Review Article

Cassia fistula Linn - Pharmacognostical, Phytochemical and Pharmacological Review

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ABSTRACT

The Indian Labernum *Cassia fistula* has long been used in traditional medicines. Its various parts are used against wide range of ailments. It has been reported to posses various activity like Anthelmintic Activity, Antibacterial Activity, Antifeedant and larvicidal activities, Antifertility activity, Antifungal activity, Anti-inflammatory and Antioxidant activities, Anti-leishmaniatic activity, Antimicrobial Activity, Antiparasitic activity, Antipyretic activity, Antitumor activity, Antitussive activity, Clastogenic effect, CNS activities, Hepatoprotective activity, Hypocholesterolemic and hypoglycaemic activity, Hypolipidemic activity, Larvicidal and ovicidal activity, Laxative activity, Leukotriene inhibition activity, Sedative effect and Anti-anxity effect, Wound healing activity. Hence this article aims to provide a comprehensive review on pharmacognostic, pharmacological properties and phytochemical constituents of *Cassia fistula*.

KEYWORDS : *Cassia fistula,* Anthelmintic Activity, Anti-leishmaniatic activity, Clastogenic effect, Sedative effect and Anti-anxiety effect.

INTRODUCTION

Cassia fistula L., (Caesalpinioideae), a very common plant known for its medicinal properties is a semi-wild Indian Labernum known as the golden shower. it is distributed in various regions including Asia, South Africa, China, West Indies and Brazil[1] .

Traditional Medicinal Use

The Indian subcontinent is a vast repository of medicinal plants that are used in traditional medical treatments [2]. Traditional and alternative medicine is extensively practiced in the prevention, diagnosis, and treatment of various illnesses. It has attracted increasing public attention over the past 20 years as this type of medicine is easily accessible in some regions [3].

Ayurvedic Preparations

It is one of the ingredients, of the preparation known as Constivac (Lupin Herbal) a bowel regulator, relieves constipation. It is also one of the ingredients of the preparations known as Pilex, Purian (Himalaya Drug Company) for piles and detoxifier respectively [4]

Taxonomic Classification [5]

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

Vernacular Names [6]

Bengali: *amultash,sondal,sonali; Cantonese (kakke)*

English: *golden shower, Indian laburnum, pudding pipe tree, purging cassia, purging fistula*

French: *Bâton casse, casse doux, casse espagnol*.

Gujarati: *Girmala*

Hindi:*Bandarlathi,bharva,suvarnaka ,amaltas,rajataru,girimalah*

Malayalam: *Tengguli,rajah kayu,bereksa*

Sanskrit:*saraphala,survanaka,argwadha ,rajtaru*

Spanish: *Canâfístula mansa,chácara,Guayaba cimarrona*

Tamil: *kavani,konnai,tirukontai,sarak-konne*

Telugu: *Kondrakayi, Raelachettu, Aragvadhamu, Koelapenna* [5]

Thai: *chaiyaphruek,khuun*

Trade name: *Indian laburnum, rajbrikh'*

Geographical Source

In deciduous and mixed monsoon forests throughout greater parts of India, ascending to 1300 m in outer Himalaya. In Maharashtra, it occurs as a scattered tree throughout the Deccan and Konkan [7]. The plant is cultivated as an ornamental throughout India [8].

TRADITIONAL USES

Traditional uses of *Cassia fistula* are given in table.1.

PHARMACOGNOSTICAL STUDIES

Morphological Description [9]

C. fistula is a medium sized deciduous tree, with a straight trunk, spreading branches and 10 m tall. Bark of young stem will be pale grey, smooth and bark of old stem will be dark brown, rough. Leaves are alternate pinnate, 30-40 cm long, 4-8 pairs of ovate, opposite leaflets. Leaflets are 7.5-1.5cm long. Flowers are bright yellow colour, drooping racemes. calyx is oblong, obtuse, pubescent. Corolla – 5 sub equal, obovate, shortly clawed petals. Stamens are 10 in number with versite, curved anthers. Pistle – sessile. Ovary – pubescent

Stigma- long terminal. Fruit are indehiscent pod- 40 to 60cm long, cylindrical, pendulous containing 25-100 seeds.

Table.1: Traditional uses of various parts of *C. fistula*

Part of *C. fistula*	Traditional uses
Seed	• used to treat skin diseases, fever, abdominal pain and leprosy[9] • possess laxative, carminative, cooling and anti-pyretic properties Treatment of constipation • slightly sweet and possess laxative, carminative, cooling and anti-pyretic properties and they are given in cases of constipation [10]
Flower	• used to treat skin diseases, fever, abdominal pain and leprosy[9] • possess astringent, purgative, febrifugal and wound healing properties • decoction of the flowers is given for stomach troubles[11]
Fruit	• used to treat skin diseases, fever, abdominal pain and leprosy [9]
Root	• useful against cardiac disorders, biliousness, • rheumatic condition, • haemorrhages, wounds, ulcers and boils, • tubercular glands and various skin diseases [12,13]
Pulp	• safe purgative for children and pregnant women • given in disorders of liver, and in biliousness, and used as a tonic also applied in gout and rheumatism[14,15] • used as an antipyretic and it is a remedy for malaria and black water fever [16] • Blood - poisoning, anthrax and dysentery, and given in leprosy and diabetes and for the removal of abdominal obstructions [10]
Leaves	• contains laxative property [17]
Ripe pod	• used in traditional medicines as a laxative drug [18

PHYTOCHEMICAL STUDIES

Some of the Phytochemical constituents of various parts of *C.fistula* was given in Table.2

The fruit was a good source of Fe and Mn, and their concentrations were considerably higher than those in apple, apricot, peach, pear and orange. Aspartic acid, glutamic acid and lysine constituted 15.3, 13.0 and 7.8%, respectively, of the total amino acids in the pulp. In the seeds the same amino acids constituted, respectively, 16.6, 19.5 and 6.6% .This was reported by Barthakur NN *et al.*, (1995) [49].

