



**THERAPEUTICS, PHYTOCHEMISTRY AND PHARMACOLOGY OF *CASSIA FISTULA*
LINN: A REVIEW**

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ABSTRACT

The tree of *Cassia fistula* L. is a middle sized, erect tree, glabrous in its all parts. It is popularly known as golden shower Indian laburnum. It is cultivated as an ornamental tree for its attractive yellow blossoms in pendant racemes in many places of India. It is believed that it was introduced into Indian and European medicine through Arabs. The tree is found throughout India. It is also distributed in different parts of the world like Asia, Brazil, Mexico, East Africa and South Africa, Ceylon- Malaya, China and Burma. The different parts of the tree have various pharmacological activities viz laxative, antispasmodic, antipyretic, astringent, purgative, abortifacient, demulcent and emetic etc. The drug has been used in Unani Medicine (*Tibb-e-Unani*) and other Traditional Systems of Medicine since centuries. Keeping in view the medicinal importance of the drug, an attempt has been made in the present paper to review the available literature on traditional uses, phytochemistry and pharmacological properties of various parts of *Cassia fistula* plant.

KEYWORDS: Amaltas, *Cassia fistula*.

INTRODUCTION

Cassia fistula Linn (F-Caesalpinaceae), popularly known as golden shower Indian laburnum (Chauhan *et al.*, 2011), is a moderate sized handsome deciduous tree about 8-15 m high (Prajapati *et al.*, 2003). It is cultivated as an ornamental tree for its attractive yellow blossoms in pendant racemes in many places of India (Chatterjee & Pakrashi, 1992). The tree is occasional in the forests and roadsides, and an elegant in full bloom. The flowering occurs from March to June and fruits in most parts of the year (Anonymous, 1984). The tree has been known to Arabs for many centuries and it is believed that it was introduced into Indian and European medicine through them (Deshpande & Bhalsing, 2013). In Indian medicine, the *Cassia fistula* tree is used for constipation, flatulence, fever, anorexia, gout, jaundice, itching skin conditions (Anonymous, 2000). The different parts of the plant have various pharmacological activities viz laxative, antispasmodic, antipyretic, astringent, purgative, abortifacient, demulcent and emetic etc (Kirtikar & Basu, 1991).

The morphology of the tree has been described in detail in classical literature by certain Unani physicians. The plant called as *Amaltas* in Urdu, is a moderate sized tree with small stem. Leaves are grown in 4-8 pairs on its 1-1.5 feet long branches along with a one hand long raceme of yellow flowers are borne. 1-2 feet pods are

grown which ripe in winter. The pods are 1 inch in diameter, pointed, blackish brown in colour, very hard and intact. Internally it has numerous transverse chambers which contain a single, smooth and flat, oval brown coloured seed embedded in the pulp. The pulp is brownish black, sticky and nauseated in odour (Ghani, 2011). The pulp is used as a medicine (Ibn Baitar, 1985).

Distribution

The tree is found throughout India (Prajapati *et al.*, 2003; Kirtikar & Basu, 1991; Chatterjee & Pakrashi, 1992; Nadkarni, 1954; Chopra *et al.*, 1956; Anonymous, 1992; Chauhan *et al.*, 2011). It is distributed from Punjab to Sri Lanka (Anonymous, 1992) and central and eastern Himalayas (Hooker, 1973). In Maharashtra, it occurs as a scattered tree throughout Deccan and Konkan (Gupta, 2010). It is cultivated as an ornamental throughout India (Khare, 2007). It is also distributed in different parts of the world like Asia, Brazil, Mexico, East Africa and South Africa (Seyyednejad *et al.*, 2014; Chauhan *et al.*, 2011), Ceylon, Malaya, China (Kirtikar & Basu, 1991; Hooker, 1973) and Burma (Anonymous, 1992).

Vernaculars

The plant is known by different vernacular names in different language, areas and traditions: *Khayarshambar*, *Kathaulhind*, *Khiyarshambur* (Arabic); *Sonaru*, *Sunaru* (Assam); *Kritamala*, *Nripapaadapa*, *Aragvadha*,

Raajvraksha (Ayurvedic); *Amultas*, *Bundarlati*, *Sonalu*, *Sondal* (Bengali); *Gnookyee*, *Gnooshway* (Burma); *Kakkaemara* (Canarese); *A Po Le*, *Koui Hoa Ts'in* (Chinese); *Amaltas*, *Girmalah* (Deccan); Indian Laburnum, Pudding pipe tree, Purging cassia, Golden shower (English); *Garmala* (Gujrati); *Konna* (Malyalam); *Amaltas*, *Bandarlauri*, *Amulthus*, *Sonhali* (Hindi); *Bahava* (Maharashtra); *Khayarchambar* (Persian); *Aragvadha*, *Rajavraksha* (Sanskrit); *Konai*, *Irjviruttam*, *Konraikkai* (Tamil); *Kondrakayi*, *Aragvadamu*, *Koelapenna* (Telgu); *Amaltas*, *Khayarshambar* (Unani); *Amaltas* (Urdu) (Chatterjee & Pakrashi, 1992; Ghani, 2011; Khare, 2004; Kirtikar & Basu, 1991; Nadkarni, 1954; Prajapati *et al.*, 2003).

