal tea that promotes clear skin.	Chandrasekara and Shahidi, 2018
Straw Flower herbal tea (*helichrysum plicatum*)	Turkey	Take 1:1 ratio dried flowers and leaves and boil it for 15 – 20 mins. This can be consumed 1 to 2 times per day.	Antihyperglycemic, antioxidant	Aslan et al, 2007
Pawatta (*Adhatoda Vasica)*	Sri Lanka	Take Pawatta Flowers, Leaves and roots and simply boil it with water for 15 – 20 mins. Drink 2 to 3 tbs two times a day.	The flowers are regarded as antiseptic, insecticidal and expectorant, used to treat cough, chronic bronchitis and asthma. The fresh flowers are used for ophthalmia. Flowers are given as an infusion to treat fever and used in the treatment of gonorrhea, jaundice, rheumatism and abdominal tumour.	Rajamanna, 2000
Dandelion (*Taraxacum)*	China, North America	To make this decoction, combine 1 to 3 teaspoons chopped dandelion dried flowers and root per cup of water, and season to taste. Bring to a boil, then reduce to a low heat and cook for 10 to 20 minutes in a covered saucepan. As a general tonic, drink 1 to 2 cups per day.	It Could Promote Liver Health, Can Act As a Natural Coffee Substitute, May Soothe Digestive Ailments, It May Help Prevent Urinary Tract Infections.	Moemin and Aboraya, 2014 Yarnell and Abscal, 2009
Rosemary flower tonic (*Salvia rosarinus)*	Europe	Boiled in clean water until the liquid reduces by half. consumed as atea 2 times a day.	Rosemary is a supreme digestive aide. Simple solution for headaches. Its abilities to thicken and often regrow hair. Can be a helpful strategy in coping with stress and anxiety.	Combs, 2016
Ashok (*Sarasa asoca)*	E. Asia - India, Sri Lanka, Bangladesh, Myanmar	The mix of Dried Powdered Flower and leaves and consumed as tea with warm water.	It is a flower extract that is effective in the treatment of haemorrhoids and dysentery. The flowers can also be used to treat scabies in children and a variety of other skin conditions	Kauser et al, 2016 Kapoor, 2001
Nageswar (*Mesua ferrea)*	India, Sri Lanka, Nepal, Burma, Thailand	1 – 3 g of powdered flower mixed with water or with warm water.	Useful in skin decease like leprosy, itching,erysipelas, scabies, wounds and excessive sweating as it	Chauhan, 2019

			provides fragility and transparency to the skin.	

Table4. Flower Based Decoctions Consumed in the Various Parts of the World.

5.0 Anti-Nutritional Factors and the Risks Associated with the Consumption of Edible Flowers

According to the Merriam-Webster dictionary, anti-nutritional factors are substances found in plant-derived foods that interfere with the absorption or proper functioning of nutrients in the body. Plants generally contain antinutrients obtained from fertilizer and pesticides and several naturally occurring chemicals (Igile, 1996). Some anti-nutritional factors include saponins, tannins, alkaloids, oxalates, phytates, and cyanogenic glycosides just to mention a few. Anti-nutritional factors have been known to hinder with proper digestion of nutrients and sometimes can even cause health-related problems.
However, several physical methods can be used to remove anti-nutrients in our food. Autoclaving, pressure cooking at ultrahigh temperatures (>100oC) or 121oC (15 psi) can reduce the amount of anti-nutritional factors. Blanching or mild heating can also be applied to inactivate enzymes. Ordinary cooking usually proceeded by soaking or other domestic processing, de-hulling, germination is another way to remove anti-nutritional factors. Extrusion a form of high-temperature short time (HTST) processing removes anti-nutritional factors. Roasting, soaking, and chemical processing are used to remove anti-nutritional factors in foods.

5.1 Tannins

A tannin is an astringent, polyphenol biomolecule that binds to and precipitates proteins and various other organic compounds including amino acids and alkaloids. These tannins are widely distributed in nature and play a vital role in protection from predators and regulation of plant growth. Their molecular weights range from 500-3000 with some exceeding 20,000. Tannins are known to form complexes with proteins under certain pH conditions. These protein-tannin complexes are responsible for low protein digestibility, decreased amino acid availability, and increased faecal nitrogen (Jain et al 2009). In a study, it was observed that there is a depression in the activity of trypsin and alpha-amylase in the upper, middle, and lower parts of the intestine of rats on the inclusion of black locust tannins in the diet (10 g/kg). and also on digestion trials it was revealed that there is a decrease in digestibilities of proximate constituents, except crude fat, and increased faecal bile acid excretion on the inclusion of tannins in the diet (20 g/kg) (Horigome et al ., 1988).