Vaishnav MM *et al*., (1996) confirmed that Rhamnetin 3-*O*-gentiobioside was isolated from the roots [41, 50].

The hexane fraction of fruits (collected from India) exhibited activity against *Klebsiella* sp. 5-Nonatetracontanone, 2-hentriacontanone, triacontane, 16-hentriacontanone and beta -sitosterol was isolated from the hexane fraction was reported by Misra TN *et al.*, (1996) [51].

Isolation of a new diterpene, 3 beta -hydroxy-17-norpimar-8(9)-en-15-one from the pods of *Cassia fistula* was done by Misra TN *et al.*, (1997) [52].

The pods of *Cassia fistula*, an anthraquinone derivative, characterised as 3-formyl-1-hydroxy-8-methoxy-anthraquinone *1*, was isolated and reported by Meena Rani *et al.,* (1998) [53].

Seeds of *Cassia fistula* were grown under different soil and climatic conditions of Bangladesh, contained 3% golden coloured oil. The oil was fractionated into mono, di, and triglycerides by silicic acid column chromatography. The triglycerides varied from 89.16% to 91.01%, diglycerides from 2.51% to 3.32% and monoglycerides from 0.91% to 0.98% depending on the areas from which the seeds were collected. Fractionation of lipids into three major lipid groups neutral lipids, glycolipids and phospholipids was carried out by silicic acid column chromatography. The neutral lipids were accounted for over 89.80% of the total weight of the lipid employed. Saturated and unsaturated fatty acids present in the oil were separated and varied from 23.79% to 28.20% and 63.28% to 66.71% respectively depending on the areas. The fatty acid composition of the oil was analysed by gas liquid chromatography (GLC). The major fatty acids found in the oil were linoleic acid (42.42%), oleic acid (29.62%), stearic acid (14.33%) and palmitic acid (11.41%). In addition to the above, caprylic acid (0.76%) and myristic acid (1.44%) were also present in minor amounts

This was observed by Sayeed MA *et al.,* (1999) [54].

Lee *et al.,* (2001) reported that the aril of *Cassia fistula* containing 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, beta -sitosterol, stigmasterol, beta -sitosteryl-3-*O*-D-glucopyranoside; one triterpene, lupeol; eight anthraquinones, chrysophanol, emodin, physcion, citreorosein, rhein , rhein methyl ester, ziganein, 1,4,5-trihydroxyanthraquinone; two coumarins, isoscopoletin, scopoletin; two chromones, 2,5- dimethyl-7-hydroxychromone, 2,5-dimethyl-7-methoxychromone; three aromatic compounds, isovanillic acid, vanillic

acid and 2,4-dihydroxybenzaldehyde were isolated and identified. Their structures were determined on the basis of spectral data [55].

Yueh-Hsiung Kuo *et al.,* (2002), revealed that the seeds of *Cassia fistula* posses four new compounds, 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-gluco-pyranosyl-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, were isolated and identified. The structures were determined on the basis of spectral data explanation, and the synthesis of a compound was carried out [56].

Yadav RN *et al.,* (2003) isolated a new bioactive flavone glycoside from defatted seeds of *Cassia fistula* i.e., 1 (mp 252-2540C, C28H32O16, [M]+ 624 (EIMS)) was isolated from the acetone soluble fraction. It was characterized as a new bioactive flavone glycoside 5,3',4'-trihydroxy- 6-methoxy-7-*O*- alpha -L-rhamnopyrano syl-(1 -> 2)-*O*- beta -D-galactopyranoside by several colour reactions, spectral analysis and chemical degradations [57].

Three lectins are isolated from the *Cassia fistula* seeds, i.e. CSL-1, CSL-2 and CSL-3, purified and were tested for their antibacterial activities against different pathogenicbacteria was done by M. A. Ali *et al.,* (2003) [58]. The neutral sugar contents of CSL-1, CSL-2 and CSL-3 were estimated to be 3.5, 3.1 and 2.0%, respectively. The sugar composition of the lectins was found to be galactose in CSL-1, galactose and glucose in CSL-2, and galactose and mannose in CSL-3 [59].

Sartorelli P *et al.,* (2007) studied the bioguided fractionation which resulted in the isolation of a sterol, clerosterol, which was further analysed in different models [60].

The chemical compositions of the flower and leaf essential oil of *Cassia fistula* by GC and GC/MS was examined by Tzakou O *et al.,* (2007). Forty-four compounds were identified representing 92.6% and 90.7% of the flower and leaf oil, respectively. The main components of the flower oil were (E)-nerolidol (38.0%), and 2-hexadecanone (17.0%), while the leaf oil consisted mainly of phytol (16.1%) [61].

The discovery of the fractionation through bioguided antileishmanial activity of the dichloromethane extract of *Cassia fistula* fruits (Leguminosae) led to the isolation of the active isoflavone biochanin A, identified by spectroscopic methods was done by Sartorelli P et al. (2009) [36].

Vasi *et al.,*(1980) reported 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 [62].

