The Journal of Phytopharmacology 2017; 6(5): 300-306
Online at: www.phytopharmajournal.com

Research Article

ISSN 2320-480X
JPHYTO 2017; 6(5): 300-306
September- October
Received: 15-09-2017
Accepted: 24-10-2017

Dilip Kumar Sharma
Vardhaman Mahaveer Open University, Kota, Rajasthan, India

Enumerations on phytochemical, pharmacological and ethnobotanical properties of *Cassia fistula* Linn: yellow shower

Dilip Kumar Sharma

ABSTRACT

Indian Laburnum or Yellow shower (*Cassia fistula* Linn.) of Fabaceae (caesalpiniaceae) is a semi-wild deciduous and ornamental tree with long and cylindrical fruits. It is a native of tropical Asia widely cultivated in South Africa, Mexico, East Africa and Brazil. Its species are native to the Indian subcontinent and adjacent regions of Southeast Asia. It is suppose to closely associate with the Mullai (forest) region of Sangam landscape. It ranges from southern Pakistan eastward throughout India to Myanmar Thailand and south Sri Lanka. The plant parts have medicinal uses and important for antimicrobial, anthelmintic and phytochemical aspects for its pod, leaves bark and seed extracts. Pharmacologically it is hypoglycaemic, anticancer, abortifacient, anticolic, antifertility, estrogenic, laxative, antimicrobial, antipyretic, anti-inflammatory, smooth muscle stimulant, antiarthritic, antitussive, purgative, analgesic, antiviral, antimicrobial and hepatoprotective activity. It is known as rich source of tannins, flavonoids and glycosides. It is also used to cure burns, constipation, convulsions, diarrhea, dysuria and epilepsy. Ayurvedic medicines recognize it as carminative, laxative and to cure leprosy, skin diseases and syphilis. This article provides a comprehensive review on plant profile, morphology, traditional or ethnobotanical uses, phytochemical constituents and pharmacological activities of plant.

Keywords: *Cassia fistula* Linn. ayurvedic medicines, secondary metabolites, phenolic compounds, pharmacological activities, phytochemical profile, ethnobotanical uses.

INTRODUCTION

India is a one of the richest countries in the world in regard to genetic resources of medicinal plants since Ayurveda or Siddha systems. These medicinal plants contain several chemical active substances that produce a definite physiological action on the human or animal body. In ayurvadic medicine, the golden shower tree is known as aragvadha, meaning disease killer. Its species are native to the Indian subcontinent and adjacent regions of Southeast Asia, South Africa, Mexico, East Africa and Brazil. It is the national tree of Thailand and its flowers is Thailand national flower. In India, it is the also state flower of Kerala and of immense importance amongst the Malayali population.

The plant is widely planted as tree and has a number of common names in various languages from its native range surrounding regions such as [1] in English (golden shower cassia, Indian laburnum, golden shower, pudding pipe tree, purging cassia, purging fistula), Cantonese (kakke); French (Bâton casse, casse doux, casse espagnole); Spanish (Canâfístula mansa, chácara, Guayaba cimarrona), Greek (kassia-the generic name), Arabic (khiār shambar), Assamese (xonaru), Bengali (sonalu, soondali, sondal, sonal, bandarlathi, amaltas), Burmese (ngu wah), Chinese /Taiwan (sausage tree), Gujarati (garmalo), Hindi (amaltās, bendra lathi, bandarlauri), dhanbaher (dhanbohar, girimaloah), Hindi (bandarlathi, bharva, suvarnaka, amaltas, rajataru, girimalah), Japanese (nanban saikachi, Kanji), Khmer (reachapreuk), Kannada (kakke, Kakkemara), Lao (khoun), Marathi (bahava), Malayalam (kanikkonna, kani konna, vishu konna, ophirpponnu, karnikaram, konnappoo), Meitei/ Manipuri (chahui), Nepali (amaltash, rajbriksya), Oriya (sunari), Sanskrit (aragvadha, chaturangula, kritamala, suvarnaka, nripadruma), Sanskrit (saraphala, survanaka, argwadha, rajtaru), Sinhalese (aehaela, or ahalla, ehela), Thai (rachapruek, khun, dok khuen), Tamil (shrakkonnai, konai, irjviruttam), Telegu (raela, kondrakayi, raelachettu, aragvadhamu, koelapenna), Punjabi (amaltaas, kaniyaar, girdnalee) and Urdu (amaltaas) [2, 3, 4].

Correspondence:
Dilip Kumar Sharma
Vardhaman Mahaveer Open University, Kota, Rajasthan, India
Email: dksharma[at]vmou.ac.in

Biochemical Constituents

The plant is widely used in traditional Indian medicinal system reported to possess hepatoprotective, anti-inflammatory, antitussive, antifungal, antibacterial and to improve wounds healing. It is a rich source of tannins, flavanoids and glycosides, carbohydrates, linoleic, oleic, stearic, oxalic acids, tannins, oxyanthraquinones, anthraquinones derivatives. *Cassia fistula* contains rhein glycosides fistulic acids, sennosides A, B, anthraquinones, flavanoid-3-ol-derivatives, ceryl alcohol, kaempferol, bianthraquinone glycosides, fistulin, essential oils, volatile components, phytol (16.1%), 2-hexadecanone (12%), crystals and 4-hydroxy benzoic acids hydrate [5, 6, 7, 8].

The seeds contain 24% crude protein, 4% crude fat, 7% crude fiber, and 50% carbohydrates with an 81% *in vitro* digestibility. The leaves contain 16% crude protein, 40% carbohydrates with an 88% *in vitro* digestibility. FAO reports the leaves to contain, on a zero moisture basis, 17.6 g protein, 66.8 g total carbohydrate, 30.2 g fiber, 7.8 g ash, 3 270 mg Ca, and 330 mg P per 100 g. Flowers contain ceryl alcohol, kaempferol, rhein and a bianthroquinone glycoside, which on hydrolysis, yields fistulin and rhamnose. Leaves contain rhein, rheinglucoside, and sennosides A and B. The root bark contains tannin, phlobaphenes, and oxyanthraquinone substances, which probably consist of emodin and chrysophanic acid; also contains (bark and heartwood) fistuacacidin, barbaloin and rhein. Stem bark contains lupeol, beta-sitosterol and hexacosanol [2, 9, 10, 11-15].