Ethnobotanical description

Tree: The tree of *Cassia fistula* L. is a middle sized, erect tree, glabrous in its all parts (Hooker, 1973). Height of the tree is 6-9 m (Kirtikar & Basu, 1991) and girth is 0.9- 1.2 m (Chatterjee & Pakrashi, 1992). The tree is deciduous, occasionally found in forests and planted on the roadside (Anonymous, 1984).

Trunk: Trunk is straight, hard, smooth and pale grey when young which becomes rough and dark brown when old (Kirtikar & Basu, 1991). It consists of hard reddish heavy wood (Chauhan *et al.*, 2011).

Bark: The tree has smooth greenish grey bark when young and rough when old, exfoliating in hard scales (Prajapati *et al.*, 2003) and dark brown (Anonymous, 2000).

Leaves: Leaves are 20-40 cm long (Anonymous, 2000), main rachis pubescent, stipules minute, linear- oblong, obtuse and pubescent (Kirtikar & Basu, 1991), 4- to 8-paired (Anonymous, 2000), pinnately compound (Prajapati *et al.*, 2003), composed of large leaflets (Kurian, 1998).

Leaflets: Leaflets are in 4-8 pairs, ovate, acute (Anonymous, 2000; Prajapati *et al.*, 2003), 5-12.5 cm long & 3.8-9.5 cm broad (Kirtikar & Basu, 1991) bright green coloured, above glabrous and paler, below silvery-pubescent when young having numerous main nerves (Prajapati *et al.*, 2003; Kirtikar & Basu, 1991). Base is cuneate (Kirtikar & Basu, 1991, Anonymous, 2000), coriaceous, pubescent when young (Anonymous, 1984), conspicuous beneath and close, petiolules are 6-10 mm long, pubescent or glabrous (Kirtikar & Basu, 1991).

Flowers: Flowers are borne in lax pendulous racemes (Chatterjee & Pakrashi, 1992; Prajapati *et al.*, 2003; Hooker, 1973) 30- 50 cm long (Anonymous, 2000; Kirtikar & Basu, 1991), yellow (Anonymous, 1992) and fragrant (Chatterjee & Pakrashi, 1992). The petals are 5 (Anonymous, 2000), subequal, veined, obovate, shortly clawed (Kirtikar & Basu, 1991; Anonymous, 1992) and 3/4-1 inch deep (Hooker, 1973). The diameter of corolla is approximately 3.8 cm (Anonymous, 2000; Kirtikar &

Basu, 1991). The calyx measures about 1/4-1/3 inches, glabrous, caduceus (Hooker, 1973), pubescent and divided to the base; segments are oblong and obtuse. All stamens bear anthers of which those of the lowest 3 are the longest with very long curved filaments and oblong anthers dehiscing longitudinally, the 4 lateral with short straight filaments and versatile anthers opening by pores at the base, the remaining 3 much smaller, erect with indehiscent anthers (Kirtikar & Basu, 1991).

Fruits: Fruits are cylindrical pods (Chatterjee & Pakrashi, 1992), 30-60 cm long (Prajapati *et al.*, 2003), 2-2.5 cm in diameter (Kirtikar & Basu, 1991; Anonymous, 1992), brownish black, nearly straight, smooth, shiny (Prajapati *et al.*, 2003; Kirtikar & Basu, 1991; Anonymous, 1992), pendulous and indehiscent (Chatterjee & Pakrashi, 1992) with 40-100 horizontal seeds immersed in a dark coloured sweetish pulp and separated by transverse dissepiments (Kirtikar & Basu, 1991; Anonymous, 1992).

Pulp: Pulp is black (Chatterjee & Pakrashi, 1992; Anonymous, 1992), or dark coloured sweetish (Prajapati *et al.*, 2003; Kirtikar & Basu, 1991).

Seeds: The seeds are numerous, small, flat smooth, yellowish grey (Chatterjee & Pakrashi, 1992) and broadly ovate horizontally immersed in dark sweetish pulp (Prajapati *et al.*, 2003). Seeds measure about 8 mm long, slightly less in breadth and 5 mm thick (Kirtikar & Basu, 1991).

Mizaj (Temperament)

Some Unani physicians described the temperament of *Amaltas* as Hot and Wet. While the others categorized *Post Amaltas* as Hot and Dry in second degree (Kabiruddin, YNM).

