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A Review on Botanical characteristics, Phytochemistry, Pharmacology and Traditional uses of selected Medicinal plants: *Juniperus communis, Ficus carica, Garcinia indica*

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Abstract: Herbal plants have been used since centuries for the treatment of various disease conditions due to their medicine like properties. In traditional system of medicine these herbal plants have been known to possess various activities such as: anticancer, antiulcer, antidiabetic, anti-inflammatory, antimicrobial, antioxidant, antiseptic, analgesic and also found to be effective against various disease conditions as well. Due to this reason these plants have been the part of research since centuries by various scientists and researchers all over the world in order to identify various chemical constituents present in these plants along with their biological uses. This review has been written with the aim to include all studies, experiments done on the phytochemistry and pharmacology of three important medicinal herbal plants: *Juniperus communis*, *Ficus carica* and *Garcinia indica*. This review includes the major results and findings of research and review papers published between 2010-2021 via various search engines like Google Scholar, Pubmed, Sci hub and many more. The aim of this article is to highlight the major phytoconstituents present in all 3 plants which are responsible for contributing to the pharmacological activities exhibited by these plants. To obtain a valid relationship between the chemical compounds present in plants and biological uses. To highlight those areas corresponding to these 3 plants where still more research and reviews are required to be perform by the researchers in order to identify any new chemical constituents present in these plants and to detect any novel pharmacological activities possess by these pants which can further prove to be useful in curing diseases.

Keywords: Juniperus communis, Ficus carica, Garcinia indica, **Traditional uses, Phytochemistry, Pharmacology**

I. INTRODUCTION

Herbal plants have been used since centuries in the Indian folk medicine for the treatment of various illnesses. These herbal plants when extracted by the people centuries back ago, then the herbal extracts known to possess various beneficial activities and also proved to cure various diseases due to the presence of some chemical compounds in these herbal extracts. Various research studies have been conducted by scientists on establishing the relationship between the phytoconstituents and pharmacological activities possessed by these herbal plants and the studies are still going on. In the previous studies performed by scientists it had been proved that the herbal plants are a good source of beneficial phytoconstituents which can be easily extracted, identified and these chemical constituents can be checked for any biological uses produced by them via conducting various *in vitro* and *in vivo* experiments in laboratory. Thus, it is proven that these herbal plants can act as an alternative therapy as compared to the allopathic medicines for the prevention and treatment of various diseases like bacterial infections, fungal infections, diabetes, ulcers, fever, cough, helminthic diseases, malaria, dengue, hepatitis, jaundice, cancer, asthma, kidney stones, Alzheimer's, Parkinson's, anxiety, depression, HIV- AIDS and many more diseases. This review on the three important medicinal plants i.e., *Juniperus communis*, *Ficus carica* and *Garcinia indica* has been written with the aim to highlight the major phytoconstituents present in all 3 plants which are responsible for contributing to the pharmacological activities exhibited by these plants. To obtain a valid relationship between the chemical compounds present in plants and biological uses. To highlight those areas corresponding to these 3 plants where still more research and reviews are required to be performed by the researchers. Botanical description, Phytochemistry, pharmacology, traditional uses and future prospective of all herbal medicinal plants was discussed in this review.

II.BIOLOGICAL SOURCES, DISTRIBUTION AND BOTANICAL CHARACTERISTICS

Juniperus communis is a perennial, evergreen, long-lived coniferous plant belonging to family Cupressaceae [1]. Juniperus is the second largest genus of the conifers which is composed of approximately 75–80 taxa of useful aromatic and medicinal plants [2-3]. *J. communis* is known by various regional names such as: In English: Juniper Berry, Common Juniper; In Sanskrit: Havusa, Matsyagandha; In Hindi: Havuber, Havubair; In Gujrati: Palash and In Urdu: Abhal, Aarar [4]. This plant has been widely distributed throughout the various geographical areas like: in the cool temperate regions of Northern Hemisphere, from the Arctic south, in mountains, to around latitude of 30° north in Europe, Asia, North America and divided into three sections as Caryocedrus, Juniperus, and Sabina. They grow as scattered single individuals of the undergrowth in dry pinewoods or mixed forests or may form a stand [1]. In India, *J. communis* is found in Himachal Pradesh at an altitude of 3000 m–4200 m. It is mainly distributed in Manimahesh in Chamba, Kullu, Churdhar in Sirmour, Chhota and Bara Bhnghal in Kangra, and Kinnaur and Pattan valley in Lahaul Spiti districts [4]. A wide geographical distribution is the main reason for the remarkable variation in the morphological characteristics and chemical composition of the secondary metabolites of *J. communis* [5]. *J. communis* has green and sharp needle like leaves in whorls of a three, which are 10–15 mm long and 1–2 mm wide; the leaves remain on the branch for up to 4 years. Juniper is a dioecious species: male and female cones grow on separate plants which are wind-pollinated. The male plants of common junipers are often similar to trees, occasionally reaching 10 m tall, while the female plants as more sprawling better resemble the shrubs. The plant blooms in April–May; however, the cones of *J. communis* mature in late autumn of the 2nd year. Therefore, the unripe 2nd year and ripe 3rd year berries may be collected from the same plant simultaneously. The spherical, 5–12 mm diameter, cones are berry-like, blue-black with a waxy coating and usually have 3 or 6 scales, each scale with a single seed. *J. communis* is a very slowly growing plant reaching approximately 20 and 50 cm in height after 5 and 10 years, respectively [6]. Junipers have thin bark and varying in size and shape. Leaves on young branches are acicular and rigid, in whorls of three, or scale-like and decussate, rarely short and not jointed. Male flowers have numerous stamens and female flowers are surrounded at the base by small persistent bracts, composed of 3 to 8 scales. These scales form a hard, globular fleshy berry-like fruit ripening in 1–3 years. These ripened berries are red to brown or orange in some species but in most they are blue to black and have a distinct odor. Number of unwinged seeds varies 1 to 9 between species [7]. *J. communis* is a volatile secondary metabolite essential oil-bearing and wide-spreading conifer. The high ecological amplitude is typical of this species, it is frequent in dry pinewoods, on river valleys, and also occurs on wet soils. It is light-demanding, but can grow in rather little daylight. Wide ecological amplitude is the reason for the quantitative and qualitative diversity of essential oils. *Juniperus communis* has been used in folk medicine and also in folk veterinary medicine [8].

The genus Ficus (Moraceae) constitutes one of the largest genera of angiosperms with more than 800 species of trees, epiphytes, and shrubs in the tropical and sub-tropical regions worldwide [9]. *Ficus carica* belongs to the family Moraceae. The most significant species of Ficus found in India, are *F. bengalensis*, *F. carica*, *F. racemosa* and *F. elastica*. It is native to Sub-Himalayan tract, Bengal, and central India, it has been extensively cultivated worldwide. *Ficus carica* is a temperate species, native to southwest Asia and the Mediterranean region (from Afghanistan to Portugal) and has been widely cultivated from ancient times for its fruits (nutritional value). Different plant parts like fruits, seeds, leaves, tender, bark, shoots and latex have numerous medicinal applications [10]. Major producers of figs are Turkey, Egypt, Morocco, Spain, Greece, California, Italy, Brazil, and other countries with hot dry summers and mild winters [11]. Some countries like Turkey, Egypt, Algeria and Morocco account for more than 65% of the world production, and Turkey is the leading country in both fresh and dry figs, accounting for 51% of fig fruit world exports [12]. *F. carica* is also known by various vernacular names such as: In English (Common fig tree, Fig); In Hindi (Anjeer, Anjir, Tin); In Sanskrit (Angira, Phalgu, Rajodumbara, Udumvara); In Eastern India (Doomoor, Angir, Dumur); In Western India (Anjeer, Angir); In Southern India (Anjoora, Cevvatti, Chikappatti, Madipatu, Shimayatti); In Northern India (Fagari); In Urdu (Poast, Darakht Anjir, Anjir Zard); In Unani (Anjir); In Arabic (Anjir, Teen, Ten) [13-16].

Figs have considerable cultural importance throughout the tropics, both as objects of worship and for their many practical uses. This plant also invites attention of the researchers worldwide for its biological activities. The therapeutic utilities of *F. carica* have been indicated in the traditional systems of medicine such as Ayurveda, Unani, and Siddha [17]. Many Ficus species consist of numerous varieties, significant genetic diversity, and outstanding pharmacological activities that are of remarkable commercial importance [18]. *F. carica* is usually a 15–20 ft tall deciduous tree, with numerous spreading branches and trunk rarely more than 7 ft in diameter. The latex of the plant is milky white and mainly contains ficin, i.e., protein hydrolytic enzyme [19].

The root system in the plant is typically shallow and spreading. The species name carica means having papaya-like leaves. Figs are axillary on leafy branchlets, paired or solitary, and usually pear shaped. The matured ‘‘fig’’ has a tough peel (pure green, green suffused with brown, brown or purple), often cracking upon ripeness, and exposing the pulp beneath. Flowers are seen in receptacles; arise from the axils of old leaves. The upper part of receptacle is occupied by female flowers and the lower part by male flowers. The ripen receptacle, saikonium, contains a large number of small whitish seeds. Seeds may be large, medium, small, or minute and range in number from 30 to 1600 per fruit. The edible seeds are numerous and generally hollow, unless pollinated. Pollinated seeds provide the characteristic nutty taste of dried figs. The interior portion is a white, inner ring containing a seed mass bound with jellylike flesh. The leaves of the plant are bright green, single, alternate, and large (usually up to 1 ft in length). They are more or less deeply lobed with 1–5 sinuses, rough hairy on the upper surface and soft hairy on the underside. The bark is smooth. The outer bark is silvery gray or ash-colored, exfoliated with irregular rounded flakes. The middle bark sections appear as brownish or light reddish brown in color. The inner part consists of the layers of light yellowish or orange brown colored granular tissue. *Ficus carica* has been cultivated for a long time worldwide for its edible fruit. It can be propagated by seeds or by vegetative methods. The main method of propagation is by hardwood cuttings. Vigorous 1-year shoot or 2- to 3-year old wood are successfully used for vegetative propagation [20]. Dried figs are an excellent source of fiber, Vitamin K and minerals like copper, manganese, magnesium, potassium, calcium relative to human needs [21]. The phytochemistry of *F. carica* shows that it is a potent source of flavonoids and polyphenols and various other compounds like arabinose, β-amyrins, β-carotines, glycosides, β-setosterols and xanthotoxol [22-24]. Economic importance Fresh and dry fig (fruit) has been popularly consumed as a dietary food material since the beginning of civilization. Fig syrup (10–20 ml) is used as a remedy for mild constipation [25]. It is reported that F. carica leaves have shown beneficial effects in gastrointestinal diseases, respiratory diseases, cardiovascular diseases [26–28] diabetes, skin diseases, ulcers, dysentery, and hemorrhoids [29].

