CHAPTER

# Health benefits of plant extracts 12

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## 12.1 Introduction

Around 250,000−500,000 plants have been documented throughout the world to date, out of which relatively 1%−10% have been biologically screened by humans (Dekebo, 2019). WHO reports that 80% of individuals in developing nations use traditional plant- derived medicine for their health care (Van Wyk & Prinsloo, 2018). Although developed countries are highly advanced in medicinal science, over one-fourth of leading medicines are originated directly or indirectly from plants (Srivastava, Singh, Devi, & Chaturvedi, 2014). Of all life-saving medicines for clinical use worldwide are extracted from natural produce, almost 25% is contributed by higher plants (Dekebo, 2019). New plants are always been in research, and their extracts are studied for various health benefits in the search to find new plants with a different action spectrum. Globalization has increasingly renewed the interest of plant extracts in functional foods with a balanced nutritional profile, healthy ingredients, and disease prevention properties. Thus researchers have focused on unfolding and redesigning traditionally known products by replacing some preservatives and flavor components with ingredients having positive physiological effects including natural plant extracts with rich bioactivity (Franzen & Bolini, 2019).

The word "extract" is derived from "*extractus*" a Latin word meaning "things extracted from another," a process that aims to extract certain components present in plant matrix (Franzen & Bolini, 2019). Extracts of plants are complex in nature, and different parts of plants also vary in composition. Usually plants contain various types of polar and non-polar chemical components. These may be organic acids, alkaloids, glycosides, resins, oils, carbohydrates, amino acids, proteins, enzymes, tannins, plant pigments, waxes, and other inorganic components in traces (Regnier, Combrinck, & Du Plooy, 2012). These bioactive compounds are not easily accessible. Therefore, for the extraction of these phytochemical compounds and for the elimination of other inactive fractions, which showcase no or low relevant benefits, plants are subjected to several works. This in turn will lead to the achievement of phytochemicals, in a concerted form, which could be readily incorporated in other produces than whole plant inclusion (Veiga, Costa, Silva, & Pintado, 2018). With the advance of numerous studies such as extraction, isolation, techniques of structural and compositional determinations and pharmacological effects, separated and purified extracts has initiated to be taken earnestly. There are more than a million types of extracts derived from plants, which have been validated for various beneficial purposes like for food stuffs (antioxidant, stabilizer, texturizer, antifungal, substitute

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for food colorants, etc.), processing aids (chemical replacers, bio preservation), pharmaceutical properties (preventive and curative) such as hepatoprotection, antitumoral, antimutagenic, antimicrobial, antidiabetic, antiallergic, vaso-dilatory, antiinflammatory, protection against oral diseases etc. (Mir, Shah, Ganai, Ahmad, & Gani, 2019; Veiga, et al., 2018). These plant bioactives also present antioxidant actions particularly against low-density lipoproteins (LDLs) and nucleic acid oxidative changes (Kiokias, Proestos, & Oreopoulou, 2018).

The past decade has seen an upsurge in life expectation as well as the public concerns with quality of life. Several researchers scientifically proved that proper nutrition is one of the major factors behind the well-being of an individual. Proper nutrition plays a prominent role on one's health, with a stable diet being ultimate for the maintenance of homeostasis without causing any health risk and hence the suitable functioning of human body. The exploitation of plant extracts is gaining more popularity in the food industry because of their low cost, functional properties, and renewable source of biologically relevant compounds (Mourtzinos et al., 2018). This chapter is aimed to highlight several bioactive compounds and the prevailing evidence about various probable health benefits of consuming plant extracts and extract-based substances supported by in vivo and epidemiological studies.

## 12.2 Plant polyphenolic composition

Plants are richest sources of secondary metabolites like phenolics, carotenoids, anthocyanins, xanthophylls, or other constituents that play a photo-protective role and several other functions vital for plant metabolism and survival such as defense against pathogenic diseases. Moreover, they are also responsible for pigmentation and other organoleptic attributes of plants like flavor and color (Cheynier, 2012; Lattanzio, 2013). About 8000 distinctive phenolic species have been described in nature so far. These substances may be present in leaf, stem, fruit, flower, or roots of the plants and can be divided into several groups according to their chemical structures ranging from comparatively simple to highly polymerized compounds. Chemically, phenolics could be defined as the molecules containing at least one phenolic unit, and the molecules comprised of more than one of these subunits are usually categorized as polyphenols (Veiga et al., 2018).

The various other phenolic compounds present in the plant materials are flavanols like kaempferol, quercetin, myricetin, gallocatechin, catechin gallate, catechin, gallocatechin gallate, epicatechin, epicatechin gallate, epigallocatechin, and epigallocatechin gallate (Da Silva et al., 2013). The plants are also richest sources of phenolic acids like gallic, *p*-coumaric, caffeic and quinic acids, which provide one of the most broadly exploited metabolic pathways in plant research (Deotale, Dutta, Moses, & Anandharamakrishnan, 2019). In fruits like berry, apple, and pears, caffeic acid (CA) together with p-coumaric acid was present in higher amounts (75%−100%) of total hydroxycinnamic acids (Da Silva et al., 2013). Also, CA is reported to be present in *Eucalyptus globulus* bark and was reported as the major phenolic compound in coffee and its oil (Deotale et al., 2019). The 3,4,5-trihydroxybenzoic acid also known as Gallic Acid (GA) is the major tea phenolic acid, also present in higher concentrations in berries and chestnuts (Pandurangan, Mohebali, Norhaizan, & Looi, 2015). Recently, Souza et al. (2020) isolated GA from extracts of black tea at 0.8 mg/kg concentration. It is also found among a number of land plants, like *Cynomorium coccineum* (a parasitic plant), aquatic plants, and the some blue-green algal species (Liu, Carver, Calabrese, & Pukala, 2014). Rosmarinic acid (RA) is present in some plants of family Lamiaceae like *Perilla* spp., *Rosmarinus offcinalis*, *Origanum* spp., and *Salvia offcinialis* as the main phenolic component (Oreopoulou et al., 2018). The various other researchers also reported it in several herbs like oregano, thyme and rosemary in 0.05 and 26 g/kg concentrations (Yashin, Yashin, Xia, & Nemzer, 2017). Additionally, Tsimogiannis et al. (2017) reported 19.5 (g/kg) of RA in pink savory leaves. Carnosic acid, a phenolic diterpene of labdane-type is present in a number of plants of family Lamiaceae, like rosemary, and common salvia (Loussouarn et al., 2017). Carnosic acid is lipophilic compound and is mainly found in the dry sage leaves at a concentration of 1.5%−2.5% (Raes, Doolaege, Deman, Vossen, & De Smet, 2015).

