



**International Journal of Biology, Pharmacy
and Allied Sciences (IJBPAS)**
'A Bridge Between Laboratory and Reader'

www.ijbpas.com

**A COMPREHENSIVE REVIEW ON PHARMACOLOGICAL AND PHYTOCHEMICAL
POTENTIAL OF *CASSIA FISTULA LINN*: A MAGICAL HERB**

**SAMREEN TANVEER^{1,2,*}, ABIDA LATIF^{1,2}, KANWAL ASHIQ^{1,2}, MEHWISH
QAYYUM², MAYYDA ASIF BAJWA²**

¹University College of Pharmacy, University of the Punjab, Lahore, Pakistan

²Superior University, Raiwind Road, Lahore, Pakistan

***Corresponding Author: Samreen Tanveer: Email: samreen_tanveer@yahoo.com**

Received 29th Dec. 2018; Revised 19th Jan. 2019; Accepted 28th Jan. 2019; Available online 1st June 2019

<https://doi.org/10.31032/IJBPAS/2019/8.6.4734>

ABSTRACT

The importance of medicinal plants in treatment of various disorders is undeniable owing to their efficacy, fewer adverse effects and cost effectiveness. *Cassia fistula Linn* is a magical herb and used worldwide for treatment of various pathological conditions. The current article aims to provide a comprehensive review on pharmacological activities and phytochemical constituents present in *Cassia fistula Linn*. Related articles published between 1995 and 2018 were reviewed with help of different database including PubMed, Springer Link, Medline, Google scholar and Science direct. In order to ensure credibility and accuracy of data only those articles were considered which are published only in index journals. *Cassia fistula Linn* is a deciduous tree with grey bark and beautiful yellow flowers. It is naturally distributed in various parts of different countries including Pakistan, India, West Indies, China, South Africa and Brazil. This plant is enriched with numerous therapeutically important phytochemicals such as polyphenols, polysaccharides, flavonoids, tannins, glycosides, anthraquinones and amino acids exhibiting antifungal, hepatoprotective, antimicrobial, anti-inflammatory, analgesic and nephroprotective activities. Various phytochemical investigations and numerous pharmacological studies have demonstrated its significance as an important medicinal plant in cure of various ailments.

Keywords: *Cassia fistula Linn*, Phytochemicals, Pharmacological activities, Polyphenols, Tannins

INTRODUCTION:

In many countries, traditional use of medicinal plants is becoming popular than their allopathic alternatives because of their availability and cost effectiveness [1]. Europeans are also using traditional medicines especially Indian Ayurvedic therapies for treatment of long term diseases. Traditional medicines always have an edge over conventional medicines as later cause dependency in patients and have more undesirable effects. Hence traditional medicines can play an important role in improving patient quality of life by reducing their health issues and sufferings [2].

World Health Organization has included Japanese, Chinese and Ayurvedic traditional medication systems in disease control program due to effectiveness, availability and inherited practice of traditional drugs [3].

Many therapeutically beneficial compounds are being isolated from different herbs and used in treatment of chronic diseases. They are also used as pesticides [4]. According to research, approximately 70-80% of population in developing countries is using herbal drugs for treatment of their ailments and 25% of commercial medicines are synthesized from medicinal herbs [5].

Phytochemicals are chemical moieties that are present in plants naturally. These

Phytochemicals are being increasingly used as therapeutic agents as they are capable to produce different pharmacological effects in living organisms. There are various classes of Phytochemicals depending upon their chemical structure and biological action. These include phenols, alkaloids, lipids, proteins, flavonoids and carbohydrates [6].

Plants use secondary metabolites and other bioactive molecules as a shield against vegans and fungi. Plants produce antifungal protein enzymes that kill fungi by hydrolyzing their cell wall. Plants also synthesize certain antifungal proteins which act by combining with membrane constituents of fungi. For example napins are proteins which are not only big source of nitrogen in plant seeds, it also contain certain enzymes like protease inhibitors that protect plants against insects and fungi [7].