The genus Garcinia includes greater than 300 species worldwide and one of the important species it consists of is *Garcinia indica* which is an endemic plant species of the Western Ghats of India and it belongs to the family Clusiaceae. Plants of this genus have multiple applications in pharmaceutical, culinary and industrial fields. *G. indica* can be used as an ornamental plant due to its dense canopy of green leaves and red-tinged tender emerging leaves. About 35 species are common in India and are endemic to the evergreen forests of Western Ghats, Gujarat, Andaman-Nicobar Islands, North-Eastern region of India and this plant also found in Asia and Africa [30]. *G. indica* is known by other synonym names as well in different languages such as: In English (Kokum, Goa butter tree, Kokum butter tree); In Hindi (Kokum); In Sanskrit (Vrikshamia, Vrikshamla, Amlabija, Raktavikshamla, Amlapura, Amlashaka) and In Gujarati (Kokum, Kokani, Bhirind) [31-32]. Kokum is a slender but very sturdy evergreen tree and does not need elaborate irrigation or use of fertilizers, pesticides or herbicides. Kokum tree is dioecious (having separate male and female plants) and grows up to a height of 12 to 20 m. Kokum trees are generally found growing in the riversides, forests, wastelands. Plantlets can also be generated by adventitious bud differentiation on mature seeds and by in vitro propagation. The tree is large, having elliptic, oblong with deep-green glossy leaves up to 5–8 cm long and 2–3 cm broad. An average kokum tree bears hundreds of fruits and each fruits weigh around 21–85 g. The mature trees flower annually during the winter in the months of November–February. The process of fruiting takes approximately five months to complete and by May, the ripe fruits are ready for harvesting [32,38]. The emerging young leaves are tender and red-tinged. The leaves are simple, opposite, elliptic or oblong and deep green in color in the upper side, while pale in the lower side. They are 5 to 8 cm in length and 2.5–3.5 cm in breadth and shining [32]. The flowers are fleshy, dark pink, solitary or in spreading cluster. The fruit is brownish or purple about the size of an orange, marbled with yellow, and is crowned by the 4-parted, stalk less stigma. The fruit pulp is juicy, white, and delicious in taste and odor, consists 6–8 seeds [34]. Kokum fruit contains three to eight large seeds and is covered with whitish pulp which is sweet in taste. Ripe fruits are sour to taste and have a short shelf life of approximately a week. Seed amounts to nearly a quarter of the total fruit weight and chemical studies have shown that it contains 40-42% oil. From the time of planting, a seedling requires about six to seven years to grow and fruit. The maximum yield is mostly observed in a tree that is 20–50 years old. Oil remains solid at room temperature and is known as kokum butter which is light gray to yellow in color, greasy in texture and is bland to taste [38]. It is commercially exploited due the presence of 2 pharmaceutically important bioactive compounds such as hydroxycitric acid (HCA) and garcinol which have anti-obesity and anti-cancerous activities respectively [33]. Kokum is propagated through seeds which lead to heterozygosity, along with heterozygous character, cross-pollination and polygamodioecious nature are responsible for variation in habit, branching pattern, leaf morphology, flowering-fruiting season, fruit shape, size and color, thickness of fruit rind and biochemical composition of fruit [35-37].

III.TRADITIONAL USES

Juniperus species are widely consumed for various purposes within the traditional medicine round the world. Its fruit is fleshy and pulpy which is edible [39]. Juniper fruit is also used to produce flavors in different meals and dishes. It is also an important element of gin, a spirit that derives its flavor from juniper. It can also be used in place of pepper [40]. The cooked seeds can be used in place of coffee [41]. Boiled branches, leaves and juniper berries are used to make the tea which has flavor of gin [42]. Additionally, *J. communis* is also utilized in loss of appetite and dyspeptic complaints and its unproven uses are mentioned as “to regulate menstruation, to relieve menstrual pain, flushing out therapy for inflammatory diseases of the lower urinary tract, gout, arteriosclerosis, for severe irritation resulting from bronchitis, diabetes, halitosis, and rheumatic symptoms” [43-44]. Different parts of *J. communis* plant have been used since centuries in folklore medicine for treating various ailments. Berries of *J. communis* have been used as diuretic, sudorific, anti-inflammatory, carminative, emmenagogue, urinary antiseptic and digestive agent. Aerial parts of juniper have been used for the treatments of albuminuria, renal suppression, amenorrhoea, leucorrhoea, catarrh of the bladder, acute and chronic cystitis [45-46]. Juniper fruits were utilized in the treatment of migraine, piles, dropsy, chronic Bright’s disease, styptic, infantile tuberculosis, rheumatic and painful swellings and also shown to give stimulant, antiseptic and disinfectant effects. Bark of juniper has been utilized for the treatment of various diseases such as asthma, pulmonary blennorrhoea, respiratory infections, bladder infections, cough, skin infections, abdominal disorders, chronic pyelonephritis, diabetes, arthritis, gonorrhoea and nephrotic dropsy of children [45,47].

Figs have been traditionally used for its medicinal benefits as laxative, cardiovascular, respiratory, antispasmodic and anti-inflammatory remedies [48]. Its fruit is generally referred as figs which have been used as food and medicine for several centuries [49-50]. Its fruit, root and leaves are used in the native system of medicine in different disorders, such as colic, indigestion, diarrhea, sore throats, coughs, bronchial problems, inflammatory, cardiovascular disorders, ulcerative diseases, and cancers [49-53]. Fresh and dry fig (fruit) has been popularly consumed as a dietary food material since the beginning of civilization. Fig syrup (10–20 ml) is used as a remedy for mild constipation. Leaves are traditionally used as fodder for domestic animals. The plant latex is used as a curdling agent in the production of extremely well-known milk product like cheese by several indigenous communities. The wood is used for hoops, garlands, and for ornamental purposes also [54]. *Ficus carica* was emollient, demulcent, cooling, laxative and nutritive. The edible fruits of *Ficus carica* were traditionally used for treatment of hemorrhoids, insect stings, gout, ulcers, and skin infections such as warts and viruses. Fruits were usually recommended for people suffering from constipation, nutrient for pregnant women and for mental and physical exhaustion. They were considered as antipyretic, tonic, purgative, alexiteric, aphrodisiac, lithontriptic, anti-inflammatory, expectorant, diuretic, and used for treatment of pharyngitis, gastritis, bronchitis, irritative cough, weakness, paralysis, thirst, diseases of the liver and spleen, pain in the chest, to cures piles, to stimulate growth of hair, and for leprosy and nose bleeding. The root was used as tonic for leucoderma and ringworm [55-59].

G. indica has got multifarious uses and finds various applications among the local population. The dried fruit rind of kokum impart a sweet-tangy taste to food and is widely used as flavouring agent in food preparations as substitute for tamarind [60]. The fruits are also used as a substitute for grapes in wine making [61]. The fruit rind has also been utilized as a pink and purple food coloring agent [62]. From the fruits of *G. indica*, Kokum drinks were made. Konkani people of Goa and Maharashtra make bhirindi saar, a soup using kokum juice and also kokum kadi by mixing kokum juice and coconut milk, both used as after-meal

drink to relieve any gastric problems [63]. Kokum butter is an important ingredient in cosmetic products like lip balms, lotions and soaps [61]. Traditionally, kokum is used in herbal medicines to treat diarrhoea, inflammatory ailments, dermatitis, bowel problems, rheumatic pains and to prevent hyper perspiration. Fruits are used as antihelmintic and cardiotonic. Kokum juice from the rind is used against piles, colic problems, dysentery and diarrhoea [61,64]. Decoction of fruit rinds are traditionally used against diabetes. Kokum butter is used traditionally to heal wounds, fissures in hands and is supposed to restore elasticity of skin and used as a moisturizer [65-66]. Kokum fat is utilized in confectionary preparation. It is utilized in production of soaps, ointments and candles. Kokum rind can be applied to cure skin lesions and on wounds due to its relaxing and therapeutic properties. Gastric problems like flatulence, acidity, indigestion and constipation are cured by kokum fruit extracts. Antihelmintic properties are also present in it and also act as stimulant of craving. Kokum infusions are used in Ayurvedic medicine to treat dysentery, piles and infections. Cardio-vascular system is strengthened by kokum and function of liver is stabilized by it. Hydroxycitric acid is present in fruit that beats lipogenesis effect and lowers cholesterol level, so helps in weight loss. To avoid loss of nutrients and dehydration, powder of kokum rind is used. Also improve appetite and digestion, reduce constipation, cleans blood and fight infections, control the cardiovascular system, and minimize burning sensations that happens in all over the body. The rind of kokum fruit has powerful antiulcer and anti-cancer properties. Kokum oil and paste are used for skin problems and healing of wounds [67].