Luximon-Ramma *et al.,* (2002) investigation that characterized the contents of total phenolics, proanthocyanidin and flavonoid in vegetative and reproductive organs of *C. fistula* found in Mauritius and harvested at different stages, showed that among the vegetative organs, the young and old leaves showed the highest total phenolic, flavonoid and proanthocyanidin contents.[63]

Table.2: Phytochemical constituents of various parts of *C.fistula*

Name of the part	Phytochemical constituents	References
Seeds	galactomannan free sugars and free amino acids glycerides with linoleic, oleic, stearic and palmitic acids as major fatty acids together with traces of caprylic, myristic acids, cephalin and lecithin phospholipids and contained 11.8% carbohydrates, galactomannan, Chrysophanol	[19], [20], [21], [22], [23]
seed oil	cyclopropenoid fatty acids, viz, vernolic, malvalic and stetculic acids	[24], [25]
Flowers	ceryl alcohol, kaempferol, rhein and a bianthraquinone glycoside, fistulin, Aurantiamide acetate (0.011), β sitosterol (0.006) and its β D glucoside (0.02%),anthraquinone, tannin, oxyanthraquinone, rhein, volatile oils, Kaempferol, leucopelargonidin tetramer (with free glycol unit), rhein, fistulin, alkaloids, triterpenes, (-)-epiafzelechin 3-O-B-Dglucopyranoside, 7 biflavonoids and two triflavonoids together with (-)-epiafzelechin, (-)-epicatechin and procyanidin B-2	[19], [26], [27], [25], [28], [29], [30], [31]
Flower's pollen	phenylalanine, methionine, glutamic acid and proline	[32]
Leaves	free rhein, and its glycosides- sennosides A & B. The cuticular wax of leaves contain hentriacontanoic, triacontanoic, nonacosanoic and heptacosanoic acids; anthraquinone, tannin, oxyanthraquinone, rhein and volatile oils, (-) epiafzelechin, (-) epiafzelechin-3-Oglucoside, (-) epicatechin, procyanidin B2, biflavonoids, triflavonoids, rhein, rhein glucoside, sennoside A, sennoside B, chrysophanol, physcion,	[19], [26], [27], [24], [25], [33], [34], [35]
Fruit	Isoflavone: biochanin A	[36]

Pulp of the fruit	sugar, tannic matter, albuminous starch, oxalate of calcium, sugar, gum, astringent matter, gluten, coloring matter, water, proteins (19.94) and carbohydrates (26.30%); arginine, leucine, methionine, phenylalanine, tryptophan, aspartic and glutamic acids, a new dimeric proanthocyanidin CFI isolated along with (-) epiafzelechin, (+)catechin, kaempferol, dihydrokaempferol and 1,8-dihydroxy-3-methylanthraquinone and its structure was determined. Rhein, volatile oil, waxy and resinous derivatives	[26], [27], [37], [38], [39], [40]
Pulp of the pod	anthraquinone glycosides, sennosides A & B, rhein and its glucoside,barbaloin, aloin, formic acid, butyric acid and their ethyl esters, oxalic acid, pectin, tannin, sugar, gum, astringent matter, gluten, coloring matter, water, contain 5 nonatetracontanone, 2-hentriacontanone,1,8-dihydroxy-3-anthraquinone carboxylic acid	[12], [26], [27], [37], [38], [41], [42]
Leaf oil	phytol (16.1%)	[43]
Flower oil	(E)-nerolidol (38.0%), and 2-hexadecanone (17.0%)	[43]
Root	7-methylphyscion, betulinic acid and βsitosterol, Rhamnetin-3-O-gentiobioside	[24], [25], [44], [45]
Root bark	Tannins, phlobaphenes, oxyanthraquinone	[37], [26]
Plant	rhein glucoside, rhein, fistulic acid, sennoside A & B	[24], [46]
Heart wood	Fistucacidin (3,4,7,8,4'-pentahydroxyflavan)	[47]
Steam bark	two flavonol glycosides, 5,7,3',4'-tetrahydroxy-6, 8-dimethoxyflavone-3-O-α-arabinopyranoside (C22H22O13), 5,7,4'-trihydroxy-6,8,3'-trimethoxyflavone-3-O-α-L-rhamnosyl (1→2)-O-β-D-glucopyranoside (C30H36O18), a xanthone glycoside, 1,8-dihydroxy-3, 7 dimethoxyxanthone-4-O- α-L-rhamnosyl(1→2)-O-β-D glucopyranoside(C27H32O16, m.p. 2170), lupeol, ß-sitosterol and hexacosanol	[24], [25], [48]

PHARMACOLOGICAL STUDIES

1. Anthelmintic Activity

Irshad M *et al.*,(2010) had studied the Anthelmintic Activity of *C.fistula* fruit pulp and seeds extracts. *Pheretima postnuma* worms are taken to test this activity and both the extracts at a concentration of 100 mg/ml shows significant effect. Piperazine citrate is taken as reference drug at a concentration of 10mg/ml. The correlation coefficient between paralysis and death of worms by seeds and pulp were 0.9986 and 0.9976 respectively [64].

2. Antibacterial Activity

Yadav RN *et al.,* (2003) isolated compound which showed antimicrobial activity against *Staphylococcus aureus, Bacillus subtilis, Klebsiella pneumoniae, Escherichia coli, Aspergillusniger* and *Fusarium oxysporum* [57].

Ali MA *et al.,* (2004) reported that the antibacterial and antifungal activities of *C. fistula* and *M.ferrea* extracts were tested on 14 bacteria and 6 fungi. *C. fistula* extracts showed stronger antibacterial activity than *M. ferrea* [65].

Sundararaju P *et al.,* (2006) reported that 100% mortality was recorded from the *C. fistula* extract at 48 h at 50 and 100% concentrations. At 72 h, 100% mortality was observed in all extracts at all three concentrations. The mortality rate was minimum at 24 h in all three extracts. All plant extracts exhibited a high degree of nematicidal action against the adults and juveniles of *P.coffeae* [66].

