REVIEW ARTICLE

Kareel plant: A natural source of medicines and nutrients

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Capparis decidua or kareel is an indigenous medicinal plant of India having large biodiversity in different north-western states of India. The young flower bud and fruits are used to make pickles while caper berries are used as vegetable. Plant has its wider utility in traditional folk medicine and is used as ailments to relieve variety of pains or aches such as toothache, cough and asthma heal. Plant contains few important secondary metabolites such as quercetin which act as melanogenesis stimulator and also increase tyrosinase protein expression. *Capparis sp.* seeds contain lectin that exhibit potent anti HIV-1 reverse transcriptase inhibition activity and also inhibits proliferation of hepatoma HepG2 and breast cancer MCF-7 cells. It shows anti-rheumatic, anti-diabitic, anti-arthritis and anti-gout agent. *C. decidua* contains generous quantities of alkaloids, fatty acids, terpenes, vitamins, fibre and oils that show greater medicinal and nutritive value. It also contains saccharides, glycosides, flavonoids, volatile oils, sterols and steroids, which showed multiple pharmacological effects such as anti-inflammatory, odynolysis, anti-fungus, hepatoprotective effect, hypoglycemic activity, anti-oxidation, anti-hyperlipemia, anti-coagulated blood, smooth muscle stimulation, anti-stress reaction. Cadabicine an alkaloid that occurs in leaves shows anti-parasitic activity, while root bark and pulp are used to kill helminthes. Due to enzymatic inhibition plant extract shows the ability to control *Leishmania major* and *L. infantum*, *L. donovani, L. braziliensis, Crithidia fasciculata* and *Herpetomonas muscarum* infection. In the present review article both medicinal and nutraceutical properties of *C decidua* have been described in detail and special emphasis is given on its sustainable use of plant and its conservation in natural habitat.

Key words: *Capparis decidua,* folk medicine, neutraceuticals, pharmaceuticals, secondary metabolites

INTRODUCTION

Capparis decidua (CD) is a xerophytic dominating shrub found in desert region of Rajasthan showing strong climatic adaptations. It is a densely branched, thorny plant with smaller scanty and caduceus leaves having pink to red flowers and green berry fruits. The name caper is derived from Arabic Caper and relates to *Capparis spinosa* belong to family Capparidaceae. In Greek it is known as Kapparis derived from kabar or caber.[1] It is recognized by different common names in the different regions of world and in India. In India mainly Rajshthan, Uttar Pradesh and Madhya Pradesh *Capparis decidua* plant has wider diversity where it is commonly known as 'Kureel' or Kareel in Hindi. In Harayan it is known as ker, Krail, Karry, Kary or Pinju by some of the tribes of northwestern India. In Indian texts, Capparis plant is recognized differently in different languages, in Sanskrit it is named as Karira while Kerada in Gujrati, Nepati in Marathi, Kair in Punjabi, Shengan in Tamil, Titali in Urdu, Enugadanta in Telegu Nispatige in Kannada. In English it is recognized as caper berry, while in Arabian as Caper and Kabar in Persian. Caper fruits are widely used in traditional folk medicine in the Mediterranean basin and in central and West Asia. Fruits of *Capparis spinosa* and *Capparis decidua,* known as caper berries,[2] are used as food as well as medicine.[3] The young flower bud and fruits are used to make pickles.[4]

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The dried fruits are used as an ingredient in anti-diabetic compositions while floral buds of *Capparis spinosa* L. are commonly used in the Mediterranean cuisine as flavoring for meat and other foods. Seed clumps of *Capparis spinosa* L. together with shoots, leaves and fruits possess high pharmacological value[5] and are used to treat inflammatory disorders such as rheumatism and arthritis.[6] Flower buds, root bark and fruits are used in folk medicine as analgesic, wound healing, cell regeneration, tonic and anti-diuretic agents[7] while bark and shoot are used as analgesic, anti-inflammatory, hypolipidemic, and anti-diabetic agents. Plant is alkaloid rich and is also used to treat diabetes, arthrolithiasis, rheumarthritis and dermatosis and has broader pharmaceutical applications.[8] *C. ovata* leaves show antinociceptive action in mice.[7] In Unani medicine leaves are used as appetizer, pain soother, and to treat pyorrhea.

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In traditional medicine, plant decoction is also used for the treatment of rheumatism, lumbago, hiccough, cough and asthma by Ayurvedic practitioners.[3,9,10] Its different extractive preparations are used as carminative, tonic, emmenagogue, aphrodisiac, alexipharmic agent. The top shoots and young leaves are used to treat blister, boils, eruptions and swellings.[11] It is used as an antidote to poison, relieving pain, and used to treat pyorrhea. *C. decidua* fruit is used for astringent, and is useful in cardiac troubles. Green fruits with bitter taste are used to cure facial paralysis and to solve problems of enlarged spleen. Fruit powder is used to kill intestinal worms. It is also used to treat phthisis, heart diseases and scurvy. Root powder is used to treat jaundice, haemorrhoids, stomach and liver problems. The ground root known as an errhene is used to cure snake bite. Plant also possesses febrifuge properties and is used to treat skin diseases and as blood purifier. *Capparis spinosa* L. (Capparidaceae) is used in traditional medicine especially for the treatment of rheumatism and gout. Its fruit and roots contain spermidine alkaloids [12] similar to isocodonocarpine.[13] Mainly three alkaloids such as capparispine, capparispine 26-*O*-β-D-glucoside and cadabicine 26-*O*-β-D-glucoside hydrochloride were isolated *C. spinosa* plant that contains different biological activities.[14] Plants of genus *Capparis* are used by local shepherds as ethnomedicines or as traditional healers for the treatment of different parasitic diseases of livestock like tick and lice infestation, mange, myiasis and helminthiasis.[15] Plant shows both insecticidal[16] and antimicrobial activity.[17]