Vernacular names:

English: Golden shower, Golden rain tree

Hindi: Amaltas

Marathi: Bahava

Guajarati: Garmala

Tamil: Konai

Urdu: Amaltaas

Botanical description of *Cassia fistula****Linn:***

Botanical name: *Cassia fistula*

Kingdom: Plantae

Order: Fabales

Family: Fabaceae

Genus: *Cassia*

Species: *fistula*

Description:

Cassia fistula Linn is a deciduous tree with grey bark and beautiful yellow flowers. Its fruit is cylindrical in shape containing seeds. Seeds are separated by transverse partitions. The diameter and length of fruit pod is 20-27mm and 40-70 cm respectively. Fruit pod is slightly curved and rounded at distal ends [8]. It is decorative, medium sized and rapidly growing plant that shed its leaves at end of season [9].

Habitat:

Cassia fistula Linn is an herb, naturally distributed in various parts of different countries including Pakistan, India, West Indies, China, South Africa and Brazil [10]. *Cassia fistula* Linn is a semi-wild Indian Labernum, commonly known as Amaltas [11]. The main habitat of *Cassia fistula* Linn is Caribbean islands and tropical forests of West Indies [12].

Traditional uses:

Traditionally *Cassia fistula* Linn is used to treat fungal infections. In Indian tribal areas it is also used to cure nasal infections. Its fruit pulp is used as antifungal and has light

cathartic and laxative actions. In Asian countries, all parts of plants are used to treat various ailments. It is used as an anti-inflammatory, emollient, cathartic and antipyretic. Plant is also used to cure respiratory tract infections, cardiovascular and liver disorders. *Cassia fistula* Linn also manifests wide range of anti microbial activity and found effective against various skin diseases [10].

PHYTOCHEMICAL CONSTITUENTS:

Cassia fistula Linn contains numerous amounts of primary and secondary metabolites. These metabolites are important for its pharmacological and biological activities. Primary and secondary metabolites include polyphenols, polysaccharides, flavonoids, tannins, glycosides, anthraquinones and amino acids. Decline in concentration of amino acids and proteins can lead to various health hazards [13]. These are present in stem, bark, flowers, roots and fruits of *Cassia fistula* Linn [14].

Bahorun and coworkers in 2005 gave a detailed account on phytochemicals present in *Cassia fistula* Linn. According to their study glycerides and fatty acids are found in abundance in seeds. Among fatty acids, palmitic acid and linoleic acid are present in surplus whereas myristic and caprylic acid occur in traces. Seeds of *Cassia fistula* Linn

are also rich source of proteins and globulins. The same study also reported the presence of Phospholipids and carbohydrates in *Cassia fistula Linn* seeds. Among carbohydrates, a polysaccharide, galactomannan is found in abundance.

Stem bark of *Cassia fistula* is enriched with triterpenoids and phytosterols. It was reported that lupeol and beta sitosterols was found in abundance in stem bark of *Cassia fistula Linn* [15]. Topical use of these steroids can stimulate Hirsutism in young females [16]. Bark and stem are also good source of flavonoids. Fistulaflavonoid B and C are two newly discovered flavonoids from stem and bark of *Cassia fistula*. Their structures were also elucidated using NMR spectroscopic technique. These compounds were found useful against Mosaic virus of plants [17].

A study confirmed the presence of proteins (12%) along with free amino acids such as Glutamic acid, methionine and pyroline and in flower's pollen of *Cassia fistula Linn* [15]. Presence of anthraquinone glycoside was also confirmed in flowers especially rhein which possess excellent anticancer activity [18].

Presence of minerals such as manganese, calcium, potassium and iron was reported in edible fruit of *Cassia fistula Linn* and

findings showed that it was good source of minerals as compare to other fruits like orange, apple and peach [15]. Another study confirmed the presence of isoflavone biochanin A, in fruit of *Cassia fistula Linn* and this compound was found effective in treatment of Leishmaniasis [19].

Various studies were conducted to find out nature of phytochemicals present in *Cassia fistula Linn* leaves. Panda and coworkers carried out sequential extraction technique by using solvents of different polarity and investigated various types of primary and secondary metabolites in *Cassia fistula Linn* leaves. According to their study *Cassia fistula Linn* leaves are enriched with alkaloids, carbohydrates, phenolic compounds, tannins, glycosides, proteins, flavonoids, saponins and triterpenoids. The same study also manifested solubility of these phytochemicals in their respective solvents such as concentration of alkaloids, carbohydrates, glycosides and proteins was found maximum in alcoholic and aqueous extracts. Triterpenoids were abundant in petroleum ether, methanol and ethanol extracts whereas phenolic compounds, tannins were found soluble in chloroform, methanol and ethanol [20]. Another study confirmed the presence of alkaloids, anthraquinones, reducing sugars, coumarins

