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Review Article

CASSIA FISTULA: BOTANY, PHYTOCHEMISTRY AND PHARMACOLOGICAL LEVERAGES-A REVIEW

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ABSTRACT

Cassia fistula Linn. is also called a "golden shower". It is aboriginal to India, Sri Lanka and diffused in various countries, including Mexico, China, Mauritius, East Africa, South Africa, and West Indies. Plant and its parts, such as bark, fruit, leaves, and seeds, are used traditionally to cure diseases. Traditionally the plant possesses hepatoprotective, antipyretic, anti-inflammatory, leukotriene inhibition, antitussive activity, antioxidant, wound healing, hypo-lipidemia, anticancer, antidiabetic, central nervous system activity, antiulcer, antibacterial, antifertility, larvicidal and ovicidal, antifeedant, laxative, anti-epileptic, antimicrobial, urease inhibition, antifungal, anti-tobacco mosaic virus activities. The review contains botanical information, constituents and pharmacological leverages of the plant. The review draws attention towards the traditional, phytochemical and pharmacological knowledge accessible on *Cassia fistula* Linn, which would be beneficial for research scholars to develop novel chemical entities. This review article is written after studying most of the journal's articles, which were published between 1998 to 2019.

Keywords: Hepatoprotective, Wound healing, Antioxidant, Laxative, Anti-inflammatory

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INTRODUCTION

Since long the extracts of plants are used to relieve the symptoms of many diseases [1]. Most of the herbal drugs are not critically examined because herbs are assumed that they are safe and natural but many herbs have serious adverse effects, which might create life-threatening conditions [2]. The main objective of this review is to highlight the botanical reports, pharmacological uses, and toxicity studies. *Cassia fistula* is a deciduous-mixed monsoon forest tree species having an approximate height of 24 m and 1.8 m girth that belongs to the Fabaceae family (this family includes a large number of about 670 genera and nearly 20,000 plant species). It is famed as Amulthus, "Golden Shower" and also popularized as "Indiana Laburnum". This plant species confers huge ethnomedicinal importance and has extensively been used in Ayurveda to cure many diseases. It is native to India, Sri Lanka and diffused in various countries, including Mexico, China, Mauritius, East Africa, South Africa, and West Indies [3, 4]. It is a Thailand national tree. It grows in the shade and develops in low supplement and shallow soil. Seeds and Vegetative means are the two methods for germination [5]. A young tree's bark color is greenish-grey and it becomes dark brown colored after maturing. It is a tree that lasts for a short time. Leaves consist of leaflets that pair 2-5 cm long and contain about 3-8 reverse frill duets. Flowers of golden shower trees are golden yellow in color and showers flower bunches of length 40 cm [6-8]. *Cassia fistula* has been used in folk medicine and reported for various pharmacological properties. Every part of this plant is recognized for its medicinal properties.

Botanical reports of *Cassia fistula* Linn.

Kingdom: Plantae, Subkingdom: Tracheobinota, Superdivision: Spermatophyta, Division: Magnoliophyta, Class: Magnoliopsida, Subclass: Rosidae, Order: Fabales, Family: Fabaceae, Genus: *Cassia*, Species: *fistula* [9].

Vernacular names of *Cassia fistula* Linn.

Cassia fistula is also recognized by some other names in different languages and regions.

Table 1: Vernacular names of *Cassia fistula* Linn

	Vernacular names
➢	Guajarati: Garmala [10]
➢	Bengali: Bundaralati, Soondali, Sonalu [10]
➢	Hindi: Amultus, Sonhali [10]
➢	Punjabi: Kaniyaar, Girdnalee, Amaltaas [10]
➢	English: Golden Shower [10]
➢	Tamil: Shrakkonnai, Irjviruttam [10]
➢	Marathi: Bahava [10]
➢	Kannad: Kakkemara [10]
➢	Arab: Khayarsambhar [10]
➢	Telegu: Raelachettu, Aragvadhamu [10]
➢	Oriya: Sunaari [10]
➢	Urdu: Amaltaas [10]
➢	Sanskrit: Nripadruma [10]
➢	French: Douche d'or [11]
➢	Malaysia: Kayu raja [11]
➢	Sri Lanka: Aehaela-gaha [11]
➢	Germany: Fistul-kassie [11]
➢	Thailand: Chaiyaphruek [11]