Besides medicinal use *Capparis decidua* is a nutriet rich indigenous plant whose flowers and fruits is used for vegetables and pickle making. Its fruits are used for neutraceutical purposes by many ethnic groups of Rajshthan, Uttar Pradesh, Harayan, Madhya Pradesh, Gujarat and Maharastra. Plant contains generous quantities of alkaloids, fatty acids, terpenes, sterols, fiber and oils[18] and has greater medicinal and nutritive values.[19] Plant is used in traditional folk medicine as ailments to relieve variety of pains or aches such as toothache, cough and asthma healer. It is also used as an anti-rheumatic and anti-diabitic anti-rheumatic, anti-arthritis and anti-gout agents. *C. decidua* contains chemical constituents, which include the saccharides and glycosides, flavonoids, alkaloids, terpenoids and volatile oils, fatty acids and steroids that possess enormous pharmacological effects and shows anti-inflammatory, odynolysis, anti-fungus, hepatoprotective effect, hypoglycemic activity, anti-oxidation, anti-hyperlipemia, anti-coagulated blood, smooth muscle stimulation, anti-stress reaction, and improves memory.

Besides, human medicine plant is also used as ethno-veterinary medicine by local ethnic groups. The stem bark decoction is used to treat asthma, while flower buds are eaten to relieve stomach ache. Colloidal root paste is used to treat scorpion venom, while powdered coal from stem is used to treat fractured bone. Wood is durable and is used to make the foundations around the wells and as fire wood, while plant leaves and stem is an important source of fodder that is easily available to camels. *Capparis spinosa* possesses thick, amphistomatic and homobaric leaves with a multilayered mesophyll and having number of photosynthesizing cells per unit leaf surface. Plant photosynthesizes enormously due to presence of very high chlorophyll contents in leaves even at low water availability and high transpiration.[20] Plant possesses both medicinal and nutritional value and show many pharmacological properties.[3,4]

Pharmacological Properties

Anti-inflammatory activity

Fruits of Caper plant (*Capparis spinosa* L.) are used in folk medicine for the treatment of inflammatory disorders, such as rheumatism.[6] Its fruits contain two important flavonoids, i.e., isoginkgetin and ginkgetin, which showed anti-inflammatory activity at a low concentration of 20 μM and 7.5 μM, respectively. Both compounds have also shown strong NF-κB inhibitor activity *in vivo.* [21] Similar anti-inflammatory activity was reported in isocodoncarpine isolated from the above plant species. [22] *C. spinosa* aqueous extract contains 13 compounds (1-13) mainly flavonoids, indoles, and phenolic acids and most of them have shown anti-inflammatory effects[23] and inhibited the carrageenan-induced paw oedema in mice.[3] Similar activity was also reported in ethanolic and aqueous extract of *C. decidua.* More exceptionally, *C. decidua* was found to possess significant antipyretic effects but devoid of analgesic activity.[24] Similarly, few other compounds such as flavonols (kaempferol and quercetin derivatives) and hydroxycinnamic acids (caffeic acid, ferulic acid, p-cumaric acid and cinnamic acid) isolated from *Capparis spinosa* showed anti-inflammatory activity[25] [Table 1].

Anti-oxidant activity

Both leaves and flower buds of *Capparis spinosa* contain phenolic compounds such as rutin, tocopherols, carotenoids and vitamin C (α- and γ-tocopherol) which showed antioxidants activity[26-28] while, fruits contain Cappariside (4-hydroxy-5-methylfuran-3-carboxylic acid, 1), together with some known organic acids (2-8) showed strong DPPH free radical scavenging activity. It more effectively minimized the loss of cell viability and apoptosis induced by H_2O_2 in normal and SSc fibroblasts.[29] More interestingly, use of caper food contributes oxidizable lipids which reduce the risk of oxidative stress-based diseases[30] in man. Both rutin and isothiocyanates showed anti-carcinogenic effects.[30] Similarly, alcoholic extracts of *Capparis spinosa* buds showed *in vitro* antioxidant and *in vivo* photo-protective

Table 1: Biological activities of chemical constituents isolated from *Capparis decidua* and its other associating species