IV.PHYTOCHEMISTRY

The chemical studies of Juniperus species were started at the second half of the 20th century by Hartwell and friends. Various chemical studies have been conducted since then on *J. communis* plant for the identification and screening of useful chemical constituents which were responsible for exhibiting different pharmacological activities and for treating various diseases [68].
The oil profile of the juniper varies among species. The major components of the juniper oil are α-pinene (23%–60%), β-pinene (5.6%), limonene (6.52%), β-phellandrene (2.13%), p-cymene (9.96%), bornyl acetate (3.21%), and nerol (2.21%), while myrcene is present at a low concentration [69]. The main constituents in the *J. communis* essential oil were limonene, δ-3-carene, α-pinene, β-pinene, sabinene, myrcene, β-phellandrene, and D-germacrene [70]. Various chemical constituents were detected in the leaves of *J. communis* such as α-Pinene, α-Thujene, β-Pinene, camphene, Sabinene, Myrcene, Verbenene, limonene, α-Terpinene, γ-Terpinene, Citronellol, Terpinolene, δ-3-Carene, α-Phellandrene, δ-2-Carene, Terpinen-4-ol, α-Thujone, β-Thujone, methyl citronellate, α-Terpinyl acetate, α-Cubebene, Trans-Sabinene hydrate, β-Elemene, Myrtenyl acetate, δ-Cadinene, Germacrene-D, β-Caryophyllene and α-Humulene [71-74]. Different phytoconstituents were identified in the berries of *J. communis* plant such as α-Pinene, α-Thujene, β- Pinene, camphene, Sabinene, Myrcene, Verbenene, limonene, α-Terpinene, γ-Terpinene, Citronellol, Terpinolene, δ-3-Carene, α-Phellandrene, δ-2-Carene, Terpinen-4-ol, α-Thujone, β-Thujone, methyl citronellate, α-Terpinyl acetate, α-Cubebene, β-Elemene, Myrtenyl acetate, Elemol, Trans-Sabinene hydrate, Germacrene-B and β-Bisabolene [71,73,75-10]. Diterpenes were found to be the most frequent family of compounds, being described in more than 220 different structures. Coumarins (aesculetin, coumarsabin, siderin, skimmin, and umbelliferone), fatty acids (arachidic acid, capric, docosanoic, heneicosanoic, lauric, linoleic, linolenik, myristic, palmitic, palmitoleic, and stearic acid), flavonoids (agathisflavone, amentoflavone, apigenin, aromadendrin, bilobetin, cupressuflavone, hinokiflavone, irigenin, iridin, isocryptomerin, isoquercitrin, isorhamnetin, junipegenins, kaempferol, luteolin, naringenin, nepetin, nepitrin, nicotiflorin, podocarpusflavones, quercetin, quercitrin, robustaflavone, rutin, sciadopitysin, scutellarein, taxifolin, vitexin, and zeravschanoside), lignans (acuminatin, anhydropodorhizol, balactone, dehydropodophyllotoxin, deoxypodophyllotoxin, deoxypicropodophyllotoxin, detetrahydroconidendrin, dihydrodehydrodiconiferyl alcohol, dihydrosesamin, epipicropodophyllotoxin, epipinoresinol, epipodophyllotoxin, epipodorhizol, formosalactone, formosanol, hibalactone, hinokinin, icarisides, isobalactone, junaphthoic acid, junipercomnosides, matairesinol, nemerosin, picropodophyllin, picropodophyllotoxin, picropodophyllotoxone, pluviatolide, podophyllotoxin, podophyllotoxinic acid, podorhizol, savenin, sesamin, shonanin, sventenin, thuriferic acid, xanthoxylol, and yatein), phenolic acids (caffeic acid, chlorogenic acid, cinnamic acid, isovalerate, eicosyl ferulate,ferulic acid,gallic acid, heneicosylferulate, nonadecylferulate, p-coumaric acid, shikimic acid, syringic acid, and vanillic acid), sterols (campesterol, cholesterol, sitosterols, sitostenone, and stigmasterol), tannins (afzelechin, catechin, epiafzelechin, epicatechin, epigallocatechin, and gallocatechin), terpenoids (monoterpenes, sesquiterpenes, diterpenes, and triterpenes), other aliphatic and aromatic compounds were mentioned as the main constituents of the Juniperus species [78-81].

Phytochemical studies on *F. carica* revealed the presence of numerous bioactive compounds such as phenolic compounds, phytosterols, organic acids, anthocyanin composition, triterpenoids, coumarins, and volatile compounds such as hydrocarbons, aliphatic alcohols, and few other classes of secondary metabolites from different parts of *F. carica.* Most species of *F. carica* contain phenolic compounds, organic acids, and volatile compounds [82-83]. Phenolic acids such as 3-O- and 5-O-caffeoylquinic acids, ferulic acid, quercetin-3-O-glucoside, quercetin-3-O-rutinoside, psoralen, bergapten, and organic acids (oxalic, citric, malic, quinic, shikimic, and fumaric acids) have been isolated from the water extract of the leaves of *F. carica* L. [82]. Coumarin has been isolated from the methanol extract of the leaves of *F. carica* L. by bioassay-guided isolation, and the isolated coumarin exhibited the strongest nematicidal activity against the nematodes *Bursaphelenchus xylophilus*, *Panagrellus redivivus*, and *Caenorhabditis elegans* within 72 hours [84]. Four triterpenoids, bauerenol, lupeol acetate, methyl maslinate, and oleanolic acid have been isolated from the ficus leaves and showed irritant potential on mice ears [85]. *F. carica* leaves consist of various volatile compounds which are identified and distributed by distinct chemical classes, such as **Aldehydes:** methylbutanal, 2-methylbutanal, (E)-2-pentanal, hexanal, and (E)-2-hexanal; **Alcohols:** 1-penten-3-ol, 3-methyl-1-butanol, 2-methylbutanol, heptanol, benzyl alcohol, (E)-2-nonen-1-ol, and phenylethyl alcohol; **Ketones:** 3-pentanone; **Esters:** methyl butanoate, methyl hexanoate, hexyl acetate, ethyl benzoate, and methyl salicylate; **Monoterpenes:** limonene and menthol; **Sesquiterpenes:** *α*-cubenene, *α*- guaiene, *α*-ylangene, copaene, *β*-bourbonene, *β*-elemene, *α*-gurjunene, *β*-caryophyllene, *β*-cubebene, aromadendrene, *α*-caryophyllene, *τ*-muurolene, *τ*-cadinene, *α*-muurolene, germacrene D, and (+)-ledene; **Norisoprenoid:** *β*-cyclocitral, and **miscellaneous compounds:** psoralen [86]. Fifteen anthocyanin pigments were isolated from the fig fruit and bark of *F. carica*. Most of them contain cyanidin as aglycone and some pelargonidin derivatives [87]. Pentane extracts from the fig contain numerous volatile compounds: benzyl aldehyde, benzyl alcohol, furanoid, linalool, pyranoid (trans), cinnamic aldehyde, indole, cinnamic alcohol, eugenol, and transcaryophyllenes sesquiterpene: germacrene D, hydroxyl caryophyllene, angelicin, and

bergapten [83]. Total and individual phenolic compounds, phenolic acid, chlorogenic acid, flavones, and flavonols, have been isolated from fresh and dried fig skins of *F. carica* and dried figs contained total higher amounts of phenolics than the pulp of fresh fruits, owing to the contribution of the dry skin. Quercetin rutinoside was the major individual phenolic [88] while microbial *β*-D-glucans has been isolated from Libyan figs of *F. carica* [89]. Phenolic acids; 3-O- and 5-O-caffeoylquinic acids, ferulic acid, quercetin-3-O-glucoside, quercetin-3-O-rutinoside, psoralen, and bergapten, and organic acids (oxalic, citric, malic, shikimic, and fumaric acids) were isolated from the pulps and peels of figs [82]. Phenolics, anthocyanins, fructose, glucose, and sucrose were identified from the fig of *F. carica* [90].

Chemical examination of Ficus spp. have shown the presence of psoralen, bergapten, umbelliferone, β-sitosterol, campesterol, stigmasterol, fucosterol, fatty acids, 6-(2-methoxy-Z-vinyl)-7-methyl pyranocoumarin and 9,19-cycloarlane triterpenoid, 6-O-acyl-a-D-glycosyland 6-O-acyl-β-glucosyl-β-sitosterol and lupeol acetate [91]. described that the major volatile compound in dried figs was benzaldehyde, and after benzaldehyde, the most abundant aldehyde in dried figs was hexanal [92]. It has been reported that fig is important source of vitamins, amino acids, antioxidants, and it is nutritious fruit rich in fiber, potassium, calcium, and iron with higher level than other fruit such as apples, grapes and strawberries [93]. It has been reported that the major components detected in volatile oil of the leaves were psoralen (10.12%), β-damascenone (10.17%), benzyl alcohol (4.56%), behenic acid (4.79%), and bergapten (1.99%), but the major components detected in volatile oil of the fruits were furfural (10.55%), 5-methyl-2-furaldehyde (10.1%), and benzeneacetaldehyde (6.59%). Total 121 volatile constituents in the leaves and 108 in the fruits, and 18 volatile constituents are identified in both leaves and fruits [95]. *F. carica* species are rich source of naturally occurring antioxidant and antimicrobial activity, and its compounds play an important role in preventing innumerable health disorders related to oxidative stress including cardiovascular diseases, neurodegenerative and cancer [94].