5.2 Saponins

Saponins are non-volatile, surface-active secondary compounds found primarily in the plant kingdom and are widely distributed in nature. The word'saponin' comes from the Latin word sapo, which means'soap,' and saponin molecules form soap-like foams when shaken with water. The glucosides with foaming characteristics are saponins. Most of the saponins form insoluble complexes with 3-*b*-hydroxysteroids and are known to interact and form large mixed micelles with bile acids and cholesterol (Mohan et al., 2016). The potentially toxic effects of intravenous injection of saponin extracts have resulted in this class of compounds being regarded as antinutritive factors in foods (Savage, 2016). Liu and Xu, 2015 studied Inhibitory Effects of Phenolics and Saponins From Commonly Consumed Food Legumes in China Against Digestive Enzymes Pancreatic Lipase and α-Glycosidase. In this study 13 commonly produced food legumes in China were investigated. Saponin extract (1 mg/mL) from black bean exhibited the highest (41.8%) pancreatic lipase inhibitory effect, followed by a phenolic extract from adzuki bean (36.3%), saponin extract from yellow soybean (34.1%), saponin extract from the pinto bean(32.6%).

5.3 Alkaloids

Alkaloids are a broad group of chemical compounds produced by plants, and they are typically found as salts of plant acids like oxalic, malic, tartaric, or citric acid. Alkaloids are small organic molecules found in 15 to 20% of all vascular plants. They usually consist of multiple carbon rings with side chains, with one or more carbon atoms substituted by nitrogen. Plants produce them from aminoacids. Toxicity is dosage-dependent, exposure time, and individual characteristics such as sensitivity, site of action, and developmental stage(Matsuura and Neto, 2015). Since alkaloids disturb the nervous system and disrupt or improperly enhance electrochemical transmission, they are considered anti-nutrients. Consumption of high tropane alkaloids results in rapid heartbeat, paralysis, and, in the worst-case scenario, death (Fernando R. Pinto MDP. and Pathmeswaran A. 2012).

5.4 Cyanogenic Glycosides

Cyanogenic glucosides are a derivative of 5 protein amino acids Valine, Isoleucine, Leucine, Phenylalanine, and Tyrosine and the non-protein amino acids cyclopentenyl glycine. When chewed or digested, cyanogenic glycosides are chemical compounds found in foods that release hydrogen cyanide. The act of chewing or digestion causes hydrolysis of the compounds, resulting in the release of cyanide. At least 2000 plant species contain cyanogenic glycosides, with some species used as food and produced as secondary metabolites. The toxicity is determined by the amount of hydrogen cyanide released. Acute cyanide poisoning can be caused by toxicity, and it's also been linked to the development of a number of chronic diseases. (Cressey P and Saunders D 2012). Cyanide toxicity can occur in an animal including humans at doses between 0.5 and 3.5 mg HCN per kilogram body weight. Symptoms of cyanide toxicity in humans have been reported to include vomiting, stomachache, diarrhea, convulsion, and in severe cases death (World Health Organisation)

Edible flower	Extract	Alkaloids	Glycosides	Saponins	Tannins	Reference
Rose Flower (petals)	Methanolic	—	+ve	+ve	+ve	***Belal et al., 2016***
	Aqueous	—	+ve	+ve	+ve	
	n hexane	+ve	+ve	+ve	—	
Jasmine (flower)	Methanol	+ve	+ve	—	+ve	**Kumaresan et al., 2019**
	Ethanol	+ve	+ve	—	+ve	
	Ethyl acetate	—	+ve	—	—	
	Chloroform	—	—	—	—	
	Aqueous	—	—	—	+ve	
Marigold (Tagetes erecta)	Water	+ve	—	+ve	+ve	**Arefin et al., 2015**
	Methanol	+ve	—	+ve	+ve	
	Chloroform	—	—	—	—	
	Petroleum ether	—	—	—	—	
Banana Flower (Musa x paradisiaca flower)	Petroleum ether	+ve	+ve	—	—	**Mahmood et al., 2011**
	Ethanol	—	—	+ve	+ve	
	aqueous	—	—	+ve	+ve	
Hibiscus Flower (Hibiscus rosa sinensis)	**Color**	—	+ve	—	+ve	**Patel and Adhav, 2016**
	Hibiscus red					
	Hibiscus pink	—	+ve	—	+ve	
	Hibiscus yellow	—	+ve	—	+ve	
	Hibiscus white	—	+ve	—	+ve	

Table5. Antinutritional Factors in Some Edible Flowers

6.0 Risks Associated

As edible flowers contain some phytochemicals that are antinutrients, their consumption may cause risk to the consumer. However, their moderate usage won't show a negative effect. So after a proper study, edible flowers should be used in consumption. Guine et al., 2017 studied the knowledge and consumption habits of edible flowers. In this investigation, a questionnaire survey was undertaken to a sample of 100 possible consumers aged between 20 and 84. The study revealed that only a few members of the participants are aware of the potential risks. edible flowers have external impurities i.e bacteria and chemical compounds (Matyjaszczyk and Śmiechowska, 2019).

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