Botanical Profile

Cassia fistula is widely grown ornamental profusely yellow flowering tree in tropical area which blooms in late spring but many times no leaf being seen. A tree 6-9 m high; trunk straight; bark smooth and pale grey when young, rough and dark brown when old; branches spreading, slender. The leaves are deciduous and pinnate with three to eight pairs of leaflets. The flowers are pendulous racemes, slender, pubescent and glaborous 4–7 cm diameter. Calyx long divided to the base, pubescent; segments oblong, obtuse, corolla yellow, stamens all antheriferous. The fruit is a legume with a pungent odor and containing several seeds.

The long pods green pods turn black on ripening after flowers shed [16]. Pulp is dark brown in colour, sticky, sweet and mucilaginous, odour characteristic, and somewhat disagreeable [17, 18]. Drug occurs in flat or curved thick pieces; outer surface smooth to rough with warty patches; greenish grey to red; inner surface rough, reddish with parallel striations; fracture, laminate; odour, sweet and characteristic; taste, astringent [2].

The pods are pendulous, with numerous (40-100) horizontal seeds immersed in a dark coloured sweetish pulp. Seeds are broadly ovate, slightly less in breadth and thick [19]. Internally the pod is divided by thin, buff coloured, transverse dissepiments at intervals. Each compartment contains one seed which is flat, oval, reddish brown with a well marked raphe. The seed contains a whitish endosperm in which the yellowish embryo is embedded [3, 20]. The fruit pulp is considered a purgative [21] and self-medication or without medical supervision strongly advised against in Ayurvedic texts.

The new leaves normally appear during March-July and flowers in April to July in India. The long cylindrical pods develop rapidly and reach their full length by October and they ripen during December-March and ripe pods in May. It will grow well in dry climates and growth of tree is best in full sun on well-drained soil. It is relatively drought tolerant and slightly salt tolerant light brief frost tolerates, but can get damaged if the cold persists [16, 22]. It is deciduous and mixed-monsoon forests upto hight of 1300 m in outer Himalaya [8, 23].

The plant is reported to tolerate precipitation of 480-2 720 mm, annual temperature of 18-28.5 deg C, and pH of 5.5-8.7. It grows properly by means of annual temperature of 18-29^0 C with mean annual rainfall 480-720 mm and pH 5.5-8.7.

Taxonomic Position [24]

Kingdom : *Plantae*
Subkingdom : *Tracheobinota*
Super Division : *Spermatophyta*
Division : *Mangoliophyta*
Class : *Magnoliopsida*
Sub Class : *Rosidae*
Order : *Fabales*
Family : *Fabacae*
Genus : *Cassia*
Species : *fistula*

Medicinal and Ethnobotany uses

It is a popular ornamental plant widely used in herbal medicine. The fruit helps greatly in soothing senses in many ways. The fruit and seed pulp and root have immense medicinal value. It is prescribed as emetics, purgatives, febrifuges and relievers of thoracic congestion. It used in reliving asthma, leprosy, ringworm, fever and heart related diseases.

In Ayurvedic medicine system, seed used as antibilious, aperitif, carminative and laxative, root for adenopathy, burning sensations, leprosy, skin diseases, syphilis, and tubercular glands, leaves for erysipelas, malaria, rheumatism and ulcers, the buds for biliousness, constipation, fever, leprosy and skin disease, the fruit for abdominal pain, constipation, fever, heart disease and leprosy. In Unani system, leaves used for inflammation, flowers as purgative, the fruit as anti-inflammatory, antipyretic, abortifacient, demulcent, purgative, refrigerant, good for chest complaints, eye ailments, flu, heart and liver ailments, and rheumatism, though suspected of inducing asthma [8, 25-27].

The entire plant or plant parts are used by several ethnic groups for their tradation, rituals and to cure several diseases from their inherent knowledge. Plant has bright yellow flowers in spring and summer in northern India. The flowers used in decorating hair specialty in Bihar, Gujrat and several other states. As per Gujrati folk songs Rama fell in love with Sita mainly due to the beautiful floral decoration of her hair.

In rituals of tribes the flowers are importance in the Vishu festival of Kerala and the tree depicted on a 20-rupees stamp. The golden shower tree is the national flower of Thailand; its yellow flowers symbolize Thai royalty. The tree of *Cassia fistula* has strong and very durable wood, and has been used to construct "Ahala Kanuwa", a place at Adams Peak, Sri Lanka as *ahala*, *ehela*, or *aehaela*, in Sinhala [16, 25, 26] heartwood. A 2006-2007 flower festival, the Royal Flora Ratchaphruek, was named after the tree, which is known in Thai as Ratchaphruek and the blossoms known as *dok khuen***.**

The flowers are consumed by Santal people of India. It is used in apiculture by several ethinic groups. The plant has been considered as a fuelwood in Mexico. It has reddish wood, hard and heavy, durable, suited for cabinetwork, farm implements, inlay work, posts, wheels and mortars. The bark of plant employed in tanning. The pulp of fruit used as folk remedy for burns, cancer, constipation, convulsions, delirium, diarrhoea, dysuria, epilepsy, gravel, hematuria, pimples and glandular tumors in tribal communities. Zimbabweans use the pulp for anthrax, blood poisoning, black water fever, dysentery and malaria. Konkanese use the juice to alleviate ringworm and blisters caused by the marking nut, a relative of poison ivy. Leaf poultices are applied to the chilblains so common in the upper Sind; also used in facial massage for brain afflictions, and applied externally for paralysis and rheumatism and gout. In the West Indies, the pulp and/or leaves are poulticed onto inflamed viscera, e.g. the livers similarly bark/leaves for skin diseases. The flowers used for fever and root as diuretic, febrifuge for gout and rheumatism. Ghana natives used fruit pulp as purgative. In Far East, the uncooked pulp used as popular remedy for constipation and decoction of the root bark for cleaning wounds [7, 22, 25-33].

