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Cassia fistula Linn. (Amulthus)- An Important Medicinal Plant: A Review of Its Traditional Uses, Phytochemistry and Pharmacological Properties

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Abstract

Medicinal herbs are moving from fringe to mainstream use with a greater number of people seeking remedies and health approaches free from side effects caused by synthetic chemicals. India officially recognizes over 3000 plants for their medicinal value. It is generally estimated that over 6000 plants in India are in use in traditional, folk and herbal medicine. This article aims to provide a comprehensive review on the phytochemical and pharmacological aspects of Cassia fistula. It is obtained from deciduous and mixed-monsoon forests throughout greater parts of India, ascending to 1300 m in outer Himalaya, is widely used in traditional medicinal system of India has been reported to possess hepatoprotective, anti-inflammatory, antitussive, antifungal and also used to check wounds healing and antibacterial. It is known as a rich source of tannins, flavanoids and glycosides. The innumerable medicinal properties and therapeutic uses of Cassia Fistula as well as its phytochemical investigations prove its importance as a valuable medicinal plant.

Keywords *Cassia fistula*, Amulthus, pharmacological activities, phytochemistry, Sennosides, traditional uses.

INTRODUCTION

Over the last few years, researchers have aimed at identifying and validating plant-derived substances for the treatment of various diseases. Interestingly it is estimated that more than 25% of the modern medicines are directly or indirectly derived from plants. It is worth mentioning that Indian medicinal plants are considered as a vast source of several pharmacologically principles and compounds that are commonly used as home remedies against multiple ailments [1]. Since early 1990s, the use of forest products for medicine has been emerging as a vital

income generating resource for the development of various social groups, hence, there is an increased attention for their long-term sustainability [2].

Indian traditional medicine is based on various systems including Ayurveda, Siddha, Unani and Homoeopathy. The evaluation of these drugs is primarily based on phytochemical, pharmacological and allied approaches including various instrumental techniques such chromatography, microscopy and others. With the emerging worldwide interest in adopting and studying traditional systems and exploiting their potential based on different health care systems, the evaluation of the rich heritage of traditional medicine is essential [3]. In this regard, one such plant is *Cassia fistula.*

Cassia fistula Linn. (Cassia) family Caesalpiniaceae commonly known as Amulthus and in english popularly called "Indian Laburnum" has been extensively used in Ayurvedic system of medicine for various ailments. It is deciduous and mixed-monsoon forests throughout greater parts of India, ascending to 1300 m in outer Himalaya, is widely used in traditional medicinal system of India has been reported to possess hepatoprotective, anti-inflammatory, antitussive, antifungal and used also check wounds healing and antibacterial [3].

Taxonomic Classification

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

Vernacular names

Bengali	*Bundaralati, Sonalu, Soondali, Sondal*
English	*Indian Laburnum, Purging Fistula, Cassia, Golden Shower.*
Guajarati	*Garmala*
Hindi	*Sonhali, Amultus*
Kannad	*Kakkemara*
Marathi	*Bahava*
Tamil	*Shrakkonnai, Konai, Irjviruttam*
Telegu	*Kondrakayi, Raelachettu, Aragvadhamu, Koelapenna*
Sanskrit	*Nripadruma*
Arab	*Khayarsambhar*
Oriya	*Sunaari*
Punjabi	*Amaltaas, Kaniyaar, Girdnalee*
Urdu	*Amaltaas*

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 [3]. The plant is cultivated as an ornamental throughout India [4].

Morphology

It is a deciduous tree with greenish grey bark, compound leaves, leaf lets are each 5-12 cm long pairs. A semi-wild tree known for its beautiful bunches of yellow flowers and also used in traditional medicine for several indications. A fruit is cylindrical pod and seeds many in black, sweet pulp separated by transverse partitions. The long pods which are green, when unripe, turn black on ripening after flowers shed [3]. Pulp is dark brown in colour, sticky, sweet and mucilaginous, odour characteristic, and somewhat disagreeable [5]. 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 [6].

A tree 6-9 m high; trunk straight; bark smooth and pale grey when young, rough and dark brown when old; branches spreading, slender. Leaves 23-40 cm long; main rhachis pubescent; stipules minute, linear-oblong, obtuse, pubescent. Leaflets 4-8 pairs, ovate or ovate-oblong, acute, 5-12.5 by 3.8-9.5cm, bright green and glaborous above, paler and silvery-pubescent beneath when young, the midrib densely pubescent on the underside, base cuneate; main nerves numerous, close, conspicuous beneath; petiolules 6-10 mm long, pubescent or glaborous. Flowers in lax racemes 30-50 cm. long; pedicels 3.8-5.7 cm. long, slender, pubescent and glaborous. Calyx 1 cm long divided to the base, pubescent; segments oblong, obtuse. Corolla 3.8 cm across, yellow; stamens all antheriferous. The pods are pendulous, cylindric, nearly straight, smooth, shining, brown-black, indehiscent, with numerous (40-100) horizontal seeds immersed in a dark coloured sweetish pulp. Seeds broadly ovate, 8mm. long, slightly less in breadth, and 5mm thick [7].