Ali MA *et al.,* (2006) reported that 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, Shigella dysenteriae, 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 haemolyticus* and *Sarcina lutea*. All the lectins significantly affected the mortality rate of brine shrimp. Among them, CSL-2 was highly toxic (6.68 µg/ml) followed by CSL-1 (10.47 µg/ml) and CSL-3 (13.33 µg/ml) [67].

Vimalraj TR *et al.,* (2009) studied the antibacterial activity of the aqueous and alcoholic extract of stem bark of *C. fistula*. 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. One of the field isolates of *S. aureus* resistant to chloramphenicol was also susceptible to the alcoholic extract of *C. fistula*. Zones of inhibition of alcoholic and aqueous extracts were in the range of 7.0-12.0 mm and 7.0-11.6 mm, respectively. MIC values of the alcoholic extracts against *S. aureus* were in the range of 0.78-6.25 mg/ml [68].

3. Antifeedant and larvicidal activities

Duraipandiyan V *et al.,* (2011) studied the Antifeedant and larvicidal activities of rhein (1,8-dihydroxyanthraquinone-3-carboxylic

acid) isolated from the ethyl acetate extract of *Cassia fistula* flower were studied against lepidopteron pests Spodoptera litura and Helicoverpa armigera. Significant antifeedant activity was observed against H. armigera (76.13%) at 1000 ppm concentration. Rhein exhibited larvicidal activity against H. armigera (67.5), S. litura (36.25%) and the LC50 values was 606.50 ppm for H. armigera and 1192.55 ppm for S. litura. The survived larvae produced malformed adults [69].

4. Antifertility activity

Rajesh Yadav *et al.,* (2009) investigated that petroleum ether extract of seeds of *Cassia fistula* was screened for the antifertility activity in proven fertile female albino rats at the doses 100, 200 and 500 mg/kg b.wt./day. 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 extract (100 mg/kg b.wt.) exhibited weak estrogenic activity when given alone and tested in immature bilaterally ovariectomized female albino rats, but exhibited slight antiestrogenic activity when administration along with estradiol valerate (0.1 mg/kg b.wt.). Blood sugar and haematological parameters were within normal range. Thus, the results of the present study indicate that the petroleum ether extract of *Cassia fistula* seeds possesses pregnancy terminating effect by virtue of anti-implantation activity [70].

5. Antifungal activity

Padma Singh *et al.,* (2006) tested the leaf extract of *Cassia fistula* for antifungal activity against *Candida albicans*. Extracts of the leaves of *Cassia fistula* were prepared in acetone, diethyl ether and methanol. The antifungal activity was performed by paper disc diffusion assay. The methanol extract showed highest activity i.e., upto 21 mm which was comparable with the standard antifungal antibiotic, clotrimazole [71].

Duraipandiyan V *et al.,* (2007) evaluated 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. Among the Gram-negative bacteria, only *Pseudomonas aeruginosa* was susceptible to the extracts. Ethyl acetate crude extract was fractionated using chromatographic techniques. A crystal was isolated, which was confirmed as 4-hydroxy benzoic acid hydrate using X-ray crystallography. It exhibited antifungal activity against *Trichophyton mentagrophytes* (MIC 0.5 mg/ml) and *Epidermophyton floccosum* (MIC 0.5 mg/ml) [72].

6. Anti-inflammatory and Antioxidant activities

Raju Ilavarasan *et al.,* (2005) reported that Anti-inflammatory and Antioxidant activities of the aqueous (CFA) and methanolic extracts (CFM) of the *C. fistula* bark were assayed in wistar albino rats. The extracts were found to posses significant anti-inflammatory effect in both acute and chronic models. *Cassia fistula* bark extracts showed significant radical scavenging by inhibiting lipid peroxidation initiated by CCl_4 and $FeSO_4$ in rat liver and kidney homogenates. Both extracts exhibited significant

antioxidant activity in DPPH, Nitric oxide and Hydroxyl radical induced invitro assay methods. Both extracts showed Dose-Dependent protective effect against lipid peroxidation and free radical generation in liver and kidney homogenates. Thus it could be concluded that *Cassia fistula* bark extracts (CFA & CFM) possess significant anti-inflammatory and anti oxidant properties [73].

Bhakta T *et al.,* (1999) evaluated that the extract of leaves of *C. fistula* was tested for
antiinflammatory effects, and compared with those of phenylbutazone, using carrageenan-,
histamine- and dextran-induced paw oedema assays in rats. Potent antiinflammatory activity
against all phlogistic agents was noted [74].

Amitabye Luximon-Ramma, *et al.,* (2002) investigated the total phenolic, proanthocyanidin, and flavonoid contents and the antioxidant activities, of fresh vegetative and reproductive organs of *Cassia fistula* harvested at different stages of growth were determined using the Trolox equivalent antioxidant capacity (TEAC) and ferric-reducing antioxidant power (FRAP) assays. The antioxidant activities were strongly correlated with total phenols (TEAC r) 0.989; FRAP r) 0.951) in all organs studied, and with proanthocyanidins (TEAC r) 0.980; (FRAP r) 0.899; in reproductive organs including fruits. The antioxidant activities of reproductive parts were higher than those of the vegetative organs, with the pods having highest total phenolic, proanthocyanidin, and flavonoid contents and antioxidant potentials (TEAC) 992 (0.4 ímol/g dry weight; FRAP) 811 (23 ímol/g dry weight) [75].

Siddhuraju P *et al.,* (2002) investigated the antioxidant properties of 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 could be the presence of 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, O2 - and DPPH radical scavenging ability [76].