Afa'al (Actions)

In classical Unani literature, various actions of the drug *Amaltas* (*Cassia fistula*) have been described in details. *Amaltas* is *mushil* (Ghani, 2011; Ibn Baitar, 1985; Jurjani, 2010; Shamsuddin, 1314H; Bakhsh, 1316H) and *mushil-e-akhlat-e-salasa* (purgative of three humours) (Khan, 1331H; Husain, 1285H; Kabiruddin, YNM). It possesses *mulayin* (Khan, 1331H; Ibn Sina, 1992; Jurjani, 2010) and *mulayin-e-sadr* (Ibn Baitar, 1985; Kabiruddin, YNM) *wa taba* (Husain, 1285H; Shamsuddin, 1314H; Bakhsh, 1316H) properties. It also acts as *mohallil-e-awram* (Ghani, 2011; Kabiruddin, YNM; Khan, 1331H; Ibn Sina, 1992; Jurjani, 2010), *mohallil-e-awram-e haarra dahan wa halaque wa ahsha* (Shamsuddin, 1314H) and *musakkin hiddat-e-khoon*, *munaqqi-e-asab* (Husain, 1285H; Bakhsh, 1316H). It also possesses *dafe dard* (Ghani, 2011), *mukhrij-e-safra*, *dafe tap* (Khan, 1313H), *mufatteh sudad-e-amaa wa jigar* (Husain, 1285H), *munaqqi-e-jigar* (Ibn Baitar, 1985), and *rade* (Nabi, 1920) properties. Its gargle with *a'ab-e-kishneez taza* is *rade khunaque* (Khan, 1331H; Husain, 1285H). *Post-e-Amaltas* is *mudir-e-bol wa haiz*

(Nabi, 1920), *musqit* (Anonymus, 1992) and *mukhrij-e-janeen wa masheema* (Kabiruddin, YNM). The flowers of the tree are *mulaiyan*, *badi*, *qabiz* and *dafe safra wa balgham* (Ghani, 2011).

Istemat (Uses)

Amaltas has been described to be useful in various diseases. The pulp of its pod is useful in *tap*, *qoolanj* (Jurjani, 2010), *yarqan* (Khan, 1331H; Baghdadi, 2005; Husain, 1285H; Ibn Baitar, 1985; Ibn Sina, 1992), *khushunat-e-seena*, *dama*, *josh-e-khoon*, *pechish* and *marod* (Ghani, 2011). Its paste is efficacious in *awram* (Khan, 1331H), *niqras*, *wajaul mafasil* (Baghdadi, 2005; Ibn Sina, 1992; Jurjani, 2010) and *daad* (Ghani, 2011; Husain, 1285H; Ibn Baitar, 1985). It removes *sudda-e-jigar wa ama'a* and relieves *dard-e-jigar* (Baghdadi, 2005; Ghani, 2011; Husain, 1285H; Ibn Sina, 1992; Khan, 1331H). It is very beneficial for *dard-e-sar*, *shaqueeqa*, *ezm-e-khusyatain*, *riyah-e-qoolanj* and stagnation of urine when used internally. The gargle of its decoction is efficacious in *dard-e-halaque* (Baghdadi, 2005), *khunaque* (Khan, 1331H; Jurjani, 2010; Nabi, 1920) and *awram-e-halaque* (Ghani, 2011; Husain, 1285H; Ibn Sina, 1992; Ibn Baitar, 1985). The swallowing of pulp is also beneficial in *zabha* (Ghani, 2011). It resolves *awarm-e-ahsha* (Baghdadi, 2005; Ghani, 2011; Ibn Baitar, 1985), *salabat* (Khan, 1331H; Bakhsh, 1316H; Husain, 1268H) and heals internal wounds. Its application around the umbilicus of children is useful in *nafakh* and *dard-e-riyahi* (Ghani, 2011). It reduces *hararat-e-khoon* (Ibn Baitar, 1985). It cleanses stomach and intestine from *safra* and other *ratoobat* (Jurjani, 2010), and expels *balgham* and *mirra mohtariqa* (Ibn Sina, 1992).

Post-e-Amaltas (rind of pod) is useful in *usr-e-wiladat* and *ikhraj-e-masheema* when taken with saffron, sugar and rose (Ghani, 2011; Husain, 1268H; Bakhsh, 1316H). Its decoction is very useful for smooth delivery of foetus. The seeds are used to remove *reeh*. The *gulqand* of flowers is useful in *qabz* (constipation) and *bukhar* (fever). It removes *safra* and *balgham*. Application of leaves is used in skin diseases, furuncles of nose, *daad*, *kharish-e-tar wa khushk*, *juzam*, *gathiya* skin numbness and paralysis. The cooked leaves remove *qabz*, *dauran-e-sar* and *ghabrahat*. Decoction of leaves is taken in diseases of forehead, *sailan-e-uzn* and syphilis (Ghani, 2011). The leaves also used to resolve warm (Nabi, 1920).

Application of bark removes skin diseases and small furuncles of nose. The root is ground and applied locally to resolve warm and boils, and also applied or inhaled in gandmala. The decoction of root is responsible for forceful purgation (Ghani, 2011).

Pharmacological Actions

(As described in ethnobotanical and traditional literature)

The drug *Amaltas* (*Cassia fistula* Linn.) is described in detail in ethnobotanical and scientific literature and various actions have been reported to possess by it. Some pharmacological actions and therapeutic uses are as follows.

