REVIEW ARTICLE

Pharmaceutical, insecticidal, and therapeutic potential of Amaltash (*Cassia fistula* family: Caesalpinioideae)

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Abstract

The present review article emphasized the pharmaceutical, insecticidal, and therapeutic role of *Cassia fistula* and its associating species. This is an ornamental plant grown in all parts of India and has a long traditional use in Ayurvedic medicines for the treatment of cough, cold, and sneezing. Plant is a good depository of chemical constituents which display wide array of biological activities such as antipyretic, analgesics, antiseptic, anticancer, antidiabetic, anti-inflammatory, anti-arthritic, antiparasitic, antitumor, antioxidant, chemopreventive, and hepatoprotective. Plant contains important nutraceuticals such as protein 12%, carbohydrate 11.75%, lipid 12%, and free amino acid 1.42%, respectively. *C. fistula* contains quality antioxidants which provide relieve in ulcers, jaundice, and piles, treat migraine and blood dysentery, treat fever, and relieve from chest and joint pain. The fruit of *C. fistula* is a good source of Fe and Mn, it is used in treatment of eczema cough, throat troubles, gastric, and liver complaints. Root extract shows tonic, astringent, febrifuge, and strong purgative activities. Plant is also a good source of nutrients, essential oils, antioxidants, and diverse phytochemicals which could be used for production of herbal drugs for the treatment of various diseases.

Key words: *Cassia fistula*, pharmaceutical, insecticidal and therapeutic, nutraceuticals, medicinal plant

INTRODUCTION

Cassia fistula commonly known as Amaltash in Hindi belongs to family Caesalpinaceae/Fabaceae. This is an edible indigenous flowering plant of India and its neighboring/adjacent countries [Photograph 1]. This is a very popular ornamental plant grown in all parts of the country. This is a multipurpose plant and is grown in South Indian states for the preparation of colorful garlands bear by women of all ages. Plant is state flower of Kerala. Plant is also cultivated in other part of the world. *C. fistula* plant blooms in late spring, with long profuse hanging bunches of yellow flowers.[1] In beginning of summer plant lost all the leaves except long bunches of flowers and long pods [Photograph 1]. Plant also grow in dry climates in well-drained soil and is drought and slightly salt-tolerant. Plant is intolerant to frost, and cold, but shows fast growth in rainy season and bear deciduous green leaves 5.9–23.6 in long.

Amaltash is a deciduous tree found in subtropical climate in Himalayan and sub-Himalayan region in larger density. Plant grows up to a medium height 8–28 m. Plant bears compound leaves, small leaf lets 5–12 cm long in pairs. It is an ornamental semi-wild tree famous for its beautiful bunches of yellow flowers in clusters. Plant bears deciduous small leaves, pinnate with three to eight pairs of leaflets. These are ovate or ovate-oblong, 7–22 cm long and 4–10 cm broad. Flowers pendulous racemes, slender, pubescent, and glabrous bloom in spring season. Its flowers are pendulous racemes 20–40 cm long and bear long fruits/legumes of 25–65 cm long and 1.5–2.6 cm broad. Green cylindrical pods turn black on ripening with multiple seeds found in sweet pulp separated by transverse partitions. Its green seeds and fruit pulp is used as vegetable by local tribes. Seeds broadly ovate contains a whitish endosperm in which the yellowish embryo.

An old *C. fistula* tree become strong and its trunk convert into durable heartwood, which is used to construction

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Photograph 1: Floral and aerial parts of *Cassia fistula* plant grown in Indian sub-tropical climate

furniture and toys. The plant leaves are used as a soft food for cattle, sheep, and goats.[2] Plant is also recognized by other common names in different languages in different surroundings/regions. In Bengali, it is called as, Sonalu, in English; Golden shower, Gujarati garmalo; Kannada: *kakke*, Malayalam: *kanikkonna/ Vishu konna*, Nepali: *rajbriksya*, *amaltash,* Odia: *sunari*, Punjabi: *amalatāsa*, Sanskrit: *aragvadavrksa*, Tamil: *konrai*, Telugu: *raela*, and Urdu: *amaltās.* Cassia plant is used for decoration of houses as these are emblem of happiness and provides good luck to the household.

C. fistula contains important bio-organic constituents which are highly useful in primary health care. *C. fistula* ingredients are established "disease killer" and are used for preparation of Ayurvedic medicines for the prevention of diseases. *C. fistula* and their constituents possess disease curing potential. *C. fistula* possesses significant anti-fertility[3] and antimicrobial activity.[4,5] Seeds scatter pungent odor and used for the preparation of "ghutti" an Ayurvedic preparation for the treatment of cough, cold, and sneezing. *C. fistula* bark extracts showed significant radical scavenging activity.[6] *C. fistula* bark extract is used to treat the infected wound tissue regeneration at the wound site.[7] It is also one of the important herbal medicines used for the treatment of gastric problems.