The fruit pods are 40-70 cm long and 20-27mm in diameter, straight or slightly curved, smooth but finely striated transversely, the striations appearing as fine fissures. The rounded distal ends bear a small point marking the position of the style. The dorsal suture appears as a single vascular strand and the ventral suture as two closely applied strands. Internally the pod is divided by thin, buff coloured, transverse dissepiments at intervals of about 0.5cm. 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 [8].

Traditional uses

The root is prescribed as a tonic, astringent, febrifuge and strong purgative [3, 5, 7, 9, 10, 11, 12]. The leaves extract reduced mutagenecity in *E. coli* [6]. Extract of the root bark with alcohol can be used for backwart fever. The leaves are laxative and used externally as emollient, a poultice is used for chilblains, in insect bites, swelling, rheumatism and facial paralysis [3, 6, 9, 11]. Leaves posses anti periodic and laxative properties, the leaves are used in jaundice, piles, rheumatism ulcers and also externally skin eruptions, ring worms, eczema. The leaves and bark mixed with oil are applied to pustules, insect bites [7, 11]. The roots are used in chest pain, joint pain, migraine and blood dysentery. The extract of the root lowered the blood sugar level up to 30 % [13].

Leaves and flowers are both purgative like the pulp [3, 7]. Ashes from burnt pods mixed with little salt are used with honey taking 3- 4 times to relieve cough [3]. Root is useful in fever, heart diseases, retained excretions and biliousness [9]. Fruits are used as catharatic and in snake bite. Juice of leaves is used in skin diseases [10, 12]. Flowers and pods are used as purgative, febrifugal, biliousness and astringent. The ethanolic 50% extract of pods show antifertility activity in female albino rats. The heated pods are applied to swellings on the neck due to cold. The fruits are reported to be used for asthma [7, 11]. Pulp is given in disorders of liver. The drug

is used as analgesic as an antipyretic, it is a remedy for malaria and fever. It is also applied in blood poisoning, anthrax and antidysentric, leprosy and antidiabetic, for the removal of abdominal obstruction [11]. The extract of the flower inhibits the ovarian function and stimulate the uterine function in albino rats. Fruits are used in the treatment of diabetes [6], antipyretic, abortifacient, demulcent, lessens inflammation and heat of the body; useful in chest complaints, throat troubles, liver complaints, diseases of eye and gripping [7].

Juice of leaves is useful as dressing for ringworm, relieving irritation and relief of dropsical swelling. The pulp of the fruit around the seeds is a mild purgative [3, 7, 9, 11, 14]. It is also used in biliousness and in diabetes. Externally, it is useful for evacuation in flatulent colic, as dressing for gouty or rheumatic joints [3, 7, 9, 10, 11, 12]. The pith is particularly useful if there is swelling in stomach, liver or intestine. The seeds are emetic, used in constipation and have cathartic properties [3, 7, 9, 10, 11, 12]. The seeds are slightly sweet and possess laxative, carminative, cooling, improves the appetite [7, 11], and antipyretic activity. They are useful in jaundice, biliousness, skin disease and in swollen throat. A seed dried produce marked hypoglycaemic activity [11].

Seed powder is used in amoebiasis [4, 11]. The fruit pulp is used for constipation, colic, chlorosis and urinary disorders [4]. The bark possess tonic and antidysentric properties, it is also used for skin complaints, the powder or decoction of the bark is administered in leprosy, jaundice, syphilis and heart diseases. The aqueous extract of the root bark exhibits anti-inflammatory activity. The root is used in cardiac disorders biliousness, rheumatic condition, haemorrhages, wounds, ulcers and boils and various skin diseases [11, 14]. The stem bark is used against amenorrhoea, chest pain and swellings [6].

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 [12].

Phytochemistry

Pulp of the pod contains anthraquinone glycosides, sennosides A & B, rhein and its glucoside, barbaloin, aloin, formic acid, butyric acid and their ethyl esters and oxalic acid, presence of pectin and tannin is also reported [4, 12]. Seeds give galactomannan free sugars and free amino acids; flowers gave ceryl alcohol, kaempferol, rhein and a bianthraquinone glycoside, fistulin. Leaves gave free rhein, its glycosides- sennosides A & B [4].

The pulp contains sugar, tannic matter, albuminous starch, oxalate of calcium and other important constituents. Leaves and flowers contain anthraquinone, tannin, oxyanthraquinone, rhein and volatile oils [3, 10]. Pulp consists of sugar, gum, astringent matter, gluten, coloring matter and water [9, 12]. Root bark besides tannins contains phlobaphenes and oxyanthraquinone substances [10, 12]. The plant contains rhein glucoside, rhein, fistulic acid, sennoside A & B [5, 13].