The flowers are cooling, emollient, expectorant, demulscient (Prajapati *et al.*, 2003), purgative, astringent, febrifugal and anti-bilious (Khare, 2007). The fruit is cathartic (Nadkarni, 1954; Chopra *et al.*, 1956), emollient, anodyne, anti-inflammatory, depurative, diuretic, cooling, purgative, antipyretic, abortifacient (Prajapati *et al.*, 2003) and demulscient (Kirtikar & Basu, 1991). The pods are purgative, febrifugal, astringent, anti-bilious (Khare, 2007), laxative and tonic (Chatterjee & Pakrashi, 1992).

A confection made up of the pulp free from seeds with equal quantity of sugar was administered to adults and was found to possess satisfactory action as a purgative. It did not cause any irritation or discomfort to the patients (Kirtikar & Basu, 1991). Pulp of pods is an agreeable laxative safe for children and pregnant women. The pulp of ripe pod mixed with tamarind pulp taken at bed time acts on the bowels mildly causing one or two soft motions the following morning (Nadkarni, 1954). The green fruit pulp is cathartic (Agarwal, 1986). The seeds are emetic (Agarwal, 1986), laxative (Anonymous, 1984; Chatterjee & Pakrashi, 1992; Khare, 2007; Kirtikar & Basu, 1991; Chopra *et al.*, 1956) and purgative (Nadkarni, 1954). It also acts as carminative (Kirtikar & Basu, 1991), cooling, antipyretic (Khare, 2007) and tonic (Chatterjee & Pakrashi, 1992). The leaves possess laxative (Anonymous, 1984; Chopra *et al.*, 1956), tonic (Chatterjee & Pakrashi, 1992), antiperiodic (Kirtikar & Basu, 1991), depurative (Prajapati *et al.*, 2003) and purgative properties (Nadkarni, 1954). The root is tonic, febrifuge (Kirtikar & Basu, 1991), purgative (Nadkarni, 1954), astringent (Chopra *et al.*, 1956), cooling (Prajapati *et al.*, 2003) and laxative (Anonymous, 1984). The bark is laxative, anthelmintic, emetic, febrifuge, diuretic and depurative (Prajapati *et al.*, 2003). The root bark is purgative (Nadkarni, 1954), laxative (Chopra *et al.*, 1956) and tonic (Chatterjee & Pakrashi, 1992). The stem bark aqueous extract is given internally as laxative (Anonymous, 2004).

Therapeutic Uses

The root is useful in skin diseases, leprosy, tuberculous glands syphilis, burning sensation (Kirtikar & Basu, 1991; Prajapati *et al.*, 2003), chest pain, joint pain, migraine, dysentery (Anonymous, 2004), fever, heart-diseases, retained excretions and biliousness etc. (Nadkarni, 1954).

The leaves are beneficial for ulcers (Kirtikar & Basu, 1991; Prajapati *et al.*, 2003), rheumatism and facial

paralysis when rubbed externally on affected parts. It is useful in chilblains in the form of poultice, ringworms in the form of paste as well as juice (Kirtikar & Basu, 1991; Nadkarni, 1954). The leaves are also efficacious in erysipelas, inflammation, paralysis, brain affections (Kirtikar & Basu, 1991) and skin diseases in the form of leaf juice (Chopra *et al.*, 1956; Agarwal, 1986; Anonymous, 1984; Prajapati *et al.*, 2003). It is also useful in intermittent fevers (Prajapati *et al.*, 2003), swelling (Anonymous, 2004), pustules and insect bites externally (Nadkarni, 1954).

The buds improve taste and cures biliousness, skin diseases, leprosy. The flowers are used in biliousness (Kirtikar & Basu, 1991), skin diseases, pruritus, burning sensation, dry cough and bronchitis (Prajapati *et al.*, 2003). The decoction of flowers is used in stomach affections (Nadkarni, 1954).

The fruit is useful in rheumatism (Anonymous, 1984; Chopra *et al.*, 1956; Nadkarni, 1954), inflammations, eye diseases, liver complaints, cardiac disorders, leprosy (Kirtikar & Basu, 1991), skin diseases, pruritus, burning sensation, flatulence, anorexia, intermittent fever, strangury, general debility (Prajapati *et al.*, 2003). They are also useful in snake-bite (Chopra *et al.*, 1956), gout (Prajapati *et al.*, 2003), diabetes (Anonymous, 2004; Nadkarni, 1954), colic (Prajapati *et al.*, 2003; Khare, 2007), abdominal pains, chest complaints, throat troubles and griping. It decreases heat of the body (Kirtikar & Basu, 1991). The fruit pulp is used in constipation (Anonymous, 2004; Khare, 2007), dysentery, tonsillitis, boils (Anonymous, 2004), chlorosis and urinary disorders (Khare, 2007). Pulp from green fruit is given in blood purification (Agarwal, 1986). It is applied round the pavel to produce motions in the flatulent colic of children (Nadkarni, 1954).