The fruit pulp possesses strong purgative constituents while leaves show laxatives action.[8,9] Various plant parts of *C. fistula* are used to cure burns, constipation, convulsions, diarrhea, dysuria leprosy, skin diseases, syphilis, and epilepsy. Leaves of *C. fistula* are used in the treatment of eczema, ulcers, jaundice, and piles. Its roots are used to treat fever, relieve from chest and joint pain. Water root extract is used to treat migraine and blood dysentery Anonymous[10] and relieve from urinary problems and biliousness.[11] Root extract shows tonic, astringent, febrifuge, and strong purgative activities.[12-14] Hot water root extract is used in cardiac disorders, rheumatic pain ulcers and boils wounds, and various skin diseases The Wealth of India; Ben Erik 2009.[10,15] Leaves show laxative activity and are used for the treatment of rheumatism and facial paralysis.[11,12,16,17] Long green fruits provide relief in diabetes.[16] Dried seed powder is hypoglycemic in nature and provides relief in amoebic dysentery.[17] Fruit are antipyretic, and used in throat troubles, liver complaints, and diseases of eye and gripping.[14] *Cassia tora* Linn is also used for the treatment of cataract of eyes.[18]

Black carbon or ash is used to treat cold cough and sneezing. The fruit pulp provides quick relief in constipation, colic, chlorosis, and urinary disorders.[19] *C. fistula* L is used by tribal people for the treatment of ring worm, skin infections[20] fever, diarrhea, leprosy, and abdominal pain.[21] Hepatoprotective activity of the aqueous extract of fruit pulp of *C. fistula* (AFCF) against carbon tetrachloride (CCL4)-induced liver damage in albino rats.[22] Phytochemical investigations prove its importance as an important valuable medicinal plant.

Nutraceutical Uses

Plant is a rich source of water soluble proteins and carbohydrates and important amino acids such as arginine, leucine, methionine, phenylalanine, tryptophan, aspartic, and glutamic acids; a new dimeric proanthocyanidin. Plant is a good source of sugar, protein, minerals, and essential oils.[16] Plant also contains neutral lipids mainly unsaturated fatty acids in seed oil. Oleic acid and linoleic acid were identified in smaller quantities. Cassia buds contain sesquiterpenoids and are used in food spice, dietary supplements, flavoring agents, and preservatives,[23] Cassia nomame is a processed nutraceutical obtained from *Cassia* sp.[24] *C. fistula* seeds are used as food by tribes. In India, flowers of the golden shower tree are sometimes eaten by people. The leaves have also been used to supplement the diets of cattle, sheep, and goats fed with low quality forages.[2] *Cassia* seed powders are most popularly used in the pet-food industry.[25,26] Long fruits and fruit pulp are source of sugar and gum and are used as health food additives.[27] Plant is also a good source of commercial essential oils.[28] Roasted seeds of the cassia are substituted for coffee, like tephrosia seeds. Seed extracts may be considered for use in food and nutraceutical applications.[29]

Phytochemistry

C. fistula seed, pollen, fruit, leaf, and pods possess physiologically important metabolites. On an average contains protein (10–12%), carbohydrate (10–11.75%), lipid (12%), and free amino acid (1.5%), respectively. Plant leaves are rich in crude protein, crude fat, fiber, carbohydrates, and essential oils. Leaves also contain alkaloids, terpenoids, reducing sugars, saponins, tannins, carbonyl, phlobatanin, and steroids[30] [Figure 1]. *C. fistula* stem bark possesses flavanol glycosides, i.e., 5, 7, 3', and 4'-tetrahydroxy-6, 8-dimethoxyflavone-3-O-α-arabinopyranoside.[31] The stem