The phenolic acid (ferulic acid) arises from the metabolism of tyrosine and phenylalanine and is present in both free and conjugated forms in seeds and leaves. FA is found in the coffee, peanut, apple, artichoke, and orange seeds. Flaxseed has been reported as the richest FA glucoside source (4.1−0.2 g/kg) occurring naturally (Bagchi, Moriyama, & Swaroop, 2016). According to Mojica, Meyer, Berhow, and de Mejía (2015), an average 0.8 g/kg concentration, FA has been isolated from black beans. In addition, FA is also present in Brassica species and tomatoes.

p-Coumaric acid is present in huge number of plants species, and the richest sources of p-coumaric acids are fungi, peanut, navy beans, tomatoes, carrot, basil, and garlic (Trisha, 2018). The p-Coumaric acid substance is also abundant in most of the fruits and cereals especially in pears and berries (Bento-Silva et al., 2020). A dihydroxybenzoic acid derivative, Vanillic Acid is obtained from various fruits, olives, and cereals like wheat, and also found in wine, beer, and cider products (Siriamornpun & Kaewseejan, 2017).

Carotenoids are natural colored substances present in birds, plants and fish meat, algae, fungi, and insect's cuticle. Based on their function, carotenoids may be grouped under two categories: xanthophylls including lutein, zeaxanthin and carotenes like lycopene, α-carotene and β-carotene (Kumar et al., 2014). These carotenoids prevent various diseases and help the human body in several positive ways. The Astaxanthin has strong antioxidant, antiinflammatory, anticancerous properties and promotes cardiac health (Fasano et al., 2014). Lutein prevents cataract, muscle age-related degeneration and circulatory diseases and has antioxidative and anticancer functions (Manayi et al., 2016). β-Carotene checks night blindness, acts as antioxidant and protects against liver fibrosis (Virtamo et al., 2014).

Anthocyanins exist in numerous plant parts, like stem, fruit, flower, leaf, and root. In higher plants, commonly anthocyanidins comprises of cyanidin, petunidin, pelargonidin, malvidin, peonidin and delphinidin. These anthocyanidins are distributed in edible plant parts in the concentration of 50%, cyanidin, 12% pelargonidin, 12% peonidin, 12% delphinidin, 7% petunidin and 7% malvidin. Among these most abundant glycosides comprises of delphinidin, cyanidin and pelargonidin, which represents 80% of leaf, 69% of fruits and 50% of flower pigments, respectively. The furthermost prevalent anthocyanin in fruits is cyanidin-3-glucoside (Pascual-Teresa & Sanchez-Ballesta, 2008).

## 12.3 Health benefits of plant extracts

The plant extracts obtained from various plant parts impart health benefits through their numerous active principles and bio complexes prepared by different methods and processes (Table 12.1).

**Table 12.1 Health benefits of plant extracts.**

| Part of plant | Species/name of plant | Health beneficial properties | Reference |
|---|---|---|---|
| Fruit | Mulberry (*Morus alba*) | Hypolipidemic/cardio-protective; antidiabetic; antitumor; antiobesity; antioxidant; hepatoprotective and protection against brain damage | Zhang, Ma, Luo, and Li (2018, 2016) |
| | *Berberis vulgaris* | Antidiabetic; anticancer; antiacne; cardio-protective and antihypertensive. | Rahimi-Madiseh, Lorigoini, Zamani-gharaghoshi, and Rafieian-Kopaei (2017) |
| | Dragon fruit *(Hylocereus undatus)* | Antioxidant; anticancerous; antihypertensive; antidiabetic and decrease arterial stiffness and lipid peroxidation. | Divakaran, Lakkakula, Thakur, Kumawat, and Srivastava (2019) |
| | Raspberry *(Rubus idaeus)* | Antiinflammatory; chemopreventive; antidiabetic; antioxidative; anticancer; antiproliferative; immunoregulatory and improves lipid metabolism. | Kowalska, Olejnik, Zielińska-Wasielica, and Olkowicz (2019), Stagos (2019) |
| | Persimmon *(Diospyros kaki)* | Anticancer; antioxidant; antiinflammatory; gastro-protective; antidiarrheal, hypolipidemic and antidiabetic. | Guler et al. (2021), Dhawefi et al. (2021) |
| | Kiwi *(Actinidia arugata)* | Gastro and hepatoprotective; cardiovascular protective; antiinflammatory; antidiabetic; antioxidant, anticancerous; antiangiotensin converting enzyme activity; attenuates DNA damage and antiplatelet aggregation activity. | D'Eliseo et al. (2019), Hussein et al. (2015) |
| Seed | Fennel *(Foeniculum vulgare)* | Immune enhancement; antioxidant; antimutagenic; antioxidant; antiinfertility; hepatoprotective; antiinflammatory, hypolipidemic; regulates hormonal & biochemical changes associated with PCOS syndrome; antiosteoarthritic and protection against nephrotoxicity. | Bayrami et al. (2020), Samadi-Noshahr, Hadjzadeh, Moradi-Marjaneh, and Khajavi-Rad (2021) |
| | Moringa (*Moringa oleifera*) | Antiproliferative against breast and colorectal cancer cells; antioxidant; antiinflammatory; pro-apoptotic activity on cancer cells; immunomodulatory; healing power; antidiabetic. | Potestà et al. (2019), Xu, Chen, and Guo (2019) |
| | Fenugreek *(Trigonella foenum-graecum)* | Antiinflammatory; antioxidative; antifibrotic; PCOS reduction; antidiabetic; antiobesity; prevents pancreatic damage and have phytoestrogenic effect. | Thomas et al. (2020), Rahmani et al. (2018) |
| | Pomegranate (*Punica granatum*) | Antitumor; antioxidant; antiradical; antiatherogenic; prevents dental plaque and gingival inflammation; hypolipidemic; effects on insulin resistance; neuroprotective; antiosteoporosis and impressive on neurodegenerative diseases. | Doostan et al. (2017), Thitipramote et al. (2019) |
| | *Parkia biglobosa* | Antianemic; antimutagenic; antioxidant; antiinflammatory; antiulcer; antihypertensive; anticancer/antitumor and hypoglycemic. | Saleh et al. (2021) |