Species/plant parts	Compounds	Biological activity
Capparis deciduas		
Leaves and flowers	Rutin, tocopherols, O-glycosides, quercitin	Antiviral
	3-O-glycoside-7-0-rhamnoside, caretinoids	Analgesic
	Volatileoils, fatty acids, protein, fiber	Nutraceutical
	Oils, minerals, sugar, protein and Pro-vitaminA.	Nutraceutical
	Isocodoncarpine	Anti-inflammatory
	3-methyl-2butenyl-3-beta-glucoside	Anti-oxidant
	Steroids	Hepatoprotective
	Ascorbic acid, Phthalic acid	Anti-oxidant
	Beta-sitosterylglycoside6'octadecanaote	Anti-oxidant
	3-O-(16"-alpha-L-rhamnoside-6 beta o glycosyl)-beta–D glycoside	Anti- inflammatory
	Flavonoid, lutin, neoxanthin, violaxanthin	Nutraceutical
	Quercitin, stachydrine	Anticancer
	Vitamin C, lutin	wound healing, diuretie effects
Flower buds	α and γ tocopherol, vitamin C glycosides, alkaloids	Anti-oxidant
	Polyprenol (Cappaprenol-12, Cappaprenol 13, 14. Kampferol glucosides	Anti-oxidant
	Cappariside (4-hydroxy-5 methyl furan-3-carboxylic acid	Anti-oxidant
	Isothiocyanates	Anticarcinogenic
Fruits	Biflavonoids	Anti-hyperchloestimia
	Isoginkgetin, Ginkgetin, Sakuranetin, P- hydroxyl benzoic acid	Anti-inflammatory
	5-(Hydroxymethyl) furfural, Bis (5-formyl furfuryl) ether	Anti-inflammatory
	Daucosterol, α – D fructo furanosides methyl	Anti-arthritic
	Uracil, stachydrine, cadabicine P-hydrobenzoic acid	Anti-oxidant, anti-arthritic
	Glucosids – (65) – hydroxyl-3-oxo-α –ionl glucosides corchoionoside C (6S, 9S)- roseside) prenyl glucoside, cappariloside A and B	Anti-oxidant
	1H-indole-3acetonitrile glycosides	Anticancer
Mature fruit	5-(hydroxymethyl, furfural, Bis (5-formylfurfural) ether	Anti-inflammatory
	Daucosterol α -Dfructofuranosides, methylstachydrine	Anticancer
	Hydrocinnamic acids Corchoionoside C, Prenyl glycoside	Anti-oxidant
	Phthalic acid, cappariside, 4-hydroxy-5 methylfuran 3-carboxylic acid	Anti-oxidant
	Flavonoids, isoginkgetin, ginkgetin, isocodonocarpine	Anti-oxidant
Seeds	Fatty acids tocopherols sterols, proteins	Nutraceutical
	Glucosinolales oilic and vaccenic acid	Nutraceutical
	Stestent, campestent stigmasterol	Nutraceutical
	Palmitic acid, linoleic acid, p-methoxybenzoic acid, Glucoside, Glucocapparin, n-pentacosane,n-tricantanol	Nutraceutical
Root bark	Diterpene alcohol and ester	Anti-inflammatory and analgesic
	Spermidine alkaloids, Isocodonocarpine	Anti-parasitic
	Capparisinine, Capparisesterpenolide	Anti-microbial
	14 N- acetyl Isocodonocarpine	Anticancer
	Cadabicine, Stachydrine, Rutin, Codonocarpine	Anticancer
	Beta sitosterol, L stachydrine, Capparoidisin, capparisin	Nutraceutical
Root	Alkaloid capparine, Cappariline, Capparinine	Anticancer
Stem	Shikimate derivative, acyclic terpinoids	Anticancer
	Fatty acids, sterols, Lupin tercantanol, polyprenols	Anti-oxidant
	Cappaprenol-12, Cappaprenol-13	Hepatoprotective
	Capparprenol -14, flavonoids, inodoles, phenolic acids, lectins	Anticancer
	Quercitin 3-O-glycoside-7-O rhamnoside	Anti-oxidant, anticancer
Stem buds	Quarcitin, kaempferol, glycosides	Anti-allergic and anti-cancer
	Heneicosylhexadecanoate, triacontanol	Insecticidal
	2-carboxy-1,1-dimethylpyrrolidine6-(1-hydroxy-non-3-enyl)	Antmicrobial
	Tetrahydropyran-2-one	Insecticidal
Capparis coriaceae		
Leaf	Dolichol polyprenols	Anti-oxidant
Capparis species		
Leaf	Polyisoprenol alcohol	Anti-allergic

(*Continued*)

Table 1: (*continued*)

Species/plant parts	Compounds	Biological activity
Capparis mosaikai Linn.		
Seed	2-Hydroxyethyl glucosinolate, mabinlins	Anti-oxidant, neutraceutical
Capparis tomentosa Linn.		
Root bark	Stachydrine	Anti-arthritic, toxic
Capparis zeylanica Linn		
Root	E-octadev\c-7-en-5-4 noic acid	Anti-ulcer
Capparis sikkimensis Kurz		
Root	2H-1,4-benzoxazin-3(4H)-one, 6-methoxy-2-methyl 1-4-carbaldehyde	Anti-ulcer
	Cappamesin	Anti-cancer
S. spinosa		
Buds	Rutin, 6-hydroxy-3-oxo-aplha-ionolglycosides	Anti-oxidant
Seeds	Linoleic acid, oleic acid, vaccoric acid, Delta5 avenosterol, Corchoinoside (6S-9S)-roseoside) prenylglycoside, glucosinolates	Antioxidant
Leaves, buds and flowers	Beta carotene, lutein, neoxanthin, tocopherols, violaxanthin.	Hepatoprotective
C. ovate		
Seed	Minor and major mineral content Al, P, Na, Mg, Fe, Ca	Nutraceutical
Capparis ovate M Biers		
Seed	Palmitic, oleic acid, linoleic acid	Nutraceutical
Capparis moonii Wight		
Fruit	Beta sitosterol, stachydrine, Rutin	Anti-oxidant
Capparis sepiaria Linn		
Leaves	Alpha and beta amyrin, taraxasterol, erythrodiol, beta sitosterol, betulin, triterpin alcohol n-octacosanol, alpha beta amyrin, beta sitosterol, and glucoside betulin 28acetatetriterpinalcohol, Quercitin, 3-O-glycoside	Anti-cancer
Mature fruit, shoot and flower	Corchoinoside (6S-9S)-roseoside) prenyl glycoside Glucosinolates	Anticancer

activities.[31] *Capparis spinosa* L. buds contains polyprenols cappaprenol-12 (1), cappaprenol-13 (2) and cappaprenol-14 (3) with 12, 13 and 14 isoprene units, hence, these are used as a source of flavor[32] [Table 1].