Table 2: Chemical constituents of various parts *Cassia fistula* plant

Plant parts	Constituents
Bark	The stem bark contains lupeol, ß-sitosterol, and hexacosanol [12].
Leaves	Leaves contain heptacosanyl-5-hydroxypentadec-2-enoate, octacosan-5, and 8-diol [13]. Rhein, chrysophanol, and physcion [14].
Pod	The pod contains rhein glycoside and ferulic acid, ceryl alcohol, anthraquinone, and tannin [15, 16].
Flowers	Flowers contain kaempferol, leucopelargonidin tetramer, rhein, fistulin, and triterpene [17].
Seeds	Seeds contain glycerides with linoleic, oleic, stearic, and palmitic acids as chief fatty acids and traces of caprylic and myristic acids [18]. others: 5-(2-hydroxy phenoxy methyl)furfural, (2'*s*)-7-hydroxy-5-hydroxymethyl-2-(2'-hydroxypropyl) chromone, benzyl 2-hydroxy-3, 6-dimethoxybenzoate, and benzyl 2 β-*o*-d-glucopyranosyl-3, 6-dimethoxybenzoate together with other compounds, (2'*s*)-7-hydroxy-2-(2'-hydroxypropyl)-5-methylchromone, and two oxyanthraquinones, chrysophanol, and chrysophaneinhanein [19]. Galactomannan [20].

Pharmacological activities of *Cassia fistula* linn

The plant *Cassia fistula* has a broad variety of pharmacological activities. A lot of research has been done on this plant for many years. This plant is easily available in many regions. *Cassia fistula* and its derivatives are considered as an important source of active ingredients that can be used in drug development.

Table 3: List of pharmacological activities of *Cassia fistula* linn.

Activity	Used portion	Used solvent	Inducing agent	Extract dose	Animal model/*in vitro*	Outcome	Reference
Hepatoprotective	Leaves	n-heptane	Paracetamol	400 mg/kg	Wistar albino rats 180-200 g	Dropping the serum levels of transaminases, bilirubin and alkaline phosphatase.	[21]
	Roots	Alcoholic	CCl_4	100, and 200 mg/kg	Wistar albino rats 170-200 g	Holds significant dose-dependent protective action.	[22]
	Leaf	Ethanolic	CCl_4	500 mg/kg	Rats	Ethanolic leaf extract reverses lipid peroxidation. It also reverses the activities of catalase and glutathione reductase in the liver tissue to normal.	[23]
	Leaves and bark	Aqueous	CCl_4		Albino Wistar rats 180-200 g.	Reduced plasma enzyme and bilirubin concentration in rats.	[24]
	Seeds	Methanolic	Paracetamol	200, and 400 mg/kg	Rats	Reversed back the altered level of biochemical markers.	[25]
Antipyretic	Pod/fruit	Methanolic	Yeast	250, and 500 mg/kg	Wistar rats 200-220 g and Swiss albino mice 18-25 g	Improved hypothermal activity.	[26]
	Pod		Yeast	200, and 400 mg/kg	Rats	It helps in lowering temperature up to 4 h.	[11]
Antipyretic and anti-inflammatory	Leaf	Ethanolic	TAB vaccine Carrageenan	250, 500 mg/kg 50, 100, 250, 500, and 750 mg/kg	Wistar albino rat 180-200 g	It helps in reducing body temperature. Helps in reducing hind paw edema, and cotton pellet granuloma.	[27]
Leukotriene inhibition	Fruits	Methanolic				Inhibition of the 5-lipoxygenase enzyme.	[28]
Antitussive	Leaf	Methanolic	Sulphur dioxide gas	400, 600 mg/kg	White albino mice 30-40 g	Inhibited coughing by 44.44%, and 51.85%.	[29]
Antioxidant	Leaves	90% Ethanolic				Stem bark had more antioxidant activity.	[30]
	Stem bark, pulp, and flowers	90% Methanolic					[30]
	Fruit	Ethanolic and Aqueous	Hydrogen peroxide	Different concentrations used between 50 to 5000	*In vitro*	Ethanolic extract showed 90% protection of erythrocytes. An aqueous extract showed 75% of antioxidant and protective activity.	[31]
	Bark, stem, leaf, and root of different age groups	Methanolic			*In vitro*	Bark extracts from three different age classes showed high antioxidant activity than other parts of the plant.	[32]
Antioxidant and Anti-inflammatory	Bark	Aqueous and Methanolic	CCl_4 and $FeSO_4$		*In vitro* Wistar albino rats	Both extracts show significant antioxidant activity in DPPH, Nitric oxide and Hydroxyl radical The significant anti-inflammatory effect in both acute and chronic models.	[33]
Antioxidant	Bark	Ethyl acetate Methanolic n-hexane			*In vitro*	Antioxidant activity of Ethyl acetate extract, methanol extract, and n-hexane extract is 65.98%, 58.19%, and 32.66%, respectively.	[34]
	Pods	n-hexane Ethyl acetate Aqueous fractions			*In vitro*	Antioxidant potency was found to be in decreasing order of ethyl acetate >n-hexane>aqueous fractions, and had good co-relationship with Their polyphenolic and flavonoid material.	[35]
	Flowers	Aqueous	Alloxan	10 ml/kg	Female Wistar rats 180-200 g	In diabetic rats, decreased production of superoxide dismutase, catalase, glutathione peroxidase, glutathione reductase and glutathione were brought back to near normal range.	[36]
	Fruit pulp	Hydroalcoholic			*In vitro*	Inhibiting DPPH and hydroxyl radical, total phenol content.	[37]
Anti-	Flower		Carrageenan-	Rhein 10, 20, 40	Wistar albino rats	Inhibited paw edema.	[38]