Phytochemical Profile

Cassia fistula extracts attributed to their primary and secondary metabolite composition. Primary metabolite analysis has essentially been focussed on the seed, pollen, fruit, leaf and pod. Biochemical analysis of pollen grains play a significant allergenic role showed a protein composition of 12% with appreciable amounts of free amino acids such as phenylalanine, methionine, glutamic acid and proline. Carbohydrate, lipid and free amino acid contents were of the order of 11.75, 12 and 1.42% respectively [3, 5, 7, 34].

The edible fruit tissue is rich source of potassium, calcium, iron and manganese. The protein (19.94%) and carbohydrate (26.30%) contents are indicative of the potential of the fruit to be an important source of nutrients and energy. A polar compounds including 5-nonatetracontanone, 2- hentriacontanone, triacontane, 16-hentriacontanol and sitosterol along with an oil (probably an isoprenoid compound) showing antibacterial activityz isolated from the pods of *C. fistula* [6, 8, 35].

The plant organs are good source of secondary metabolites, notably phenolic compounds. Fistucacidin is an optically inactive leucoanthocyanidin (3,4,7,8,4' pentahydroxyflavan). The presence of kaempferol and a proanthocyanidin whose structure has been established as a leucopelargonidin tetramer having a free glycol in the acetone extract of the flower has been documented. Proanthocyanidins containing flavan-3-ol (epiafzelechin and epicatechin) units with an abnormal 2S-configuration observed in pods together with the common flavan-3-ols and proanthocyanidins like catechin, epicatechin, procyanidin B-2 and epiafzelechin [10, 36].

The leaf oil composed only seven components identified as eugenol (25.0%), (*E*)-phytol (21.5%), camphor (13.5%), limonene (11.0%), salicyl alcohol (10.4%), linalool (9.9%) and 4- hydroxybenzyl alcohol (8.7%). Four new compounds as 5-(2-hydroxyphenoxymethyl) furfural, (2‘*S*)-7-hydroxy-5- hydroxymethyl-2-(2‘-hydroxypropyl) chromone, benzyl 2-hydroxy-3,6-dimethoxybenzoate, and benzyl 2β-*O*-d-glucopyranosyl-3,6-dimethoxybenzoate, together with four known compounds, 5-hydroxymethylfurfural, (2‘*S*)-7-hydroxy-2-(2’-hydroxypropyl)-5-methylchromone, and two oxyanthraquinones, chrysophanol and chrysophanein, isolated and identified from the seeds. Twenty-seven compounds including eight long-chain hydrocarbons, 1-hexacosanol, 1-octacosanol, palmitic acid, stearic acid, oleic acid, linoleic acid, heptacosyl eicosanate, glyceryl-1-tetraeicosanoate; three sterols, β-sitosterol [2], stigmasterol [8], β-sitosteryl-3-*O*-D-glucopyranoside [19], one triterpene, lupeol [3], eight anthraquinones, chrysophanol [19], emodin [20], physcion, citreorosein [3], rhein [3], rhein methyl ester [22], ziganein [37], 1,4,5-trihydroxyanthraquinone [22]; two coumarins, isoscopoletin [8], scopoletin [38]; two chromones, 2,5-dimethyl-7-hydroxychromone [48], 2,5-dimethyl-7-methoxychromone [49]; three aromatic compounds, isovanillic acid [38], vanillic acid [2], and 2,4-dihydroxybenzaldehyde [16] isolated and identified from the bark [10]. *Cassia fistula* traditionally used by native populations of Tanzania, Zimbabwe, Mozambique and Brazil to treat malaria or symptoms associated with this disease. The plant drug used in the treatment of hepatitis as folk medicine and water extract from the pods investigated for antihelmintic activity [3, 12-15, 27, 28, 39, 40]. Different parameter after 1ppm, 5ppm and 10 ppm arsenic concentrations it is works as phytoremediation of soils contaminated with heavy metals arsenic. Extract of seeds of it to mated female rats from day 1-5 of pregnancy at the doses of 100 and 200 mg/kg body weight resulted in 57.14% and 71.43% prevention of pregnancy, respectively, whereas 100% pregnancy inhibition was noted at 500 mg/kg bw. The efficacy of a crude hydro-alcoholic extract of *C. fistula* fruit to protect the kidney against bromobenzene-induced toxicity was studied. The stem bark extracted with water extracts were vacuum dried to yield Aqueous Extract (AQET). The extracts were evaluated for hepatoprotective activity against Carbon tetrachloride (CCl_4) induced liver damage. The biochemical parameters in serum were total bilirubin, alkaline phosphatase (ALP), Serum glutamate oxaloacetate transaminase (SGOT), Serum glutamate pyruvate transaminase (SGPT) levels and total protein were observed. The extracts exhibited dose dependant reduction in total bilirubin, ALP, SGOT, SGPT, AST, ALT and increase in total protein (serum and liver) levels. It is reported that *Casia fistula* possessed the highest percent inhibition of DPPH (91.66%) and amount of bioactive constituents comprising alkaloids, flavonoids, saponins, tannins and total phenol content where *Cassia fistula* was observed comparatively richer source of these phytochemicals among all the *Cassia* species studies of secondary metabolites using qualitative test analysis was done for various phytoconstituents [41-47].