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| Flower | Dandelion *(Taxaxacum officinale)* | Hepatoprotective; antidiabetic; antifibroblastic; mito-inhibitory or stimulative (cell division); antioxidant, antiplatelet aggregation and anticoagulant. | Li, Yang, Yang, and Zu (2018), Grauso, Emrick, de Falco, Lanzotti, and Bonanomi (2019) |
| | Lavender *(Lavandula augustifolia mill)* | Antioxidant; sedative & hypnotic; antiproliferative; neuroprotective (Alzheimer's disease); antiinflammatory; antianxiety and antidiabetic. | Dhasthakeer, Kavitha, and Vishnupriya (2020), Nurzyńska-Wierdak, and Zawiślak (2016). |
| | Rose *(Rosa rubiginosa)* | Cardiovascular prevention; antioxodative; antiinflammatory; anticonvulsant; hypoglycemic; analgesic; preventive against neurological atrophy; bronchodilatory; antiHIV; antiaging, antilipase and ophthalmic effects. | Yang and Shin (2017), Liu, Tang, Zhao, Xin, and Aisa (2017) |
| | *Hibiscus rosa* | Gastro-protective; cardio-protective; anticancer; antioxidative; antidiabetic; antifertility; antihyperlipidemic; wound healing activity; hair growth promoter and immune response. | Missoum (2018). |
| | Passiflora | Antihypertensive; antioxidative; antianxiety; antiinflammatory; anticancerous; prevents psychological disorders and relieves menopausal transition. | Taïwe and Kuete (2017), Hameed, Cotos, and Hadi (2017) |
| Leaf | *Aloe vera* | Immunomodulatory; antiinflammatory; hepatoprotective; antioxidant; anticancer; purgative; wound and cell proliferation; antihyperlipidemic; antiulcer. | Salehi et al. (2018) |
| | Ginseng *(Panax ginseng)* | Hypoglycemic; antiaging; prevents oxidative damage; antiobesity; cytotoxic against cancer cells; protection against testicular damage; cardio-protective and neuroprotective. | Shin, Lee, Son, Park, and Jung (2017), Lee, Lee, Jang, Kwon, and Nam (2017) |
| | Peppermint *(Mentha piperita)* | Cytotoxic and anticarcinogenic; antihepatotoxic; antibreast carcinoma; antioxidant; antidiabetic; nephron-protective; antiinflammatory. | Konda et al. (2020), Li, Al-Misned, El-Serehy, and Yang (2021) |
| | Artichoke *(Cynara scolymus)* | Cholesterol lowering; hypoglycemic; hepatoprotective; antioxidant; pre/probiotic; antiatherosclerotic; immune-modulatory; cholerectic; cardio-protective; anticancer; antiinflammatory; gastro-protective. | Salem et al. (2015) |
| | Olive *(Olea europaea)* | Anticancer; antiinflammatory; hypotensive; hypolipidemic; hypoglycemic; antiproliferative (breast cancer cell line); antioxidative; prevention against hepato toxicity; immune-modulatory and antiatherosclerotic. | Lins, Pugine, Scatolini, and de Melo (2018), Qabaha, Al-Rimawi, Qasem, and Naser (2018) |
| Stem/ bark | Cinnamon *(Cinnamomum verum)* | Antidiabetic; antioxidant; anticholinergic; hypolipidemic; antiinflammatory; antiallergic; anticancer and hepatoprotective. | Vijayakumar et al. (2020), Gulcin et al. (2019). |
| | *Berberis aristata* | Anticancer; anti spasmodic and antidiarrheal; anticonvulsant; hypoglycemic; hypolipidemic; protection against mitochondrial damage and tyrosinase inhibitor. | Rahimi-Madiseh et al. (2017), Chander, Aswal, Dobhal, and Uniyal (2017) |
| | Ginger *(Zingiber officinale)* | Antiinflammatory; antioxidant; antihypercholesteraemic; hypotensive; antiulcer and antiemetic; cardio-protective; hypoglycemic; vasodialatory; antirheumatic. | Al-Awwadi (2017), Wu et al. (2018) |
| | Pine bark *(Pinus radiata)* | Antioxidant/radical scavenging; antiinflammatory; anticancer; immune enhancement; reduction in side effects of radio and chemotherapy; cardiovascular protection; neuroprotective and antiatherosclerotic. | Li, Feng, Zhang, and Cui (2015). |

(*Continued*)

| Table 12.1 Health benefits of plant extracts. *Continued* | | | |
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| **Part of plant** | **Species/name of plant** | **Health beneficial properties** | **Reference** |
| Root/ tuber | Ginseng *(Panax ginseng)* | Antiinflammatory; antiParkinson activity; antiarthritic; cardio-protective; antidiabetic; anti stress; antiAlzheimer activity; antiischemic and antihypoxic activity. | Dar, Hamid & Ahmad (2015) |
| | Turmeric *(Curcuma longa)* | Antiarthritic; hypoglycemic; antioxidant; antiinflammatory; immune stimulation; anticancer; hepatoprotective; cardiovascular protection chemo protective; neuroprotective; antiallergic. | Mohammed et al. (2017), Daily, Yang, and Park (2016) |
| | Beet root *(Beta vulgaris)* | Lipid lowering; antihypertensive; antiinflammatory; antioxidant; cytotoxic against cancer cell lines (prostate and breast); osteoarthritis prevention; anticancer; antiobesity; antidiabetic; neuroprotective. | Hadipour, Taleghani, Tayarani-Najaran, and Tayarani-Najaran (2020), Kapadia et al. (2011) |
| | *Berberis integerrima* | Cardiovascular protection; antihypertensive; anticonvulsant; antidiabetic/ hypoglycemic; improves renal dysfunction; hypolipidemic; antioxidant; antiarthritic and antihepatopathic. | Rahimi-Madiseh et al. (2017), Aryaeian, et al. (2020) |

### 12.3.1 Fruit extracts

Fruits are primary sources of nutritional compounds in human diet. Fruit extracts from different plants have numerous health benefits that include antioxidant, antidiabetic, antiinflammatory, and antitumoral activity among several other activities. The main biologically active compounds present in fruit extract mainly include vitamins, polyphenols, carotenoids, polysaccharides, dietary fiber, alkaloids, essential oils etc. Their natural origin makes them an excellent substitute for synthetic compounds present in fruit extracts that have carcinogenic and toxicological effects. These biologically active compounds are proven to be more beneficial when present together.

Early studies on kiwi (*Actinidia deliciosa*) fruit extracts (hexane, acetone and methanol) have revealed its potential in cancer prevention (Motohashi et al., 2002). Cardio-protective properties of kiwi fruit extract (water and 70% ethanol) were also investigated in in vitro models by analyzing its hypotensive, antihypercholesterolemic and antioxidative activities (Jung et al., 2005). In vitro studies on lyophilized aqueous extracts of kiwi fruit also demonstrate its antioxidant activity by monitoring its radical scavenging efficiency (Bursal & Gülçin, 2011).

Mulberry (*Morus* spp.) fruit extract offers high amounts of polyphenols like anthocyanins, phenolic acids, flavanol derivatives, chlorogenic acid, and quercetin glycoside. Ability of mulberry fruit extract (MFE) in prevention of liver fibrosis is of vital importance. Mulberry water extracts reduced lipid peroxidation and hampered pro-inflammatory gene expression displaying their protective and therapeutic effects against Carbon tetrachloride ($CCl_4$)-induced fibrosis and liver damage (Hsu et al., 2012). In a study, protective effect of polyphenolic-rich MFE has been investigated against Ethyl Carbamate (EC)-generated cytotoxicity and oxidative stress. The mechanism for protection of human liver Hep G2 cells from EC generated cytotoxicity included scavenging of excess cellular reactive oxygen species (ROS). Also, pretreatment of MFE significantly reduced the EC induced mitochondrial membrane potential collapse, mitochondrial lipid peroxidation plus intracellular glutathione (GSH) depletion. It further prevented GSH depletion and returned the function of mitochondrial membrane (Wei, Yuting, Tao, & Vemana, 2017).

An investigation was carried out by Dahham, Agha, Tabana, and Majid (2015) on antiangiogenic and anticancerous activities of banana peel extracts. Results revealed that highest antiangiogenic activity (85.32% inhibition at concentration of 100 μg/mL) was exhibited by banana extract and it also effectively reduced the growth of colon cancer cell line.