inflammatory	Rhein isolated		induced hind paw edema Croton oil-induced ear edema Cotton pellet-induced granuloma Acetic acid-induced vascular permeability models	mg/kg 20, 40 mg/kg 10, 20 and 40 mg/kg	200-220 g and mice 24-28 g	Inhibited ear edema in mice in dose-dependent manners. 17.24% and 36.12% reduced granuloma formation Rhein significantly inhibited acetic acid-induced vascular permeability.	[38]
	Dried fruits of *Solanum xanthocarpum Schrad* and *Wendl*, and dried pulp of *Cassia fistula*	Water	Carragenan	100, 200, 300, 400 and 500 mg/kg *Solanum xanthocarpum Schrad and Wendl*: *Cassia fistula* 250:50, 250:100	Wistar Albino rats 150-300 g	*Solanum xanthocarpum Schrad* and *Wendl* showed more activity than the dried fruits of *Cassia fistula.* Both extracts had maximum activity at 500 mg/kg dose. The combination was found to have synergistic effects.	[39]
Anti-inflammatory	Leaf	Methanolic	Carrageenin, Histamine, and dextran induced paw edema	200, 400, and 800 mg/kg	Male Wistar albino rats 130-150 g	Suppress the inflammation that carrageenan, histamine, and dextran induced.	[40] [40]
	Bark	Aqueous and alcoholic	Air pouch granuloma and cotton pellet granuloma models		In sub-acute models	Significant anti-inflammatory activity.	[41]
Wound Healing	Bark	Hexane	Streptozotocin induced Diabetes	0.15, 0.30, and 0.45 g/kg	Wistar albino Rats 150-200 g	Antidiabetic effect and ideal for coronary artery disease treatment.	[42]
	Leaves	Alcoholic	Full-thickness wound (1.5*1.5) *Staphylococcus aureus* ATCC 29213 and *Pseudomonas aeruginosa* ATCC 2785	10% formulated ointment 0.125+/-0.101 micro g/ml 250+/-0.204 micro g/ml	Wistar albino rat 150-200 g *In vitro* anti-microbial activity	Significant prohealing activity. Effective wound closure, better tissue regeneration at the wound site and support for wound-related histopathological parameters.	[43]
	Leaves	Methanolic	Excision and Incision	5% and 10% w/w ointment	Rats	Comparable results with standard medication, nitrofurazone in terms of wound contraction capacity, duration of epithelization, tensile strength and tissue regeneration at wound location.	[44]
Hypolipidemic	Legume	50% Ethanolic	Cholesterol fed rats	100, 250, and 500 mg/kg b. wt./day	Rats	Specifically prevented the dose-dependent rise of serum total and LDL-cholesterol, triglycerides, and phospholipid.	[45]
Anticancer activity	Seeds	Methanolic	Ehrlich ascites carcinoma (EAC)	100, 200, and 300 mg/kg/day	Male albino Swiss mice 18-22 g	Increased lifespan and reduced tumor volume and a viable number of tumor cells in the EAC tumor hosts.	[46]
	Flower	Aqueous	MCF-7 and Vero cell lines	1000 mg/ml 7.19 µg/ml	*In vitro*	AgNPs can be used in the development of novel anticancer drugs. 90.5%, and 89.7% cell death was noticed in MCF-7 and Vero cell lines, respectively. The inhibitory concentration (IC50) against MCF-7 was observed.	[47]
	Rhein isolated from flower	Ethyl acetate	Colon cancer cell lines. cell line such as COLO320DM Normal cell line VERO	200 µg/ml	*In vitro*	Rhein showed 40.59%, 58.26%, 65.40%, 77.92%, and 80.25% cytotoxicity at 200 µg/ml concentration for 6, 12, 24, 48, and 72 h incubation time.	[48] [48]
	Leaves	Ethanolic, methanolic, diethyl ether, and chloroform extract			CDRUG server to check the anticancer activity	The results of our study clearly show that HOP-22(29)-EN-3. BETA.-OL may serve as a promising inhibitor for cancer treatment and guide future research.	[49]
Anti-diabetic	Flowers	Hexane, ethyl acetate, and methanol	Streptozotocin	10, 30 mg/kg	Male Wistar albino rats 160-180 g	The decrease in blood glucose, cholesterol, and triglyceride levels on aloe-emodin glycoside therapy.	[50]
	Flower	Petroleum ether, chloroform, acetone, ethanol, aqueous, and crude aqueous extracts and two fractions of ethanol extract	Alloxan	200, 400 mg/kg	Wistar rats of either sex 150-180 g	Appreciable results in a drop in the plasma glucose level and other diabetes complications	[51]
	Bark	Aqueous extract	Streptozotocin	60 mg/kg	Male albino Wistar rats 150-200 g	Gold nano-particles with *Cassia fistula* have promising anti-diabetic properties.	[52] [52]