Anti-cancer activity

Capparis spinosa seeds contain a 38 kDa protein similar to imidazoleglycerol phosphate synthase that inhibits proliferation of hepatoma HepG2 cells, colon cancer HT29 cells and breast cancer MCF-7 cells with an IC(50) of about 1, 40 and 60 microM, respectively.[33] Similarly, its aromatic plant extract showed significant stimulating effect on melanogenesis in B16 murine melanoma cells at very low doses (0.0005, 0.005, and 0.05% w/v) without causing cytotoxicity.[34] It may be due to presence of quercetin compound, a well known melanogenesis stimulator that also increases tyrosinase protein expression. It is also used as a tanning agent and for the treatment of hair de-pigmentation.[35] Similarly a dimeric 62-kDa lectin isolated from caper (*Capparis spinosa*) seeds exhibit a novel N-terminal amino acid sequence and potently inhibit HIV-1 reverse transcriptase activity (IC_{50} of 0.28 microM). It also inhibits proliferation of both hepatoma HepG2 and breast cancer MCF-7 cells with an IC_{50} of approx. 2 microM. It induces apoptosis in HepG2 and MCF-7 cells.[36] Similarly, ethanolic extract of *Capparis spinosa* (ECS) significantly inhibit the proliferation of fibroblast and reduce the expression of alpha2 (I) collagen mRNA and type I collagen protein in PSS in a dose-and time-dependent manner.[29] ECS did not affect the proliferation of fibroblast and expression of type I collagen mRNA and protein in normal human. ECS could counteract the harmful effects on fibroblast by H_2O_2.[29]

Stachydrine is a potent anti-metastatic agent, which can markedly inhibit the malignancy and invasive capacity of malignant cancer cells.[37] It inhibits the expression of chemokine receptors (CXCR3 and CXCR 4) in cancer cells. *Capparis spinosa* L showed anti-ulcer activity in experimental animals. Its root bark extract showed antitumor activity against Ehrlich Ascites carcinoma in albino mice.[38] It significantly decreased the tumor volume, packed cell volume, and viable cell count and it prolonged the life span of EAC tumor-bearing mice.[38] Similarly *Capparis zeylonica* Linn showed protective efficacy against gastric ulcer. Its stem extracts significantly cause reduction in gastric volume, free acidity and ulcer index in comparison to control.[39] It showed 88-90% inhibition in ethanol- and indomethacin-induced ulcer. Similarly, n-butanol extract of *Capparis spinosa* L. contains alkaloids, which inhibit proliferation of SGC-7901 cells and show apoptosis and increase [Ca2+]I flux.[40] Similarly, chloroform extraction/fractions of *Capparis spinosa* L. also impose inhibitory effects on SGC-7901 cells, while polar alkaloids showed mitochondrial apoptotic pathway induced by

the component A10 and effect MPTP hole opening, membrane potential losing, cytochrome C releasing and showed IC_{50} value 33.437μg·mL-1. *Capparis spinosa* L. alkaloids also showed inhibitory effect against human gastric cancer SGC-7901 cells.[40] *Capparis deciua* L. is used to eliminate dampness, stasis, swelling, relieving pain and activating blood circulation.[41] Similarly alkaloids from *Capparis himalayensis*[42] a and capparimesin from *Cappris sikkimensis* have shown potential anticancer activity.[43]

Anti-microbial activity

Various plant parts such as stem, leaves, flower buds and roots of *Capparis decidua* showed antibacterial and antifungal activity.[17,44] Its seeds contain some volatile principles which have shown antibacterial activity against series of microbes such as *Vibrio cholerae*, *Vibrio ogava*, *Vibrio inaba* and *Vibrio eltor*[17] and multidrug-resistant *Eschierchia coli*. Plant active principles work like an antibiotic and is used for the treatment of *E. coli* infection.[45] Similarly, caper (*Capparis spinosa)* fruits were found antibacterial activity against gram-positive and gram-negative bacteria mainly against *Lactobacillus plantarum, L. brevis, L. fermentum*.[46] It was also found effective against fungi mainly *C. albicans* and *Aspergillus flavus*. *Medicago laciniata* (ML), *Limonium axillare* (LA) and (PG).[47] Its stem aqueous extract was also found effective against *Trichophyton violaceum M. canis* and *T. mentagrophytes*,[48] while root extract shows bacteriostatic activity on the growth of *Deinococcus radiophilus*.[48] It contains few heterocylic compounds.[49] Similarly, solvent extracts of *Capparis decidua* showed growth inhibitory activity against important disease pathogens[50] such as *Bacillus subtilis* and *Aspergillus niger*[51] due to presence of isothiocynate.[52] Similarly, oxygenated heterocyclic constituents from *Capparis decidua* root bark were found effective against *Candida albicans*, *C. tropicalis*, *A. fumigatus*, *A. flavus* and *A. niger*.[53] More especially extract and pure compounds isolated from *C. decidua* have shown very high antimicrobial activity.[54] Similarly, *Capparis thonningeii* and *Capparis tomentosa*[55] showed anti-microbial activity.[56] Caper seeds possess a protein that shows antiproliferative, antifungal and HIV1 reverse transcriptase activity.[57]