Pharmacological Activities

The investigation suggested the antioxidant properties at 90% ethanol extracts of leaves, and 90% methanol extracts of stem bark, pulp and flowers from *Cassia fistula*. The antioxidant activity power was in the decreasing order of stem bark, leaves, flowers and pulp and was well correlated with the total polyphenolic content of the extracts. The reason for low antioxidant activity in the flower and pulp fractions may due to some prooxidants, such as chrysophanol and reducing sugars which dominate the antioxidant compounds present in the extracts. Thus, the stem bark had more antioxidant activity in terms of reducing power, inhibition of peroxidation, O_2 and DPPH radical scavenging ability [12-15, 42]. Aqueous extract of *Cassia fistula* flowers (ACF) antioxidant effect in alloxan induced diabetic rats. An appreciable decrease in peroxidation products viz thiobarbituric acid reactive substances, conjugated dienes, hydroperoxides was observed in heart tissues of ACF treated diabetic rats. The decreased activities antioxidant enzymes superoxide dismutase, catalase, glutathione peroxidase, glutathione reductase and glutathione in diabetic rats were brought back to near normal range upon ACF treatment [3].

It is reported the methanol extract of seeds of *C. fistula* tested for central nervous system activities at different pharmacological actions in mice and found that extract significantly potentiated the sedative actions of sodium pentobarbitone, diazepam, meprobamate and chlorpromazine. It also potentiated analgesia induced by morphine and pethidine in a dose-dependent manner. The extract also influenced behaviour in mice [10].

Wound healing potential of *Cassia fistula* to treat the infected wound on albino rat model was investigated [50]. The alcohol extract leaves was analyzed for antibacterial effect against *Staphylococcus aureus* ATCC 29213 and *Pseudomonas aeruginosa* ATCC 27853. Formulated ointment was topically applied on the infected wound. Wound reduction rate, histological analysis, biochemical analysis, and gelatin zymography were obtained to assess the healing pattern and found that treated rats showed, better wound closure, improved tissue regeneration at the wound site, and supporting histopathological parameters pertaining to wound healing [51].

The hexane, chloroform, ethyl acetate, methanol and water extracts from the flower of *Cassia fistula* were tested against bacteria and fungi. All the extracts exhibited antibacterial activity against Gram positive organisms with minimum inhibitory concentrations (MIC) between 0.078 and 2.5 mg/ml. the Gram negative bacteria only *Pseudomonas aeruginosa* was susceptible to the extracts. Ethyl acetate crude extract was isolated, which was confirmed as 4-hydroxy benzoic acid hydrate. It exhibited antifungal activity against *Trichophyton mentagrophytes* (MIC 0.5 mg/ml) and *Epidermophyton floccosum* (MIC 0.5 mg/ml). Three lectins, i.e. CSL-1, CSL-2 and CSL-3, purified from the *Cassia fistula* seeds, were tested for their antibacterial activities against different pathogenic bacteria, i.e. *Bacillus subtilis, B. megaterium, Streptococcus haemolyticus, Streptococcus aureus, Sarcina lutea, Shigella sonnei, Escherichia coli, Klebsiella sp., Shigella shiga, Shigella boydii, Shigella flexneri, Shigelladysenteriae, Salmonella typhi* and *Pseudomonas aeruginosa*, using 30 micro g/disc. CSL-3 was active against all bacterial strains and showed strong activity against *B. megaterium, Streptococcus haemolyticus* and *Shigella boydii*. CSL-2 showed poor activity against most of the bacterial strains and has strong activity against only *Streptococcus haemolyticus*. CSL-1 was inactive against all the bacterial strains except *Streptococcus* 8*haemolyticus* and *Sarcina lutea*. All the lectins significantly affected the mortality rate of brine shrimp. Among them, CSL-2 was highly toxic (6.68 micro g/ml) followed by CSL-1 (10.47 micro g/ml) and CSL-3 (13.33 micro g/ml). Aqueous extract of *C. fistula* in disc diffusion method showed significant activity against *S. aureus* but not against other bacteria tested. Alcoholic extract showed greater inhibition against *S. aureus* compared to aqueous extract [14, 15, 47, 46, 52-55].

The effects of methanolic extract (ME) of *Cassia fistula* seed on the growth of Ehrlich ascites carcinoma (EAC) and on the life span of tumour bearing mice were studied. ME treatment showed an increase of life span, and a decrease in the antitumor activity tumour volume and viable tumour cell count in the EAC tumour hosts. Cytological found reduction in the mitotic activity, and the appearance of membrane blebbing and intracytoplasmic vacuoles in the treated tumour cells. Improvement in the haematological parameters as like haemoglobin content, red blood cell count and bone marrow cell count of the tumour bearing mice have also been observed. The exact mechanism by which ME mediates its antitumor effect is still to be elucidated. Cytological changes indicate that ME might be having a direct tumorocidal effect on the tumour cells [56-60].

The petroleum ether extract of seeds screened for the antifertility activity in proven fertile female albino rats. Oral administration of the extract to mated female rats on days 1-5 of pregnancy resulted in a decline in the fertility index, numbers of uterine implants and live foetuses in a dose dependent manner as was confirmed by laparotomy on day 15 of pregnancy. The petroleum ether extract of seeds of *Cassia fistula* possesses pregnancy terminating effect by virtue of anti-implantation activity [58, 61-64].

The efficacy of concentrated boiled extract and hydroalcoholic extract of plant of *C. fistula* on leishmaniasis was compared with intralesional injection of Glucantime [meglumine antimonate]. The plant could be used topically along with Glucantime for decreasing the time and dose of treatment with Glucantime for disease. The potential of *Cassia fistula* boiled extract in the treatment of cutaneous leishmaniasis, to evaluate the efficacy of intralesional meglumine antimonate- *C. fistula* fruit gel combination for the treatment of cutaneous leishmaniasis. The fruit gel increases the efficacy of intralesional meglumine antimonate for the treatment of cutaneous leishmaniasis. Combination therapy (intralesional meglumine antimonate and *C. fistula* fruit gel) should be considered for the treatment of acute cutaneous leishmaniasis [33, 61, 65, 66].

Antioxidant potential of various extracts of *Cassia fistula* was determined by the DPPH, FRAP, Fe^{3+}reducing power, and hydrogen peroxide scavenging assay. The methanolic extract of its seed was investigated for potential antimicrobial activity against medicinally important bacteria [32, 58, 67].