In the phytochemical analysis via GC-MS it was found out that when any other natural sources were compared with kokum, anthocyanins were found to be present in highest concentration in rind of kokum (2.4 g/100 g of kokum fruit). The major pigment present in kokum are anthocyanins [99-102]. Iso garcinol and two poly iso prenylated phenolics garcinol are present in the outer rind. The major organic acid is hydroxycitric acid present in leaves and outer skin of kokum. This compound is responsible for the good taste of kokum and respectively in leaves and fruits; it is present to the amount of 4.1–4.6 and 10.3–12.7%. In minor quantities, the plant also contains lactone [97]. *G. indica* had been shown to contain following main chemical constituents such as: anthocyanins, kokum butter, garcinol and hydroxycitric acid. Hydroxycitric acid (HCA) has attained so much attention in recent years for its vital role in fat/lipid metabolism, with its implications in weight loss activity. Kokum contains about 2 to 3 % of red color pigment. Anthocyanins of kokum are water soluble and possess antioxidant activity. Some types of sugars associated with *G. indica* are glucose and xylose. Thus, the extract of kokum contains water, pigment and sugars. The kokum fruit consists of different constituents such as crude fat, ash contents, crude fibre, carbohydrates, starch, pigments, pectin, ascorbic acid and hydroxyl citric acid etc [96]. In a research, leaves of kokum were reported to contain L-leucine, fat (0.5 g), carbohydrates (17.2 g), fiber (1.24 g), protein (2.3 g), calcium (250 mg), 75% moisture [98]. The seed kernels of *G. indica* contains hard and brittle fat (mp=39 to 43 °C) up to 45 % yield, which is commercially known as 'kokum butter'. Kokum butter contains about 30% of fat content. Extensive studies have been carried out on the fatty acid composition of kokum butter and kokum fat was found to be rich in stearic acid and oleic acid [103-104]. Quantitative analysis of kokum butter revealed that in addition to fatty acids, it contains glycerides such as oleodistearin and stearodiolein [105]. Seed oil is a source of palmitic acid, stearic acid, oleic acid and linoleic acid. Reports show that seed oil of *G. indica*, because of high content of fatty acid methyl esters, can be used as bio fuel or can be mixed with other fuels to enhance its efficiency [106].

Various phytochemicals were detected in the different parts of G. indica herbal plant. Leaves of G. indica contains D- Leucine [107], isogarcinol, xanthochymol, isoxanthochymol [108-109] HCA and HCA lactone [110], Cambogic acid, mangostin, garcinol, fukugicide, GB-1, GB- 2 and amentoflavone as major chemical constituents [111]. Fruit and fruit rinds contains the following chemical constituents: (-) HCA, HCA lactone [107,110,112] Garcinol, isogarcinol, citric acid, oxalic acid, xanthochymol, isoxanthochymol [108,109,112-115], Anthocyanin, glucose, xylose, cyanidin-3- glucoside, cyanidin-3-sambubioside and 14-deoxyisogarcinol [116]. Polyprenylated acylphloroglucinol derivative [114]. G. indica bark contains Euxanthone (1,7-dihydroxy xanthone), volkensiflavone and morelloflavone [107], Xanthochymol, isoxanthochymol and camboginol [108,117] chemical compounds. Seed pericarps and Seed oil obtained from kokum has been shown to contain Isoxanthochymol, camboginol, palmitic acid, stearic acid, oleic acid and linoleic acid as major phytoconstituents [117-118].

V.PHARMACOLOGICAL PROFILE

5.1 *Juniperus communis*

5.1.1 ANTIBACTERIAL ACTIVITY

Juniperus communis essential oil (EO) had been shown to have many pharmacological activities in the traditional system of medicine. One of the main activities shown by *J. communis* is antimicrobial activity. Antibacterial action of EO obtained by *J. communis* was investigated on *E. coli* and *B. cereus* and EO had shown major antibacterial activity by inhibiting the growth of both bacterial species [119]. *J. communis* EO had also inhibited the biofilm formation of *Mycobacterium intracellulare* and *Mycobacterium avium* on a polystyrene surface and can be used as potential disinfectant agent in natural water [120]. EO of *J. communis* had shown significant antibacterial activity against the gram positive strain i.e., *Bacillus megaterium* and gram negative strain i.e., *P. syringae pv. Phaseolicola* [121]. Crude leaf organic extracts (chloroform, methanol, hexane and ethanol) and aqueous extracts of Himalayan plant *J. communis* was investigated for its antibacterial potential against various drug resistant bacteria species such as: *Agrobacterium tumefaciens*, *Erwinia chrysanthemi*, *Xanthomonas phaseoli*, *Escherichia coli* and *Bacillus subtilis* by disc diffusion method. All the *J. communis* extract had shown significant antibacterial activity except the aqueous extract. Zone of inhibition (ZOI) shown by hexane extract was (16-21 mm) and chloroform, methanol and ethanol extracts had shown the ZOI (6-17 mm) which was found to be very effective as compared to the positive control i.e., standard antibiotics Erythromycin (15 mcg) and Ampicillin (10 mcg) [122].

5.1.2 ANTIOXIDANT ACTIVITY

Berries of J. communis plant have been widely utilized in pharmaceutical, food and beverage industries for to its significant antioxidant action due to the presence of polyphenols. Total 148 phenolic compounds were detected in J. communis from which major compounds responsible for its antioxidant property detected were: flavonoids (flavonols, anthocyanins, isoflavonoids and flavones) and phenolic acids (hydroxyphenylpropanoic acids, hydroxybenzoic acids and hydroxycinnamic acids) [123]. Amentoflavone a chemical constituent was isolated from the aerial parts of J. communis herbal plant extract and its antioxidant activity was investigated against H_2O_2 induced oxidative damage in human erythrocytes and leucocytes. Antioxidant potential of extract was measured by using different parameters like LPO, SOD, GPx, GSH and CAT. J. communis extract had shown the following results: GPx (128.53±3.10 and 41.7±1.420 µg gG1 Hb), CAT (28.35±2.980 and 27.73±1.580 AU gG1 Hb) and SOD (1193.5±19.7 and 1532.6±17.60 U gG1 Hb) enzyme systems of erythrocytes. J. communis extract had shown significant activities on SOD (820±14.50 U mgG1 protein) and CAT (13.79±1.832 AU mgG1 protein) enzyme systems of leucocytes. The above results had shown that Amentoflavone is a potential source of natural antioxidants which can be further utilized in the prevention and treatment of diseases due to oxidative stress [124].

5.1.3 ANTI-INFLAMMATORY ACTIVITY

In folk medicine J. communis is widely used as antiseptic and anti-inflammatory due to the presence of cedar-wood oil in it. J. communis plant extract was investigated for its anti-inflammatory activity via LPS (lipopolysaccharide)-stimulated WBCs (White blood cells). ELISA that is enzyme linked immunosorbent assay was used for the evaluation of pro-inflammatory cytokines. Extract of J. communis plant had significantly shown to reduce the production of pro-inflammatory cytokines such as gamma interferon (INF- γ), tumour necrosis factor (TNF)- α and interleukin (IL)-1β in LPS-activated WBCs. Anti-inflammatory activity in human WBCs is due to the inhibitory action of J. communis extract on the production of pro-inflammatory cytokines [125].

5.1.4 ANTIDIABETIC ACTIVITY

Antidiabetic activity of J. communis oil (JCO) on lipid levels, pancreatic enzymes levels and serum paraoxonase (PON1) levels were detected in diabetic experimental rats. 32 male Wistar-Albino rats were divided equally into 4 groups: control (C), diabetes (D), JCO (J), and diabetes + JCO (DJ). D and DJ groups were intraperitoneally (IP) injected with 45 mg/kg streptozotocin (STZ). JCO was administered as 200 mg/kg/21 days by oral gavage in J and DJ groups. Total cholesterol (TC) and triglyceride (TG) levels were significantly decreased in the J and DJ groups when compared to C and D groups. There was no difference in TG levels between D and control group. Lipoprotein levels were not statistically significant between any groups. Comparing to the control group in the diabetes and DJ groups; significant decreased amylase levels and increased lipase levels was observed. PON1 activity in D group was statistically lower than in the other groups. There is no significant difference between the C group and the J group. PON1 level has a significant elevation in the DJ in comparison with the D group. JCO caused an increase in antioxidant PON1 enzyme level and a decrease in lipid levels in diabetes. The data obtained are supportive that JC oil may be a potential protective effect against diabetes-associated complications [126].

5.1.5 ANTI CANCER ACTIVITY

Anti cancer activity of the J. communis essential oil was determined against C6 (rat brain tumor cell) cell lines and HeLa (human cervix carcinoma) cell lines by BrdU cell proliferation assay. Essential oil of J. communis had shown significant antiproliferative activity against C6 cell lines [127]. Chemical compounds with anti breast cancer properties were isolated and screened from the J. communis plant. By bioassay-guided fractionation of a crude plant extract, aryltetralin lignan deoxypodophyllotoxin (DPT) and diterpene isocupressic acid were detected as potent inducers of caspase-dependent programmed cell death (apoptosis) in malignant MB231 breast cancer cells. DPT had shown to concomitantly inhibit the cell survival pathways mediated by the MAPK/ERK and NFκB signaling pathways within hours of treatment as compared to the isocupressic acid [128]. In traditional Chinese medicine J. communis have found its usage as a potential anti cancer agent against neuroblastomas. Anti cancer activity of J. communis extract (JCo) on oral cancer was investigated and the synergistic effects of JCo combined with 5-fluorouracil (5-FU) was also evaluated. JCo had shown to inhibit the growth of oral cancer cells and it had shown less cytotoxicity to the normal cells as compared to the cancer cells. Arrest of cell cycle was noticed at the G_0/G_1 phase via modulation of p53/p21 and Rb signaling after JCo treatment. Increase in the cell apoptosis and sub-G1 phase was also observed by intrinsic and extrinsic apoptosis pathways with JCo. Cell viability had been significantly reduced by the synergistic activity of 5-FU and JCo [129].

5.1.6 HEPATOPROTECTIVE ACTIVITY

Herbal plant like J. communis was believed to exhibit hepatoprotective effects and could enhance the desired actions. Hepatoprotective action of ethanolic fruit extract of J. communis (JC) was investigated against Azithromycin (AZM) and Paracetamol (PCM) induced liver toxicity in Wistar rats for 7 days. The activity was checked by using histopathological examination, oxidative parameters and liver functional tests. JC fruit extract at the concentration of (200 and 400 mg/kg) had significantly and dose-dependently attenuated the liver toxicity by normalizing the biochemical factors and no gross histopathological changes were observed in liver of rats [130]. Leaves of J. communis were investigated for hepatoprotective activity against various models. 70% v/v ethanolic extract of J. communis was successively extracted using hexane and ethyl acetate to prepare various fractions. Total phenol content of the extract was determined by Folin-Ciocalteau's process and it was found out to be maximum 315.33 mg/GAE/g in ethyl acetate fraction (EAF). Hepatoprotective activity of EAF was calculated against PCM-Paracetamol-induced hepatic damage in Wistar albino rats. EAF treated rats had shown remarkable reduction in serum Alanine aminotransferase, serum Aspartate aminotransferase, direct bilirubin, total bilirubin and alkaline phosphatase level in treatment group as compared to the hepatotoxic group. J. communis leaf extract can be used for the treatment of various hepatic diseases and also for the benefit of mankind or animal health without causing any cytotoxicity [131].