Anti-protozoal activity

Capparis spinosa (EtOAc fraction) showed pronounced antiprotozoal activity against *P. falciparum* with an IC_{50} 0.50 microg/mL in MRC-5 cell line (CC(50) > 30 microg/mL). *Heliotropium curassavicum* (CHCl(3) fraction) showed similar activity against *P. falciparum* (IC_{50} 0.65 microg/mL; MRC-5 CC(50) > 30 microg/mL).[58] *C. spinosa* contain lectins, which control *Leishmania major* promastigotes by agglutination inside its vector host, *Phlebotomus papatasi* in laboratory assays. *Capparis spinosa* lectins do fast agglutination and kill the parasites. High mortality of promastigotes was occurred in infected flies after they ingested an extract of *C. spinosa* with the diet. The results indicate that the lectins and toxins found in the vegetation in L. major foci may decrease the transmission of the parasite.[59]

Anti-viral and Immunomodulatory

C. spinosa methanolic extract prepared from flower bud contains flavonoids, including quercetin and kaempferol glycosides, which showed antiviral (HSV-1) and immunomodulatory properties against HSV-1 and HSV-2 (Herpes simplex virus type 1 and 2)[60] [Table 1]. Its *in vitro* exposure inhibits the replication in HSV-2 and modulate the induction kinetics of IL-12, TNF-alpha IFN-gamma. Both compounds are successfully used for the treatment of HSV-2 infections in immunocompromised hosts.[60]

Anti-allergic

Pentascal is a new neutraceutical (Bionap, Italy) is prepared from *Capparis spinosa* and addition of other plants such as *Olea europaea*, Panax *Ginseng* and *Ribes nigrum,* which showed strong anti-allergic activity. (Bionap, Italy).[61] Pentascal was found effective in reducing allergic biomarkers such as CD63 protein and SLT in atopic subjects.[61] The higher inhibitory effect on CD63 expression caused cell membrane stabilization and shows protective effects.[61] Similarly, methanolic extract of *Capparis spinosa* L. flowering buds showed good protective effect against the bronchospasm induced by antigen challenge in sensitized guinea-pigs. Conversely, it showed a significant decrease in the responsiveness to histamine in CAP-C pretreated animals. Finally, the CAP-C gel formulation possessed a marked inhibitory effect (46.07%) against histamine-induced skin erythema. These two caper extracts displayed most distinguished marked antiallergic activities.[62] *Capparis spinosa* extract showed anti-allergic and anti-histaminic effect.[63]

Anti-arthritic activity

Ethanol and ethanol-water extracts of *Capparis spinosa* L. (Capparidaceae) fruits showed anti-arthritic effects due to the presence of few important chemical constituents such as P-hydroxy benzoic acid; 5-(hydroxymethyl) furfural; bis (5-formylfurfuryl) ether; daucosterol; α-D-fructofuranosides methyl; uracil and stachydrine[64] [Table 1].

Analgesic activity

Flower buds, root bark and fruits of *Capparis ovata* Desf. and *Capparis spinosa* L showed analgesic, wound healing, cell regeneration, tonic, and diuretic effects, while its methanolic fruits showed antinociceptive effect at the dose of 50 mg/kg.[7]

Anti-diabitic and hypoglycaemic activity

Capparis decidua fruit powder significantly decreases the alloxan-induced lipid peroxidation (LPO) in erythrocytes, kidney and heart. It successfully decreases the erythrocyte superoxide dismutase (SOD) and CAT enzymes to reduce

oxidative stress.[22,65] Due to alkaloid richness (AR)[66] *Capparis decidua* shows anti-diabetic or hypoglycaemic effect in normal and streptozotocin (STZ) diabetic rats, which is independent of insulin secretion and did not effect basal plasma insulin concentrations.[67] Similar effects are also noted on lipid metabolism at a dose of 20 mg/kg.[68] Similarly, *Capparis decidua* (Ker) unripe fruits contain 15.1% protein and 42.88% fibre, which significantly cut down of cholesterol level [Table 1].