The antibacterial and antifungal activities of hydroalcoholic and chloroform root extracts (5, 25, 50, 100, 250 µg/mL) were tested against two gram positive *Staphylococcus aureus, Streptococcus pyogenes,* two gram negative bacteria as *Escherichia coli, Pseudomonas aeruginosa* human pathogenic bacteria and three fungal strains *Aspergillus niger, Aspergillus clavatus, Candida albicans* respectively [68]. It is reported that antioxidant activity of the 1 mg/ ml of the crude solvent (methanol, ethyl acetate, chloroform and water) extracts of their flowers were evaluated in vitro by DPPH radical scavenging activity, reducing power and inhibition of lipid peroxidation against the standard (α-tocopherol), accompanied by phenolic and flavonoid content. Ethanol, methanol, chloroform and carbon tetrachloride, and hexane extracts from *Cassia fistula* were investigated that the ethyl acetate and ether extracts of dried flowers and pods investigated individually for in vitro antibacterial activity by well diffusion method against *Escherichia coli, Salmonella typhi, Shigella dysenteriae, Bacillus cereus and Psudomonas aeruginosa.* Rhein inhibited the growth of many fungi such as *Trichophyton mentagrophytes*, *Trichophyton simii*, *Trichophyton rubrum* and *Epidermophyton floccosum* [14, 15, 32, 47, 52, 60]. Bark extracts from three different age classes, showed total means of 16.67 % TPC and 3.12% TTC. Different fraction of roots evaluated for antimicrobial activity against *P. vesicularis, Streptococcus faecalis, Aeromonas hydrophilia, Salmonella typhae, Staphylococcus cohni, Serratia ficaria and E.coli*. The extracts of *Cassia fistula* were tested *in vitro* against 4 bacterial species as *Staphylococcus aureus, Streptococcus epidermidis, Escherchia coli* and *Klebsiella pneumoniae*. Only methanolic extract exhibited fair antibacterial activity against the entire test bacteria whereas other extract were not observed to inhibit the growth of any of the test bacteria under study. Four Gram-positive and Five Gram-negative bacteria namely *Bacillus megaterium, Bacillus subtilis, Streptococcus β-haemolyticus, staphylococcus aureus, Salmonella typhi, Shigella dysenteriae, Shigella shiga, Escherichia coli* and

Pseudomonas aeruginosa were practiced. The pods and leaves tested against infectious bovine rhinotracheitis (IBR) virus (herpes virus group). Maximum non toxic dose of both extracts using MDBK cell line was determined and found to be 5mg/ml crude extracts from leaves, bark and fruits were tested for their antiplasmodial activity against the chloroquine-sensitive strain of *Plasmodium falciparum* (D10). Three main antiplasmodial principles, phytol, lutein [16] and di-lineolylgalactopyranosyl-glycerol (DLGG) [69] were isolated and identified using spectroscopic methods [51, 66, 67, 70, 71, 72] reported two new 2"-ethyl-furanoflavones named fistulaflavones A and B together with six known furanoflavones evaluated for their cytotoxicity against five human tumor cell lines. One of the compounds showed potent cytotoxicity against SHSY5Y and MCF7 cells with IC_{50} values of 2.7 and 2.6 µmol L^{-1}, respectively.

Several modern biotechnological techniques were used as RAPD, ISSR and SSR primers were used to assess genetic diversity and phylogenetic relationships among 28 species of *Cassia* (2n = 16, 26, 28). RAPD, ISSR and SSR primers revealed 36.12, 42.7 and 54.4% polymorphism, respectively. Polymorphic index varied from 0.1 to 0.5 for both SSR and RAPD markers; primer index values were substantially higher for RAPD primers (0.35–4.65) than for SSR primers (0.35– 1.73). *C. fistulla* is widely used in Indian medicine to treat diabetes. Methanol extract of stem of plant, reduced the blood glucose levels in Streptozotocin-induced diabetic rats. Catechin was administered to Streptozotocin (60 mg/kg b.w.) induced diabetic male Wistar rats at different doses (5, 10, 20 mg/kg b.w.) for 6 weeks to assess its effect on fasting plasma glucose. Catechin isolated from methanol extracts, the plasma glucose was significantly ($p<0.05$) reduced and oral administration markedly increased tissue glycogen, and 14C-glucose oxidation without any change in plasma insulin and C-peptide. Catechin restored the altered Glucokinase, glucose-6 Phosphatase, Glycogen Synthase and Glycogen Phosphorylase levels to near normal. GLUT4 mRNA and protein expression were enhanced after Catechin treatment. Catechin possesses hypo-glycemic, Glucose oxidizing and insulin mimetic activities. Ethanolic extract leaf effect as antifertility on male rats was studied [29, 30, 67, 73-76].

It is defined that *Cassia nodosa* (Pink shower) and *Cassia fistula* (Golden shower) both are exhibited maximum plant height and number of leaves when N: P: K was applied at 1g/l in a growing medium comprising of sand: peat moss: humus (1:1:1 v/v) compared to other fertilizer levels [64]. Immonomodulatory effect of fruit of *C. fistula* and amoxicillin named Amoxy-*Cassia* studied on humoral immune system of BALB/c mice [14, 27, 39, 40, 46, 47]. Animal immunized with sheep RBC and treated with *C. fistula* fruit, amoxy *Cassia*, amoxicillin and saline Number of activated anti-SRBC producing cell in spleen calculated by haemolytic plaque assay. Haemagglutinating Antibody (HA) titer was evaluated on post-immunized day 4, 6, 8, 10. Rising antibody titer was observed in all animals but Amoxy-*Cassia* treated mice serum had the highest HA titer throughout the experiment suggesting its therapeutic usefulness. Detailed studies of mechanisms of immunomodulation individual are still to be investigated. The plant possess several secondary metabolic compounds specially phenolic compound may be used to discover several bioactive natural produvcts serve as leads in the development of new pharmaceuticals research and positive potential source for contribution in the modern herbal medicine system [7, 59, 60].