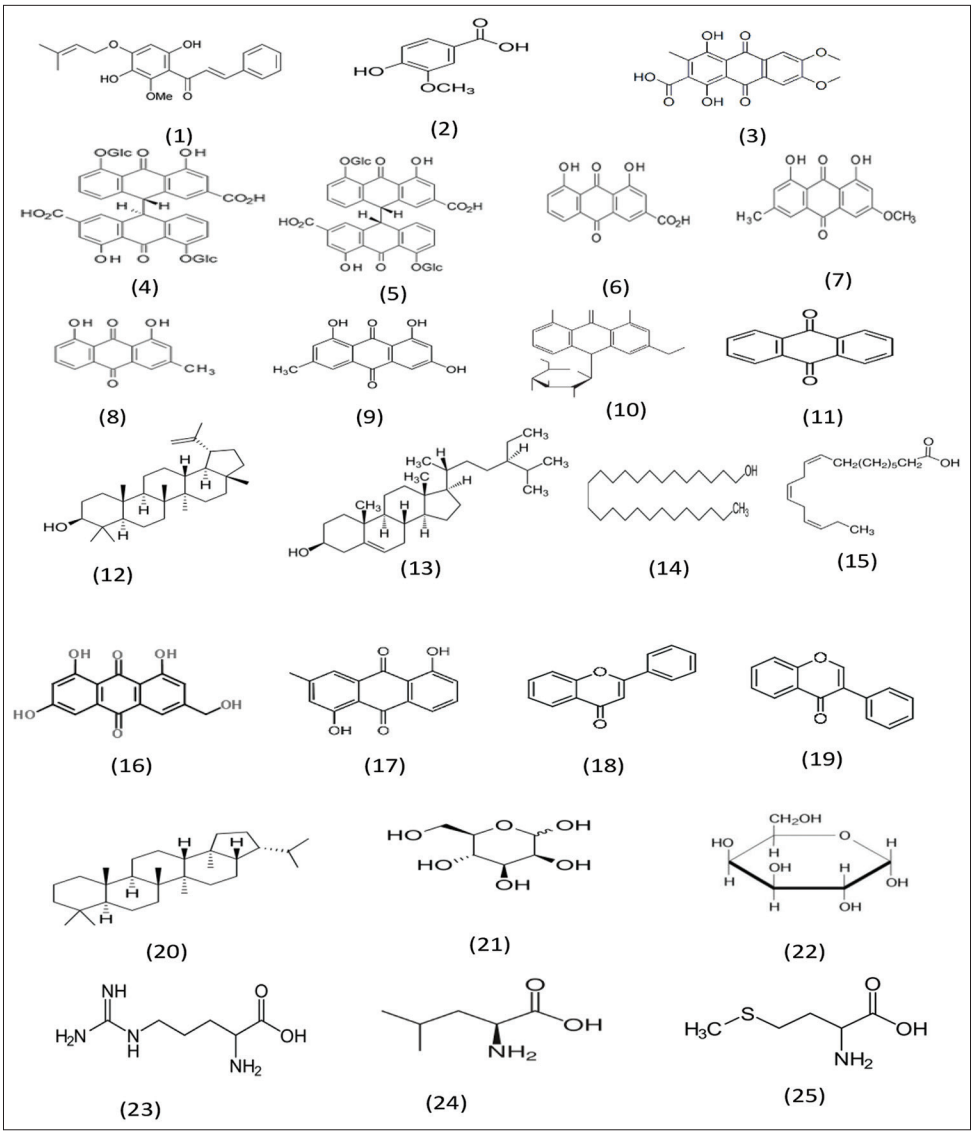

Figure 1: Various bio-organic compounds isolated from various species of Amaltash. (1) Helichrysum, (2) Vanillic acid, (3) anthracenecarboxylic acid, (4) Sennoside B, (5) Sennoside A, (6) Rhein, (7) Emodin, (8) Chrysophanol, (9) physcion, (10) barbaloin, (11) Anthraquinones, (12) lupeol, (13) beta-sitosterol, (14) hexacosanol, (15) linoleic acid, (16) Emodin, (17) ziganin, (18) flavone, (19) isoflavone, (20) triterpene, (21) lectin, (22) galactose, (23) arginine, (24) leucine, (25) Methionine

bark also contains xanthone glycoside, and 1, 8-dihydroxy-3, 7-dimethoxyxanthone-4-O- α-L-rhamnosyl (1→2)-O--D-β glucopyranoside.[32] The plant is rich in phenolic antioxidants such as anthraquinones, flavonoids, and flavan-3-ol derivatives.[33,34] *C. fistula* contains emodin, chrysophanic acid, fistulic acid, phenolic, proanthocyanidin, rhein, rheinglucoside, galactomannan, sennosides A and B, tannin, phlobaphenes, oxyanthraquinone substances, fistuacacidin, barbaloin, lupeol, beta-sitosterol, and hexacosanol [Figure 1].[33,34]

The fruit pulp of *C. fistula* contains good quantity of amino acids.[35,36] Its seeds contain gum (7.65%) (Anonymous). The *C. fistula* seeds contain 5-Nonatetracontanone, 2-hentriacontanone, triacontane, 16 hentriacontane, and beta-sitosterol. Dried seeds are source of yellow oil that contains chrysophanic acid[16] and mucilage (25.8%).[37] *C. fistula* leaves and flowers possess essential oil.[38] The main fatty acids found in the oil are linoleic acid (42.42%), oleic acid (29.62%), stearic acid (14.33%), palmitic acid (11.41%), caprylic acid (0.76%), and myristic acid (1.44%) [Figure 1]. The seeds contain approximately 2% anthraquinones, 24% crude protein, 4.5% crude fat, 6.5% crude fiber, and 50% carbohydrates. Seeds of *C. fistula* also contains benzyl 2-hydroxy-3,6-dimethoxybenzoate, 5-(2-hydroxy phenoxy methyl) furfural, (22 S)-7-hydroxy-5-hydroxymethyl-2-(22-hydroxypropyl) chromone, and benzyl 2-O-D-glucopyranosyl-3,6-dimethoxybenzoate. It is also source of 5 hydroxymethylfurfural, (22 S)-7-hydroxy-2-(22 -hydroxypropyl)-5-methylchromone, and two oxyanthraquinones, chrysophanol, and chrysophanein[31] [Figure 1]. Fruit pulp contains sugar, gum, astringent matter,