	Stem barks of *Tamarind us indica* and *Cassia fistula*	Alcoholic extracts	Alloxan	250, 500 mg/kg *In vitro* Different Doses	Wistar rats 150-200 g	The combination has a lowering level of blood glucose along with antioxidant and defensive levels on renal complications. Both extracts showed promising free radical DPPH scavenging activity in a concentration-dependent manner up to 250 µg/ml. *Cassia fistula* showed more scavenger behavior than *Tamarindus indica.*	[53]
	Stem bark	Methanol	Streptozotocin	Catechin20 mg/kg	Male albino wistar rats	Results confirm that catechin has a hypoglycemic effect. We may infer that catechin can become a potential oral hypoglycemic medication.	[54]
Anti-leishmaniatic	Fruits	Methanolic			*in vitro* activity of the isolated biochanin A	The methanolic extract showed significant antileishmanial activity.	[55]
Central nervous system	Seed	Methanolic	Morphine and pethidine	1, 1.66, and 2.5 g/kg	Swiss albino mice of either sex 20-25 g	Methanolic extract showed a significant CNS depressant action in a dose-dependent manner.	[56] [56]
Anti-ulcer	Leaf	Ethanolic extract	Pylorus ligation-induced gastric ulcer	250, 500, and 750 mg/kg	Rats	Decreased gastric acid secretion, protection of the mucosal barrier, and inhibition of free radical generation. Ethanolic leaf extract (750 mg/kg) produced maximum antiulcer activity comparable to ranitidine treatment.	[57]
Antifertility	Seeds	Petroleum ether		100, 200, and 500 mg/kg	Fertile female albino rats	A decline in the fertility index, dose-dependent numbers of uterine implants and live fetuses (100 mg/kg) and poor estrogenic activity when administered alone	[58]
	Seeds	Aqueous		100 mg/kg 200 mg/kg 500 mg/kg	Female rats	Prevents pregnancy 57.14% 71.43% pregnancy inhibition 100% pregnancy inhibition respectively	[59]
Larvicidal and ovicidal	Leaf	Methanolic		LC50 values of 17.97 and 20.57 mg/l,	The filarial and malarial vector mosquitoes, *Culex quinquefasciatus and Anopheles stephensi*	The extract was more lethal to the larvae *of Anopheles stephensi* than *Culex quinquefasciatus* with LC50 values of 17.97 and 20.57 mg/l, respectively	[60] [60]
	Leaf			0.5, 1.0, and 2.0%, topically applied	Eggs	Inhibited hatching of the eggs and increased extract concentration resulted in an improved abrogation of 3-day-old eggs.	[61]
Antifeedant and larvicidal	Rhein isolated from flower	Ethyl acetate		1000 ppm concentration	Lepidopter-on pests *Spodoptera litura* and *Helicoverpa armigera*	Considerable antifeedant activity against Helicoverpa armigera (76.13%) was observed. Rhein exhibited larvicidal activity against Helicoverpa armigera (67.5%), Spodoptera litura (36.25%) respectively. The survived larvae were malformed adults.	[62]
	Leaves of *Cassia fistula* and Ripened fruits of *Piper nigrum*	Methanol		10, 30, 50, 70 Ppm	Mosquitoes *Anopheles stephensi* *In vitro*	Exhibited remarkable Adulticidal and Larvicidal potentials. *Cassia fistula* pod infusion could be safely utilized as laxative drugs and as a substitute for the official Senna.	[63]
Laxative activity	Rhein content in pod pulp	Decoction extract using ethyl acetate: methanol: water 100:17:13as the solvent system		2.4, 3.6 g of decoction extract	Rats	It shows the laxative property.	[64]
Anti-epileptic	Seeds	Methanolic	Pentylenetetrazol (PTZ)	100, 200 mg/kg	Mice	Methanolic extract of seeds of *Cassia fistula* showed anticonvulsant activity.	[65]
Removal of toxic metal ions	Seeds			182.2 mg/g		Ni(II) ion adsorption system undergoes chemisorption, exothermic, feasible and spontaneous. The excellent properties of the *Cassia fistula* seeds can be alternate for commercial activated carbon.	[66]
Urease inhibition	Leaves	Aqueous, methanol, hexane, chloroform and ethyl acetate			*In vitro*	Ex. cept for chloroform extract, all four samples exhibited more than 50% urease inhibitory activity.	[67]
Antifungal	Leaves, barks, and seeds	Ethanol, chloroform, petroleum ether and aqueous			*In vitro*	Showed excellent anticandidal activity. Ethanol extract of *Cassia fistula* seed exhibited the most inhibitory activity. Gallic acid is a potent natural antifungal agent.	[68]
	Leaves *Cassia alata, Cassia. fistula and Cassia tora*	Methanolic extract			*In vitro* *Trichophyton rubrum, Microsporum gypseum,* and *Penicillium marneffei.*	*Cassia fistula* was the most potent inhibitor of *Penicillium marneffei.* The hyphal growth of *Trichophyton rubrum, Microsporum gypseum,* and *Penicillium marneffei* was inhibited by all the extracts in a concentration-dependent manner.	[69] [69]
Anti-tobacco mosaic virus	Bark	70% aqueous Methanolic			*In vitro*	Results showed that compounds 1 and 2 showed high Anti-tobacco mosaic virus activity with an inhibition rate of 28.5% and 31.3%. Compounds 4-7 showed modest anti-Anti-tobacco mosaic virus activity with an inhibition rate of 18.5%, 22.7%, 16.4%, and 15.3%, respectively.	[70]