*Berberis* plant species are largely consumed as fresh, dehydrated, or used in the production of juices (Farhadi Chitgar, Aalami, Maghsoudlou, & Milani, 2017). Among these species, *Berberis vulgaris* is widespread due to their nutritional and phytochemical significance as these are abundant sources of vitamins, minerals, alkaloids, flavonoids, anthocyanins, and antioxidants (obtained from all plant parts), which can be extensively used in a collection of pharmaceutical and nutraceutical stuffs. Most important alkaloids in the plant are berberin, bermamine, oxycontin, palmatine, bervulcine, columbamine, and coptisine (Sarraf, Beig-babaei, & Naji-Tabasi, 2019). The crude extract of these phytochemicals demonstrate a number of biological activities including antiinflammatory, antioxidant, antipyretic, hypotensive, antinociceptive anticholinergic and antiseptic Zarei, A., Ashtiyani, S. C., Taheri, S. & Ramezani, M. (2015). Phytochemical analysis of *B. vulgaris* extracts detected several alkaloids like tertandrine, berbamine, and chondocurine which are wee-known for their antioxidant and antiinflammatory activities (Salehi et al., 2019). The possible antioxidant property of *B. vulgaris* is through inhibiting NF-κB, 1,1-diphenyl-2-picrylhydrazyl (DPPH) scavenging and inhibiting lipoxygenase activity owing to its phenolic and flavonoid constituents (Eddouks, Maghrani, Lemhadri, Ouahidi, & Jouad, 2002). The berberine rich fruit extracts of *Berberis* species demonstrate significant antitumor properties, with reported efficiencies in mitigating various eye ailments (Srivastava, Srivastava, Misra, Pandey, & Rawat, 2015). Furthermore, reported plasma glucose lowering and hyper-lipidemic properties of *Berberis* may be due to barberine-induced adjustment in adipokine secretion which in turn results in improvement in insulin sensitivity (Zhu, Bian, & Gao, 2016). Efficiency of *Berberis* extracts in maintaining cardiovascular health confers to its ability of improving hypertension, cardiac arrhythmias, cardiomyopathy and ischemic heart disease (Imenshahidi & Hosseinzadeh, 2016).

Dragon fruit (*Hylocereus polyrhizus*) is a store house of variety of biochemical constituents like alkaloids, saponins, flavonoids, steroids, tannins, and terpenoids that have excellent health-promoting effects. Dried dragon fruit extracts were evaluated for antioxidant capacity using total phenol essay, which was found to be equivalent to that of GA (Rebecca, Boyce, & Chandran, 2010). Also, ethanolic extract of dragon fruit flesh was determined for antiinflammatory effects in animal model (mice) induced by tetramethyl benzidine. The results showed a significant reduction in the expression of pro-inflammatory molecules and degradation of protein NF-κB levels (Macias-Ceja et al., 2016).

Apple fruit extracts and its rich phenolics confer potent antioxidant activities against free radicals generated through lipid oxidation. Also, results on the treatment of apple extracts on colon cancer cells showed a dose-dependent inhibition of cell propagation with a maximum inhibition (43%) at a concentration of 50 mg/mL. Similar results with highest cell inhibition (57%) were seen in Hep G2 liver melanoma cells at a dosage of 50 mg/mL (Eberhardt, Lee, & Liu, 2000). *Carica papaya* extract has been seen to have wound healing properties in animal models. Diabetic wounds that are difficult to manage due to their slow, non-healing nature continue for weeks in spite of adequate and proper care. Topical application of *C. papaya* extract in streptozotocin-generated diabetic rats showed that wound size reduced within 5days of treatment (Nayak, Pereira, & Maharaj, 2007).

### 12.3.2 Leaf extracts

Although fruits are rich in numerous bioactive compounds, leaves also have been reported to possess significant amount of beneficial compounds. Several studies have documented that leaves contain higher amount of phenolic compounds as compared to fruits (Veiga et al., 2018). The possible reason for the difference could be the photosynthetic function of leaves and subsequent production of oxygen resulting in the generation of ROS that are injurious to tissues. Thus taking into consideration the known antoxidant properties of phenolics, these may be present in higher concentration in leaves and protect its tissues to against the stress caused by solar radiations. The aqueous extracts of passion fruit leaves were found to possess significantly high antioxidant properties including leaves of other berries like blackberry, strawberry and raspberry than the fruit themselves (Da Silva et al., 2013). Tea (*Camellia sinensis*) leaf extracts have been investigated for their preventive effect against *cardiovascular diseases*. The strong antioxidant activity of tea polyphenols (catechins) decrease free radical damage to cells and reduce oxidation of LDL cholesterol which may inhibit the development of atherosclerotic plaques, thus preventing heart diseases (Lorenzo & Munekata, 2016). Much focus has also been put on its *anticancerous properties* due to the presence of tea polyphenols (epigallocatechin gallate, epigallocatechin and epicatechin gallate). In animal model, Zhang, Duan, Owusu, Wu, and Xin (2015) have documented that green tea supplementation in rats resulted in induction of apoptosis and cell cycle arrest inhepatoma cells (AH109A cell line) and murine melanoma cells (B16 cell line) Also, *antiinflammatory properties* of an antioxidant rich polyphenolic extract from green tea were reported in rats. The study showed a significant reduction in the incidence of arthritis in the mice fed with green tea polyphenols which is attributed to the marked decrease in the expression of inflammatory mediators including cyclooxygenase 2, interferon (IFN) and tumor necrosis factor (TNF) (Cooper, Morré, & Morré, 2005).

Artichoke (*Cynara scolymus*) leaf extracts have been investigated for antioxidant, bile-enhancing, hepatoprotective, lipid lowering, and choleretic effects which also corresponded with its historical use. Numerous in vitro studies have documented that the antioxidant activity of Artichoke leaf extracts is mainly due to radical scavenging and metal ion chelating effects of its components like chlorogenic acid, cynarin, and flavonoids (Pérez-García, Adzet, & Cañigueral, 2000). *Hepatoprotective effects* of artichoke leaf extracts may be due to its ability to remove harmful toxins and digest fats by increasing the bile production of the liver. The *antiatherosclerosis action* of Artichoke leaf extracts was supposed to be the outcome of two mechanisms of action: an antioxidant effect of its bioactive compound cynarin that reduced LDL oxidation and inhibition of cholesterol synthesis. Studies have also shown many powerful phenol-type antioxidants like GA, rutin and quercetin found in Artichoke leaf extracts that could play a crucial in the prevention and management of various type of *cancers* (leukemia, prostate and breast cancer) by inducing apoptosis and reduction in cancer cell proliferation. Researchers confirm that Artichoke leaf extracts help to maintain *cardiovascular health* by increasing the cholesterol breakdown to bile salts thereby enhancing its elimination by increasing the production of bile and also prevents the internal production of cholesterol in the liver, thus preventing atherosclerotic deposits (Salem et al., 2015).