gluten, coloring matter and water proteins (19.94%), and carbohydrates (26.30%). Seeds are also good source of amino acids such as arginine, leucine, methionine, phenylalanine, tryptophan, aspartic, and glutamic acids.[36]

C. fistula also contains chrysophanol, rhein, physicion, and kaempferol proanthocyanidins containing flavon-3-ol (epiafzelechin and epicatechin)[39,40] *C. fistula* fruit is a good source of Fe and Mn.[41] *C. fistula* roots contain diterpene, while its pods contain 3 beta -hydroxy-17-norpimar-8(9)-en-15-one Misra *et al*. (1997)[35] and rhamnetin 3-O-gentiobioside.[42]

C. fistula plant contains long-chain hydrocarbons, fatty acids, i.e., 1-hexacosanol, 1-octacosanol, palmitic acid, stearic acid, oleic acid, linoleic acid, heptacosyl eicosanate, and glyceryl-1-tetraeicosanoate; three sterols, beta-sitosterol, stigmasterol, and beta-sitosteryl-3-O-D-glucopyranoside. Aril of *C. fistula* contains triterpene, lupeol; anthraquinones, chrysophanol, emodin, physcion, citreorosein, rhein, ziganein, 1,4,5trihydroxyanthraquinone; coumarins, scopoletin, chromones, isovanillic acid, and vanillic acid. Plant also contains flavone glycoside 5,3',4'-trihydroxy-6-methoxy-7-O-alpha -L-rhamnopyrano syl-(1→2)-O-beta-D-galactopyranoside Yadava *et al*.,[43] lectins, neutral sugar galactose, mannose,[44] isoflavone biochanin A, and sterols.[45,46]

Pharmaceutical Activities

Antipyretic activity

C. fistula pod's extracts (Patel *et al*., 1965)[47] showed a marked antipyretic effect by causing a reduction in yeast-induced fever in experimental rat [Table 1].[48]

CNS Depressant Activity

C. fistula methanolic seed extract significantly relieved from antinociception and sedative actions of sodium pentobarbitone, diazepam, meprobamate, and chlorpromazine.[49] *Cassia leptophylla* contains piperidine alkaloid that shows antinociceptive [Table 1],[50] Sedation,[51] or CNS depressant properties[52] [Table 1].[53]

Proteolytic Activity

Proteases are enzymes which provide defense to both plant and animal systems. *Cassia tora* seed extract possess protease inhibitor activity and it acts against trypsin and proteases of Bacillus sp. and *Aspergillus flavus*[54] [Table 1]. Similarly, a protease inhibitor named "fistulin" was isolated from the leaves of *C. fistula.*[55] and *Cassia absus* Linn.[56]

Antitussive Activity

The methanolic extract (ME) of *C. fistula* relieves cough and exhibits antitussive activity in a dose-dependent manner like the standard drug (codeine phosphate).[57] The leaves are laxative, antiperiodic, and heal ulcers, used in rheumatism and cure cough.[58,59] Similarly, ME of *C. fistula* buds relieved from cough in experimental mice induced by sulfur dioxide gas [Table 1].[48]

Hepatoprotective Activity

C. fistula n-heptane extract of leaves showed hepatoprotective effects in paracetamol treated rats. At a very low dose of 400 mg/kg body wt. oral treatment significant protective effect by lowering the serum levels of transaminases (SGOT and SGPT), bilirubin, and alkaline phosphatase.[48] Similar hepatoprotective effect was noted in *Cassia occidentalis* against paracetamol and ethyl alcohol intoxication in rats.[60] *Cassia occidentalis* L. is also used in Unani medicine for the treatment of liver ailments. *Cassia nigricans* leaves are used in folk remedies to stop progression of aspirin-induced peptic ulcer [Table 1].[61]

Gxenotoxic Effects

Cassia species showed gxenotoxic effects that may be attributed due to the presence of alkaloids, triterpene, anthraquinone, and polyphenolics.[62] These also contain anti-clastogenic ingredients that induce xenotoxic effects in Chinese hamster ovary K1 (CHO-K1) cells.[63] Anthraquinone glycosides of *Cassia angustifolia* and *C. fistula* anthraquinone sennoside B and rhein showed weaker genotoxicity[64] while flavonoids, catechins, and proanthocyanidins are strong genotoxic agents [Table 1].[65]