5.1.7 ANALGESIC ACTIVITY

Methanolic extract of J. communis plant at the dose of (100 mg/kg and 200 mg/kg) was evaluated for its analgesic activity on adult Albino mice by using Acetylsalicylic acid (100 mg/kg) as a standard drug. Analgesic potential was investigated on adult

Albino mice via different *in-vivo* tests such as formalin test, acetic acid induced writhing test and tail flick test. The effect of the extract and Pethidine (10 mg/kg) i.p on tail flick test was inhibited by Naloxone (2 mg/kg) i.p. Significant inhibition of writhing response was observed with the treatment with J. communis extract in a dose dependent manner. In formalin test, the extract had shown prominent inhibition of the late phase in dose dependent manner as compared to the Aspirin drug. After 30 minutes of administration with the extract, it had shown central activity in the tail flick test. This central analgesic activity was confirmed by the blocking effect of Naloxone. J. communis plant had depicted significant antinociceptive activity by both the mechanisms that is centrally and peripherally and can be utilized further as a potent and safe analgesic agent [132].

5.1.8 NEUROPROTECTIVE EFFECTS

Anti-Parkinson's activity of the methanolic extract of J. communis leaves (MEJC) was investigated in chlorpromazine (CPZ) induced experimental animal model. Effects of MEJC (100 and 200 mg/kg, i.p.) was studied by using different behavior parameters like locomotor activity (actophotometer), muscle rigidity (rotarod test), catalepsy (bar test) and its effect on neurochemical parameters (total protein, GSH, TBARS and nitrite) in rats. When rats were administered with CPZ for 21 days, it had caused significant symptoms of Parkinson's disease like motor dysfunctions (hypo locomotion, muscle rigidity and catalepsy). MEJC had significantly shown to decrease muscle rigidity, catalepsy and it had increased the locomotor activity in rats. Maximum reduction in the symptoms was observed on 21st day at a dose of 200 mg/kg (i.p.). The MEJC extract also showed an increase in the level of reduced glutathione (GSH), total protein and decreased the elevated levels of TBARS and nitrite preferably at a higher dose (200 mg/kg) as compared to CPZ group [133]. Methanolic extract of J. communis leaves (MEJC) was evaluated for its anti-parkinson's activity against reserpine induced catalepsy in rat experimental model. In rats through intra peritoneal (i.p) route catalepsy was induced by administering 2.5 mg/kg reserpine. MEJC was screened for its efficacy against reserpine induced catalepsy in rats at the concentrations of 100 mg/kg and 200 mg/kg (i.p.). MEJC extract had shown significant effectiveness against Parkinson's disease by reducing catalepsy as compared to the reserpine treated rats, maximum reduction was observed at a dose of 200 mg/kg. Leaf extract of J. communis had shown significant neuroprotective effect and can be further used in treating the Anti-Parkinson's disease [134].

5.1.9 GASTROINTESTINAL EFFECTS

Anti ulcer property of J. communis leaf extract was investigated on various animal models such as alcohol, serotonin, stress, salicylic acid, indomethacin induced gastric ulcerations in rats and histamine induced duodenal lesions in guinea pigs. Different biochemical parameters like total acidity, pH and peptic acidity of the gastric juice was also determined. At the 50 mg/kg and 100 mg/kg dose via i.p., the crude leaf extract had significantly inhibited alcohol, serotonin, stress, salicylic acid, indomethacin induced gastric ulcerations in rats and histamine induced duodenal lesions in guinea pigs. J. communis leaf extract had also shown to enhance the healing rate of acetic acid induced ulcer in rats. Leaf extract of J. communis had shown highest anti-ulcer activity as compared to the standard drug ranitidine. Biochemical analysis of gastric juice revealed that the extract significantly decreased its volume and total acidity, but did not alter its pH and peptic activity. J. communis leaf extract is a potent anti-ulcer agent which relieves pain due to ulcerations and also promotes healing which are the two ultimate goals for treatment of ulcers in patients [135].

5.1.10 ANTI FERTILITY EFFECTS

J. communis plants have been used worldwide for the treatment of various human ailments and it had also shown to possess birth control characteristics and used for fertility regulation. J. communis ethanolic fruit extract had been investigated for its anti fertility potential in Swiss Albino female rats. 300 mg and 500 mg of the drug per kg body weight of the rat were administered orally from day 1 to 7 of pregnancy. Ethanolic fruit extract had shown to possess anti implantation activity when Laparotomy was performed at the 10th day in rats and the anti implantation activity was found to depend upon the dose of drug. J. communis fruit extract had also shown abortifacient activity at both the dose levels when administered on 14th, 15th and 16th days of pregnancy. No evidence of teratogenicity was observed. J. communis fruit extract had shown significant anti fertility activity and can be utilized further as a birth control measure or natural contraceptives with less side effects as compared to other modern contraceptives [136].

5.2 Ficus carica

5.2.1 ANTIBACTERIAL ACTIVITY

Extraction was performed with acetone, ethanol and chloroform to isolate phytoconstituents from *Ficus carica* leaves. All the above leaf extracts were evaluated for their antimicrobial activity by agar well diffusion method against human pathogenic bacteria such as: *Pseudomonas aeruginosa*, *Enterococcus faecalis, Escherichia coli, Enterobacter aerogenes, Staphylococcus aureus, Klebsiella* species and *Shigella* species isolated from intestinal and urinary tract infections. In case of acetone plant extract, inhibition zone at 400, 500 mg/ml was (11±1, 15±1 mm) and (13.3±0.57, 15.6±0.57 mm) against S. aureus and E. coli respectively; (13±1 mm) at 500 mg/ml against P. aeruginosa; (15±1 mm) at 500 mg/ml against *Klebsiella* species. In case of ethanolic plant extract, zone of inhibition at the concentration of 400, 500 mg/ml was (12±1, 13±1 mm) and (11±1, 13.6±0.57 mm) against E. faecalis and *Klebsiella* species respectively; at 500 mg/ml was (14±1 mm) and (16±1 mm) against E. aerogenes and Shigella species respectively. In case of chloroform plant extract, zone of inhibition at 300, 400, 500 mg/ml concentration was found out to be (11±1, 15±1, 30±1 mm), (13.3±0.57, 16±1, 20.6±0.57 mm), (15±1, 20.3±0.57, 25±1 mm) against E. aerogenes, E. coli and *Klebsiella* species respectively; at 400, 500 mg/ml the inhibition zone was (11±1, 13.3±0.57 mm) against Shigella species. The chemical constituents of F. carica extract had shown effective antibacterial activity against various disease causing pathogenic bacteria in humans [137].

5.2.2 ANTIDIABETIC ACTIVITY

Various parts of *F. carica* plant such as leaves, fruits and stem barks were extracted with different solvents i.e., ethanol, hexane, water and ethyl acetate separately to estimate the total flavonoids and polyphenol contents. Among all the extracts, ethanolic fruit extract had shown highest content of flavonoids (81.67±4.00 µg/mL) and polyphenols (104.67±5.51 µg/mL). Inhibition of α-glucosidase and α-amylase enzymes was determined in order to find antidiabetic potential of all the plant extracts. IC_{50} value of the ethanolic fruit extract was found out to be: α-amylase inhibition (315.89 ± 3.83 mg/mL) and α-glucosidase inhibition (255.57 ± 36.46 mg/mL) which is better than all the other plant extracts. Ethanolic fruit extract was further analyzed by GC-MS and 13 compounds were detected: 5-hydroxymethyl furfural, tetradecanoic acid, n-hexadecanoic acid, sitosterol, 3,5-dihydroxy-6-methyl-2,3-dihydro-4H-pyran-4-one, butyl butyrate, phytol acetate, stearic acid, 2,4,5-trimethyl-2,4-dihydro-3H-pyrazol-3-one, 1-butoxy-1-isobutoxy butane, 9Z,12Z-octadecadienoic acid, malic acid and *trans* phytol. These phytoconstituents which were obtained from ethanolic fruit extract of *F. carica* are responsible for antidiabetic activity via inhibition of α-glucosidase and α-amylase enzymatic activity [138].

5.2.3 ANTIVIRAL ACTIVITY

F. carica fruit latex has been used traditionally for the treatment of viral skin infections and it had exhibited antiviral action against some human viruses. Antiviral potential of latex obtained from unripe fruit of fig was determined against the echovirus type 11 (ECV-11), herpes simplex type 1 (HSV-1) and adenovirus (ADV). Antiviral action of the hexane and hexane-ethyl acetate latex extracts was investigated by the intracellular inhibition, virucidal and penetration-adsorption assays via observing cytopathic effects (CPE). Antiviral action of both the extracts against these three viruses were found out to be 100% by inhibiting the virus intracellular replication, by interacting with the cellular receivers and by inhibiting the virus after direct contact these extracts had prevented the penetration and adsorption of virus into the cells [139]. F. carica latex (F-latex) had shown effectiveness against caprine herpesvirus-1 (CpHV-1) by interfering with the CpHV-1 replication [140].