Anti-hyperlipidaemic effects

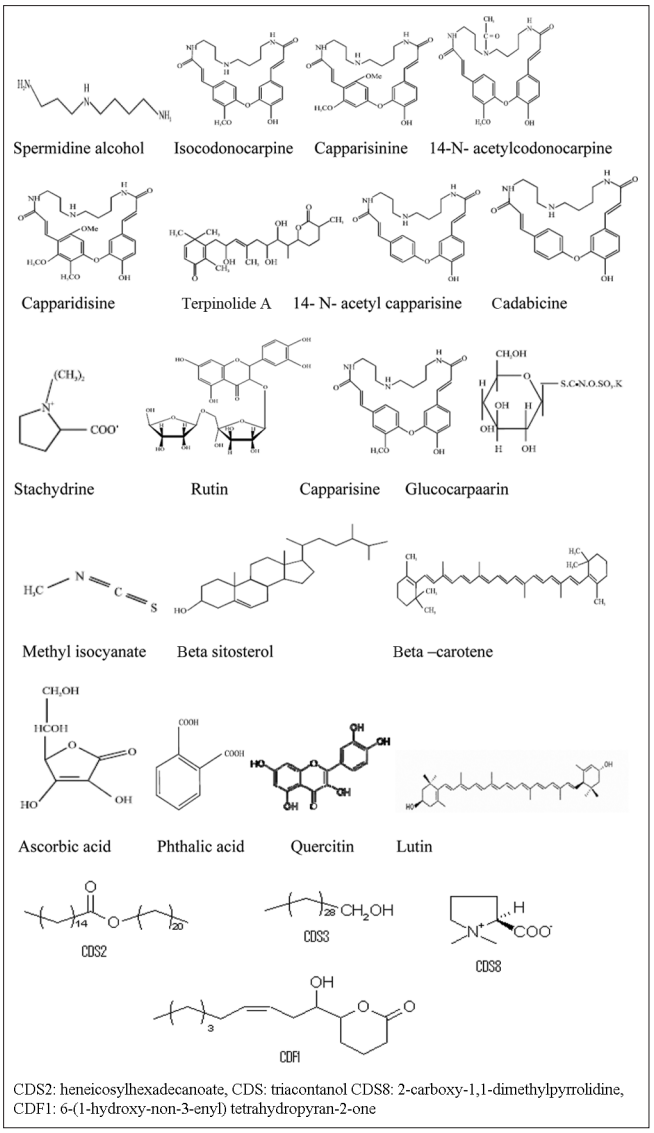
C. decidua fruit and shoot extract (50% ethanolic) significantly reduced serum total cholesterol (61%), Low-density lipoprotein (LDL) cholesterol (71%), triglycerides (32%) and phospholipids (25%) levels at the dose of 500 mg/kg body weight. The cholesterol content of aorta was decreased by 44% and 28% in fruit and shoot extract treatment, respectively. *C. decidua* fruit and shoot significantly decrease the HDL level, total cholesterol ratio and atherogenic index and show anti-atherosclerotic hypolipidaemic potential.[69,70] Use of fruit powder significantly cuts down plasma triglycerides, total lipids and phospholipids concentration,[71] while powder recipes cause lower lipidemia in hyperlipidemic adults (40-60 yrs.). Similarly stem extracts also showed hypolipidemic potential.[72,73] *Capparis decidua* contains capparidisine, a spermidine alkaloid, which showed good cardiovascular activity[74] [Table 1, Figure 1].

Anti-diuretic and anti-hypertensive

Lyophilised methanolic extract of *Capparis spinosa* L (LECS) flower buds showed chondroprotective and antihypertensive effects and control uncontrolled lipid peroxidation. The extract contains many constituents, in particular some flavonoids (kaempferol and quercetin derivatives) and hydrocinammic acids, which are able to counteract the harmful effects induced by IL-1beta[75] [Table 1].

Anti-parasitic effects

Capparis spinosa help to control *Leishmania major* infections and shows nutritive potential for survival of *Phlebotomus papatasi* (Scopoli).[59] The vector of *Leishmania major. Capparis spinosa* contains Cadabicine an alkaloid, beta-sitosterylglucoside-6'-octadecanoate (1) and 3-methyl-2-butenyl-beta-glucoside, which showed anti-parasitic activity.[76] The root extract of *C decidua* is shown to have purgative activity, while root bark and pulp are used to kill helminthes.[44,50] Similarly, *Capparis spinosa* fruit diet cut down alpha-amylase and alpha-glucosidase activities both inside *Phlebotomus papatasi* gut and in salivary gland preparations. Due to inhibition of these two enzymes *C decidua* extract shows the ability to control *Leishmania major* and *L. infantum, L. donovani, L. braziliensis, Crithidia fasciculata* and *Herpetomonas muscarum* parasites.[77] Plant caused significant mortality in above parasite.[77]



CDS2: heneicosylhexadecanoate, CDS: triacontanol CDS8: 2-carboxy-1,1-dimethylpyrrolidine, CDF1: 6-(1-hydroxy-non-3-enyl) tetrahydropyran-2-one

Figure 1: Showing major components isolated from various plant species of genus Capparis

Hepatoprotective action

Capparis spinosa shows hepatoprotective effect in cirrhotic patients, which also attribute diuretic, anti-inflammatory, anti-oxidative, and immunomodulating properties.[78] Similarly, p-Methoxy benzoic acid isolated from methanolic extract of *Capparis spinosa* L. (Capparidaceae) showed significant anti-hepatotoxic activity caused by carbontetrachloride and paracetamol *in vivo*.[79] It also released thioacetamide- and galactosamine-induced hepatotoxicity in isolated rat hepatocytes,[80] Oral administration of aqueous and methanolic extracts of *C. decidua* stems significantly decrease the level of serum aspartate amino transferase, alanine amino transferase, alkaline phosphatase and bilirubin activity.[81]

Nutraceutical Properties

Aerial parts mainly leaves, flowers, fruits of *Capparis decidua* are nutrient rich. Plant contains many important dietary

constituents such as vitamins, minerals, fibers and proteins. These possess very high nutritional value and are used as supplements.[82] Due to nutrient richness, *C decidua* is a large source of non-conventional food source in India.[83] Plant is used for various nutritional purposes by local people of Rajshthan and other western states. Its flower buds are used to make pickles and for food flavoring, [84] while fruit is blanched and used as a vegetable[65] (Agarwal and Chauhan, 1988). In many parts of India, Kair (*Capparis decidua*) fruits and seeds are used blanched, dried and roasted to make an edible diet.[84] Both flower buds and fruits of *Capparis decidua, Capparis ovata and C. spinosa* contain appreciable amounts of tocopherols and vitamin C, which react with most reactive form of oxygen and protect unsaturated fatty acids from oxidation [Table 1]. Both leaf powder and fruit husk contain high fiber content, which is used to cure arteriosclerosis.*C masikai* contain protein, mabinlin as a sweetener, which could become a possible source of sweetener other than sugar cane available in other *Capparis* species.[85] Seed and flower contain oils, sugars, protein that substantiates its nutritional value.[86] *C. spinosa* buds are rich source of anti-oxidants, while important phyto-chemicals such as p-hydroxy benzoic acid, syringic, vanillic, ferulic and saponin showed different biological activities[87] [Table 1]. Leaves and seeds contain beta carotene, thiogalactoside, glycocapparin, n-tricortane, alpha amyrin and fixed oil, while root bark contains alkaloids and phytosterols[87] [Table 1, Figure 1].