Antioxidant Activity

Cassia species possess ferric reducing antioxidant power, DPPH free radical scavenging, and metal chelating activity. Ethanol and MEs of *Cassia tora* show potent antioxidant activity.[66] Similar antioxidant activity is also reported in ethanol extracts of leaves, and methanol extracts of stem bark, pulp and flowers from *C. fistula.*[67] *C. fistula* contains total polyphenolic content and pro-oxidants, such as chrysophanol, proanthocyanidin, and flavonoid which show antioxidant activity [Table 1].[33]

Flavonoids are also isolated from seed, leaf, stem, and pods of *Cassia absus, Cassia alata,* and *C. fistula.*[67] *C. tora* showed *in vitro* antioxidant activity.[68] Seed extract *Cassia surattensis* shows antioxidant activity against paracetamol intoxication in mice: *In vitro* and *in vivo* Studies of Herbal Green.[69] The importance of *C. fistula* in diseases control has ancient background due to high sources of antioxidants. Mainly green floral parts of plants which are used as green tea showed strong antioxidant potential are due to the presence of tocopherol, flavonoids, and polyphenols,[70,71] Intake of bioflavonoids provides freshness due to ferric ion reducing capacity.[72] *C. fistula* ethanolic fruit extracts work against

Table 1: Major and minor biochemical ingredients found in Cassia plant with their biological activity

***Cassia* species**	**Plant part**	**Biochemical component/s**	**Biological activity**
Cassia fistula	Leaf and pod extracts Flowers	Flavonoids, xanthone anthraquinones, Terpenoids, reducing sugars, Saponins, Tannins, Steroids, Glucoside,	Hepato protective, hypolipidemic, antioxidant, anti-inflammatory, antipyretic anti-diabetic and anti-parasitic and insecticidal antimicrobial activity, antimicrobial
Cassia singueana	Leaf extracts,	Tannins, saponins, alkaloids, glycosides, flavonoids, carbohydrate and terpenes.	Antimicrobial activity antimalarial
Cassia mimosoides			
Cassia sieberiana	root and stem bark extract	Alkaloids, anthraquinones, flavonoids, triterpenoids, tannins, cardiac glycosides, saponins, reducing sugars and carbohydrates	Anti-plasmodial activity
Cassia javanica	Leaf and stem bark extract	Flavonoids, anthraquinones, sugars, Proteins, Alkaloids, Tannins, Glycosides, Sterols, Quercetin, Emodin, Chrysophanol,, Physcion.	Antioxidant, hypoglycemic, Anticancer and antimycotic activity, antiviral activity, antimicrobial activity, haemolytic activity
Cassia grandis	Leaves	Flavonoids, alkaloids anthraquinones, Sterols, naphthalene derivatives, protein, Tannins,	Anti- inflammatory activity Animal feed, Ornamental purpose, Gum, wood, timber
Cassia abbreviata	Pods	Anthraquinone derivatives, Guibourtinidiol, Alkaloids, Tannins, Crude proteins, Flavonoids, Sterols. Anti plasmodic activity	Treatment for Malaria Treatment for Pneumonia
Cassia occidentalis	Leaves and pods	Anthraquinone, Anthrone, Cassiolein, Quercertin, Aloe emodin, Rhein, Tannins.	Treatment Stomachic Flatulence Constipation Cough Fever Asthma
Cassia obovata	Leaves,	Anthraquinones, Chrysophanic acid, Tannins, Sterols, Flavnoids.	Inhibitors of skin fungus Mice infestations
Cassia spectablis	Leaves,	Flavenol, Anthraquinone, Tannins, Alkaloids, Emodin.	Antifungal activity Antibacterial activity Antioxidant activity Anti diarrhoeal activity
Cassia tora	Pod	Cinnamaldehyde, Gum, Tannins, Mannitol, Coumarins, Pinene, Eugenol.	Laxative Anthelminitic activity Ophthalmic use Antiperiodic, Anti-leprosy activity Anti – flatulence Cough Bronchitis Cardiac disorders
Cassia nigricans	Leaves, stem bark and pods	Flavnoids, reducing sugars, Anthracene, Tannins, Alkaloids, Saponins, Hydroxyanthraquinone, Hepatadecanoic acid, βisosterol acetate.	Antiulcer activity Anti oedema Activity, ringworm, eczema) Sore throat(Infusion) Antioxidant activity Anti-inflammatory Anti-cancer activity Anti-plasmodia Treatment Gastro intestinal disorder Diarrohea Skin disease(scabies,
Cassia sieberiana	Leaves, stem bark and pods	Anthraquinone, Tannins, Saponins, Flavnoids, Alkaloids, Taxol.	Purgative, Emetics Treat skin disease Treat fish poison Treat sterility disorders
Cassia abbreviata Oliv.	Roots	alkaloids, flavonoids, anthraquinones and saponins. deoxycholic acid, menadione trihydroxyflavan-(4β→8)-3,5,7,4'-tetrahydroxyflavan-(3'→6)-3,5,7,2',4'-pentahydroxyflavan and 3,7,2,4-tetrahydroxyflavan-(4α→8)-3,5,7,4-tetrahydroxyflavan-(4α→6)-3,5,7,2,4-pentahydroxyflavan	inhibit HIV-1c replication in peripheral blood mononuclear cells
Cassia angustifolia Vahl.	Leaves, stem bark and pods	flavonoids and fistulin alkaloids, Carboxylic acid, Coumarins, Phenol, Resin, Saponin, and Steroid.	Antimicrobial activity was determined with two gram positive (Bacillus subtilis and *staphylococcus aureus*) bacteria