Manonmani G *et al.,* (2005) reported that aqueous extract of *Cassia fistula* (Linn.) flowers (ACF) was screened for its 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 of key antioxidant enzymes such as superoxide dismutase, catalase, glutathione peroxidase, glutathione reductase and glutathione in diabetic rats were brought back to near normal range upon ACF treatment. These results suggest that ACF has got promising antioxidative activity in alloxan diabetic rats [77].

7. Anti-leishmaniatic activity

Sartorelli P *et al.,* (2007) examined that the hexane extract from the fruits showed significant antileishmanial activity against the promastigote form of *Leishmania* L.

chagasi. The bioguided fractionation resulted in the isolation of a sterol, clerosterol, which was further analysed in different models. Promastigotes presented an inhibitory concentration 50% (IC50) of 10.03µg/mL and intracellular amastigotes demonstrated high susceptibility, with an IC50 of 18.10µg/mL. Mammalian cytotoxicity was evaluated and it was demonstrated that clerosterol was 3.6- fold less toxic than the standard drug pentamidine [78].

Jaffary F *et al.,* (2008) evaluated the effectiveness of *C. fistula* in the treatment of leishmaniasis, the efficacy of concentrated boiled extract and hydroalcoholic extract of *C. fistula* on leishmaniasis was compared with intralesional injection of Glucantime [meglumine antimonate] in this study. 63.6% of patients treated with the concentrated boiled extract, 52.7% of patients treated with the hydroalcoholic extract, and 45.5% of patients treated with Glucantime. In total, 22 patients (40%) given the concentrated boiled extract of *C. fistula*, 20 Patients (36.4%) given the hydroalcoholic extract of *C. fistula*, and 36 patients (65.5%) of the Glucantime group showed complete cure. The efficacy in the third group was significantly higher than the first (P<0.02) and second groups (P<0.005), but there was no difference between the efficacy of concentrated boiled extract and hydroalcoholic extract of *C. fistula*. These results show that this plant could be used topically along with Glucantime for decreasing the time and dose of treatment with Glucantime [79].

Jaffary F *et al.,* (2010) evaluated 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. A total of 140 patients with cutaneous, one group received intralesional meglumine antimonate injection and *C. fistula* fruit gel, and the second group (control) was treated with intralesional meglumine antimonite plus placebo gel. Improvement was defined as complete cure, partial cure and treatment failure. At week 12, forty-seven (67.1%) patients in the experimental group achieved complete cure, compared to 29 (41.4%) patients in the control group (*P*<0.001). Results indicate that the *C. fistula* fruit gel increases the efficacy of intralesional meglumine antimonate for the treatment of cutaneous leishmaniasis. Combination therapy with intralesional meglumine antimonate and *C. fistula* fruit gel should be considered for the treatment of acute cutaneous leishmaniasis [80].

8. Antimicrobial Activity

Aneja *et al.,* (2011) had studied the evaluation of antimicrobial potential of *Cassia fistula* flowers, leaves and bark extracts against *Staphylococcus aureus, Proteus mirabilis, Escherchia coli, Pseudomonas aeruginosa, Acinetobacter* sp., and *Candida albicans,* pathogens causing otitis externa and their comparison with locally available ear drops. Organic flower and bark extracts displayed activity against all tested ear pathogens whereas leaf extract showed activity against four tested bacteria and aqueous extracts were unable to exhibit any antimicrobial activity. Of the three organic solvents evaluated, acetonic flower extract was found to be best against *S. aureus* followed by bark extract and leaf extract. The acetonic

flower extract showed larger inhibition zones compared to the herbal ear drops with minimum inhibitory concentration (MIC) of 6.25mg/ml [81].

9. Antiparasitic activity

Sartorelli P *et al.,* (2009) discovered that the fractionation through bioguided antileishmanial activity of the dichloromethane extract of *Cassia fistula* fruits (Leguminosae) led to the isolation of the active isoflavone biochanin A, identified by spectroscopic methods. This compound showed 50% effective concentration (EC50) value of 18.96µg/mL against promastigotes of *Leishmania* (L.) *chagasi*. The cytotoxicity of this substance against peritoneal macrophages resulted in an EC50 value of 42.58µg/mL. Additionally, biochanin A presented an anti- *Trypanosoma-cruzi* activity, resulting in an EC50 value of 18.32µg/mL and a 2.4-fold more effectiveness than benznidazole [82].

10. Antipyretic activity

Bhakta T *et al.,* (2001) examined the methanol extract of buds of *C. fistula* for its antipyretic action on normal body temperature and yeast-induced pyrexia (fever) in rats. The extract showed significant activity in both the models at doses of 200 and 400 mg/kg. At a dose level of 200 mg/kg, the extract caused significant lowering of normal body temperature up to 3 h. At 400 mg/kg dose, it caused significant lowering of body temperature up to 6 h after administration. In the model of yeast-provoked elevation of body temperature, the extract showed dose dependent lowering of body temperature up to 4 h at both the dosage levels. The results obtained are comparable to those for paracetamol, a standard antipyretic agent [83].

11. Antitumor activity

Vasudevan K *et al.,* (2008) investigated the chemopreventive efficacy of *Cassia fistula* bark extracts in 7, 12-dimethyl benz(a)anthracene (DMBA) induced hamster buccal pouch carcinogenesis. Oral administration of *Cassia fistula* bark extract to DMBA painted animals completely prevented the formation of oral squamous cell carcinoma. The bark extract also restored the status of lipid peroxidation by-products, antioxidants and detoxification enzymes in DMBA painted animals. These results suggest that *Cassia fistula* bark extract has prominent chemopreventive effect during DMBA induced oral carcinogenesis, which is probably due to the presence of one or more potent anticarcinogenic principles and their synergistic effect. The chemopreventive potential of *Cassia fistula* may also be due to its antilipid peroxidative, antioxidative and modulation of detoxification agents during DMBA induced oral carcinogenesis [84].