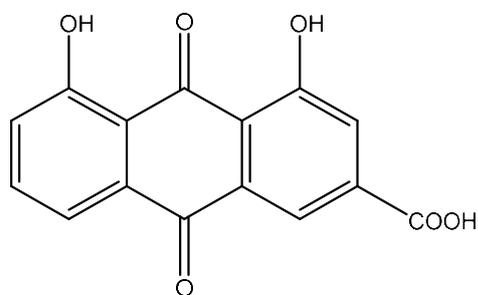
and steroids in air dried powder of leaves [21]. Leaves and pods of *Cassia fistula* Linn was found enriched with anthraquinone glycosides like rhein, aloe-emodin, sennosides and chrysophanic acid especially rhein showing excellent laxative properties [22]. Another study confirmed the presence of flavonoids, phenols, tannins, saponins and alkaloids in leaves of *Cassia fistula* Linn [11].

In one study presence of valuable Antineoplastic compounds were reported in pulp and seeds of *Cassia fistula* Linn. These cytotoxic compounds include thymol, oleic acid, furanone and rhein. Moreover butanol extract of *Cassia fistula* Linn seeds is

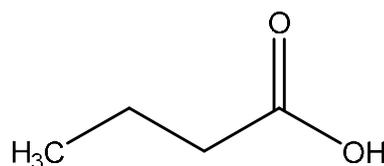
enriched with palmitic acid and inositol. Whereas butanol extract of pulp also contain pyrrolidine [23].

Danish and coworkers gave a comprehensive review on primary and secondary metabolites present in different parts of *Cassia fistula* Linn [8]. These phytochemicals and their respective plant parts are summarized in Table 1.

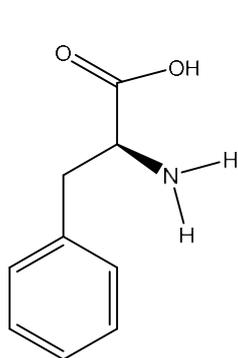
A comparison of total phenols, flavonoids and proanthocyanidins was done in different parts of *Cassia fistula* Linn. Results showed that pods of plant contain highest concentration of total phenols, flavonoids and proanthocyanidins [15]. A graphical representation is given in Figure 1.