5.2.4 ANTICANCER ACTIVITY

Anticancer activity of the F. carica crude extracts with different polarities was investigated against hepatocellular (HepG2) cells. Acetone extract of the F. carica leaves (FLA) had been shown to produce significant antiproliferative action against HepG2 cells with IC_{50} value of 0.179 mg/mL while producing the least toxicity on normal human umbilical vein endothelial cells (HUVECs). Biochemical evidence of apoptosis was confirmed by staining with DAPI and AO/EB. FLA also exhibited moderate anti-colonization potential against the population of HepG2 cells. It selectively arrested the cell cycle of HepG2 cells at the S phase and exerted anticancer activity by significantly increasing the reactive oxygen species (1.59 fold) inside the cells, which subsequently resulted in loss of the mitochondrial membrane potential as revealed by JC-1 probe assay. FLA downregulated the expression of tumor-promoter Transcription Factor (TP53), anti-apoptotic proteins (Bcl-2), and cell cycle regulatory kinases (CDK1, 5, 9) with respect to untreated cells for 24 h, 48 h, and 72 h. High-performance liquid chromatography (HPLC) of FLA revealed the presence of gallic acid and quercetin as major antiproliferative compounds along with trace amounts of rutin, luteolin, apigenin, benzoic acid, and β-sitosterol. FLA had been operating via novel mechanisms involving reactive oxygen species (ROS) generation and CDKs involvement in HepG2 cells. FLA may be used as a potential source of new drugs in the treatment of liver cancer [141]. Aqueous extract of F. carica had also exhibited excellent antimutagenic and genotoxic activities when COMET assay and AMES test was performed [142].

5.2.5 ANTI ANGIOGENIC ACTIVITY

The antiangiogenesis effect of *Ficus carica* leaves extract in an air pouch model of inflammation was investigated in rat. Inflammation was induced by injection of carrageenan into pouches. After antioxidant capacity and total phenolic content (TPC) investigations, the extract was administered at 5, 25, and 50 mg/pouch, and then the volume of exudates, the cell number, TNFα, PGE2, and VEGF levels were measured. Angiogenesis of granulation tissues was determined by measuring hemoglobin content. Based on the DPPH assay, the extract had significant antioxidant activity with TPC of 11.70 mg GAE/100 g dry sample. In addition, leukocyte accumulation and volume of exudate were significantly inhibited by the extract. Moreover, it significantly decreased the production of TNFα, PGE2, and VEGF, while angiogenesis was significantly inhibited by all administered doses. Interestingly, attenuation of angiogenesis and inflammatory parameters (except leukocyte accumulation) by the extract was similar to that shown by diclofenac. The extract has anti-inflammatory effects and ameliorated cell influx and exudation to the site of the inflammatory response which may be related to the local inhibition of TNFα, PGE2, and VEGF levels as similarly shown by diclofenac. The antiangiogenesis and anti-VEGF effects of *Ficus carica* may be correlated with its significant antioxidant potentials [143].

5.2.6 HEPATOPROTECTIVE ACTIVITY

In vivo and *In vitro* hepatoprotective activity of F. carica was determined. The methanol leaf extract of F. carica was further fractionated into n-hexane, ethyl acetate and aqueous fractions. For in vivo study, male albino mice were divided into twelve groups. Hepatotoxicity was induced in the mice using carbon tetrachloride (CCl_4). The extract of F. carica and its fractions were administered at doses of 200 and 400 mg/kg. Silymarin was used as standard hepatoprotective drug. The protective effects of the extract and fractions were determined via assay of biochemical parameters and antioxidant enzymes in the liver. The histopathology of the liver was also studied. Moreover, the *in vitro* hepatoprotective effect of the extract and fractions against CCl_4-induced damage was determined in HepG2 cell line. There were significant increases in the serum levels of liver biomarkers in CCl_4-treated group, whereas treatments with plant extract and fractions significantly reduced the levels of these parameters ($p < 0.05$). In addition, results from histopathology revealed evidence of protective effect of F. carica through reversal of CCl_4-induced decreases in the activities of liver antioxidant enzymes. These results indicate that methanol leaf extract of *Ficus carica* L. and its

fractions exert significant and dose-dependent hepatoprotective effects in vivo and in vitro [144]. The role of *Ficus carica*, a natural antioxidant substance was investigated in modulating changes in liver and kidney functions, antioxidant enzyme's gene expression, and apoptosis, in male albino rats exposed to gamma radiation. A total of 40 rats were used in this experiment and divided equally into 4 groups: Group 1, rats administered distilled H_2O (Control); Group 2, rats administered F. carica; Group 3, rats irradiated; and Group 4, rats treated with F. carica and irradiated. Groups 3 and 4 were exposed to whole-body gamma radiations at a dose level of 8 Gy and with a dose rate of 0.762 Gy/min. F. carica was administered to rats by gavage, for 3 consecutive weeks, before exposure to radiation. Five rats were sacrificed from each group at intervals of 24 and 72 h after cessation of treatment. The results revealed marked increases in alanine aminotransferase and aspartate aminotransferase levels in liver, a decrease in albumin level and increase in urea level in kidney. Irradiation resulted in cytotoxic effects as indicated by elevation in antioxidant enzyme's gene expression at 24 h, the opposite was observed at 72 h. Immunohistochemical analysis revealed that cytochrome c and p53 expressions significantly increased following exposure to radiation. Oral administration of F. carica pre-irradiation as a natural product plays a modulatory protective and anti-apoptotic role against cells damaged by free radicals induced by whole-body irradiation [145].

5.2.7 ANTI-INFLAMMATORY ACTIVITY

Ficus carica leaves are claimed to be effective in various inflammatory conditions like painful or swollen piles, insect sting and bites. Anti-inflammatory and antioxidant activity of the F. carica could be due to the presence of steroids and flavanoids, respectively, which are reported to be present in the drug. Furthermore, the anti-inflammatory activity of the drug could be due to its free radical scavenging activity. Further work is also required to isolate and characterise the active constituents responsible for the anti-inflammatory activities [146]. The edible fruit of common fig (*Ficus carica*) or just the fig has been traditionally used for treating hemorrhoids, insect stings, gout, ulcers, and skin infections such as warts and viruses. An ethanol extract of fig branches and its ethyl acetate, hexane, butanol, and water fractions were prepared and examined for their abilities to scavenge free radicals and inhibit inflammatory reactions. Data showed that the ethyl acetate fraction contained the largest amount of phenolic compounds and showed the highest free radical scavenging activity. Every fraction of fig, particularly the ethanol extract and the ethyl acetate and hexane fractions, inhibited nitric oxide production in RAW264.7 cells. Tumor necrosis factor-α level also decreased significantly in all groups tested. Results demonstrated that fig branches possessed pharmacological activity and might be useful for developing antioxidant or anti-inflammatory agents [147].

5.2.8 ANTIHELMINTIC ACTIVITY

As per WHO, only few drugs have been frequently used in the treatment of helminthes in human beings. Anthelmintics from the natural sources may play a key role in the treatment of these parasite infections. Species of *Ficus* viz., *Ficus carica* were found to be reported to have anthelmintic activity. In view of this an attempt has been made to study the, *in vitro* anthelmintic activity of different extracts of leaves of *Ficus carica* Linn. against *Pheritima posthuma*. Each extract was studied at 20 mg/ml in the bioassay, which involved determination of time of paralysis and time of death of the worms. Mebendazole (20 mg/ml) included in the assay as standard reference drug. The result shows that methanol and aqueous extracts of *Ficus carica* were showed significant anthelmintic activity and thus *Ficus carica* Linn. would be useful as an anthelmintic [148].

5.2.9 ANTI CONSTIPATION ACTIVITY

Anti constipation effects of fig paste was evaluated against loperamide-induced constipation in rat model. Animals were divided into one normal control group and four experimental groups (0, 1, 6, and 30 g/kg). Loperamide (2 mg/kg, twice per day) was injected intraperitoneally to induce constipation in the four experimental groups. Fig paste was administered for 4 weeks to assess its anti-constipation effects. Fecal pellet number, weight and water content were increased in the fig-treated groups as compared to the control group. Reductions in body weight and increased intestinal transit length were observed in the fig-treated groups. Fecal pellet number was reduced in the distal colons of the fig-treated rats. Exercise and ileum tension increased in the experimental groups as compared to the control group. According to histological analyses, the thickness of the distal colon and areas of crypt epithelial cells that produce mucin were increased in the fig-treated groups in a dose-dependent manner. Constipation was decreased when fig fruit was fed to rats. Specifically, fecal number, weight, and water content, as well as histological parameters such as thickness and mucin areas in the distal colon were improved. Fig treatment may be a useful therapeutic and preventive strategy for chronic constipation [149]. Laxative effects of fig were investigated in a beagle model of constipation induced by high protein diet and movement restriction. The experiments were consecutively conducted over 9 weeks divided into 3 periods of 3 weeks each. All 15 beagles were subjected to a non-treatment (control) period, a constipation induction period, and a fig paste treatment period. Fig paste was administered (12 g/kg daily, by gavage) for 3 weeks following a 3-week period of constipation induction in dogs. Segmental colonic transit time (CTT) was measured by counting radiopaque markers (Kolomark) using a radiograph performed every 6 h after feeding Kolomark capsules, until capsules were no longer observed. Fig paste significantly increased fecal quantity in constipated dogs, and segmental CTT was also reduced following fig paste administration. There were no significant differences in feed intake, water intake, body weight, or blood test results, between the constipation and fig paste administration periods. Results had demonstrated that fig is an effective treatment for constipation in beagles. Specifically, stool weight increased and segmental CTT decreased. Fig pastes may be useful as a complementary medicine in humans suffering from chronic constipation [150].

5.2.10 ANTIPYRETIC ACTIVITY

Anti-pyretic effect of the ethanolic extract of F. carica leaves was determined at normal body temperature and yeast-induced pyrexia, in albino rats. A yeast suspension (10 ml/kg body wt.) increased rectal temperature 19 hours after the subcutaneous injection. The ethanol extract of *Ficus carica*, at doses of 100, 200 and 300 mg/kg body wt. p.o., showed significant dose-dependent reduction in normal body temperature and yeast-provoked elevated temperature. The effect extended up to five hours after drug administration. The anti-pyretic effect of the ethanol extract of *Ficus carica* was comparable to that of Paracetamol (150 mg/kg body wt., p.o.), a standard anti-pyretic agent [151].