The seeds improve appetite and used to cure biliousness (Kirtikar & Basu, 1991). The seeds powder is used in amoebiasis (Khare, 2007) and powder of 5-7 seeds is prescribed as an emetic (Nadkarni, 1954).

The bark is given in dysentery (Kirtikar & Basu, 1991), glandular swellings (Anonymous, 1984), boils, pustules, leprosy, ringworm, colic, dyspepsia, fever, constipation, diabetes, stangury and cardiopathy (Prajapati *et al.*, 2003). The stem bark is used against amenorrhoea, chest pain and swelling (Anonymous, 2004). The wood is given in dysentery (Kirtikar & Basu, 1991).

Rhodesian natives use the plant as a remedy for malaria, blackwater fever, blood poisoning, anthrax and dysenteries (Kirtikar & Basu, 1991). The tree is used for flatulence, constipation, fever, anorexia, gout, jaundice, itching and skin conditions (Anonymous, 2000). It is good in liver diseases and intestinal ulceration. Externally, it is used as a paste to resolve, as gargle and is useful in chest diseases of children (Nadkarni, 1954).

Adverse Effects

It has adverse effect on stomach and produces nausea, vomiting and dysentery (Ghani, 2011; Shamsuddin, 1314H). No health hazards are known in conjunction with the proper administration of designated therapeutic dosage. The increase in probability of colon carcinoma following long-term administration of anthracene drugs has not yet been fully clarified. However, the recent studies have shown no connection between administration of anthracene drugs and frequency of colon carcinoma (Anonymous, 2000).

Phytochemistry

Root: The roots contain 7-methylphyscion betulinic acid and β - sitosterol (Anonymous, 2004); root bark contains phlobaphenes and oxy- anthraquinone substance with tannins (Chopra *et al.*, 1956).

Bark: The bark contains barbaloin, fistucacidin, an optically inactive leucoanthocyanidin, 3,4,7,8,4'-pentahydroxyflavan and rhein. Besides tannins stem bark contains lupeol, β - sitosterol, and hexacosanol (Chatterjee & Pakrashi, 1992). The stem bark contains two flavonol glycosides, 5,7,3',4' -tetrahydroxy-6,8-dimethoxyflavone-3-O- α -arabinopyranoside (C₂₂H₂₂O₁₃, m p 285°), 5,7,4'-trihydroxy-6,8,3'-trimethoxyflavon-3-O- α -L-rhamnosyl (1 \rightarrow 2)-O- β -D-glucopyranoside (C₃₀H₃₆O₁₈, m p 210°) and a xanthone glycoside, 1,8-dihydroxy-3,7-dimethoxyxanthone-4-O- α -L-rhamnosyl (1 \rightarrow 2)-O- β -D-glucopyranoside (C₂₇H₃₂O₁₆, m p 217°) (Anonymous, 2004). The bark has (+)-catechin, epicatechin, kaempferol, fistacacidin, leucocyanidin, leucopelargonidin trimer, rhein glycoside, hexacosanol, lupeol and beta-sitosterol (Khare, 2004). Fistucacidin is a component of stem bark (Chopra *et al.*, 2005).

Leaves: New leaves have highest sennoside contents. The cuticular wax of leaves contains hentriacontanoic, triacontanoic, nonacosanoic and heptacosanoic acids (Anonymous, 2004). The leaves gave free rhein, its glycosides, sennosides A and B (Khare, 2004; Chatterjee & Pakrashi, 1992). Leaves contain anthraquinone derivatives and very little tannin (Chopra *et al.*, 1956). Sennosides A and B are derived from leaves (Chopra *et al.*, 2005). The leaves contain anthraquinone glycosides (Sakulpanich & Gritsanapan, 2009).

Flowers: Flowers contain ceryl alcohol, kaempferol, rhein and a bianthraquinone glycoside and fistulin and also leucopelargonidin tetramer having a free glycol unit (Khare, 2004). Ceryl alcohol, fistulin, leucopelargonidin tetramer, kaempferol, rhein and a new dianthraquinone glucoside occur in the flowers (Chatterjee & Pakrashi, 1992).

Pods: The pods contain procyanidin B-2, epicatechin-(4 β \rightarrow 8)-*ent*-epicatechin, epiafzelechin-(4 β \rightarrow 8)-epiafzelechin, epiafzelechin-(4 β \rightarrow 8)-*ent*- epiafzelechin, epicatechin-(4 β \rightarrow 8)- epiafzelechin and epicatechin-(4 β \rightarrow 8)-*ent*- epiafzelechin and their enantiomers. The

highest percentage of sennoside in pods is recorded at the mid stage of fruit maturation when the pods are pale brown in colour (Anonymous, 2004). The crushed ripe pod pulp is rich in protein (19.94 %) and carbohydrates (26.3%). They contain sennosides A and B, rhein and its glucoside, barbaloin, aloin, formic acid, butyric acid, their ethyl esters and oxalic acids. It is also reported that pectin, tannin, maltose, glucose, fructose, sucrose and a small quantity of volatile oil is also present (Khare, 2004). The finely powdered fruit (pod) give a dark yellow volatile oil with honey like odour on steam distillation. Water which distils over with the oil contains normal butyric acid (Nadkarni, 1954).