(Contd...)

Table 1: *(Continued)*

***Cassia* species**	**Plant part**	**Biochemical component/s**	**Biological activity**
Cassia didymobotyra	Roots	steroids, terpenoids, anthraquinones, tannins, saponins, glycosides, flavonoids, alkaloids and phenols silver nanoparticles generated from methanol leaf extract of	antimicrobial activity of seed extracts
Cassia obtusifolia	Leaves	saponins, tannins, alkaloids and flavonoids	are used in Cholesterol-Lowering Probiotics
Cassia leptophylla	Leaves and green pods	piperidine alkaloid	antinociceptive
Cassia tora	seed extract possess	contains ononitol monohydrate	analgesic activity, protease inhibitor
Cassia absus	seed extract possess	Fistulin, Flavonoid, phenol, sterol and alkaloid	content was carried out. The antioxidant, anti-inflammatory, and anti-glycation capacities
Cassia alata	leaf	kaempferol 3-o-sophoroside	
Cassia surattensis	Seed Extract		antioxidant activity
Cassia occidentalis L.		Flavanoids, terpenes, saponins, glycosides, terpinoids, anthraquinones.	Treatment of respiratory tract diseases, hepatoprotective, hypoglycemic, antimalarial, anti-inflammatory, immunosuppressant, hypolipidemic, anti-atherosclerogenic, and antipyretic activities
Cassia siamea		Caffeic acid, Vallinic acid, Ferulic acid, Cinnamic acid, Cyclolanost-23-ene-3,25-diol	antimicrobial activity
Cassia auriculata	Leaves	alkaloids, tannins flavonoids, glycosides, saponins along with proteins	antimicrobial activity

oxidative damage in human erythrocytes[73] (Abid *et al*., 2014). Similar antioxidant activity in *C. fistula* L. extracts of bark, stem, leaf, and root is also reported due to the presence of polyphenolic compounds [Table 1][74] stem bark, leaves, and fruit pulp stem bark (*C. fistula* L.), and water extract of flowers *C. fistula* (Linn.)[75] hydro alcoholic extract from the fruit pulp of *C. fistula* Linn exhibit significant antioxidant activity and reversed the function of certain metabolic enzymes superoxide dismutase, catalase, glutathione peroxidase, glutathione reductase, and glutathione to normal.[76] The biosynthesis of silver nanoparticles (AgNPs) from methanol leaf extract of *C. didymobotyra* showed antioxidant properties *in vitro*.[77]

Anti-inflammatory

Aqueous and alcoholic extracts of *C. fistula* bark anti shows inflammatory activity of in sub-acute models of inflammation in Wistar albino rats.[78,79] This anti-inflammatory activity is due to the presence of anthraquinones[80] and flavonoids in *Cassia* species. Similar anti-inflammatory activities of coumarin and Indonesian cassia extract in RAW264.7 murine macrophage cell line.[81] Similar anti-inflammatory activity is also reported in *Cassia tora*[82] and *Cassia occidentalis* L. in ovalbumin-induced airways inflammation in a mouse model of allergic asthma [Table 1].[83]

Wound Healing

C. fistula flower extracts showed wound healing protection against bacterial infections in treated rats. Experimental animals showed improvement in tissue regeneration at the wound site and it disappears after regular treatment.[84] The alcohol extract of *C. fistula* leaves in the treatment of the infected wound[85] and cutaneous lesions [Table 1].[70,86]

Immunomodulatory Effect

A study has investigated the immunomodulatory effect of *C. fistula* in rats and study stated that *C. fistula* shows a significant stimulation of the cell-mediated immunity and no effects on the humoral immunity [Table 1].[87]

Analgesic Activity

Cassia tora contains ononitol monohydrate that shows analgesic activity Antonisamy *et al*.[82] Similarly, *Cassia siamea* Lam. stem bark extracts[88] and *Cassia alata* leaf extract showed analgesic activity due to the presence of kaempferol 3-o-sophoroside [Table 1].