Papaya (*C. papaya L.*) leaf extract has been documented in literature for its antiinflammatory, antitumor, and antidiabetic effects due to the presence of many complex bioactive compounds including esterified phenolics, flavonols, organic acids, carpaine alkaloids and other constituents. Papaya leaf extracts have been used from ancient time as a remedy to treat many disorders, such as cancer and other infectious diseases. Immunomodulatory, antiinflammatory and antiarthritic activity of papaya leaf extracts has also been investigated which may be due to the presence biologically active compounds like carpaine and nicotinic acid. Besides, antibacterial, antiviral, antihelminthic, gastro-protective, cardio-protective and antioxidative activities of papaya leaf extracts has also been documented (Tatyasaheb, Snehal, Anuprita, & Shreedevi, 2014).

*Artemisia absinthium* have various biological activities like antiinflammatory, antidiabetic, anticancer, antitumor, antihelminthic, antipyretic, antioxidant, hepatoprotective, neuroprotective, bile stimulant, antiarthritic, antifertility, menopause, premenstrual syndrome, dysmenorrhea, analgesic, and antidote to insect poison (Koul, Taak, Kumar, Khatri, & Sanyal, 2017; Nigam et al., 2019 Goud & Swamy, 2015). Goud and Swamy (2015) investigated *antidiabetic effect* of methanolic and ethanolic leaf extract of *A. absinthium* in both normal and diabetic animals. It lead to a significant reduction in blood glucose level in a dose-dependent manner which may be due to the presence of active components such as α- and β-thujone, thujyl alcohol, azulenes, bisaboline, cadinine, sabinene and pinene (Dabe & Kefale, 2017). Li, Zheng, et al. (2015) also studied antidiabetic effect of powdered leaf extracts in humans and they concluded that plant possesses good hypoglycemic effect in a dose-dependent manner through insulinotropic (to increase insulin secretion) action. These herbs are also believed to be involved in the repairment and regeneration of pancreatic β-cells (Bhat et al., 2019). Also, animal model (rats) based study on aereal parts of *A. absinthium* extracts (methanol, hexane, ethanol and CCl4) revealed its antiulcer property. This was followed by depletion in secretion of gastric juice and peptic activity with the elevation in mucin levels (Shafi, Khan & Ghauri (2004).

*Aloe vera* plants have been extensively known and used by mankind by centuries in folklore for therapeutic purposes due to their health-promoting properties (Surjushe, Vasani & Saple, 2008). *Aloe vera* leaf extracts promotes a variety of antiinflammatory responses in the body by reduction of leukocyte adhesion and pro-inflammatory cytokine production (Duansak, Somboonwong, & Patumraj, 2003). *Aloe vera* gel extracts also exhibit hepatoprotective effects by inhibiting ethanol-induced fatty liver by suppressing mRNA expression of lipogenic genes in liver (Radha & Laxmipriya, 2015). *Aloe vera* contains many physiologically active substances which prove beneficial for its *antidiabetic activity*. Several in vitro and in vivo studies conducted on water soluble leaf fractions of *Aloe vera* demonstrated its glucose lowering activities. Polysaccharides play a major role in antidiabetic activities by preventing β-cells from oxidative damage (Das et al., 2011), increase insulin levels and hence show hypoglycaemic effects. The main anthraquinone of *Aloe* namely Aloin has been proposed to be a potential therapeutic option against cancer by having anti-proliferation effect on some cancer cell types like lung, squamous, glioma and neuroectodermal cancer cells by inhibiting both N-acetyl transferase activity and gene expression (Masaldan & Iyer, 2014).

### 12.3.3 Stem and bark extracts

Stem and bark extracts possess several potential health benefits due to their phytochemical content including phenols, flavonoids, tannins, saponins, alkaloids, glycosides, steroids, anthocyanins, and resins. *Ficus racemosa* stem bark extracts have antioxidant, hypoglycemic, hepatoprotective, antiinflammatory, antibacterial/antifungal, gastro-protective, analgesic, antidiarrheal, hypotensive, antipyretic, and wound healing activities, which may be contributed by its phytochemical compounds like steroids, alkaloids, tannins, quercetin, gluanol acetate, stigmasterol, β-sitosterol, and β-sitosterol-D-glucoside (Ahmed & Urooj, 2010). Hypoglycemic capacity of different solvent extracts of *F. racemosa* stem bark powder displayed a noticeable long term effect on reducing glucose levels of blood (up to 80%) in diabetic rats (alloxan-induced). This glucose lowering capacity of bark extracts was analogous to that of compound glibenclamide, a standard antidiabetic agent (Vasudevan, Sophia, Balakrishanan, & Manoharan, 2007). Also, in diabetic rats (alloxan-induced), aqeous and ethanolic extracts of *F. racemosa* bark showed a noteworthy radical quenching activity. This in turn ominously improved the radical quenching status by reducing Thiobarbituric acid reactive substances and enhancing GSH levels and other antioxidant defense system (Vasudevan et al., 2007). Methanol extract of its bark on oral administration along with carbon tetrachloride at 250 and 500 mg/kg body weight showed liver protection as is clearly evident by serum transaminase reversal elevations (Channabasavaraj, Badami, & Bhojraj, 2008). Studies conducted on in vitro antiinflammatory potential of bark extracts (ethanolic) of *F. racemosa* presented a significant hindrance in COX-1 enzyme activity to an extent of 89%, 71%, and 41%, respectively (Li, Myers, Leach, Lin, & Leach, 2003). Gastro-protective effect of bark extracts (ethanolic) of *F. racemosa* may be attributed to its antiulcerogenic activity (Malairajan, Gopalakrishnan, Narasimhan, & Kavimani, 2007).

*Artocarpus chaplasa* stem bark extract was used traditionally for the treatment of various ailments and skin diseases in north eastern India. Antioxidant activity of stem extracts of *A. chaplasa* was evaluated by using superoxide radical quenching assay and was found to have a significant radical scavenging activity for both superoxide and DPPH. This may be attributed to the phenolic contents of the plant showing a positive relationship between total polyphenol constituents and DPPH free radical quenching action (Siriwardhana & Shahidi, 2002). Methanolic stem extracts of *A. chaplasa* may be used as a potential supplement for treating noninsulin dependent diabetes mellitus by inhibiting α-glucosidase activity (Bhattacharjee, Singha, Banik, Dinda, & Maiti, 2012).