Pulp: Arginine, leucine, methionine, phenylalanine, tryptophan, aspartic and glutamic acids are isolated from fruit pulp. A new dimeric proanthocyanidin CFI isolated along with (-) epiafzelechin, (+) catechin, kaempferol, dihydrokaempferol and 1,8-dihydroxy-3-methylanthraquinone (Rastogi & Mehrotra, 1993). The crushed ripe pod pulp is rich in protein (19.94 %) and carbohydrates (26.3%). They contain sennosides A and B, rhein and its glucoside, barbaloin, aloin, formic acid, butyric acid, their ethyl esters and oxalic acids. It is also reported that pectin, tannin, maltose, glucose, fructose, sucrose and a small quantity of volatile oil is also present (Khare, 2004). pulp contains rhein, the major anthraquinone derivative, small amount of volatile oil, three waxy substances and a resinous substance (Chopra *et al.*, 1956). Sugar, gum astringent matter, gluten, colouring matter and water also found in pulp (Nadkarni, 1954). Resins, essential oil etc. are extracted from the pulp (Chopra *et al.*, 2005).

Seeds: Sugar and galactomannan have been isolated from the seeds. Seven new biflavanoids and two triflavanoids besides clitorin, chrysophanic acid, emodin, epicatechin, (-)-epiafzelechin and its 3-O-glucoside, kaempferol-3 β -glucoside, kaempferol-3-neohesperidoside, phlobaphene and procyanidin have also been reported (Chatterjee & Pakrashi, 1992). The compounds cyclopropanoid fatty acids, viz. vernolic, malvalic and sterculic acids are reported in the seed oil. Two anthraquinones, chrysophanol and physcion have been isolated from the callus cultures (Anonymous, 2004). Fatty oil, sterols including beta-sitosterol also present in the seeds (Anonymous, 2000).

Pharmacological Studies

A number of studies have been carried out on *Cassia fistula* in recent years showing that it possesses diverse pharmacological effects. Some of the important pharmacological effects are as follows.

Analgesic

The analgesic activity of *Cassia fistula* methyl alcohol extract was studied by thermal, mechanical and writhing methods. As compared to potent inhibitory activity of morphine and aspirin, the analgesic activity of extract was moderate against acute inflammatory pain. The

findings validate the therapeutic use of this drug in analgesia (Sheikh *et al.*, 2010).

Antibacterial

The ethanolic and methanolic extracts of *Cassia fistula* exhibited antibacterial activity against three gram positive species including *S. aureus*, *S. epidermidis* and *B. cereus* and two Gram negative bacterias including *E. coli* and *K. pneumoniae* (Sayyednejad *et al.*, 2014).

Anti-cancer

Cassia fistula pulp and seed extracts contained anticancer compounds and inhibited the proliferation of cervical and breast cancer cells by inducing the apoptosis. MTT and LDH assays confirmed the cytotoxic activity whereas inhibition of colony formation proved the growth inhibitory effect of *C. fistula* pulp and seeds. Modulation of apoptosis regulatory genes, caspase enzymes activity and fragmentation of genomic DNA is suggesting the pulp and seed extracts induced apoptosis and can be successfully exploited in the herbal formulation of cancer chemoprevention and chemotherapy (Irshad *et al.*, 2014).

Anticonvulsant

A study revealed significant anti-convulsant activity of methanolic extract of *Cassia fistula* seeds pentylenetetrazol induced convulsions in mice. The extract significantly delayed the onset and antagonized the PTZ induced seizures. Thus it is suggested that the methanolic extract of seeds of *Cassia fistula* may be effective against human generalized myoclonic seizures (Swadadkar *et al.*, 2014).

Antidiabetic

The methanolic and aqueous extracts of all parts of *Cassia fistula* were investigated for the hypoglycemic effect in both normoglycemic and streptozotocin-nicotinamide induced Type 2 diabetic rats. Different extracts of *Cassia* were administered to diabetic rats at 250 and 500mg/kg doses for 21 days. The methanolic extracts of bark and leaves were more effective in causing hypoglycemia in normoglycemic rats. After oral administration of the bark and leaf methanolic extracts showed increased levels of glycosylated haemoglobin and reduced levels of plasma insulin, were reverted to significantly near normal (Einstein *et al.*, 2013).

Antifertility

A study reported that oral administration of aqueous extract of *Cassia fistula* seeds at doses of 100 and 200 mg/kg of body weight to mated female rats from day 1-5 of pregnancy resulted in 57.14% and 71.43% prevention of pregnancy respectively, whereas 100% pregnancy inhibition was seen at 500mg/kg bw (Yadav & Jain, 1999).