Aurantiamide acetate (0.011), β sitosterol (0.006) and its β D glucoside (0.02%) has been isolated from flowers [15]. The roots contain 7-methylphyscion, betulinic acid and βsitosterol [13, 15, 16]. The stem bark contains two flavonol glycosides, 5,7,3',4'-tetrahydroxy-6, 8-dimethoxyflavone-3-O-α-arabinopyranoside ($C_{22}H_{22}O_{13,}$ m.p.285^0), 5,7,4'-trihydroxy-6,8,3'-trimethoxyflavone-3-O- α-L-rhamnosyl (1→2)-O-β-D-glucopyranoside ($C_{30}H_{36}O_{18,}$ m.p. 210^0)

and a xanthone glycoside, 1,8-dihydroxy-3, 7-dimethoxyxanthone-4-O- α-L-rhamnosyl(1→2)-O-β-D-glucopyranoside($C_{27}H_{32}O_{16}$, m.p. 217^0). The cuticular wax of leaves contain hentriacontanoic, triacontanoic, nonacosanoic and heptacosanoic acids. The seed oil contains cyclopropenoid fatty acids, viz, vernolic, malvalic and stetculic acids [13, 15].

Analysis of the pulp seed and shell (dry basis) gave: moisture, 60.4, 70.1, 34.2; protein, 5.8, 15.9, 3.8; total N, 0.93, 2.5, 0.6; ash, 5.6, 4.5, 1.8% respectively; and energy (fruit) 4.25kcal/g. the pulp contains sucrose, 31.3; fructose, 26.2; and glucose, 42.5% and high concentration of potassium (1809mg/100g dry basis). The pods contain 5-nonatetracontanone, 2-hentriacontanone [17].

Fruit pulp contained proteins (19.94) and carbohydrates (26.30%); arginine, leucine, methionine, phenylalanine, tryptophan, aspartic and glutamic acids isolated from fruit pulp; a new dimeric proanthocyanidin CFI isolated along with (-) epiafzelechin, (+)catechin, kaempferol, dihydrokaempferol and 1,8-dihydroxy-3-methylanthraquinone and its structure was determined [18].

V. K. Mahesh et al. (1984) investigated that, studies on the plant revealed the presence of chrysophanol, rhein, physicion, and kaempferol. The identities of the compounds were confirmed by spectrometry (NMR, MS, IR) and direct comparison (Co-TLC, MMP) with authentic samples [19].

Y. Kashiwada et al (1990) reported the presence of proanthocyanidins containing flavon-3-ol (epiafzelechin and epicatechin) units with 2S- configuration, *viz*, catechin, epiafzelechin, epicatechin, procyanidin B-2 and its enantiomer, epiafzelechin-(4β→8)-epicatechin and its enantiomers, epicatechin-(4β→8)-ent- epiafzelechin and its enantiomer. An anthraquinone derivative; 3-formyl-1-hydroxy-8-methoxy anthraquinone, 3β-hydroxy-17-norpimar -8(9)-en-15-one and 26-methylheptacosanoic acid [5, 13].

N. N. Barthakur et al. (1995) reported that 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% [20].

M. M. Vaishnav et al. (1996) confirmed that Rhamnetin 3-*O*-gentiobioside was isolated from the roots [17, 21].

T.N. Misra et al. (1996) reported that 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 [22].

T. N. Misra et al. (1997) isolated a new diterpene, 3 beta -hydroxy-17-norpimar-8(9)-en-15-one from the pods of *Cassia fistula* [23].

Meena Rani et al. (1998) reported that from the pods of *Cassia fistula*, an anthraquinone derivative, characterised as 3-formyl-1-hydroxy-8-methoxy-anthraquinone *1*, was isolated. This is the first report on the isolation and characterisation of this compound [24].

M. A. Sayeed et al. (1999) observed that *Cassia fistula* seed 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 [25].

Lee et al. (2001) reported that 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 from the aril of *Cassia fistula*. Their structures were determined on the basis of spectral data [26].

Yueh-Hsiung Kuo et al. (2002), revealed that 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 from the seeds of *Cassia fistula*. The structures were determined on the basis of spectral data explanation, and the synthesis of a compound was carried out [27].

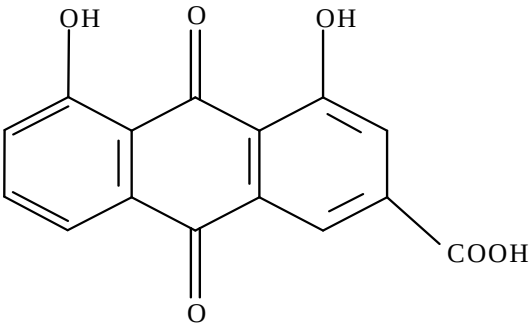
R. N. Yadav et al. (2003) isolated a new bioactive flavone glycoside 1 (mp 252-254^{0}C, $C_{28}H_{32}O_{16}$, $[M]^+$ 624 (EIMS)) was isolated from the acetone soluble fraction of the defatted seeds of *Cassia fistula*. It was characterized as a new bioactive flavone glycoside 5,3',4'-tri-hydroxy-6-methoxy-7-*O*- alpha -L-rhamnopyrano syl-(1 -> 2)-*O*- beta -D-galactopyranoside by several colour reactions, spectral analysis and chemical degradations [28].