5.3 Garcinia indica

5.3.1 ANTIBACTERIAL ACTIVITY

The antibacterial potential of G. indica was investigated against different bacterial strains such as: *Micrococcus aureus, Bacillus megaterium, Micrococcus luteus, Escherichia coli, Salmonella typhimurium, and Pseudomonas aeruginosa* via Agar Well Diffusion method. G. indica fruit (kokum fruit) was extracted by 4 different solvents like water, methanol, ethanol and acetone to form the concentrations of 30 µl, 50 µl, 100 µl for each extract. In case of 30 µl volume, ethanolic extract showed (ZOI=10 mm); methanolic extract showed (ZOI=9 mm); acetone extract showed (ZOI=9 mm); ethanolic extract showed (ZOI=5 mm); ethanolic extract showed (ZOI=6 mm) and methanolic extract showed (ZOI=9 mm) against *M. aureus, M. luteus, B. megaterium, E. coli, S. typhimurium and P. aeruginosa* as compared to the other remaining extracts. In case of 50 µl volume, ethanolic extract showed (ZOI=13 mm); water, ethanolic & methanolic extracts had shown (ZOI=10 mm); methanolic & acetone extracts showed (ZOI=10 mm); water extract showed (ZOI=11 mm); water extract showed (ZOI=16.5 mm) and methanolic extract showed (ZOI=10 mm) against *M. aureus, M. luteus, B. megaterium, E. coli, S. typhimurium and P. aeruginosa* as compared to the other remaining extracts. In case of 100 µl volume, ethanolic extract showed (ZOI=18 mm); water & acetone extracts had shown (ZOI=15 mm); ethanolic extract showed (ZOI=15 mm); water extract showed (ZOI=15 mm); water extract showed (ZOI=20 mm) and methanolic extract showed (ZOI=16 mm) against *M. aureus, M. luteus, B. megaterium, E. coli, S. typhimurium and P. aeruginosa* as compared to the other remaining extracts. GCMS analysis in kokum extract was performed and it was identified that antimicrobial activity was due to the presence of furfural and anthocyanin (cyanidin -3- glucose) [152].

5.3.2 ANTI-INFLAMMATORY ACTIVITY

The aqueous extract of *Garcinia indica* fruit rind (GIE) was studied for anti-inflammatory activity in carrageenan induced paw edema and cotton pellet induced granuloma in rats. Wistar rats were orally administered GIE (400 mg/kg and 800 mg/kg) and the standard drug diclofenac sodium (10 mg/kg) 60 min prior to a subcutaneous injection of carrageenan (0.1 ml of 1% w/v) into their right hind paws to produce edema. The paw volumes were measured at various time intervals to assess the effect of drug treatment. In the granuloma model, 4 sterile cotton pellets were implanted in the ventral region in each rat. GIE (400 mg/kg and 800 mg/kg) and the standard drug diclofenac sodium (10 mg/kg) were administered orally for 8 days to the pellet implanted rats. The granuloma tissue formation was calculated from the dissected pellets and the activities of the marker enzymes AST, ALT and ALP were assayed from the serum. A significant reduction in paw edema and cotton pellet granuloma was observed with GIE treatment when compared with the carrageenan treated and cotton pellet implanted animals respectively. GIE treatment significantly attenuated the AST, ALT & ALP activities elevated by foreign body granulomas provoked in rats by the subcutaneous implantation of cotton pellets. It may be concluded that GIE possesses anti-inflammatory activity which may be due to an underlying antioxidant activity and/ or lysosomal membrane stabilization by virtue of its phenolic constituents [153].

5.3.3 ANTIDIABETIC ACTIVITY

Significant depletion of glutathione (GSH-reduced form) was observed in type 2 diabetes due to oxidative stress. A drug which restores GSH along with its anti-diabetic activity was investigated. Aqueous extract of *Garcinia indica* at a dose of 100 mg/kg and 200 mg/kg was given orally to streptozotocin induced type 2 diabetic rats for a period of 4 weeks. At the end, parameters such as fasting blood glucose, postprandial blood glucose, and GSH in blood were analyzed. Aqueous extract of G. indica significantly decreased both the fasting and postprandial blood glucose in type 2 diabetic rats. The extract also restored the erythrocyte GSH in type 2 diabetic rats. Drug at higher dose, i.e. 200 mg/kg, had a more pronounced effect. Restoring the erythrocyte GSH, an intracellular anti-oxidant in diabetes, will be beneficial specially by preventing the risk of developing complications [154].

5.3.4 ANTI CANCER ACTIVITY

Garcinol, a natural histone acetyltransferase inhibitor, has been reported to exhibit significant anti-proliferative activity in various cancer cell types. Gall bladder carcinoma (GBC) cells (GBC-SD and NOZ) were treated by garcinol and subjected to Cell Counting Kit-8 (CCK-8), and GBC-SD cells were selected for further trans well chamber assay, quantitative real-time polymerase chain reaction (qRT-PCR) and Western blot analysis. The results indicated that garcinol could significantly inhibit the growth of GBC cells in a dose- and time-dependent manner. It also inhibited the invasion of GBC-SD cells in a dose-dependent manner. Garcinol treatment decreased the activity of matrix metalloproteinase 2 (MMP2) and MMP9 by the downregulation of mRNA levels, and these two enzymes are critical to tumor invasion. Treatment with garcinol also decreased Stat3 and Akt activation in GBC-SD cells. Taken together, the effects of garcinol on GBC-SD cells may be associated with the suppression of Stat3 and Akt signaling pathways, which may contribute to inhibiting their downstream targets such as mRNA levels of MMP2 and MMP9 [155].

Garcinol, a polyisoprenylated benzophenone, is the medicinal component obtained from fruits and leaves of G. indica and has been also been experimentally illustrated to elicit anti-cancer properties. Several in vitro and in vivo studies have illustrated the potential therapeutic efficiency of garcinol in management of different malignancies. It mainly acts as an inhibitor of cellular

processes via regulation of transcription factors NF-κB and JAK/STAT3 in tumor cells and have been demonstrated to effectively inhibit growth of malignant cell population. Numerous studies have highlighted the anti-neoplastic potential of garcinol in different oncological transformations including colon cancer, breast cancer, prostate cancer, head and neck cancer, hepatocellular carcinoma, etc. However, use of garcinol is still in its pre-clinical stage and this is mainly attributed to the limitations of conclusive evaluation of pharmacological parameters. This necessitates evaluation of garcinol pharmacokinetics to precisely identify an appropriate dose and route of administration, tolerability, and potency under physiological conditions along with characterization of a therapeutic index. Hence, the research is presently ongoing in the dimension of exploring the precise metabolic mechanism of garcinol. Despite various lacunae, garcinol has presented with promising anti-cancer effects [156].

5.3.5 HEPATOPROTECTIVE ACTIVITY

The protective effects of aqueous extracts of the fruit rind of *Garcinia indica* (GIE) in antitubercular drug (ATD)-induced liver injury were investigated in rats. GIE (400 mg/kg and 800 mg/kg) and the reference drug Liv.52 (500 mg/kg) were administered orally for 29 days to ATD (isoniazid 7.5 mg/kg, rifampicin 10 mg/kg, and pyrazinamide 35 mg/kg)-treated rats. GIE attenuated significantly the ATD-elevated levels of aspartate aminotransferase, alanine transaminase, alkaline phosphatase, bilirubin, and malondialdehyde and restored the ATDdepleted levels of glutathione (GSH), superoxide dismutase, catalase, GSH peroxidase, and GSH reductase. The present findings indicate that the hepatoprotective effect of GIE in ATDinduced oxidative damage may be due to its antioxidant activity [157].

The protective effects of aqueous extracts of the fruit rind of *Garcinia indica* (GIE) on carbon tetrachloride (CCl4)-induced hepatotoxicity were investigated in rats. GIE (400 mg/kg and 800 mg/kg) and the reference drug silymarin (100 mg/kg) were administered orally for 10 days to rats treated with CCl4 for 7 days. GIE and silymarin elicited significant hepatoprotective activity by attenuating the CCl4-elevated levels of serum marker enzymes (aspartate aminotransferase and alanine aminotransferase) and malondialdehyde, and restoring the CCl4-depleted levels of reduced glutathione, superoxide dismutase, catalase, glutathione peroxidase and glutathione reductase in liver. GIE 800 mg/kg demonstrated greater hepatoprotection than GIE 400 mg/kg. The present findings indicate that hepatoprotective effects of GIE in CCl4-induced oxidative damage may be due to an augmentation of the endogenous antioxidants and inhibition of lipid peroxidation in liver [158].

Garcinia indica Linn (Clusiaceae), a medicinal plant mentioned in Ayurveda has been used for treatment of liver disorders, dysentery, sunstroke, cancer and heart diseases. The present study was undertaken to investigate antioxidant and hepatoprotective effect of aqueous and ethanolic extract of *Garcinia indica* Linn fruit rind. The aqueous and ethanolic extract of *Garcinia indica* Linn were studied for their antioxidant and hepatoprotective effects on carbon tetrachloride (1.5 ml/kg) induced liver toxicity on Wistar albino rats. The degree of liver protection was measured by using biochemical parameters such as aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALKP) and serum bilirubin (SBRN). Whereas antioxidant effect was determine by using biochemical parameters like sulphoxide dismutase (SOD), glutathione (GSH), lipid peroxidation (LPO) and catalase (CAT). Aqueous and ethanolic extract at a dose level of 500 mg/kg produce significant ($P<0.01$) antioxidant as well as hepatoprotective activity. The effect of aqueous extract was comparable to that of standard drug silymarin (70 mg/kg) [159].