The ethanolic extract of *Cassia fistula* leaf showed significant antifertility effect on the fertile male albino rats. The sperm count was significantly decreased;

similarly the sperm vitality and sperm motility were also decreased (Priya *et al.*, 2012).

Antifungal

The hydroalcoholic and chloroform extracts of *C. fistula* were studied against three fungal strains including *A. niger*, *A. clavatus* and *C. albicans*. As compared with standard drug, the results revealed that in both extracts for fungal activity *C. albicans* showed good result as compared to *A. niger* and *A. clavatus* (Bhalodia *et al.*, 2011).

Cassia fistula showed anticandidal activity against three candida organisms' namely *C. albicans*, *C. glabrata* and *C. tropicalis*. The fruit pulp and seed extracts were compared. It was concluded that the crude extract has a promising source of anticandidal compounds. The anthraquinone and rhein actively present in both extracts may possess anticandidal property (Irshad *et al.*, 2011).

Anti-inflammatory

In a study, the aqueous and methanolic extracts of *Cassia fistula* bark exhibited significant anti-inflammatory activity in both acute and chronic models. The anti-inflammatory effect was evaluated by carrageenan induced paw oedema and cotton pellet induced granuloma in albino rats (Ilavarasan *et al.*, 2005).

Antimicrobial

The methanolic extract of *Cassia fistula* legumes was found to be effective against all pathogenic bacteria under test by disc diffusion assay. Antimicrobial activity was performed in two gram positive (*S. aureus* and *S. epidermidis*) and two gram negative (*E. coli* and *K. pneumonia*) bacteria (Chauhan *et al.*, 2011).

Antinociceptive

The anti-nociceptive activity of ethyl-acetate fraction of *Cassia fistula* pods was evaluated using acetic acid induced writhing model, hot plate test, tail immersion test and formalin induced paw licking model. The study concluded that *Cassia fistula* L. pod has central and peripheral anti-nociceptive potential and justified traditional use of this plant for treating different painful conditions (Sarvanan *et al.*, 2014).

Antioxidant

A study showed that the aqueous and methanolic extracts of *Cassia fistula* bark exhibited significant antioxidant activity in DPPH, Nitric oxide and Hydroxyl radical induced *In Vitro* assay method. Both extracts showed dose-dependent protective effect against lipid peroxidation and free radical generation in liver and kidney homogenates (Ilavarasan *et al.*, 2005).

Antileishmanial

A study was designed to evaluate the antileishmanial activity of crude extract and fractions from the fruits of *Cassia fistula*. Hexane extract from the fruits showed significant antileishmanial activity against the

promastigote form of *Leishmania L. chagasi* (Sartorelli *et al.*, 2007).

Antipsoriatic

Cassia fistula fruit extract containing herbal cream showed good activity in the psoriasis like skin mouse model by exposing antiproliferant activity, reducing epidermal thickness and including orthokeratosis. At a dose of 6.25% (w/w) fruit extract, psoriasisiform was ameliorated well without dermal irritation (Tram & Son, 2015).

Antipyretic

In an experimental study it has been revealed that methanolic extract of powdered pods of *Cassia fistula* exhibits a marked antipyretic effect in yeast induced pyrexia in rats. Methanolic extract at the dose of 500 mg/kg showed the same effect as paracetamol at dose of 20 mg/kg i. p. (Singh *et al.*, 2012).

Antitumour

A study was carried out to evaluate the methanolic extract of *Cassia fistula* seed on the growth of Ehrlich ascites carcinoma (EAC) and on the life span of tumour bearing mice. Methanolic extract treatment showed an increase of life span and decrease in tumour volume and viable tumour cell count in the EAC tumour hosts. A reduction in the mitotic activity and the appearance of membrane blebbing and intracytoplasmic vacuole are revealed in the treated tumour cells from cytological studies. The hematological parameters like Hb content, RBC count and bone marrow cell count of the tumour bearing mice have also been improved after treatment (Gupta *et al.*, 2000)

Anthelmintic

In a study it has been observed that methanolic extract of *Cassia fistula* fruit pulp and seeds showed significant anthelmintic activity against *Pheretima posthuma* earthworm. The extract paralyzed and killed the worms in a very short time at dose of 100 mg/ml (Irshad *et al.*, 2010).

Central Nervous System

The result of a study exhibited that the methanol extract of the seeds of *Cassia fistula* significantly potentiated the sedative actions of sodium pentobarbitone, diazepam, meprobamate and chlorpromazine and was also found to potentiate significantly the analgesia induced by morphine and pethidine in a dose dependent manner. It also exhibited a depressant action evident from the behavioral studies of mice (Mazumder *et al.*, 1998).

Hepatoprotective

A study revealed that the methanolic extract of *Cassia fistula* seeds possess hepatoprotective activity in paracetamol induced hepatotoxicity in rats. The extract showed significant reduction in the elevated levels of SGOT, SGPT, SALP and serum bilirubin as compared to Liv-52 used as standard drug (Chaudhari *et al.*, 2009).