Its seeds are highly anti-hypercholestemic in nature. Different *Capparis species* (Kair) contain diverse chemical compounds, which are of very great nutritional and medicinal value. Plant contains important diverse dietary chemical constituents such as saccharides, glycosides, alkaloids, terpinoids and volatile oils, fatty acids and is a richest source of beta-carotene (14%).[86] *Capparis decidua* leaves contain few important compounds such as lutin, neoxanthin and violaxanthin,[27] while flower contain phenolic compounds such as rutin, tocopherols, carotenoids (α and γ tocopherols) and vitamin C. Due to the presence of diverse chemicals plant shows high pharmacoloigical potential[87] and is used to treat arthrolithiasis, rheuma-arthritis and dermatosis.[8] It is a good source of beta-carotene, vitamin C and high amounts of oxalic acid.[88] Plant also contains oxidizable lipids, which are easy to digest and remove out oxidative stress.[89] Seed oil from *C. spinosa* and *C. ovata* contains fatty acids, linoleic acids, oleic acids and its isomers. It is also rich in tocopherols; γ tocopherol (124.3-1944.9 mg/100 gm), Š-tocopherol (2.7-269.5 mg/100gm) and α-tocopherol (0.6-13.8 mg/100 gm).[90] Seed oil also contains sterols (sitosterol, campesterol, stigmasterol) accounted for 10-16% of the total sterols and high amounts of delta 5-avenasterol (138.8-599.4 mg/kg), glucosinolates (34.5-84.6 µ mol/mg). *C. spinosa* also contains 95% gluccocapparinon on dry weight basis.[90] Plant also contains important carotenoids such as beta-carotene, lutein, neoxanthin and violaxanthin 3452.5±1639.4, 1002±518.5, and 342.7±187.9 microg/g fresh weight (FW), respectively. Violaxanthin is a minor carotenoid occurs in *C. spinosa*. The principal form of tocopherol detected in leaves was alpha-tocopherol (20.19±10 mg/100 g FW). In buds and flowers, there were both alpha- (49.12±17.48 and 28.68±9.13 mg/100 g FW, respectively) and gamma-tocopherol (48.13±15.08 and 27.8±16.01 mg/100 g FW, respectively. The combined content of pro-vitamin A and vitamin E in capers encourages researchers to explore new active principles of great pharmaceutical importance from this plant [91] [Table 1].

Unripe fruit (Teent) of *Capparis decidua* is a rich source of dietary fibers and is used to treat hypercholesterolemia. It significantly increased the fecal excretion of cholesterol as well as bile acids. The dietary fibre (42.88%) influenced total lipids, cholesterol, triglycerides and phospholipids of the liver to varying extents.[47] Fruit is a rich source of vitamin C,[88,92] oils, minerals, sugar and protein (15.1%) that substantiate its nutritional value.[90] Its seed oil contains minor and major nutritional mineral contents such Al, P, Na, Mg, Fe and Ca and fatty acids, which are important dietary constituents[93] [Table 1].[70] The highest mineral concentrations measured were 14.91-118.81 mg/kg Al, 1,489.34-11,523.74 mg/kg P, 505.78-4,489.51 mg/kg Na, 102.15-1,655.33 mg/kg Mg, 78.83-298.14 mg/kg Fe, and 1.04-76.39 mg/kg Ca. The heavy metal concentrations were less than the limit of detection in all oil samples.[93] The oil content of *C. ovata* and *C. spinosa* seeds ranged from 27.3 to 37.6 g/100 g (*C. spinosa*) and from 14.6 to 38.0 g/100g (*C. ovata*). Both species possess linoleic acid (Fatty acid), which accounted for 26.9-55.3% in *C. ovata* seed oils and for 24.6-50.5% in *C. spinosa* seed oils. Besides this, oleic acid and its isomer, vaccenic acid, are also identified in the seed oils in concentrations between 10% and 30%, respectively. The seed oils of both species contain gamma-tocopherol, (124.3-1944.9 mg/100 g); delta-tocopherol, (2.7-269.5 mg/100 g); and alpha-tocopherol, (0.6-13.8 mg/100 g) concentration. The concentration of total sterols ranged from 4875.5 to 12189.1 mg/kg (*C. ovata*) and from 4961.8 to 10009.1 mg/kg (*C. spinosa*), respectively.[93]

Leaves, fruits and flowers of *C. spinosa* contain rutin, quercetin 3-O-glucoside and quercetin 3-O-glucoside-7-O-rhamnoside[94] [Figure 1]. It also contains a new flavonoid quercetin 3-O-[6'''-alpha-L-rhamnosyl-6''-beta-D-glucosyl]-beta-D-glucoside.[95] Similarly, two new (6S)-hydroxy-3-oxo-alpha-ionol glucosides, together with corchoionoside C (6S,9S)-roseoside) and a prenyl glucoside, were isolated from mature fruits of *C. spinosa*. The alpha-ionol derivatives are metabolites of (+)-(S)-abscisic acid [96] [Figure 1]. Young shoots and raw flower buds of *C. spinosa* and *C. ovata* Desf.