The protective effects of aqueous extracts of the fruit rind of *Garcinia indica* (GIE) on ethanol-induced hepatotoxicity and the probable mechanisms involved in this protection were investigated in rats. Liver damage was induced in rats by administering ethanol (5 g/kg, 20% w/v p.o.) once daily for 21 days. GIE at 400 mg/kg and 800 mg/kg and the reference drug silymarin (200 mg/kg) were administered orally for 28 days to ethanol treated rats, this treatment beginning 7 days prior to the commencement of ethanol administration. Levels of marker enzymes (aspartate aminotransferase (AST), alanine aminotransferase (ALT) and alkaline phosphatase (ALP)), triglyceride (sTG), albumin (Alb) and total protein (TP) were evaluated in serum. Antioxidant parameters (reduced glutathione (GSH), superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and glutathione reductase (GR)), hepatic triglycerides (hTG) and the lipid peroxidation marker malondialdehyde (MDA) were determined in liver. GIE and silymarin elicited significant hepatoprotective activity by attenuating the ethanol–elevated levels of AST, ALT, ALP, sTG, hTG and MDA and restored the ethanol-depleted levels of GSH, SOD, CAT, GPx, GR, Alb and TP. GIE 800 mg/kg demonstrated greater hepatoprotection than GIE 400 mg/kg. The present findings indicate that hepatoprotective effects of GIE in ethanol-induced oxidative damage may be due to an augmentation of the endogenous antioxidants and inhibition of lipid peroxidation in liver [160].

5.3.6 CARDIO PROTECTIVE ACTIVITY

Despite incredible improvements in the diagnosis and treatment, CVD account for one-third of annual global mortality. Additionally, with approximately 80% of all cardiovascular-related deaths occurring in the low- and middle-income countries having limited health care resources the impact of CVD is catastrophic [161]. In vitro studies with the bovine artery endothelial cells have shown that cyanidin-3-glucoside enhanced the levels of eNOS, an enzyme important in maintaining blood pressure homeostasis and vascular integrity, and concomitantly increased the nitric oxide output. At molecular level cyanidin-3-glucoside stimulated the phosphorylation of Src and ERK1/2. It also enhanced the binding activity of the transcription factor Sp1 to the GC box in the proximal eNOS promoter of bovine artery endothelial cells. Together these observations suggest that cyanidin-3-glucoside induced eNOS expression and increased the NO production, may be of help in improving endothelial dysfunction, harmonize blood pressure and may possibly prevent atherosclerosis [162].

5.3.7 ANTI-OXIDANT ACTIVITY

With regard to kokum, showed that the chloroform extract prepared from the rinds of kokum possess antioxidant properties. The authors used the standard β-carotenelinoleate and 1, DPPH assays and observed the extract was effective in scavenging the free radicals. The extract exhibited 53% and 73% antioxidant effects at 50 and 100 ppm concentrations, in the βcarotene-linoleate assay. In the DPPH assay it was observed that the extract was very effective and caused 60 and 78% free radical scavenging activity at 25 and 50 ppm concentrations respectively [163].

Garcinol reduced the levels of LPS-induced intracellular ROS, blocked the activation of NF-kB, inhibited NF-kB-dependent transcriptional activity and suppressed phosphorylation of IkBa and p38- MAPK [164]. Garcinol inhibited TPA-induced superoxide generation in differentiated human promyelocytic HL-60 cells and LPS and IFN-γ -induced nitric oxide generation in the mouse macrophage RAW 264.7 cells [165]. Together all these observations suggest the utility of garcinol as an antioxidant.

5.3.8 NEUROPROTECTIVE EFFECTS

In vitro studies have shown that pretreatment of primary neuron/astrocyte with garcinol (5 μM for 7 days) promotes neuronal attachment and neurite extension. Garcinol prevented the nitric oxide accumulation in LPS-treated astrocytes and this was due to reduction in the expression of LPS-induced inflammatory mediators, iNOS and COX-2 [166]. Garcinol is also reported to possess anti-cholinesterase properties and the observed IC50 of 0.66 μM was comparable to that of the standard Galanthamine (0.50 μM) [167] mouse Neuro2a (N2a) neuroblastoma cells have also shown that cyanidin-3-glucoside possess neuroprotective effects. Cyanidin-3-glucoside blocked ethanol-induced intracellular accumulation of ROS, reversed the ethanol-mediated activation of GSK3β, inhibited the neurite outgrowth and the expression of neurofilament proteins [168]. Together these observations clearly suggest that cyanidin-3-glucoside and garcinol possess neuroprtotective effects and warranty detail studies in relevant animal models.

5.3.9 ANTI ULCER ACTIVITY

Peptic ulcer is a multifactorial disease and affects a significant number of the global population. Studies have shown that the oral administration of garcinol (40–200 mg/kg) reduced the indomethacin — induced gastric ulcerations in rats. The optimal effects were observed at 200 mg/kg and the protective effects were better than that of cetraxate-HCl used as a positive control. Garcinol was also effective in reducing water (23 °C) immersion-induced gastric ulceration and the effects were similar to that of cetraxate-HCl used as positive control [169]. In vitro studies have also shown that garcinol was effective on H. Pylori, a causative agent of gastric ulcerations and cancer, both alone [170] and in combination with clarithromycin [171]. Isogarcinol has also been claimed to possess antiulcer properties [172]. Together these observations clearly suggest the usefulness of garcinol in the prevention of gastric ulcerogenesis and merit detail investigations.

5.3.10 ANTI OBESITY ACTIVITY

In the Ayurvedic system of medicine, kokum is used to treat illness related to obesity and multiple studies have shown that hydroxycitric acid (also known as garcinia acid) a component of kokum is reported to possess anti-obesity effects. Studies have shown that consumption of hydroxycitric acid reduces appetite, inhibits fat synthesis, lipogenesis, decreases food intake and reduces body weight [173, 174]. Mechanistic studies have shown that it is a competitive inhibitor of the extra-mitochondrial enzyme ATP-citrate lyase that catalyzes the extramitochondrial cleavage of citrate to oxaloacetate and acetyl-CoA, an important precursor involved in the initial steps of de novo lipogenesis in the liver [174]. Hydroxycitric acid also inhibits pancreatic α-amylase and intestinal α-glucosidase, leading to a reduction in carbohydrate metabolism [175]. It also inhibits synthesis of fatty acid and lipogenesis from various precursors [174]. Concomitantly, it also increases the synthesis of hepatic glycogen thereby activating the glucoreceptors and causing a sensation of reduced appetite and fullness [173]. Hydroxycitric acid is non toxic as experimental studies have shown that by oral route it did not cause death or systemic or behavioral toxicity even at high dose of 5 g/kg b. wt. When extrapolated to human dose, 5 g/kg b. wt. amounts to about 350 g, which is nearly 233 times more than the recommended dose of 1.5 g/ day [174]. Hydroxycitric acid is also reported to be devoid of toxic effects like nervousness, rapid heart rate, high blood pressure, or insomnia symptoms in humans, thereby suggesting its non toxic nature [173]. Preclinical studies have also shown that feeding cyanidin 3- glucoside-rich purple corn suppressed the high fat diet-induced increase in body weight gain, and synthesis/accumulation white and brown adipose tissue in mice. Dietary feeding of cyanidin 3-glucoside rich corn decreased the sterol regulatory element binding protein-1 mRNA level in white adipose tissue. It also reduced the high fat induced increase in hypertrophy of the adipocytes in epididymal white adipose. Cyanidin 3-glucoside feeding decreased hyperglycemia, hyperinsulinemia and hyperleptinemia and concomitantly suppressed the transcription of TNF-α and enzymes involved in the fatty acid and triacylglycerol synthesis [176]. Cyanidin 3- glucoside also caused a reduction in the blood glucose levels and enhanced insulin sensitivity, upregulated the Glut4 and downregulated RBP4 in the white adipose tissue. A concomitant downregulation of the inflammatory adipocytokines (monocyte chemoattractant protein-1 and tumor necrosis factor-alpha) in the white adipose tissue was also observed [177]. In vitro studies have also shown that treatment of rat adipocytes with cyanidin 3-glucoside enhanced adipocytokine (adiponectin and leptin) secretion and up-regulated the adipocyte specific gene expression without activation of PPARγ. Feeding cyanidin 3-glucoside to mice also enhanced the gene expression of adiponectin in the white adipose tissue confirming that the in vitro mechanisms extended in to the live system [178]. Isogarcinol is also reported to possess lipase inhibitory effect and antiobesity properties [179]. Together all these observations suggest that the presence of hydroxycitric acid and cyanidin 3-glucoside in the kokum rind might have contributed towards the observed antiobesity effects and suggest the need for translational studies.

VI.CONCLUSION

These three medicinal herbal plants that are *J. communis*, *F. carica* and *G. indica* have shown to possess various important phytoconstituents which are responsible for giving pharmacological activity. *J. communis* plant extract had shown α-pinene, β-pinene, limonene, β-phellandrene, p-cymene, bornyl acetate, δ-3-carene and D-germacrene as major chemical constituents which are responsible for providing antidiabetic, anti cancer, anti fertility, hepatoprotective and neuroprotective activities. *F. carica* contains psoralen, β-damascenone, benzyl alcohol, behenic acid, bergapten, furfural, 5-methyl-2-furaldehyde and benzeneacetaldehyde as principle chemical compounds which are responsible for giving antiviral, anti constipation, anti angiogenic, anti pyretic and hepatoprotective activities. *G. indica* extract had been shown to possess anthocyanins as major class of chemical compounds. It also contains: Iso garcinol and two poly iso prenylated phenolics garcinol along with hydroxycitric

acid (HCA) which are responsible for providing anti obesity, anti ulcer, anti cancer, cardio protective, hepatoprotective and neuroprotective activities. Thus all three medicinal plants can be utilized in the prevention and treatment of various disease conditions and they can be replaced with the modern allopathic medicine which is responsible for giving more side effects. These plants can be further utilized for generating herbal lead molecules for producing herbal medicines which can act as an effective and safer alternative to the allopathic drugs by providing specific treatment with more efficacies, less side effects and toxicity. In spite of all these findings still more research studies are required to be conducted in order to screen and identify the beneficial phytoconstituents from different parts of these plants along with any novel pharmacological activity produce by these chemical constituents. Lastly, these herbal plants can prove as a boon to mankind for the treatment of various disease and disorders with more efficacy, safety and less adverse drug reactions and toxicity.

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