In an experimental study it has been observed that ethanolic extract of *Cassia fistula* bark also significantly decreased AST, ALT, ALP, triglycerides, bilirubin and protein levels in the doses of 200 and 400 mg/kg showing hepatoprotective activity against CCl₄ induced hepatic damage in Wistar rats (Patwardhan *et al.*, 2009).

Hypoglycemic

It has been concluded in a study that alcoholic extract of the root of *Cassia fistula* lowered the blood sugar level up to 30% after 2 hours when tested on fasted albino rats. The powder or decoction of fruit also showed hypoglycemic effect and used in treatment of diabetes (Anonymous, 2004).

Hypolipidemic

A study was carried out to evaluate the hypolipidemic activity of 50% ethanolic extract of *Cassia fistula* legume on serum lipid metabolism in cholesterol fed rats. The rise in values of serum total and LDL-cholesterol, triglycerides and phospholipid was significantly prevented after administration of *C. fistula* legume extract at doses of 100, 250 and 500 mg/kg /day along with cholesterol in a dose dependent manner (Gupta & Jain, 2009).

Immunomodulatory

In a study the *Cassia fistula* extract showed a significant stimulation of cell mediated immunity and no effect on humoral immunity. *Cassia fistula* was administered orally at doses of 100 and 200 mg/kg to healthy rats divided into five groups six in each. The assessment of immunomodulatory activity was carried out by testing the humoral (antibody titre) and cellular (foot pad swelling) immune, responses to antigenic challenge by sheep RBCs and by neutrophil adhesion test. *Cassia fistula* significantly potentiated the cellular immunity by facilitating the foot pad thickness responses to the sheep RBCs in sensitized rats with a dose of 100 and 200mg/kg the DTH response (Jadhav, 2014).

Larvicidal

In a study the compound rhein isolate from *Cassia fistula* exhibited larvicidal activity of 67.5% against *h. armigera* with LC₅₀ value of 606.5ppm and 36.25% against *S. litura* with the LC₅₀ value of 1192.55 ppm. The larvae after treatment with compound rhein showed

malformation and mortality in larval, pupal and adult stages (Ignacimuthu *et al.*, 2011).

Laxative

A study determined the total anthraquinone glycoside content in leaves of *Cassia fistula* which is the active laxative form. The content of total anthraquinone glycosides in the decoction leaf extracts were 0.62-2.01% dry weight (average 1.52% dry weight) while in the dried leaves were 0.09-0.63% w/w (average 0.36% w/w) calculated as rhein. The decoction extract of the leaves containing an average total anthraquinone glycosides can be used as an alternative source of raw material for different laxative preparations (Sakulpanich & Gritsanapan, 2009).

Nephroprotective

The hydro-alcoholic extract of the *Cassia fistula* fruit showed significant nephroprotective effect on bromobenzene induced nephro toxicity in mice. Negative control mice received normal saline; positive control mice were given 460 mg/kg of bromobenzene; *Cassia fistula* treated mice received 200, 400, 600 and 800 mg/kg of *Cassia fistula* fruit extract followed by 460 mg/kg bromobenzene (daily by oral gavage for 10 days). On the 11th day, the mice were sacrificed, blood samples were obtained to assess blood urea nitrogen (BUN) and creatinine levels, and kidneys were removed for histological examination (Kalantri *et al.*, 2011).

Skin diseases

The efficacy of *Cassia fistula* decoction was evaluated by purgation therapy in different skin diseases. The decoction of *Cassia fistula* fruit was given for producing purgation in fifty subjects suffering from skin diseases due to vitiated pitta dosha. The result showed that the *Cassia fistula* is having significant effect in ameliorating the skin diseases due to pitta origin and is safe drug of choice for purgation therapy (Chaudhri, 2013).

Wound healing

The alcoholic extract of *Cassia fistula* leaves was tested against wounds infected by *Staphylococcus aureus* and *Pseudomonas aeruginosa*. *C. fistula* treated rats showed, better wound closure, improved tissue regeneration at the wound site, and supporting histopathological parameters pertaining to wound healing (Kumar *et al.*, 2006).



CONCLUSION

Cassa fistula Linn (*Amaltas*) has been in use since times immemorial to treat wide range of indications. They have been subjected to quite extensive phytochemical, experimental and clinical investigations. Experimental studies have demonstrated their analgesic, antibacterial, anticancer, anticonvulsant, antidiabetic, antifertility, antifungal, anti-inflammatory, antimicrobial, antinociceptive, antioxidant, antileishmanial, antipsoriatic, antipyretic, antitumour, anthelmintic, central nervous system depressant, hepatoprotective, hypoglycemic, hypolipidemic, immunomodulatory, larvicidal, laxative, nephroprotective and effect on skin diseases and wound healing. The scientific studies have proved most of the claims of traditional medicines. However, further, detailed clinical research appears worthwhile to explore the full therapeutic potential of this plant in order to establish it as a standard drug.

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