M. A. Ali et al. (2003) isolated three lectins, i.e. CSL-1, CSL-2 and CSL-3, purified from the *Cassia fistula* seeds and were tested for their antibacterial activities against different pathogenic bacteria [57]. 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 [29].

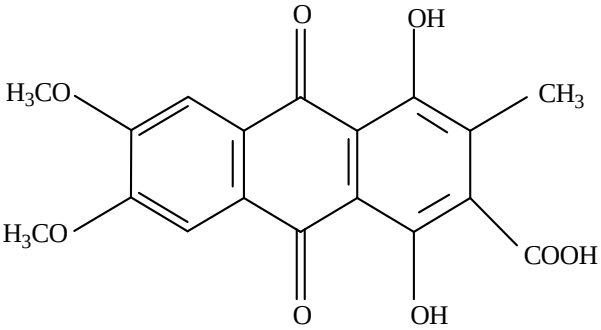
P. Sartorelli et al. (2007) examined the bioguided fractionation which resulted in the isolation of a sterol, clerosterol, which was further analysed in different models [30].

O. Tzakou et al. (2007) examined the chemical compositions of the flower and leaf essential oil of *Cassia fistula* by GC and GC/MS. 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%) [31].

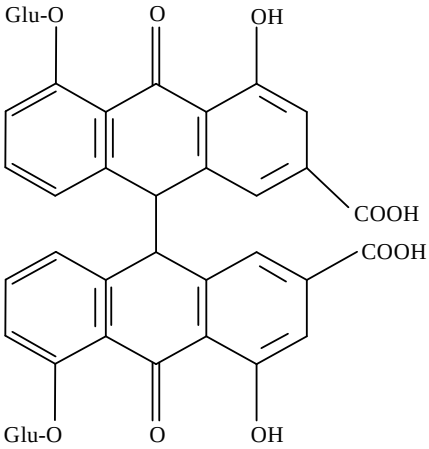
P. Sartorelli et al. (2009) discovered that the fractionation through bioguided antileishmanial activity of the dichloromethane extract of *Cassia fistula* fruits (Leguminosae) led to the isolation of the active isoflavone biochanin A, identified by spectroscopic methods [32].