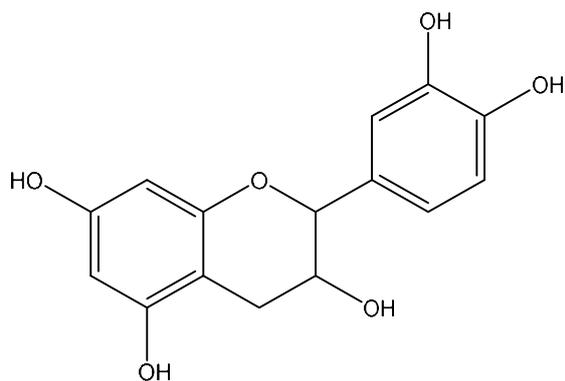
Rhein



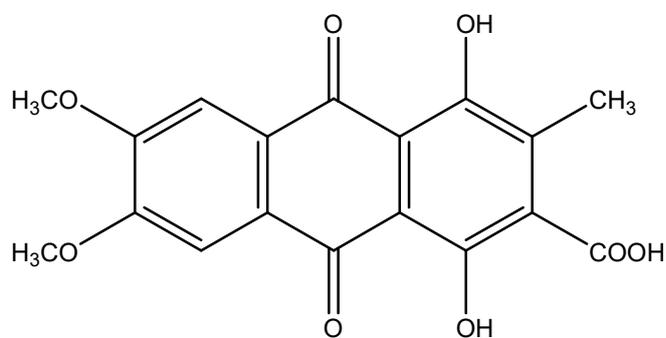
Butyric acid



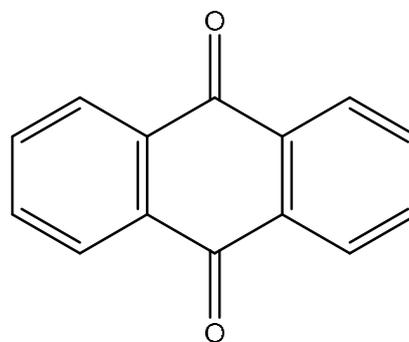
Phenylalanine



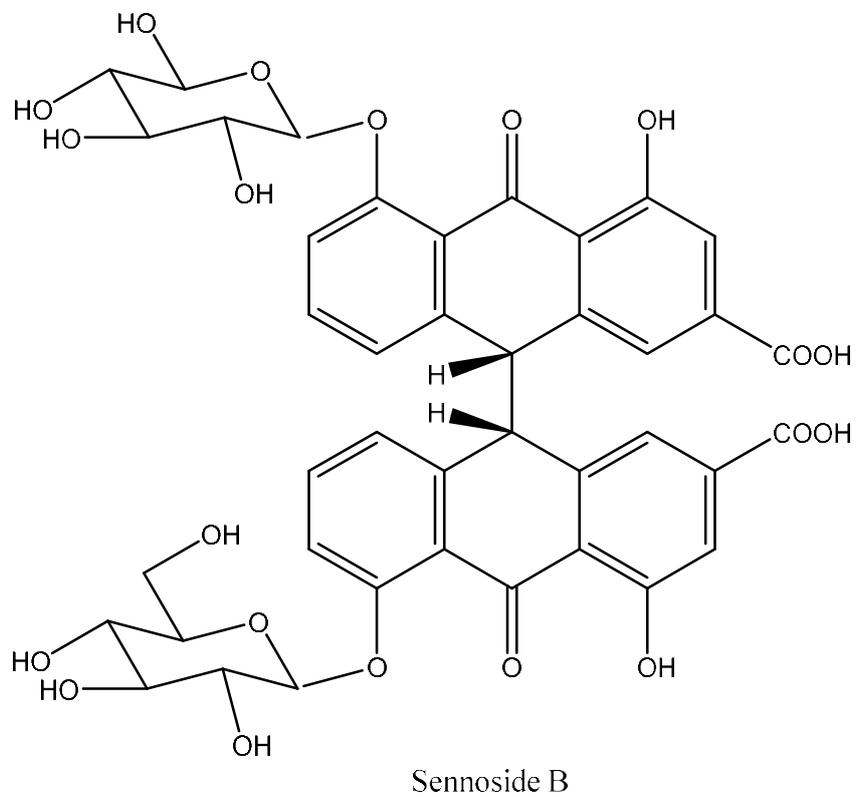
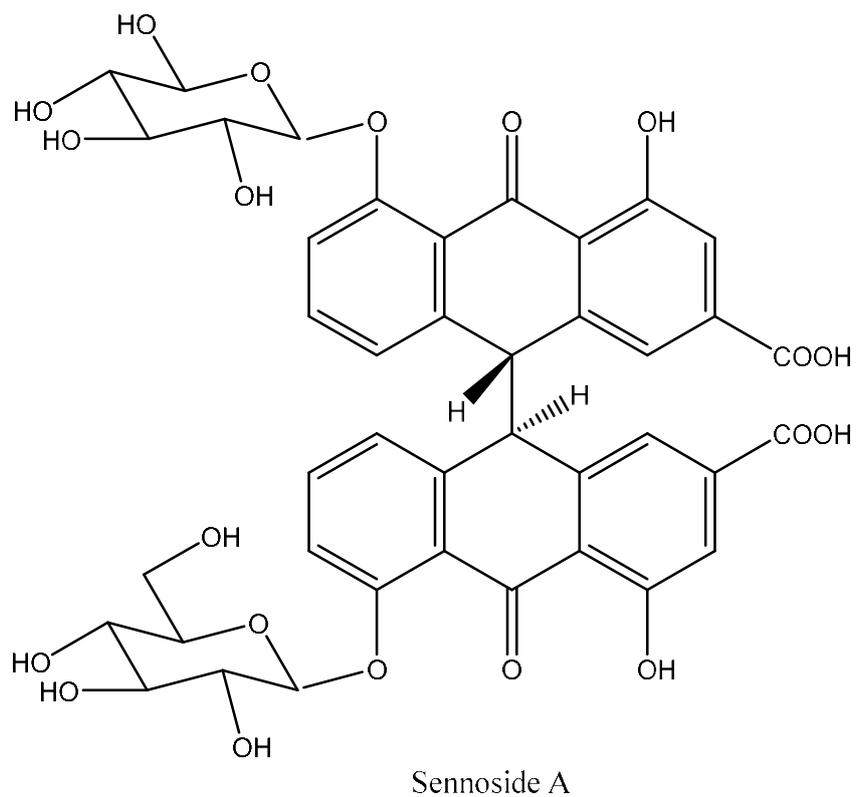
+, - Catechin