CONCLUSION

Medicinal herbs are moving from fringe to mainstream use of people seeking remedies free from side effects as compare to synthetic chemicals. In India *Cassia fistula* used in traditional, folk and herbal medicine. It is clear by review that in traditional medicinal system of India plant possesses hepatoprotective, anti-inflammatory, antitussive, antifungal, wounds healler and antibacterial properties. It found good source of tannins, flavanoids and glycosides, carbohydrates, linoleic, oleic, stearic, oxalic acids, tannins, oxyanthraquinones, anthraquinones derivatives, rhein glycosides fistulic acids, sennosides a b, flavanoid-3-ol-derivatives, ceryl alcohol, kaempferol, bianthraquinone glycosides, fistulin, essential oils, volatile components, phytol (16.1%), 2-hexadecanone (12%), crystals, 4-hydroxy benzoic acids hydrate and several other secondary metabolities. This review summarizes on pharmacological, phytochemical and traditional investigations that can be investigated further to achieve lead molecules in the search of novel herbal drugs.

Acknowledgement

Authors are grateful to Prof. Ashok Sharma, hon'ble vice-chancellor, VMOU, Kota, Prof. Kailash Agrawal Head, Department of Botany, University of Rajasthan, Jaipur, faculty members of P.G. Department of Botany for valuable support and academic guidance. Thanks to Dr. Meena Jangid, Sh. Kailash Chaudhrary and Sh. Mahesh Kumar for the valuable technical support in preparing this review article.

REFERENCES

1. Anonymous. Multilingual multiscript plant name database (MMPND) (2005): *Cassia fistula* L. Version of 12/01/2005. Retrieved 2007-DEC-20
2. Anonymous. Ayurvedic pharmacopoeia of India. Part 1, Vol.5, New Delhi, Government of India Publication, 2001; 8:9.
3. Agarwal SS, Paridhavi M. Clinically useful herbal drugs. Ahuja Publishing House, 2005; 281-282.
4. Chopra RN, Nayar SL, Chopra IC. Glossary of Indian medicinal plants. National Institute of Science Communication and Information Resources, 2006; 54.
5. Thirumal M, Surya Srimanthula S, Kishore G. *Cassia fistula* Linn-pharmacognostical, phytochemical and pharmacological review. Earth journals 2012; 1(1):48-69.
6. Trease GE, Evans WC. Text book of pharmacognosy. Alden Press Oxford 13th ed. 1989; pp.268-298.
7. Lee Ching Kuo, LEE Ping Hung, *et al*. The chemical constituents from the aril of *Cassia fistula* L. Journal of Chinese Chemical Society 2001; 48:1053-58.
8. Theesan B, Vidushi SN, Okezie IA. Phytochemical constituent of *Cassia fistula*. African Journal of Biotechnology 2005; 4:1530-40.
9. Nadkarni KM. Indian materia medica. Bombay popular prakashan, 2009; 1:285-286.
10. Yueh-Hsiung Kuo, Ping-Hung Lee, Yung-Shun Wein. Four new compounds from the seeds of *Cassia fistula*. J. Nat. Prod. 2002; 65:1165-67.
11. Barthakur NN, Arnold NP Alli I. The Indian Labernum (*Cassia fistula* L.) fruit: an analysis of its chemical constituents. Plant Foods Human Nutr. 1995; 47:55-62.
12. Sujogya KP, Padhi LP, Mohanty G. Antibacterial activities and phytochemical analysis of *Cassia fistula* (linn.) Leaf. J. Adv. Pharm. Tech. Res. 2011; 2(1):62-67.
13. Verma S. Pharmacological review on *Cassia fistula* Linn (amaltas). International journal of pharmaceutical, chemical and biological sciences 2016; 6(3):332-335.
14. Kulkarni A, Govindappa M, Channabasava Chandrappa CP, Ramachandra YL, Prasad SK. Phytochemical analysis of *Cassia fistula*