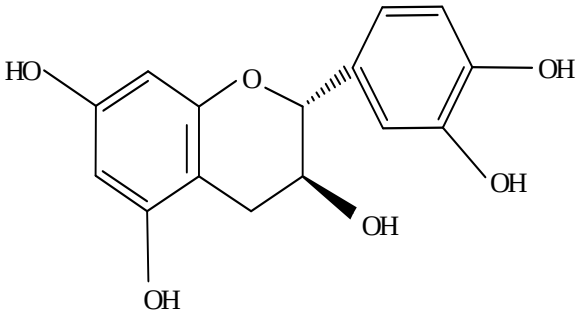
Rhein



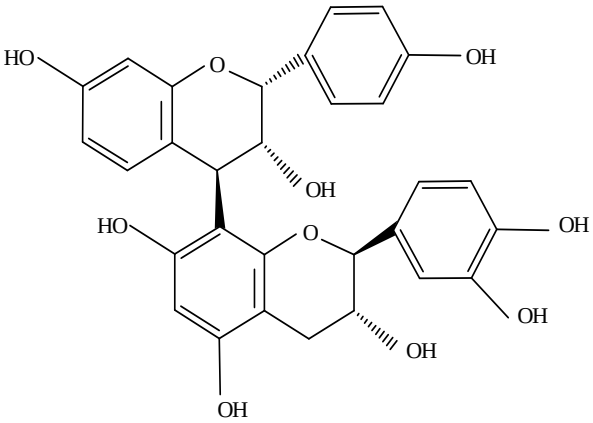
Fistulic Acid



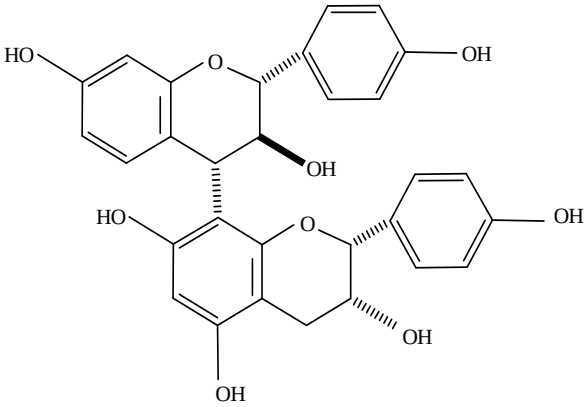
(+)-Catechin



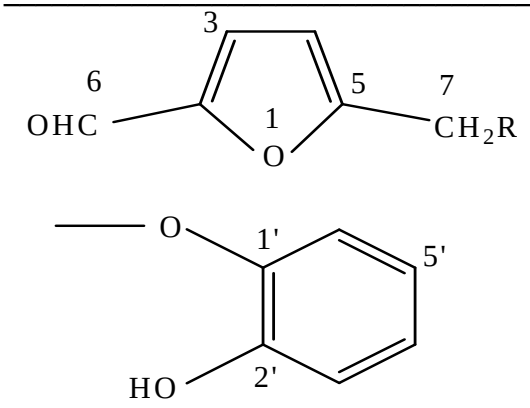
Sennoside A



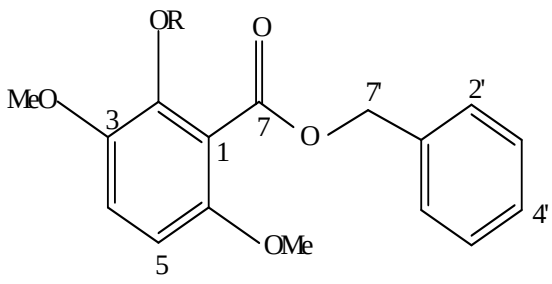
Epiafezelechin (4β→8)-ent-epicatechin



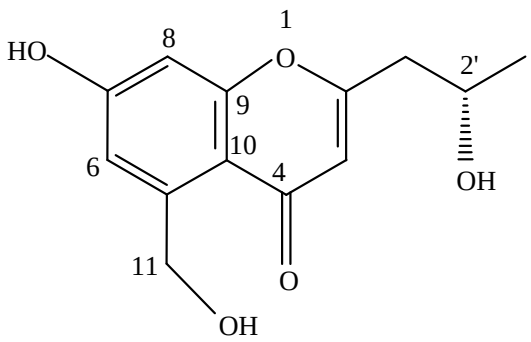
Proanthocyanidin CF1



R =R = H
5-(2-hydroxyphenoxymethyl) furfural



Benzyl 2-hydroxy-3, dimethoxybenzoate



(2'S)-7-hydroxy-5- hydroxymethyl-2-(2'-hydroxypropyl) chromone

Structures of some phytoconstituents isolated from *Cassia fistula*

Pharmacological activities

Antitussive activity

T. Bhakta et al. (1998) reported that the methanol extract of leaves of *C. fistula* (collected from India in 1995) 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 [33].

CNS activities

U. K. Mazumder 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 [34].

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 B_4 in bovine polymorphonuclear leukocytes (IC_{50} value of 38 micro g/ml). Lipid peroxidation in bovine brain phospholipid liposomes

induced with 2,2'-azo-bis-(2-amidinopropane) dihydrochloride (AAPH) was inhibited (IC_{50} of 40 micro g/ml). A linear correlation was obtained between the effects of the extract in the 2 assays suggesting a redox-based mechanism for the inhibition of the 5-lipoxygenase enzyme [35].

Clastogenic effect

M. J. Mukhopadhyay 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 source of sennosides [36].

Antipyretic activity

T. Bhakta 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 [37].

Antioxidant activity

P. Siddhuraju 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, O_2^- and DPPH radical scavenging ability [38].

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) [39].

G. Manonmani, 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 [40].

Laxative activity

M. A. Akanmu et 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 LD_{50} 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 [41].

Anti-inflammatory activity

T. Bhakta 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 [42].

Raju Ilavarasan et al. (2005) revealed the anti-inflammatory and antioxidant activities of the aqueous (CFA) and methanolic extracts (CFM) of the *Cassia fistula* bark were assayed in Wistar albino rats. The extracts were found to possess 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 in-vitro assay methods. Both extracts showed Dose-Dependent protective effect against lipid peroxidation and free radical generation in liver and kidney homogenates. Further, the acute toxicity study with the extracts showed no sign of toxicity up to a dose level of 2000 mg/po. Thus it could be concluded that *Cassia fistula* bark extracts (CFA & CFM) possess significant anti-inflammatory and anti oxidant properties [43].

R. Rajeswari et al. (2006) studied the anti inflammatory activity of aqueous and alcoholic extracts of *C. fistula* bark in sub acute models of inflammation in male albino rats. The extracts were administered at dose levels of 150, 300, 450 mg/kg body weight. The extracts were found to possess significant ($P<0.01$) anti inflammatory effect in both air pouch granuloma and cotton pellet granuloma models. Both the extracts (150 mg/kg body weight) showed a significant reduction in the biomarker enzymes like acid phosphatase, cathepsin-D and alkaline phosphatase in the serum. In conclusion, *C. fistula* bark extracts (150 mg/kg body weight) possess anti inflammatory activity as compared to the standard drug diclofenac (5 mg/kg body weight) [44].