Gupta M *et al.,* (2000) studied 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 tumour volume and viable tumour cell count in the EAC tumour hosts. Cytological studies have revealed a reduction in the mitotic activity, and the appearance of membrane blebbing and intracytoplasmic vacuoles in the treated tumour cells. Improvement in the haematological parameters following ME treatment, like haemoglobin content, red blood cell count and bone marrow cell count of the tumour bearing mice have also been observed. The results of the present study suggest that ME of *C.*

fistula seed has an antitumor activity. Haematological studies have revealed that out of the three doses of ME, ME at the dose of 100 mg/kg has shown better results than at the doses of 200 and 300 mg/kg. 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 [85].

12. Antitussive activity

Bhakta T *et al.,* (1998) reported that the methanol extract of leaves of *C. fistula* was investigated for its effect on a cough model induced by sulfur dioxide gas in mice. The extract exhibited significant, dose-dependent antitussive activity compared with the control. The antitussive activity was comparable with that of codeine phosphate, a prototypes antitussive agent. *C. fistula* extract (400 and 600 mg/kg, p.o.) inhibited coughing by 44.44 and 51.85%, respectively, with respect to the control group [86].

13. Clastogenic effect

Mukhopadhyay MJ *et al.,* (1998) Anthraquinone glycosides of *Cassia fistula* were investigated for their ability to induce a clastogenic effect on the bone marrow cells of Swiss albino mice. The endpoints screened were chromosomal aberrations and frequency of aberrant cells. Oral exposure to doses of these anthraquinones and their equivalent amount in leaf and pod extracts did not induce significant numbers of chromosomal aberrations or aberrant cells. The results indicate that anthraquinone sennoside B and rhein are weakly genotoxic. Pure sennoside B and rhein were weakly clastogenic. Crude extracts of C. fistula (leaves and pods) each containing sennoside B and rhein were also weak clastogens. The CA/cell and % DC were lower than those induced by an equivalent amount of pure sennoside B. Therefore, these phytolaxatives do not behave as potent clastogens and pods or leaves of C. fistula can be used as an alternative sourcemof sennosides [87].

14. CNS activities

Mazumder UK *et al*., (1998) showed that the methanol extract of seeds of *C. fistula* was tested for different pharmacological actions in mice. The 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 [88].

15. Hepatoprotective activity

Jehangir *et al.,* (2010) studied the effect of ethanolic extract of *Cassia fistula* leaves in experimentally induced drug hepatitis (DIH) in rodents. The rats were divided into four groups, i.e. a control group (A), antituberculous (ATT) group (B), and the remaining two groups (C and D) served as experimental therapy groups. They received *Cassia fistula* extract as hepatoprotective agent. Rats having normal liver functions were included in this study. Group C experimental rats received (INH/RIF) (50 mg/kg) each and ethanolic extract of *Cassia fistula* at 400 mg/kg of body weight. On the other hand group D experimental rats received (INH/RIF) (50 mg/kg) each and ethanolic extract of *Cassia fistula* at 500 mg/kg of body weight. Blood samples were taken at 30th day and liver in each was taken out for microscopical examination on day 30th. The (ATT) group rats showed variable increase in serum ALT, AST, ALP and total bilirubin levels. Group C treated with 400 mg/kg of body weight

Cassia fistula treatment decreased the level of these parameters in rats. On the other hand group D rats treated with 500 mg/kg body weight of *Cassia fistula* dose significantly decreased levels of these biochemical parameters. high dose of *Cassia fistula* ethanolic leaves extract (500 mg/kg) body weight showed hepatoprotection against INH/RIF induced hepatitis in rats [89].

Das S *et al.,* (2008) reported aqueous extract of fruit pulp of *Cassia fistula* possesses significant hepatoprotective activity. The study was done by aqueous extract of fruit pulp of *Cassia fistula* (AFCF) against Carbon tetrachloride (CCL4) induced liver damage in albino rats and compared to standard drug silymarin.in this experiment animals are divided in to four groups. Hepatic injury was induced to animals belonging to group B, C and D by giving CCL4 & olive oil mixture s.c on 2nd and 3rd day of experiment. Standard and test drugs were administered for 5 days. Blood samples were collected on 6th day for determination of enzyme markers viz, aspartate transaminase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), total bilirubin (TB) and total protein (TP). Histopathological examinations of liver tissues were done [90].

Bhakta T *et al.,* (2001) investigated the hepatoprotective activity of the n-heptane extract of *Cassia fistula* leaves. The extract at a dose of 400 mg/kg body weight exhibited significant protective effect by lowering serum levels of transaminase (serine glutamic-oxaloacetate transaminase [aspartate aminotransferase] and serine glutamic-pyruvic transaminase [alanine aminotransferase]), bilirubin and alkaline phosphatase. The protective effect is comparable to that of a standard hepatoprotective agent [83].