Several bioactive components from asparagus stem like polyphenols, dietary fiber, saponins, and anthocyanins have achieved growing courtesy in recent times due to their anticancer, antitumor, antioxidative, immune-modulatory, hypotensive, and hypoglycemic effects studied through in vitro and in vivo studies. Anticancer activities of Asparagus extracts have been indicated by many studies. In early 1996, some studies reported antitumor potential of Asparagus saponins extracted from shoots in a dose-dependent manner (Shao et al., 1996). antitumor action of ethanolic asparagus extract saponins extracted from matured stalk was evaluated by using prostate cancer (PC-3) cell lines. Results illustrated these extracts have cytotoxic impact against these cells at 1.5 mg/mL concentrations. Stems of Asparagus displayed a major dose-dependent cytotoxic capacity against 3 tumor cell lines comprising colon, breast and pancreatic cancers. This cytotoxic action is possibly achieved by inhibiting the invasive capability of human breast cancer cell MDAMB-231 and by regulation of small G protein action to hinder motility of tumor cells (Jaramillo et al., 2016). Also, in animal model (Wistar rats) it was observed that extracts of asparagus stem showed positive action against Bisphenol (toxic substance) by boosting antioxidant capacity (Poormoosavi, Najafzadehvarzi, Behmanesh, & Amirgholami, 2018). Asparagus polysaccharides reportedly showed a significant improvement in the phagocytic activity of peritoneal macrophages of normal mice by enhancing cellular and humoral immunity. Also, these polysaccharide extracts improve the conversion rate of lymphocytes and encourage the development of hemolysin and hemolytic plaques (Zhang, 2003). It is also supposed that polysaccharides of asparagus accelerate release of NO in macrophages by expression of iNOS gene activation. Zhao, Xie, & Yan, 2012 reported the hypoglycemic effects of old matured stem extracts of asparagus which indicated extraordinary results in model rat. Hypoglycemic activity of AEO may be due to its ability to alleviate the oxidative damage by improvement of antioxidant shielding enzymes activity which in turn stimulate insulin secretion and adjust blood glucose metabolism. Hypolipidemic potential of Asparagus were also been studied. It has been reported that old stem extract of asparagus could remarkably inhibit the elevated serum cholesterol in hyperglycemic rats and had a regulatory influence on the lipid metabolism syndrome. The polysaccharides from Asparagus stem extracts also reduce the levels of LDL cholesterol and the manifestation of atherosclerosis to uphold blood lipid metabolism (Guo et al., 2019; Guo, Wang, & Liu, 2020; Zhao, Xie, & Yan, 2012).

Information on the ethano-botanical and pharmacological use of plants from genus *Parkia* was regained owing to its phytochemistry and it was found that their extracts possess anticancer, antimicrobial, antihypertensive, antiinflammatory, antiulcer, antidiabetic, antioxidant, hepatoprotective and antidiarrheal activities (Saleh et al., 2021). The stem bark of *Parkia biglobosa* comprises of phenols, sugars, saponin, flavonoid, tannin, terpenoid, steroid, alkaloid and other glycoside components. In vitro study on anticancer activity of methanol extracts of *Parkia* species has been studied on various human cancer cell lines. The results show that methanolic extract of barks of *Parkia* *filicoidea and P. biglobosa* exhibit varying degrees of antiproliferative activities on prostate cancer (T-549 and BT-20), acute T cell leukemia (PC-3) and colon cancer (SW-480) cells at concentration ranging between 20−200 μg/mL (Fadeyi, Fadeyi, Adejumo, Okoro, & Myles, 2013). Also, the antitumor ability of the extracts of some *Parkia* species such as *Parkia biglandulosa and Parkia speciosa* could be a characteristic of their antiangiogenic activities (Shete, Mundada, & Dhande, 2017). Aqueous extracts of *P. biglobosa* stem also demonstrates sound antihypertensive effect in adrenaline-induced hypertensive female rabbits. The hypotensive potential of *P. biglobosa* could be attributed to its key phytochemical compounds like phenols and flavonoids. These compounds promote vaso-relaxation by hampering angiotensin converting enzyme (ACE), and by regulating nitric oxide availability and decreasing oxidative stress that ultimately leads to blood pressure lowering effects (Takagaki & Nanjo, 2015; Yi et al., 2016). antidiarrheal activities of aqueous bark extracts of *P. biglobosa* was investigated in mice. The study revealed that the aqueous stem extract possess antidiarrheal activities which may be linked to their direct inhibitory effect on the propulsive movement of smooth muscles of gastrointestinal (GI) tract and antimicrobial effect on the diarrhea causing pathogenic organisms (Tijani et al., 2009).

Rhubarb is a perennial plant having laxative tendency and is used to treat constipation problems. Study conducted by Fallah Hossini, FakhrZade, Larijani, & Sheikh Samani, 2005; revealed a significant correlation between rhubarb extract use and blood glucose, total cholesterol and LDL declination in diabetic patients (type II). Another investigation was conducted on the efficacy of extracts of rhubarb stem on the HbA1C and blood glucose levels in patients with type II diabetes. The results revealed a significant reduction in HbA1C after rhubarb use. Also, fasting blood sugar level showed a significant decrease after consuming oral capsules of rhubarb stem extracts for 3 months in type II diabetic patients. The blood glucose reducing effect of rhubarb stem extract was attributed to the presence of tannins which stimulates pancreatic beta cells causing a reduction in blood glucose level (Shad & Haghighi, 2018).

### 12.3.4 Seed extract

Seed extracts have proven numerous health benefits. There are several studies that have shown the protective effect of seed extracts on human health. Extracts from seeds such as grape seed, nigella seeds, pumpkin seeds, fenugreek seeds, sunflower seeds, chia seeds, etc. have been studied extensively for their phytochemical properties. The phytochemicals present in seed extracts have antioxidant, antidiabetic, anticancerous effects. These beneficial effects of seed extract have led to increased use of these as food substitutes. The amount of phytochemicals present in seeds varies with the kind of seed and other conditions under which the seed has developed.

Grape seeds contain proanthocyanidins, which are polyhydroxyflavan polymers. The conjugated and colonic metabolites of proanthocyanidins present in grape seed promote beneficial health properties. Numerous in vitro and in vivo studies have shown that the proanthocyanidin have pharmacological properties. The effects include antioxidant, antineurodegenerative, antiobesity, anticancer, antidiabetic, antiosteoarthritis, and cardio-protective capabilities. In a study, effect of procyanidin on Wister female rats was carried out. In this study the rats were treated for 30 days with 25 mg/kg grape seed extracts. The results showed an enhanced homeostatic model valuation insulin resistance index attended by primers down regulation: The 4(Glut4) Glucose transporter, 1(Irs1) Insulin receptor, and (PPARg2) peroxisome proliferator-activated receptor gamma isoform-2 in mesenteric white adipose tissue. Therefore this study suggested that seed procyanidin of grape have positive effect homeostasis glucose (Montagut et al., 2010). The procyanidin antiinflammatory effects of grape seeds were also studied by Terra et al. (2009).

Cumin, a widely used spice mainly used for its unique flavor in several cultural cuisines, contains major compounds that possess antioxidant and antispoilage capabilities. Cumin seed extracts are used as natural antioxidants in foods. The antiradical and antioxidant activities of cumin seed extract decreases the occurrence of several health issues (Al-Juhaimi & Ghafoor, 2013).

*Nigella sativa* (black seed), an annual herb, has many pharmacological assets due to its active compounds. Most health-promoting effects black seeds are attributed to thymoquinone components present in it. A study on *Nigella sativa* seed extract for its antihypertensive effects was carried out by Dehkordi and Kamkhah (2008). The results showed that consumption of *Nigella* extracts for 2 weeks at 200 or 400 mg/day decreased systolic as well as diastolic blood pressure in patients.