Wound healing activity

T. Bhakta 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, epithelization period, tensile strength and regeneration of tissue at wound area [45].

M. S. Kumar 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, hypoglycemic, 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 [46].

Hepatoprotective activity

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. (500 mg/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 [47].

T. Bhakta 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 [48, 49].

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 [50].

V. Duraipandiyan 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) [51].

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 3 days 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 [52].

M. Govindarajan 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 LC_{50} 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* [53].

Antibacterial Activity

R. N. Yadav et al. (2003) isolated compound which showed antimicrobial activity against *Staphylococcus aureus, Bacillus subtilis, Klebsiella pneumoniae, Escherichia coli, Aspergillus niger* and *Fusarium oxysporum* [28].

M. A. Ali 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* [54].

P. Sundararaju 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* [55].

M. A. Ali 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 micro g/ml) followed by CSL-1 (10.47 micro g/ml) and CSL-3 (13.33 micro g/ml) [56].

T. R. Vimalraj 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 [57].

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 [58].

Antitumor activity

M. Gupta, 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. [59].

K. Vasudevan 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 [60].

Antiparasitic activity

P. Sartorelli 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 (EC_{50}) value of 18.96 micro g/mL against promastigotes of *Leishmania* (L.) *chagasi*. The cytotoxicity of this substance against peritoneal macrophages resulted in an EC_{50} value of 42.58 micro g/mL. Additionally, biochanin A presented an anti-*Trypanosoma-cruzi* activity, resulting in an EC_{50} value of 18.32 micro g/mL and a 2.4-fold more effectiveness than benznidazole [32].

Hypolipidemic activity

U. C. Gupta 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 [61].

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 [62].

Anti-leishmaniatic activity

P. Sartorelli 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% (IC_{50}) of 10.03 micro g/mL and intracellular amastigotes demonstrated high susceptibility, with an IC_{50} of 18.10 micro g/mL. Mammalian cytotoxicity was evaluated and it was demonstrated that clerosterol was 3.6-fold less toxic than the standard drug pentamidine [63].

F. Jaffary et al. (2008) evaluated the effectiveness of *Cassia 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 [64].

F. Jaffary 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 antimonate 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 [65].

CONCLUSION

Before the introduction of modern medicines, disease treatment was entirely managed by herbal remedies. It is estimated that about 80% of the world population residing in the vast rural areas of the developing and under developed countries still rely mainly on medicinal plants. It is quite obvious that the plant is widely used in traditional medicinal system of India and has been reported to possess hepatoprotective, anti-inflammatory, antitussive, antifungal and also used to check wounds healing and antibacterial properties. It is known as a rich source of tannins, flavanoids and glycosides present in *Cassia fistula* might be medicinally important and/or nutritionally valuable. The plant is rich in carbohydrates, Linoleic, Oleic, and Stearic. Leaf of *Cassia fistula* mainly contains Oxalic Acids, Tannins, Oxyanthraquinones, Anthraquinones Derivatives. Fruit of *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, 4-Hydroxy Benzoic Acids Hydrate have been reported from the plant. The present review summarizes some important pharmacological studies on *Cassia fistula* and phytochemical investigations and isolated principles from them, which can be investigated further to achieve lead molecules in the search of novel herbal drugs.