and it's *in vitro* antimicrobial, antioxidant and anti-inflammatory activities. Advancement in Medicinal Plant Research, 2015; 3(1):8-17.
15. Biji CV. Plant drug analysis - a comparative analysis of *Cassia fistula*. International journal of applied research and technology 2017; 2(1):60-72.
16. Pawar AV, Patil SJ, Killedar SG. Uses of *Cassia fistula* Linn as a medicinal plant. International Journal of Advance Research and Development 2017; 2(3):85-91.
17. Gupta RK. Medicinal and aromatic plants. CBS publishers & distributors, 1st edition, 2010; 116-117.
18. Gupta M, Mazumder UK, Rath N, Mukhopadhyay DK. Antitumor activity of methanolic extract of *Cassia fistula* L seed against Ehrlich *Ascites carcinoma*. Journal of Ethanopharmacology 2000; 72:151-156.
19. Gupta AK, Tondon N, Sharma M. Quality standards of Indian medicinal plants, Medicinal plants unit, Indian Council of Medical Research, 2008; 2:47-53.
20. Kirtikar KR, Basu BD. Indian medicinal plants. International book distributors, 2006; 2:856-860.
21. Anonymous. Indian herbal pharmacopoeia. Revised new edition Indian Drug Manufacturers Association Mumbai, 2002; 106-113.
22. Sebastian P. Ayurvedic Medicine: the principles of traditional practice. Singing Dragon. 2012; p. 129.
23. Anonymous. The wealth of India, first supplement series (raw materials). National Institute of Science Communication and Information Resources, CSIR, 3 (Ca- Ci), 2007; 340-342.
24. Mohd D, Singh P, Mishra G, Srivastava S, Jha KK, Khosa RL. *Cassia fistula* Linn. (Amulthus)-an important medicinal plant: a review of its traditional uses, phytochemistry and pharmacological properties. J.Nat.Prod.Plant Resour 2011; 1(1):101-118.
25. Arora M, Rahar S, Rageeb Md, Nagpal N. Phytopharmacological importance of traditional healer tree: golden shower. International journal of pharmacy and life sciences 2016; 7(5):5051-5061.
26. Atarzadeh F, Kamalinejad M, Dastgheib L, Amin G, Jaladat AM, Nimrouzi M. *Cassia fistula*: A remedy from Traditional Persian Medicine for treatment of cutaneous lesions of *Pemphigus vulgaris*. Avicnna Journal Of Phytomedicine 2017; 7(2):107-115.
27. Savina, Kumar M. A review on traditional medicinal uses, phytochemical profile and pharmacological activities of *cassia fistula* L plant. World journal of pharmacy and pharmaceutical sciences 2017; 6(7):401-414.
28. Ali MA. *Cassia fistula* Linn: A review of phytochemical and pharmacological studies. Int J Pharm Sci Res 2014; 5(6):2125-30.
29. Bhakta T, Mukherjee P, Saha K, Pal M, Saha BP. Studies on antitussive activity of *Cassia fistula* (Leguminosae) leaf extract. Journal of Pharma Bio 1998; 36:140-43.
30. Bhakta T, Mukherjee PK, Sana K, Pal M, Saha BP. Hypoglycemic activity of *Cassia fistula* Linn (Leguminosae) leaf (methanol extract) in alloxan-induced diabetic rats. J. Ethnopharmacol 1997; 9:35-38.
31. Mazumder UK, Gupta M, Rath N. CNS activities of *Cassia fistula* in mice. Journal of Phytotherapy Research 1998; 12:512-22.
32. Abo KA, Lasaki SW, Deyemi AA. Laxative and antimicrobial properties of Cassia species growing in Ibadan. Nigerian Journal of Natural Products and Medicine 1193; 3:47-50.
33. Dash B, Vaidya. Materia medica of Ayurveda. India: B. Jain. Retrieved November, 2002, 2012; 10:41-42.
34. Duraipandiyana V, Ignacimuthu S. Antibacterial and antifungal activity of *Cassia fistula* L an ethnomedicinal plant. Journal of Ethanopharmacology 2007; 112:590-94.
35. Mondal AK, Parui S, Mandal S. Biochemical analysis of four species of *Cassia* L. pollen. Aerobiologia, 1998; 14:45-50.
36. Mishra TN, Singh RS, Pandev HS, Pandev RP. Chemical constituents of hexane fraction of *Cassia fistula* pods. Fitoterapia L, 1996; XVII(57):173-174.
37. Kashiwada Y, Toshika K, Chen R, Nonaka G, Nishioka I. Tannins and related compounds, XCIII, Occurrence of enantiomeric proanthocyanidins in the Leguminosae plants, *Cassia fistula* L.; *Cassia Javanica* L. Chem. Pharm. Bull. 1996; 38:888-893.
38. Ben Erik, Van Wyk, Michael Wink. Medicinal plants of the world. Briza Publications, 2009; 403.
39. Miraj S. *Cassia fistula* Linn: Evidence for pharmaceutical applications. Der Pharmacia Lettre, 2016; 8(14):129-131.
40. Sundaramoorthy S, Gunasekaran S, Arunachalam S, Sathiavelu M. A phytopharmacological review on *Cassia* species. J. Pharm. Sci. & Res. 2016; 8(5):260-264.
41. Kumar U, Prakash V. Comparative analysis of antioxidant activity and phytochemical screening of some indian medicinal plants. Int J Pharm Pharm Sci 2012; 4(3):291-295.
42. Siddhuraju P, Mohan PS, Becker K. Studies on the antioxidant activity of Indian Laburnum (*Cassia fistula* L.): a preliminary assessment of crude extracts from stem bark, leaves, flowers and fruit pulp. Food Chemistry, 2002; 79(1):61-67.
43. Ilavarasan R, Mallika M, Venkataraman S. Anti-inflammatory and antioxidant activity of *Cassia fistula* Linn bark extracts. Afr. J. Trad. Cam, 2005; 2:70-85.
44. Das S, Sarma G, Barman S. Hepatoprotective activity of aqueous extract of fruit pulp of *Cassia fistula* against Carbon Tetrachloride (CCL4) induced liver damage in albino rats. Journal of Experimental Research 2008; 2:1133-38.
45. Bhatnagar M, Sunil V, Vyas Y, Sharma D, Sharma K. Antioxidant activity of fruit pulp powder of *Cassia fistula*. Pharmacognosy Journal 2010; 2:219-28.
46. Lavanya B, Maheshwaran A, Narayanan N, Suganya S, Suryasree Y, Velaravindhan S, Vigneshwar M. A review: *Cassia fistula* Linn (Caesalpiniaceae). International Journal of Innovative Research and Advanced Studies (IJIRAS) 2016; 3(8):479-483.
47. Kushawaha M, Agrawal RC. Biological activity of medicinal plant *Cassia fistula*- A review. Journal of Scientific Research in Pharmacy 2012; 1(3):7-11.
48. Patil HM. Ethnobotanical notes on Satpura hills of Nandurbar district, Maharashtra, India. Res. J Recent Sci 2012; 1:326-328.
49. Patil SJ, Patil HM. Ethnomedicinal herbal recopies from Satpura hill ranges of Shirpur Tahsil, Dhule, Maharashtra, India. Res. J Recent Sci 2012; 1:333-336.
50. Kumar A, Pande CS, Kaul RK. Chemical examination of *Cassia fistula* flowers. Indian J. Chem 1966; 4:460.
51. Satyavati GV, Sharma M. Medicinal plant in India. ICMR: New Delhi, India, 1989; 112-113.
52. Satpute SM, Bhamburdekar SB, Kutwal DN, Waghmare SR, Gaikwad DK. Evaluation of antibacterial potential of *Cassia fistula* L. World journal of pharmacy and pharmaceutical sciences 2015; 4(2):635-640.
53. Ali AM, Abu SM, Absar N. Antibacterial activity and cytotoxicity of three lectins purified from *Cassia fistula* Linn seeds. Journal Medical Science 2003; 3:240-44.
54. Venkatesan D, Karrunakaran CM. Antimicrobial activity of selected Indian medicinal plants. Journal of Phytology 2010; 2:44-48.
55. Hegde CR, Madhuri M, Swaroop T, Nishitha DA, Bhattacharya S, Rohit KC. Evaluation of antimicrobial properties, phytochemical contents and antioxidant capacities of leaf extracs of *Punica grantum* L. ISCA J. Biological Sci 2012; 1(2):32-37.
56. Luximon-Ramma A, Theeshan B, Mohammed AS, Okezie IA. Antioxidant activities of phenolic, proanthocyanidin and flavonoid components in extracts of *Cassia fistula*. Journal of Agri. Food Chemistry 2002; 50:5042-47.
57. Sen AB, Shukia YN. Chemical examination of *Cassia fistula*. J. Indian Chem. Soc 1968; 45:744.
58. Aweng ER, Nur H, Mohd NMA, Nurhanan MY, Shamsu M. Antioxidant activity and phenolic compounds of *Vitex trifolia* var. *Simplicifolia* associated with anticancer. ISCA J. Biological Sci 2012; 1(3):65-68.
59. Awal MA, Ahsan SM, Haque E, Asghor QH, Ahmed M. In-vitro antibacterial activity of leaf and root extract of *Cassia fistula*. Dinajpur Med. Clg. Journal 2010; 3:10-13.
60. Anonymous. The Ayurvedic pharmacopoeia of India, Government of India, Ministry of health and family Welfare department of AYUSH, New Delhi, 2007; 2(I):10-12.
61. Deepika PS, Sujatha V. Antioxidant assessment for various solvent fractions of *Cassia fistula* Linn Flower. 2012; 4(1):510-517.
62. Abu SM, Abbas AM, Astaq M, Khan GRM, Rahman MS. Studies on the characterization and glyceride composition of *Cassia fistula* seed oil. Bangladesh J. Sci. Indust. Res 1999; 34:144-148.
63. Gupta M. A study of *Cassia fistula* pulp. Indian J. Pharm 2000; 4:61-63.
64. Phongpaichit S, Pujenjob N, Rukachaisirikul V, Ongsakul M. Antifungal activity from leaf extracts of *Cassia alata*, *Cassia fistula* and *Cassia tora* L. Songklanakarin Journal Sci. Technology 2004; 26:741-48.
65. Habibah SAM, Ouhoud AR, Abdullah AS, Mathew M, Suresh N. Effect of fertilizer concentration on the growth performance of *Cassia nodosa* buch.-ham. Ex roxb. and *Cassia fistula* L seedlings under greenhouse conditions of Kuwait. international research journal plant science 2012; 3(2):019-022.
66. Patricia S, Samanta P, Andrade MSC, Melhem FOP, Andre GT. Isolation of antileishmanial sterol from the fruits of *Cassia fistula* using bioguided fractionation. Journal of Phytotherapy Research 2011; 21:644-47.
67. Patricia S, Camila SC, Juliana QR, Marcelo JPF, Andre GT. Antiparasitic activity of biochanin A, an isolated isoflavone from fruits of *Cassia fistula* (Leguminosae). Journal of Parasitology Research 2009; 104:311-314.
68. Madhurima SH, Ansari SAM. Anti-oxidant potential of aqueous extract of *Cassia fistula* L. leaves. 2010; 10(2):181-183.
69. Silawat N, Jarald EE, Jain N, Yadav A, Deshmukh TP. The mechanism of hypoglycemic and antidiabetic action of hydro alcoholic extract of *Cassia fistula* Linn. In rats. Journal of the Pharma Research 2009; 01:82-92.