Pradeep Kannampalli *et al.,* (2007) evaluated that the hepatoprotective and antioxidant effect of *Cassia fistula* leaf extract on liver injury induced by diethyl nitrosamine (DEN) was investigated. Wistar rats weighing 200±10 g was administered a single dose of DEN (200 mg/kg b.w., i.p.) and left for 30 days. For hepatoprotective studies, ethanolic leaf extract (ELE) of *C. fistula* Linn. (500mg/kg b.w., p.o.) was administered daily for 30 days. AST, ALT, ALP, LDH and bilirubin were estimated in serum and liver tissue. Lipid peroxidation (LPO), SOD and CAT were also estimated in liver tissue as markers of oxidative stress. DEN induced hepatotoxicity in all the treated animals were evident by elevated serum ALT, AST, ALP and bilirubin levels and a simultaneous fall in their levels in the liver tissue after 30 days. Induction of oxidative stress in the liver was evidenced by increased LPO and fall in the activities of SOD and CAT. ELE administration for 30 days prevented the DEN induced hepatic injury and oxidative stress. In conclusion, it was observed that ELE of *C. fistula* protects the liver against DEN induced hepatic injury in rats [91].

Chaudhari NB *et al.,* (2009) tested methanolic extract of *Cassia fistula* seeds was prepared and tested for its hepatoprotective effect against paracetamol induced hepatitis in rats. Alteration in the level of biochemical markers of hepatic damage like SGOT, SGPT, ALP and Billirubin were tested in both treated and untreated groups. Paracetamol (2g/kg) has enhanced the SGPT, SGOT, ALP and billirubin level

reduced. Treatment with Methanolic extract of *Cassia fistula* seeds (200mg/kg and 400mg/kg) has brought back the altered level of biochemical markers to the near normal levels in the dose dependant manner. With aid of enzyme levels and histopathological studies of rat liver we can concluded that methanolic extract have shows better hepatoprotective activity as compared with standard. (Liv-52) While Aqueous extract has exhibited moderate hepatoprotective activity [92].

16. Hypocholesterolemic and hypoglycaemic activity

Nirmala *et al.,* (2008) reported the hypocholesterolemic and hypoglycemic effects of the hexane extract of stem bark of *C. fistula*, in normal and streptozotocin induced diabetic rats. Hexane extract of *C. fistula* bark at doses 0.15, 0.30, 0.45 g kg-1 body weight for 30 days suppressed the elevated blood glucose levels in diabetic rats. The extract at 0.45 g kg-1 was found to be comparable with glibenclamide, the reference drug. The lipid profile (total cholesterol, triglyceride, HDL-cholesterol, LDL and VLDL-cholesterol) after the extract treatment at 0.45 g kg-1 body weight showed remarkable improvement compared to the diabetic control animals. Antioxidant and polyphenol content present in the extracts might contribute to the antihyperglycemic and antilipidemic properties. Thus the results suggest that *Cassia fistula* barks would be effective in the treatment of diabetes and in prevention and management of coronary artery disease [93].

Christine *et al.,* (2011) reported methanol extract of *Cassia fistula*, having significant hypolipidemic activity in diet-induced lipidemia in mice.The bioassay was conducted in three-week old female mice.In addition, parametrial fat weight of mice was also decreased in a dosedependent manner, thus confirming the weight lowering potential of these plants [94].

17. Hypolipidemic activity

Gupta UC *et al.,* (2009) studied the effect of 50% ethanolic extract of *Cassia fistula* legume on serum lipid metabolism in cholesterol fed rats. Oral feeding of cholesterol (500 mg/kg b.wt./day) dissolved in coconut oil (0.5 ml/rat/day) for 90 days caused a significant ($P<0.001$) elevation in total and LDL-cholesterol, triglycerides and phospholipid in serum of rats. Administration of *C. fistula* legume extract at the doses 100, 250 and 500 mg/kg b.wt./day along with cholesterol significantly prevented the rise in the serum total and LDL-cholesterol, triglycerides and phospholipid in a dose dependent manner. The ratio of HDL-cholesterol/total cholesterol ratio was elevated in serum of *C. fistula* extract treated groups as compared to cholesterol alone fed control rats [95].

18. Larvicidal and ovicidal activity

Ashok Verma *et al.,* (2003) reported that the ovicidal effect of leaf extracts of *C. fistula* (at 0.5, 1.0 and 2.0%, topically applied) was evaluated on the viability and hatching of eggs (0, 1 and 3days old) of *D. koenigii*. Application of leaf extracts of the plant inhibited hatching of the eggs,and increasing concentration of the extract resulted in increased non-viability of 3-day-old eggs [96].

Govindarajan M *et al.,* (2008) reported the methanolic leaf extract of *Cassia fistula* was tested for larvicidal and ovicidal activity against *Culex quinquefasciatus* and *Anopheles stephensi*. The extract was found to be

more lethal to the larvae of *A. stephensi* than *C. quinquefasciatus* with LC50 values of 17.97 and 20.57 mg/l, respectively. Mean percent hatchability of the ovicidal activity was observed 120 h after treatment. The percent hatchability was inversely proportional to the concentration of extract and directly proportional to the eggs. The egg raft of *C. quinquefasciatus* was found to be more hatchable than *A. stephensi*. The results show that the leaf extract of *C. fistula* is promising as a larvicidal and ovicidal agent against *C. quinquefasciatus* and *A. stephensi* [97].

19. Laxative activity

Akanmu MA e*t al.,* (2004) discussed the in-vitro effect of *Cassia fistula* infusion on isolated guinea-pig ileum. The acute and sub-chronic toxicity of the infusion of *C. fistula* and *Cassia acutifolia* sp. Del. Pod-(Senokot tablet) as the reference drug were also determined. The results obtained for *C. fistula* infusion when compared with senokot tablet showed that the infusion of *Cassia fistula* pods possessed very low levels of toxicity, having the LD50 of 6600 mg/kg and also without any pathological effects on the organs examined microscopically. It is therefore concluded from the study that *C. fistula* pod infusion could be safely utilized as laxative drugs and as a substitute for the official Senna [98].