Antidiarrhea

Raw pods and leaves of *C. fistula* used for the treatment of dysentery.[89] *Cassia* species contain alkaloids which removes from contraction of isolated intestinal smooth muscle in rats [Table 1].[90]

Antidiabetic Activity

Aqueous extract of *C. fistula* (Linn.) seeds and flowers (ACF) control sugar level in alloxan induced diabetic rats.[91,92] *C. fistula* Linn Stem bark also shows anti-hyperglycemic activity [Table 1].[93] Methanolic and aqueous extracts of whole parts of *C. fistula* exhibit hypoglycemic effect both in normoglycemic and streptozotocin-nicotinamide induced Type 2 diabetic rats.[94]

Anticonvulsant

Cassia siamea contains barakol a potential anxiolytic agent[95] that causes lowering of intraocular pressure in a DBA/2J mouse glaucoma model.[96] *Cassia* species are also used for treating epilepsy by indigenous communities of sub-Himalayan region of Uttarakhand [Table 1].[97]

Anti-fertility

C. fistula contains flavonoids which reversibly suppresses fertility in male rats. These obstruct reproduction and control of hormone involve in reproduction [Table 1].[3]

Anticancer Activity

C. fistula fruit extracts and its anticancer activity against human cancer cell lines Irshad *et al*.[98] Similar effects are also reported in twigs and leaves of *Cassia auriculata* against human colon cancer cell line.[99] Cassia species also showed anti-proliferative activities on HeLa cancer cell line,[100] Rhein inhibits angiogenesis and the viability of hormone-dependent and -independent cancer cells under normoxic or hypoxic conditions *in vitro*[101] while chromones and other constituents from *Cassia petersiana* showed strong anticancer activity [Table 1].[102]

Antitumor Activity

ME of *C. fistula* seed stops growth of Ehrlich ascites carcinoma (EAC).[103] ME treatment caused decrease in the tumor volume and viable tumor cell count and increase of life span in the EAC tumor bearing mice.[104] Similarly, *C. fistula* bark extracts showed chemopreventive effect in 7, 12-dimethyl benz(a)anthracene induced hamster buccal pouch carcinogenesis.[105] This anticancer activity may be due to the presence of anthraquinones, fistula quinones A-C (1-3).[106] Rhein also showed anticancer in human colon adenocarcinoma cell line COLO 320 D at a very low dose of 200 μg/mL concentration.[107] *C. fistula* fruit extracts showed anticancer potential against human cervical cancer (SiHa) and breast cancer (MCF-7) cell lines Irshad *et al*.[98] Furthermore, rhein also showed inhibition of growth of cancer cell lines including human cervical cancer (SiHa), breast adenocarcinoma (MCF-7), and hepatocellular carcinoma (HepG2) in a dose-dependent manner [Table 1].[107]

Laxative Activity

Infusion of *C. fistula* and *Cassia acutifolia* sp. showed laxative effect on isolated guinea-pig ileum compared with senokot tablet Akanmu *et al*. (2004) [Table 1].[108]

Antiparasitic Activity

Cassia singueana is used against acute malaria attack in northern Nigeria.[109] The methanol extract of *Cassia alata* L.[110] and *C. fistula*[111] showed antiplasmodial activity.[112] It kills Plasmodium falciparum Gametocytes.[113] Ethanolic extract of root and stem bark of *Cassia sieberiana* showed anti-plasmodial activity in mice model.[114] Hexane extract from the fruits showed significant antileishmanial activity against the promastigote form of *Leishmania* L. chagasi.[45] This antiplasmodial activity in *Cassia siamea*[115] is due to the presence of cassiarins A and B, novel alkaloids [Table 1].[116]

Antimicrobial Activity

Cassia tora and *C. fistula* various plant parts showed antimicrobial potential.[117,118] This strong antimicrobial potential is due to the presence of anthraquinones,[119] fistulins (A and B), and bischromones.[105] Flavones from *Cassia siamea* also showed anti-tobacco mosaic virus activity.[120] *Cassia alata* leaf extract generated AgNPs[121] showed strong bactericidal activity.[122,123] Similar antibacterial activity is reported in AgNPs generated from methanol leaf extract of *Cassia didymobotyra*.[77] Both flavonoids and fistulin from *Cassia angustifolia* Vahl.[124] and *C. fistula* leaves showed antimicrobial activity [Table 1].[125]

C. angustifolia possess quercimeritrin, scutellarein, and rutin, which showed antimicrobial activity.[121] *Cassia alata* leaf extract showed activity against *Chromobacterium violaceum*.[126] 4-hydroxy benzoic acid hydrate obtained from the extracts of the flower of *C. fistula* showed antifungal activity against *Trichophyton mentagrophytes* (MIC 0.5 mg/ml) and Epidermophyton floccosum (MIC 0.5 mg/ml).[126]