Bactericidal	AgNPs synthesized from *Cassia fistula* fruit		Dose-dependent (0, 10, 20, 40, and 80 µg/ml		fruit extract showed a heightened bactericidal activity against *Escherichia coli* and *Klebsiella pneumonia.* 100% against former and 91% in the case of latter Gram-negative bacteria. AgNPs did not exhibit cytotoxic activity in mammalian cells.	[71]
Antibacterial	Fistulin isolated from Leaves A protease inhibitor named "fistulin"	Crude extracts were obtained by homogenizing the leaves		*In vitro*	The Plant protease inhibitor was found to be very active against *Staphylococcus aureus, Escherichia coli, Bacillus subtilis*, and *Klebsiella pneumonia.*	[72]
	Flowers	Methanolic, and ethanolic	5, 10, 20, 40, 80, and 160 mg/ml	*In vitro*	The most susceptible microorganisms to extracts were *Escherichia coli* and *Klebsiella pneumoniae,* respectively. Also, *Bacillus cereus*, and *Staphylococcus aureus* showed the least sensitivity to extracts respectively.	[73] [73]
Antibacterial and antifungal	Leaf	Hydroalcoholic	5, 25, 50, 100, 250 µg/ml	*In vitro*	Results demonstrated strong inhibition of bacterial growth against the studied species. This is because of the presence of various secondary metabolites.	[74]
	Fruit pulp	Hydroalcoholic	5, 25, 50, 100, 250 µg/ml	*In vitro*	Crude extracts showed moderate and strong activity against most of the bacteria tested.	[75]
	Flowers	Hexane, chloroform, ethyl acetate, methanol,and water	(5, 2.5, and 1.25 mg per disc) with three replicates	*In vitro*	Extracts of *Cassia fistula* flowers showed inhibition against "Gram-positive" bacteria. And "Gram-negative" bacteria were not inhibited.	[76]
	Active flavone glycoside from the seeds	Petroleum ether		*In vitro*	Results showed that the antibacterial activity of compound 1 was found to be fairly good against Gram+ve bacteria, and Gram-ve bacteria. The antifungal activity of compound 1>*Aspergillus niger* and *Fusarium oxysporum.*	[77]
Antimicrobial activity	Seeds	Methanolic	1.563-50.00 mg/ml	*In vitro*	Results showed Antimicrobial activity and it was non-toxic to human.	[78]