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REFERENCES

[1] Pallab Maity, Dhananjay Hansda, Uday Bandyopadhyay, Dipak Kumar Mishra, *Indian Journal of Experimental Biology*, **2009,** 47, 849-861.
[2] Chandra Prakash Kala, *Indian Journal of Traditional Knowledge*, **2006,** 5(4), 537-540.
[3] R. K. Gupta, *Medicinal & Aromatic plants*, CBS publishers & distributors, 1st edition, **2010**, 116-117.
[4] C. P. Khare. *Indian medicinal plants*, Springer, **2007**, 128.
[5] A. K. Gupta, N. Tondon, M. Sharma. *Quality Standards of Indian Medicinal Plants, Medicinal Plants Unit*, Published by Indian Council of Medical Research, Vol 2, **2008**, 47-53.
[6] Ayurvedic Pharmacopoeia of India, Part 1, Vol.5, New Delhi, Government of India Publication, **2001**. Page no. 8, 9.
[7] Kirtikar K.R., Basu B.D., *Indian Medicinal Plants*, International book distributors, **2006**, 2, 856-860.
[8] Indian Herbal Pharmacopoeia revised new edition, **2002**, Indian Drug Manufacturers Association Mumbai, page no.106-113.
[9] K. M. Nadkarni. *Indian Materia Medica*, Bombay Popular Prakashan, **2009,** Vol.1, 285, 286.
[10] R. N. Chopra, S. L. Nayar, I. C. Chpora. *Glossary of Indian Medicinal Plants*, National Institute of Science Communication and Information Resources, **2006**, page no. 54.
[11] Anonymous. *The Wealth of India, First Supplement Series (Raw Materials)*, National Institute of Science Communication and Information Resources, CSIR, **2007**, Vol 3 (Ca-Ci), 340-342.
[12] S. S. Agarwal, M. Paridhavi, *Clinically useful herbal drugs*, Ahuja Publishing House, **2005**, 281-282.
[13] Anonymous. *The Wealth of India, First Supplement Series (Raw Materials)*, National Institute of Science Communication and Information Resources, CSIR, **2007**, 1st supplementary series, Vol 1 (A-Ci), 223-224.
[14] Ben Erik, Van Wyk, Michael Wink, *Medicinal Plants of the World*, Briza Publications, **2009,** page no. 403.
[15] R. P. Rastogi, B. N. Mehrotra. *Compendium of Indian Medicinal plants*, Central Drug Research Institute, Lucknow and National Institute of Science Communication and Information Resources, New Delhi, **2004,** Vol 4, 155, 156.
[16] M. M. Vaishnava, A. K. Tripathi, K. R. Gupta, *Fitoterapia*, **1993**, 64(1), 93.
[17] Anonymous. *The Wealth of India, First Supplement Series (Raw Materials)*, National Institute of Science Communication and Information Resources, CSIR, **2007**, 2nd supplementary series, Vol 1 (A-F), 158.
[18] R. P. Rastogi, B. N. Mehrotra. *Compendium of Indian Medicinal plants*, Central Drug Research Institute, Lucknow and National Institute of Science Communication and Information Resources, New Delhi, **2004**, Vol 3, 140.
[19] V.K. Mahesh, Rashmi Sharma, R.S. Singh, *Journal of Natural Products*, **1984,** 47 (4), 733-751.
[20] N. N. Barthakur, N. P. Arnold, I. Alli, *Plant Foods for Human Nutrition*, **1995,** 47(1), 55-62.
[21] M. M. Vaishnav, K. R. Gupta, *Fitoterapia*, **1996**, 67(1), 78-79.
[22] T.N. Misra, R. S. Singh, H. S. Pandey, R. P. Pandey, *FitoterapiA*, **1996**, 67(2), 173-174.
[23] T. N. Misra, R. S. Singh, H. S. Pandey, B. K. Singh, *Fitoterapia*, **1997**, 68(4), 375-376.
[24] Meena Rani, S. B. Kalidhar, *Indian Journal of Chemistry. Section B, Organic including Medicinal*, **1998**, 37(12), 1314-1315.
[25] M. A. Sayeed, M. A. Ali, G. R. Khan, M. S. Rahman, *Bangladesh Journal of Scientific and*