Avocado (*Persea americana*) seed, which is an agro-industrial residue, contains ample amount of extractable polyphenolic compounds which confer various food and health benefits due to their antioxidant capacity. Methanolic extracts of avocado seeds exhibited anticancer and antiinflammatory activities against colon and liver cancer cell line in a dose-dependent manner (Alkhalaf, Alansari, Ibrahim, & ELhalwagy, 2019). Antioxidant activity of avocado seed extracts were assessed by its DPPH radical scavenging action with highest activity observed in methanolic seed extracts than aqueous extracts (Bahru, Tadele, & Ajebe, 2019). antidiabetic effects of aqueous seed extracts of avocado were also confirmed on alloxan-induced diabetic mice models (Alhassan et al., 2012). In vitro research findings have also determined significant reduction in heart rate and blood pressure in rat models by the treatment of aqueous avocado seed extract (Anaka, Ozolua, & Okpo, 2009).

The papaya seeds contain benzyl isothiocyanate, which is sulfur-containing compound having various positive effects. These substances play an important role in plant defense systems also (El Moussaoui et al., 2008). Papaya seed extracts have therapeutic such as carminative, antifertility effects in males. These isothiocyanate compounds present in papaya seeds have been seen to prevent various cancers like breast, lung, colon pancreas and prostate in humans. Isothiocyanate inhibits and prevents formation and development of cancer cells through numerous mechanisms (Barbra & Minton, 2008). Also, methanol seed extracts of papaya was confirmed for its antiinflammatory and antinociceptic action in a dose-dependent manner on rat models (Anaga & Onehi, 2010).

The seeds of *Moringa oleifera* have antioxidant property and decrease the oxidative damage. These seeds possess hepatoprotective, antiinflammatory and antifibrotic activities against carbon tetrachloride induced damage and fibrosis of liver (Hamza, 2010). Rats were intoxicated with $CCl_4$ and simultaneously were given these seed extracts 1 g/kg body weight. After 8 weeks of this treatment the results showed lower AST and ALT serum levels and elevated albumin levels, demonstrating better liver synthesis compared to control rats. Lower levels of globulin, diminishes myeloperoxidase action and also lower hepatic inflammatory cell infiltration and hence reduces inflammation.

### 12.3.5 Flower extracts

Flower extracts possess many health benefits due to the presence of various phytochemicals like polysaccharides, phenolics, essential oils, alkaloids, tannins, saponins, sterols, carotenoids, and prebiotics (inulin) (Zheng et al., 2021; Takahashi, Rezende, Moura, Dominguete, & Sande, 2020). Saffron (*Crocus sativus* L.) flower extracts are abundant source of biologically active compounds such as safranal, picrocrocin, and crocin, which have been explored for several health benefits and pharmacological properties. Flower extracts of saffron has been studied for *antitumor* and anticancer properties. Crocin is suggested to be the major antitumor ingredient in saffron. Also, safranal can act against HeLa cell line growth, proliferation of MCF-7 cell lines and also suppresses some toxic biochemical markers. *antitumoral potential* of crocetin is due to its capability to inhibit nucleic acid synthesis, blocking growth factor signaling pathways, causing apoptosis and improving antioxidative system (Gutheil, Reed, Ray, Anant, & Dhar, 2012). Saffron also reported *antidiabetic* response due to its active constituents (crocin, safranal and crocetin) which exhibit insulin sensitizing effects without interfering serum glutamic-pyruvic transaminase and creatinine levels. Also, saffron stimulates 5′-AMP-triggered protein kinase which encourages glucose uptake in skeletal muscles which in turn improves insulin sensitivity, thus preventing excess glucose accumulation in blood serum (Razak, Anwar Hamzah, Yee, Kadir, & Nayan, 2017). Methanolic and water–methanol extracts of saffron stigma has been evaluated for their antioxidant, antiinflammatory and cardio-protective properties by Poma, Fontecchio, Carlucci, and Chichiricco (2012). Reduction in serum triglycerides, LDLs, very LDLs and total cholesterol levels, blocking apoptosis signaling pathways and restraining myocardial cell mortality by saffron extracts could be possible events in reduction of cardiovascular diseases. In addition, saffron extracts has been reported to improve neurodegenerative diseases like Alzheimer's disease by decreasing acetylcholinesterase activity defecating the accumulation of amyloid β and improving cerebral antioxidant markers in human brain (Razak et al., 2017).

Aqueous and ethanolic extracts obtained from *Chrysanthemum morifolium* display antioxidant activities, which are characteristics of its phytochemical complexes such as phenolic acids, flavonoids and terpenes. The potential antioxidant property of *C. morifolium* is due to its ability to boost the antioxidant enzyme activity like superoxide dismutase, catalase and glutathione peroxidase and scavenging free radicals (ROS) and peroxidation of melonaldehyde (Li et al., 2019; Yang, Yang, Feng, Jiang, & Zhang, 2019). A polysaccharide (JHBOS2) obtained from aqueous extracts of *C. morifolium* flowers exhibited antiangiogenic activity at (150 μg/mL) by the possible inhibition of tube formation in HMEC-1 cells (human mammary epithelial cells) (Zheng, Dong, Du). Researchers also showed antiinflammatory effects of flower extracts (hot water and methanol) of *C. morifolium* against lipopolysaccharide-initiated human leukemia monocytic THP-1 cells at low levels of 1, 10 and 100 (μg/mL). Interestingly, it was noticed that hot aqueous fraction of *C. morifolium* restrain lipopolysaccharide stimulated emergence of pro-inflammatory mediators (Interlukin-6, Interlukin-1β and Cyclooxygenase 2). Significantly higher concentrations of phenolic acids and flavonoids in flower extracts of *C. morifolium* are the basis for its antiinflammatory potential (Zheng, Lu, & Xu, 2021). In a study, strong neuroprotective activity of *C. morifolium* was discussed in different cell and animal models. Phenolic glycoside [2,6-Dimethoxy-4-hydroxymethylphenol 1-D-(6-O-Caffeoyl)-β-D glucopyranoside] and ligans isolated from flower extracts of *C. morifolium* were tested to estimate antineurotoxicity in $H_2O_2$-provoked SH-SY5y cells. The results showed that these compounds significantly improved cell viability at a concentration of 10 μM after treatment with $H_2O_2$. *C. morifolium* flower extracts also pose antidiabetic activity against obese diabetic KK-AY mice in a dose-dependent sequence. Also, the extract was able to improve insulin resistance as a result of elevation in adiponectin levels after its administration (Yamamoto et al., 2015). Moreover, flavonoids obtained from the methanolic flower extracts of *C. morifolium* showed *antiosteoporotic* properties due to the inhibition of osteoclast growth by repressing the manifestation of tartrate-resistant acid phosphate, an enzyme responsible for the production of ROS which damage bone structure (Zheng et al., 2021). *M. oleifera* flower is an abundant store house of bioactive compounds like ethyl oleate, quinic acid and cis-9-hexadecenal which displayed promising antioxidant, anticancer and antiinflammatory properties. In vitro antioxidant potential of *M. oleifera* ethanolic flower extract was tested by DPPH free radical scavenging activity and was related with standard ascorbic acid. Results revealed a satisfactory free radical scavenging activity of flower extract. Thus consumption of *M. oleifera* flower extracts can be advantageous in preventing oxidative stress and related complications (Alhakmani, Kumar, & Khan, 2013). In another study, a detailed examination of *M. oleifera* flower extracts (ethanolic) on its antiinflammatory potential was carried out which determines successful inhibition of NO and pro-inflammatory interluekins like IL-6, IL-1β, TNF-α, and PGE 2. Simultaneously, these flower extracts aid in the formation of antiinflammatory IL-10 and IĸB-α expressions which improves inflammatory damage via NF-κB pathway in microphages. Hepatoprotective property of *M. oleifera* flower extract tested in mice models is basically the extension of its antiinflammatory and antioxidative capability (Kalappurayil & Joseph, 2017).