Table 4: Toxicity status of *cassia fistula*

Solvent for extraction	Plant part	Results	Reference
Aqueous	Pods	Possessed very low levels of toxicity, having the LD_{50} of 6600 mg/kg and no Pathological effects on the organs.	[79]
Alcoholic	Stem bark	No signs of toxicity up to a dose level of 2000 mg/p. o.	[80]
Aqueous and methanolic	Bark	Acute toxicity study with the extracts showed no sign of toxicity up to a dose level of 2000 mg/po.	[81]
Methanolic	Seeds	Seeds extract with high LC_{50} value signified that this plant is not toxic to human	[77]
Ethanolic	Fruit	In acute studies*: Cassia fistula* extract up to a dose of 5000 mg/kg did not induce mortality and In sub-acute studies: showed *Cassia fistula* extract at the doses of 250, 500 and 1000 mg/kg to rats did not induce mortality.	[82]

Toxicity status of *cassia fistula* linn

Different toxicity studies have been done by researchers and they found that different parts of the plant are non-toxic or very less toxic to humans.

CONCLUSION

Cassia fistula Linn. has been examined scrupulously for its phytochemical and pharmacological activities. From the above review, it is concluded that *Cassia fistula* Linn. has been used as an important curative agent for patients. It is a very useful herbal plant and needs to explore more to know the exact mechanism. In both *in vivo* and *in vitro* studies, *Cassia fistula* has various pharmacological properties.

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AUTHORS CONTRIBUTIONS

Shikha Sanoria, Zulfkar Latief Qadrie made the idea and participated in its design and draft of the manuscript. Surya Prakash Gautam, Amit Barwal helped in the final editing of the manuscript of review article. All authors read and approved the final draft of the review article.

CONFLICT OF INTERESTS

The author declares no conflict of interest

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