70. Panda SK, Brahma S, Dutta SK. Selective antifungal action of crude extracts of *Cassia fistula* L. a preliminary study on *Candida* and *Aspergillus* species. Malaysian Journal of Microbiology 2009; 6(1):62-68.
71. Khare CP. Indian medicinal plants. Springer, 2007; 128.
72. Sumi S, Oommen P, Saj I. Antibacterial, anthelmentic and phytochemical investigations on the pod extracts of *Cassia fistula* Linn. 2012; 2(1):6-15.
73. Kushwaha M, Banerjee M. Microbial activity of hydromethanolic extract of *Cassia fistula* seeds. 2013; 4(11):762-765.
74. Xue-Mei Gao, Yan-Qiong Shen, Xiang-Zhong Huang, Li-Ying Yang, Li-Dan Shu, Qiu-Fen Hu, Gan-Peng Li. 2"-ethyl-furanoflavone derivatives from the stems of *Cassia fistula* and their cytotoxicity. J. Braz. Chem. Soc 2013; 24(4):685-689.
75. Mule SN. Evaluation of anti-inflammatory activity of *Cassia fistula* and *Ficus benghalensis.* Journal of Pharmacy Research 2009; 2:8.
76. Gupta UC, Jain GC. Study on hypolipidemic activity of *Cassia fistula* legume in rats. Asian J. Exp. Sci 2009; 23:241-248.
77. Malpani SN, Manjunath KP, Hasanpasha S, Savadi RV, Akki KS, Darade SS. Antidiabetic activity of *Cassia fistula* Linn bark in alloxan induced diabetic rats. Int. Journal of Pharm Sciences 2010; 2:382-85.
78. Patil DD, Mhaske DK, Gurumeet MP, Wadhawa C. Antibacterial and antioxidant, anti-inflammatory study of leaves and bark of *Cassia fistula*. Int J Pharm 2012; 2(1):401-405.

HOW TO CITE THIS ARTICLE
Sharma DK. Enumerations on phytochemical, pharmacological and ethnobotanical properties of *Cassia fistula* Linn: yellow shower. J Phytopharmacol 2017; 6(5):300-306.