Hibiscus (*Hibiscus rosa sinensis)* flower extracts possess antioxidant, antiinflammatory, antidiabetic, anticancer, and antifertility properties. Besides these, hibiscus flower extracts also exhibit cardio-protective, neuroprotective, gastro-protective, and hepatoprotective characteristics (Missoum, 2018). Antioxidant potential of *H. rosa* flower extracts was determined by using DPPH essay with BHT used as a control. This study compared DPPH radical scavenging activity of methanolic and ethanolic flower extracts with BHT. The results revealed higher radical scavenging action of methanolic extracts than ethanolic extracts due to its higher concentration of flavonoid and phenolic substances. Anticancer activity of hibiscus flower (acetone) extracts was executed on viability of HeLa cell lines and the results show only 12.96% cell viability (Durga, Kumar, Hameed, Dheeba, & Saravanan, 2018). Another study was conducted on antidiabetic property of *H. rosa* flower extracts on pregnant Wister rats and albino rabbits. Ethanolic flower extracts was observed to exhibit best antidiabetic activity against alloxan initiated diabetes within female pregnant rats and reduced plasma glucose levels in albino rabbits in a progressive manner (Pethe, Yelwatkar, Gujar, Varma, & Manchalwar, 2017). Effect of aqueous flower extracts on gastro-protective activity against aspirin, pylorus ligation and ethanol-induced ulceritis on albino Wister rats was studied. The results demonstrated best gastroprotectivity of hibiscus flower extracts against these models owing to the radical scavenging activity of flower tannins and flavonoids (Kumar et al., 2014).

### 12.3.6 Roots and tuber extracts

Roots and tuber crops have been extensively studied for their possible health benefits and as a source of functional constituents. Since ancient times, roots and tuber crops have been a part of different foods and are being used in the modern diet to add variety in addition to providing numerous desired nutritional and health benefits including, antidiabetic, antiobesity, antioxidative, and immune-modulatory activities. The health benefits of roots and tuber crops have been reported to be due to the presence of bioactive compounds including phenolic compounds, bioactive proteins, saponins, phytic acids, glycoalkaloids, carotenoids, ascorbic acid and hydroxycoumarins

(Chandrasekara, 2018). In a study the extracts from tuber *Solanum jamesii* were found to have antiproliferative effect on intestinal cancer cells. The authors reported that the compounds present in the extracts have significantly high biological activity when interacting synergistically among themselves which was the basis for their antiproliferative activity (Chandrasekara, 2016). A comparative analysis was carried to determine the antiproliferative activity of anthocyanins in root tubers (var. Bhu Krishna) and leaves against colon, cervical and breast cancer cells. This was related to the ability of anthocyanins to induce apoptosis in the cancer cells and thus producing significant antitumor effect against these cells (Vishnu et al., 2019). The methanolic extracts of the peel and peel bandage of the sweet potatoes has been evaluated for their wound healing properties by excision and incision wound models on Wistar rats. The authors documented that hydroxyproline content increased significantly in the test group in comparison to that of wounded control group. The increase in the content of hydroxyproline results in enhanced collagen synthesis which ultimately improves wound healing. Furthermore, the malondialdehyde content decreased in test groups when compared to wounded control group which depicts the role of sweet potato peels in inhibiting lipid oxidation (Panda, Sonkamble, Sanjeev Panda, & Kundnani, 2012).

Yacon tubers are a rich source of phenolic compounds and fructo-oligosaccharides and have the potential ability to treat diabetes, kidney problems, and reduce the risk of colon cancer (Cocato et al., 2019). In addition, the yacon tuber extracts increase the population of health-promoting bacteria and decrease the numbers of pathogenic bacteria in the gut and thus show significantly high prebiotic effect and gut modulating properties. The prebiotic effect of yacon extract has been studied using guinea pig model and found that yacon extract increases beneficial bacteria including lactobacillus and promotes the formation of short chain fatty acids (Cocato et al., 2019). In a similar study, the inulin extracted from Jerasalem artichoke was documented to have significantly high prebiotic effect than a commercial prebiotic with inulin and was found to be associated with the reduction in colorectal cancer and intestinal pH (Barszcz, Taciak, & Skomiał, 2016). The antioxidant properties of ethanolic and aqueous extracts of yam peel on tert-butyl hydroperoxide (t-BHP) induced oxidative stress in mice liver cells have been studied. The ethanolic extracts of yam peel showed a pronounced protective effect on t-BHP treated cells as compared to aqueous extracts. Moreover, the catalase enzyme activity was enhanced by ethanolic extracts while aqueous extracts reduced it. The phytochemicals present in yam improve the activities of endogenous antioxidant enzymes. The levels of $\gamma$-glutamyl transpeptidase (GGT), triacylglycerol, and LDL were decreased in serum of rats in which carbon tetrachloride was used for inducing hepatic fibrosis (Chandrasekara, 2016; Hsu, Yeh, & Wei, 2011). Chinese yam flour extract was evaluated for its effects on the GI tract of rats and was found to enhance digestive capacity and convert some intestinal flora to helpful bacteria (Jeong et al., 2006).

## 12.4 Conclusion

Plant extracts have been used traditionally as medicine, flavor, tonic, and preservatives in foods from centuries. These extracts contribute to the biological activity through its phytochemical nature and thus people prefer their consumption than medicines. The plant extracts are richest sources of essential components having antimicrobial, antioxidant, antiproliferative, and laxative effects. Additionally, extracts rich in potential bioactive components might bestow some extra benefits when incorporated to the food products, contributing improvements of the overall strength and well-being. Globalization has greatly paved the way to renew the interest in functional foods, and nowadays majority of people prefer to take healthy diet enriched with different plant extracts as a nutraceutical remedy. This flexibility in plant remedies is essentially due to the fact that these plant extracts are highly effective in curing diseases due to their diverse functional properties and low cost. Although numerous studies have proved the health-promoting potential of these leaves, fruit, stem and root-derived extracts, additional human studies are still compulsory to ascertain their true efficacy.

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