Anti-HIV Activity

Different Cassia species possess various antiviral compounds such as chromones from the stem of *Cassia siamea,*[127] cycloartane triterpenoids from *Cassia occidentalis,*[128] *Cassia sieberiana* D.C., and *Cassia abbreviata* Oliv. inhibit *in vitro* HIV-1c replication in peripheral blood mononuclear cells (PBMCs),[129,130] flavones from *Cassia siamea,* and their anti-tobacco mosaic virus activity [Table 1].[131]

Insecticidal Activity

Various plant parts of different Cassia species display anti-insecticidal activities. The crude extracts of *C. fistula*.[132] *Cassia mimosoides*, and *Cassia didymobotrya*[133] larvicidal, ovicidal and repellent activities against insect vector of malaria *Anopheles gambiae*.[134] *Cassia roxburghii* plant leaf extract against *Anopheles stephensi, Aedes aegypti,* and *Culex quinquefasciatus* larvicidal activity,[135] *Cassia nigricans* shows insecticidal potential against Tomentosicollis, and the cowpea pod sucking bugs.[136] *Cassia tora* seed extract contains anthraquinones aurantio-obtusin and obtusin which showed much potent mosquito larvicidal activity.[137] Rotenoids from *Cassia tora* L are also reported strong larvicidal agents.[138] *Cassia siamea* ethanolic leaf extracts larvicidal and repellent activities against *Anopheles stephensi* (*An. stephensi*) and *Cx. quinquefasciatus*.[139,140] The extract of *Cassia obtusifolia* leaf extract showed concentration dependent oviposition deterrent activity.[141] *Cassia leiandra* insecticidal activity against *Aedes aegypti*,[142] crude hexane, chloroform, benzene, acetone, and methanol extracts of the leaf of *Cassia tora* were assayed for their toxicity against three important vector mosquitoes, namely, *Cx. quinquefasciatus*, *Aedes aegypti*, and *Anopheles stephensi* [Table 1].[143]

Methanol leaf and flower of *Cassia auriculata*, insecticidal against the fourth instar larvae of *An. stephensi* and *Cx. Quinquefasciatus*,[144] Ononitol monohydrate isolated from the ethyl acetate extract of *Cassia tora* L. antifeedant, larvicidal, and growth inhibitory activities against *Helicoverpa armigera* and Spodoptera litura[145] *C. fistula* against *Trogoderma granarium* insecticidal activity.[146] Similar insecticidal activity is reported in extract plant extracts of *Cassia nigricans*,[147] *Cassia tora* against *Aedes aegypti* and *Culex pipiens* pallens,[148] *Cassia occidentalis* adulticidal, repellent, and ovicidal properties of indigenous plant extracts against the malarial vector, *Anopheles stephensi*.[149] Cassia species also showed pediculicidal activity against human head lice *in vitro*.[150] AgNPs synthesized using *C. fistula* fruit pulp also showed mosquito larvicidal and pupicidal activity [Table 1].[151]

CONCLUSION

From the literature, it is established fact that *C. fistula* and its associating plant species contain important phytochemicals which are of immense pharmaceutical and therapeutic use. Plant shows vast array of health benefits due to the presence of both macro and micronutrients. The plant is rich in protein (12%), carbohydrate (11.75%), lipid (12%), and free amino acid (1.42%), respectively. The plant also contains ample percentage of fatty acids, i.e., linoleic, oleic, and stearic acid. Plant leaves also contain oxalic acids, anthraquinones and its derivatives vitamins, alkaloids, polyphenols, terpenes, fiber, protein, and oil. *C. fistula* mature fruits contain Rhein glycosides, fistulin, fistulic acids, sennosides A B, anthraquinones, essential oils, and flavanoid-3-ol-derivatives. The stem bark of *C. fistula* contains flavonol glycosides, and a good source of Fe and Mn. Plant possess enormous pharmaceutical potential such as antioxidant, showed antioxidant, anti-inflammatory, anti-diabetic, anti-inflammatory, hepatoprotective, immunomodulatory, antimicrobial, anticancer antitumor activity, and antifertility and antitussive activity effects. Plant parts possess strong adulticidal, repellent, and ovicidal agents. Its leaves and flowers possess many volatile components which are used to provide a specific aroma to vegetable curries. Cassia plant possesses enormous therapeutic potential as it shows obstruction in metastasis and lower down cancer-related mortality in patients. Its bioorganic ingredients can kill drug resistant pathogens. Plant is widely used in traditional medicinal system of India and no doubt it possesses biologically active chemicals that could be used to make highly efficacious broad spectrum pharmaceutical products or novel herbal drugs, pesticides, and therapeutic agents.

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CONFLICTS OF INTEREST

The author declares no conflicts of interest regarding the publication of this paper.

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