20. Leukotriene inhibition activity

Kumar *et al.,* (1998) studied that the methanol extract of fruits of *C. fistula* inhibited the 5-lipoxygenase catalysed formation of leukotriene B4 in bovine polymorphonuclear leukocytes (IC50 value of 38µg/ml). Lipid peroxidation in bovine brain phospholipid liposomes induced with 2,2'-azo-bis-(2-amidinopropane) dihydrochloride (AAPH) was inhibited (IC50 of 40micro g/ml). A linear correlation was obtained between the effects of the extract in the 2 assayssuggesting a redox-based mechanism for the inhibition of the 5-lipoxygenase enzyme [99].

21. Sedative effect and Anti-anxiety effect:

Miladi-Gorgi *et al.,* (2011) had studied the effect of *Cassia fistula* on sleeping time and the level of anxiety by taking 80 male albino mice (25-30 g) randomly allocated in 8 groups. For measuring the sleeping time we used the Angle method and animals were divided into three experimentals (250, 500 and 1000 mg/kg) and one control group. For evaluating of anxiety levels, animals randomly were divided into three experimentals and one control group, and elevated plus maze (EPM) model was used. The evaluation of anxiety indices included number and percent of time spent in open arm. Different doses of the aqueous extract of *Cassia fistula* (250, 500, 1000 mg/kg IP) were injected intraperitoneally to the treated groups. Controls were recived 10 ml/kg/BW normal saline intraperitoneally in both methods. The extract of *Cassia fistula* (250, 500 and 1000 mg/kg) significantly increased sleeping time [$F(3, 39)=23.19$, $P<0.05$]. This study showed that the aqueous extract of *Cassia fistula* fruit increase the sleeping time and decreasing level of anxiety in mice [100].

22. Wound healing activity

Bhakta T *et al.,* (1998) reported that the methanolic extract of *C. fistula* leaves was examined for its wound healing property in the form of an ointment in two types of wound models in rats; excision wound model and incision wound model. The ointment of the leaf extract of two different

concentrations (5 and 10% w/w ointment of leaves extract in simple ointment base) responded significantly in both models of wounds tested. The results were also comparable to that of the standard drug, nitrofurazone, in terms of wound contraction ability, epithelisation period, tensile strength and regeneration of tissue at wound area [86].

Kumar MS *et al.,* (2006) investigated the potential of *Cassia fistula* to treat the infected wound on albino rat model. The alcohol extract of *C. fistula* 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. *C. fistula* treated rats showed, better wound closure, improved tissue regeneration at the wound site, and supporting histopathological parameters pertaining to wound healing. Biochemical analysis and matrix metalloproteinases expression correlated well with the results thus confirming efficacy of *C. fistula* in the treatment of the infected wound. Along with the other activities such as antitumor, antioxidant, hypoglycaemic, hepatoprotective, antibacterial, hypocholesterolaemic, and antidiabetic activity, the healing potential of *C. fistula* provides a scientific rationale for the traditional use of this plant in the management of infected dermal wound and can be further investigated as a substitute to treat infected wounds without using synthetic antibiotics [101].

TOXICITY POTENTIAL :

Subramanion L Jothy *et al.* revelled that the acute oral toxicity of *C. fistula* seeds extract was investigated in mice. Oral administration of crude extract at the highest dose of 5000 mg/kg resulted in no mortalities or evidence of adverse effects, implying that *C. fistula* in nontoxic. Throughout 14 days of the treatment no changes in behavioural pattern, clinical sign and body weight of mice in both control and treatment groups. Also there were no any significant elevations observed in the biochemical analysis of the blood serum. Further, histopathological examination revealed normal architecture and no significant adverse effects observed on the kidney, heart, liver, lung and spleen. Overall, the results suggest that, the oral administration of *C. fistula* methanolic seeds extract did not produce any significant toxic effect in mice. Hence, the extract can be utilized for pharmaceutical formulations [102].

The aqueous extract of the pods of *Cassia fistula* Linn (Leguminosae Caesalpinoideae), cultivated in Ile-Ife, Nigeria were investigated for pharmacological and toxicological properties. The in-vitro effect of *Cassia fistula* infusion on isolated guinea-pig ileum was examined. The acute and sub-chronic toxicity of the infusion of C. fistula and Cassia acutifolia Del. Pod-(Senokot tablet) as the reference drug were also determined. The results obtained for *C.fistula* infusion when compared with senokot tablet showed that the infusion of *Cassia fistula* pods possessed very low levels of toxicity, having the LD50 of 6600mg/kg and also without any pathological effects on the organs examined microscopically. It is therefore concluded from the study that C. fistula pod infusion could be safely

utilized as laxative drugs and as a substitute for the official Senna [103].

CONCLUSION

Cassia fistula possessing a wide range of phytochemicals almost in every part of it and has been reported to posses various activity like Anthelmintic Activity, Antibacterial Activity, Antifeedant and larvicidal activities, Antifertility activity, Antifungal activity, Anti-inflammatory and Antioxidant activities, Anti-leishmaniatic activity, Antimicrobial Activity, Antiparasitic activity, Antipyretic activity, Antitumor activity, Antitussive activity, Clastogenic effect, CNS activities, Hepatoprotective activity, Hypocholesterolemic and hypoglycaemic activity, Hypolipidemic activity, Larvicidal and ovicidal activity, Laxative activity, Leukotriene inhibition activity,Sedative effect and Anti-anxity effect and Wound healing activity. Since the global scenario is now changing towards the use of nontoxic plant product having traditional medicine use, development of modern drug from *C. fistula* should be emphasized for the control of various diseases. Hence, the active principles needs to be isolated and can formulate to treat various ailments by performing clinical trail studies to understand the molecular mechanism of action, in search of lead molecules from natural resources.

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