Industrial Research, **1999**, 34(1), 144-148.
[26] Lee Ching Kuo, Lee Ping Hung, Kuo Yueh Hsiung, *Journal of the Chinese Chemical Society*, **2001**, 48(6A), 1053-1058.
[27] Yueh-Hsiung Kuo, Ping-Hung Lee, Yung-Shun Wein, *J. Nat. Prod*, **2002**, 65, 1165-1167.
[28] R. N. Yadava, Vikash Verma, *Journal of Asian Natural Products Research*, **2003**, 5(1), 57-61.
[29] M. A. Ali, M. A. Sayeed, A. Nurul, *Journal of the Chinese Chemical Society*, **2004**, 51(3), 647-654.
[30] P. Sartorelli, C. S. Carvalho, J. Q. Reimao, M. J. P. Ferreira, A. G. Tempone, *Phytotherapy Research*, 2007, 21(7), 644-647.
[31] O. Tzakou, A. Loukis, A. Said, *Journal of Essential Oil Research*, **2007**, 19(4), 360-361.
[32] P. Sartorelli, C. S. Carvalho, J. Q. Reimao, M. J. P. Ferreira, A. G. Tempone, *Parasitology Research*, 2009, 104(2), 311-314.
[33] T. Bhakta, P. K. Mukherjee, K. Saha, M. Pal, B. P. Saha, *Pharmaceutical Biology*, **1998**, 36(2), 140-143.
[34] U. K. Mazumder, Malaya Gupta, Nandita Rath, *Phytotherapy Research*, **1998,** 12(7), 520-522.
[35] K. C. S. Kumar, K. Muller, *Phytotherapy Research*, **1998,** 12(7), 526-528.
[36] M. J. Mukhopadhyay, A. Saha, A. Dutta, A. Mukherjee, *Food and Chemical Toxicology*, **1998**, 36, 937-940.
[37] T. Bhakta, S. C. Mandal, B. P. Sanghamitra Sinha Saha, M. Pal, *Journal of Medicinal and Aromatic Plant Sciences*, **2001**, 22/23(4A/1A), 70-72.
[38] P. Siddhuraju, P. S. Mohan, K. Becker, *Food Chemistry*, **2002**, 79(1), 61-67.
[39] Amitabye Luximon-Ramma, Theeshan Bahorun, Mohammed A. Soobrattee, Okezie I. Aruoma, *J. Agric. Food Chem.* **2002,** *50*, 5042-5047.
[40] G. Manonmania, V. Bhavapriyaa, S. Kalpanaa, S. Govindasamya, T. Apparanantham, *Journal of Ethnopharmacology*, **2005,** 97, 39–42.
[41] M. A. Akanmu, E. O. Iwalewa, A. A. Elujoba, K. A. Adelusola, *African Journal of Biomedical Research*, **2004**, 7(1), 23-26.
[42] T. Bhakta, P. K. Mukherjee, K. Saha, M. Pal, B. P. Saha, S. C. Mandal, *Journal of Herbs, Spices & Medicinal Plants*, **1999,** 6(4), 67-72.
[43] Raju Ilavarasan, Moni Mallika, Subramanian Venkataraman, African *Journal of Traditional, Complementary and Alternative Medicines*, **2005**, 2(1), 70-85.
[44] R. Rajeswari, P. Thejomoorthy, L. N. Mathuram, K. V. S. N. Raju, *Tamilnadu Journal of Veterinary and Animal Sciences***, 2006**, 2(5), 193-199.
[45] T. Bhakta, P. K. Mukherjee, K. Saha, M. Pal, B. P. Saha, *Natural Product Sciences*, **1998,** 4(2), 84-87.
[46] M. S. Kumar, H. V. Ramasamy Sripriya Raghavan, P. K. Sehgal, *Journal of Surgical Research*, **2006**, 131(2), 283-289.
[47] Kannampalli Pradeep, Chandrasekaran Victor Raj Mohan, Kuppannan Gobianand, Sivanesan Karthikeyan, *Chemico-Biological Interactions*, **2007**, 167, 12–18.
[48] T. Bhakta, S. Banerjee, S. C. Mandal, T. K. Maity, B. P. Saha, M. Pal, *Phytomedicine*, **2001,** 8(3), 220-224.
[49] T. Bhakta, P. K. Mukherjee, S. Banerjee, S. C. Mandal, T. K. Maity, M. Pal, B. P. Saha, *Journal of Ethnopharmacology*, **1999**, 66(3), 277-282.
[50] Padma Singh Pratima Karnwal, *Indian Journal of Microbiology*, **2006**, 46(2), 169-170.
[51] V. Duraipandiyan, S. Ignacimuthu, *Journal of Ethnopharmacology*, **2007**, 112(3), 590-594.
[52] Ashok Verma, G. K. Yadav, *Journal of Experimental Zoology*, **2003**, 6(2), 251-256.
[53] M. Govindarajan, A. Jebanesan, T. Pushpanathan, *Parasitology Research*, **2008**, 102(2),

289-292.
[54] M. A. Ali, M. A. Sayeed, M. S. A. Bhuiyan, F. I. Sohel, M. S. Yeasmin, *Journal of Medical Sciences(Pakistan)*, **2004,** 4(1), 24-29.
[55] P. Sundararaju, V. Saritha, *Indian Journal of Nematology*, **2006**, 36(1), 144-145.
[56] M. A. Ali, M. A. Sayeed, A. Nurul, *Journal of Medical Sciences (Pakistan)*, **2003**, 3(3), 240-244.
[57] T. R. Vimalraj, S. S. Kumar, S. Vadivel, S. Ramesh, P. Thejomoorthy, *Tamilnadu Journal of Veterinary and Animal Sciences*, **2009**, 5(3), 109-113.
[58] A. Nirmala, J. Eliza, M. Rajalakshmi, P. Edel, P. Daisy, *International Journal of Pharmacology*, **2008**, 4(4), 292-296.
[59] M. Gupta, U. K. Mazumder, N. Rath, D. K. Mukhopadhyay, Journal of Ethnopharmacology, **2000**, 72, 151–156.
[60] K. Vasudevan, S. Manoharan, L. M. Alias, S. Balakrishnan, L. Vellaichamy, M. Gitanjali, *International Journal of Chemical Sciences*, **2008**, 6(3), 1341-1354.
[61] U. C. Gupta, G. C. Jain, *Asian Journal of Experimental Sciences*, **2009**, 23(1), 241-248.
[62] Rajesh Yadav, G. C. Jain, *International Journal of PharmTech Research*, **2009**, 1(3), 438-444.
[63] P. Sartorelli, C. S. Carvalho, J. Q. Reimao, M. J. P. Ferreira, A. G. Tempone, *Phytotherapy Research*, 2007, 21(7), 644-647.
[64] F. Jaffary, S. Moradi, M. Nilfroushzadeh, R. Darakhshan, N. Ansari, *Iranian Journal of Dermatology*, **2006**, 9(3), 211-216.
[65] F. Jaffary, M. A. Nilforoushzadeh, N. Ansari, N. Rahimi, *Tehran University Medical Journal*, **2010**, 67(10), 705-711.