var. canescens contain glucosinolates ranged from 6.55 micromol/g (large buds of *C. spinosa*) to 45.56 micromol/g (young shoots of *C. ovata*). The main glucosinolate was glucocapperin, which amounted to approximately 90% of the total glucosinolates. In both species the total glucosinolate content varied in dependence on the bud size, whereas a greater variability was given for buds from *C. spinosa*.[88]

CONCLUSION

Capparis dedcidua is one of the most important floras among 44% of all species of vascular plants which come under 'biodiversity hotspots'. Being a desert plant, it possesses diverse chemical constituents, which are of great nutritional and medicinal value[3] and can be used as a potential food supplement.[89] It is an important non-conventional food source in India.[83] Plant is a richest source of beta-carotene (14%), oils and fats[90] and minerals.[91] Fruits are used to make pickles that also possess very high nutritive value. Its flower buds contain ample amount of vitamins, which showed high anti-oxidant activity while stem, leaves and flowers contain phenolic compounds, which showed anti-oxidant, anticancer, antimicrobial, anti-protozoal, antiviral and immunomodulatory activity[92-94] Its seed proteins contain anticancer activity and inhibit proliferation of hepatoma HepG2 cells, colon cancer HT29 and breast cancer MCF-7 cells. Plant also shows cytotoxic activity against malignant B16 cells. Seed volatiles showed anti-bacterial activity against multidrug resistant bacteria, while heterocyclic constituents from root bark are anti-fungal in nature. Flower buds showed good protective efficacy against bronchospasm and showed inhibitory effect against histamine-induced skin erythemia. Plant shows good immunomodulatory activity against Herpes Simplex Virus type 1 and type 2 and also used to control *Leishmania major* and other promastigotes by agglutination inside the host vector. Caper extracts showed anti-allergic, anti-arthritic, ant-inflammatory and anti-hypertensive activity due to presence of hydroxyl cinnamic acids such as caffeic acid, ferulic acid and cinnamic acid. Flower buds and fruits are chondraprotective and showed analgesic, antidiabetic, hypoglycemic and anti-hypertensive effects and control lipid peroxidation. Its fruit and shoot extracts cause significant decrease in the level of LDL cholesterol, triglycerides and phospholipids. Its fruits contain flavanoids, which showed anti-inflammatory activity, its stem extract shows antipyretic effect but devoid of analgesic activity.[94]

Phytochemical studies of *C. decidua* have shown presence of many beneficial compounds, which have shown analgesic, laxative, anti-helmintic, antiparasitic and antiprotozoan activity. Root bark powder is traditionally used to cure rheumatism, dropsy, ulcer, gout, fever, cough, asthma, boils, piles and inflammation.[95] It is also a traditional anti-dote to snake bite,[96,97] small pox, boils, cholera, colic, hemiplegia, neuralgia, pneumonia and pleurisy.[98] Few active principles such as stachydrine; odourless, hygroscopic bitter compound shows hyponotic activity.[99] Similarly ethanolic extract of *Capparis cartilaginea* shows hypnotensive and spasmolytic activity.[100] Especially methanolic extract of *Capparis zeylanica* Linn showed sedative and anti-ulcer activity and inhibits indomethamic-induced ulcer in rats.[101] *Capparis zeylanica* is also known as Asadhua or Ardanda and is used to prepare Rasayna or drug in traditional Ayurvedic medicine. Its leaves are used as counter-irritant, febrifuge and as a cataplasm in swelling,[102] boils and piles. Dried leaved and stem of *Capparis tomentosa* are toxic to calves and goats.[103] Similarly, few active principles such as 1H indole-acetonitril glycosides are isolated from fruits of *Capparis spinosa*[104] and from seeds E-octadec-7-en-5-yonic acid from roots of *Capparis zeylanica*[105] and Beutilin-28 acetate from *Capparis sepiaria,*[106] 2-hydroxy-ethyl glucosinolate from *Capparia masaiki*.[85] Long chain polyisoprenoid alcohols from leaves[107] and volatile oil from seeds of *Capparis* sp.[108]

Capparis decidua is one of the important desert plant species and is only hope for the sustenance of human life. It is used as a fodder and vegetable plant which also help to resist soil erosion and forcefully walled against running sand dunes in deserts.[109] Its root system is too deep and consolidates the weathering of stones, rocks and soil formation. But unfortunately, in spite of conservation efforts there is a heavy loss of plant diversity in desert habitat.[110] It is due to increasing human activities like mining excavations, urban site development and road construction, which are engraving these floral species very fast. Due to uncontrolled human activities *Capparis decidua* is under threat and plant is forcibly confined to few locations. Hence, there must be striking focus on conservation of these hotspots, as various *Capparis* species possess strongest adaptation to the environment, but its vast diversity is diminishing very fast and available flora rich region is converting in to barren lands.[110] For fast conservation habitat destruction should be stopped at once and barren deforested areas are being recovered by *Capparis* plantation in its local adaptation area.[111] To keep the traditional practices alive it is essential to preserve the plants in larger habitat, by modifying and making environment more favorable for conservation of all kinds of plant diversity in deserts. Efforts should be made to start field cultivation of various *Capparis* species for its *in situ* conservation for future generations. Therefore, there is a need to grow *Capparis* by afforestation in all climatic conditions according to their basic adaptations. Its cultivation should be extended to fetch industrially important compounds. Hence, it can be concluded that

C decidua and its associating species may become the major source of medicine. No doubt plant possesses very high ethnomedicinal and nutritional value.

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