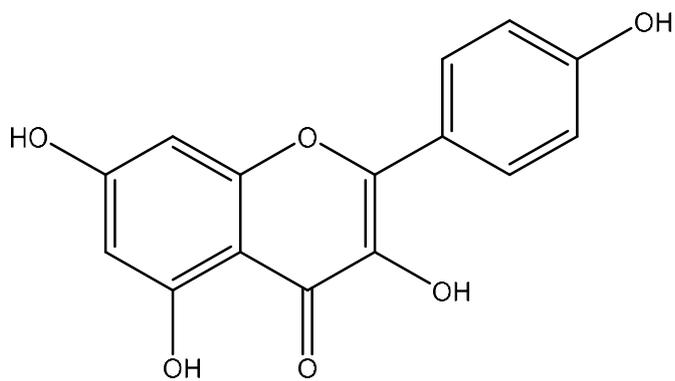


Fistulic acid

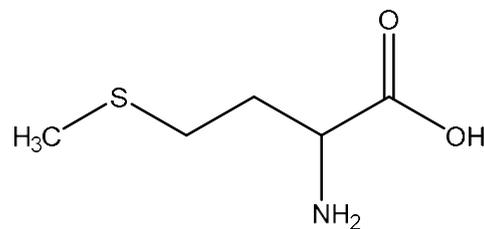


Anthraquinone

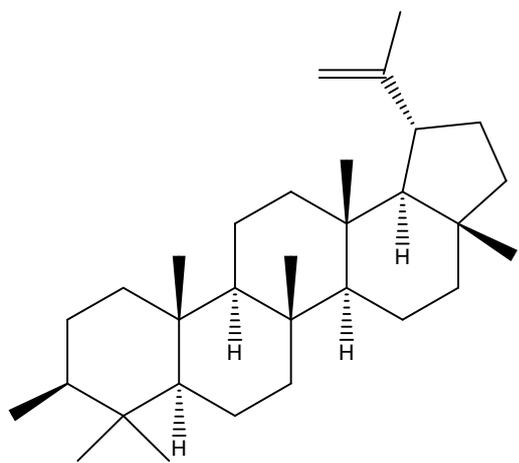




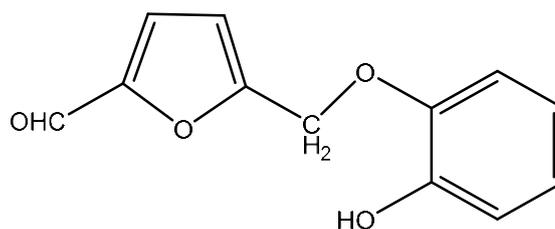
Kaempferol



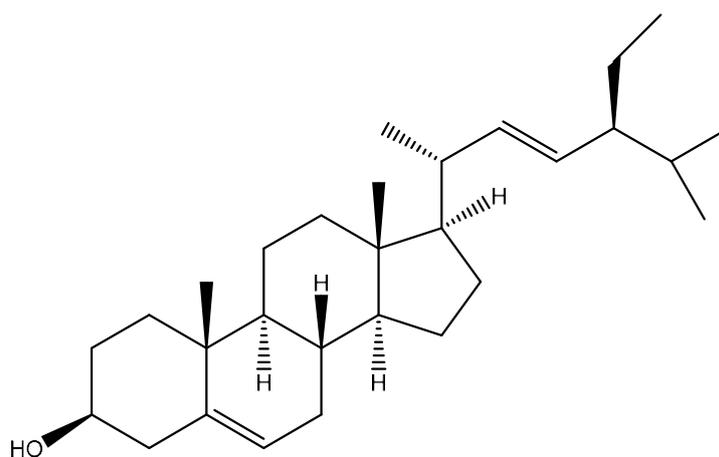
Methionine



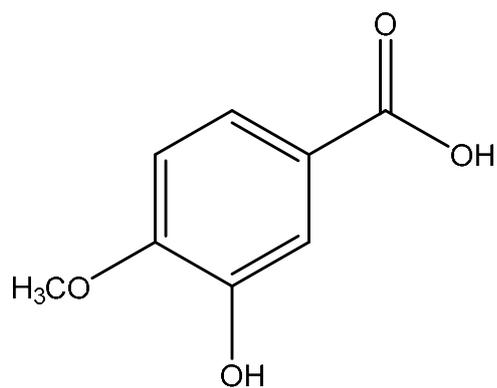
Lupeol



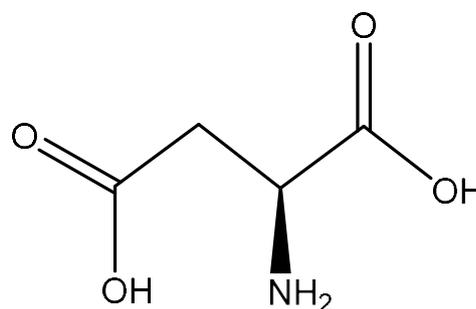
5-(2-hydroxyphenoxy)methyl furfural



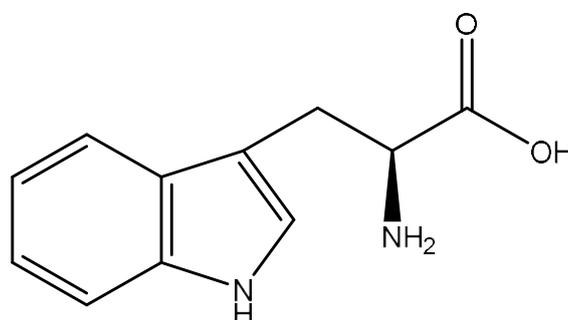
Stigmasterol



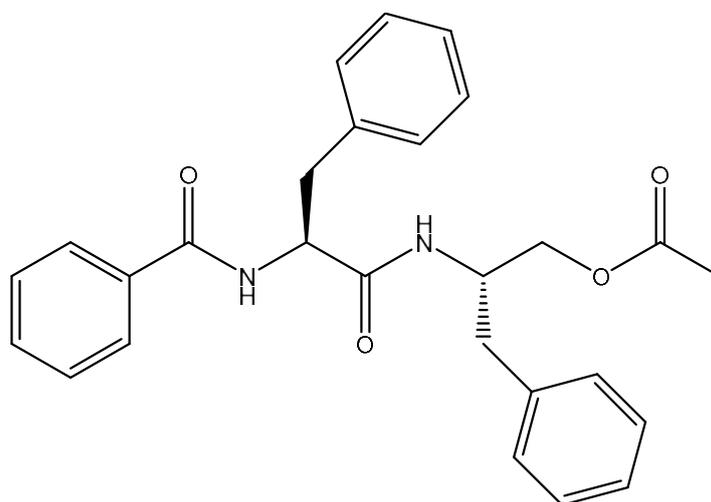
Isovanillic acid



Aspartic acid



Tryptophan



Aurantiamide acetate

Structures of some Phytochemicals of *Cassia fistula* Linn.

Table 1: Phytochemicals in different plant parts of *Cassia fistula* Linn.

<i>Cassia fistula</i> (parts)	Primary and Secondary Metabolites
Seeds	Amino acids, galactomannan, Kaempferol, fistulin, triglycerides, vernolic acid, sterculic acid, furfural derivatives, oxyanthraquinones, galactomannan free sugars and amino acids.
Leaves	Sennoside A and B, Rhein, Tannins, nerolidol, hexadecanone, phytol, Volatile oils.
Flowers	Bianthraquinone glycosides, ceryl alcohol, aurantiamide acetate, rhein and volatile oils.
Pulp	Gluten Oxalates, oxyanthraquinones, albuminous starch, sugar, gum, astringent matter.
Root bark	Tannins, phlobaphenes, betulinic acid, rhamnetin 3- <i>O</i> -gentiobioside, oxyanthraquinone, 7-methylphyscion.
Pod	Sennoside A and B, Oxalic acid, rhein, 5-nonatetracontanone, anthraquinones derivatives.
Stem bark	Flavonol glycosides, Xanthone glycosides, dimethoxyflavone arabinopyranoside.
Fruit	Methionine, aspartic acid, leucine, catechin, 1,8-dihydroxy-3-methyl anthraquinones, Glutamic acid, 5-nonatetracontanone, triacontane.
Aril part	Isovanillic acid, palmitic acid, Oleic acid, sterols, stigmasterol, lupeol, emodin, ziganein, scopoletin.

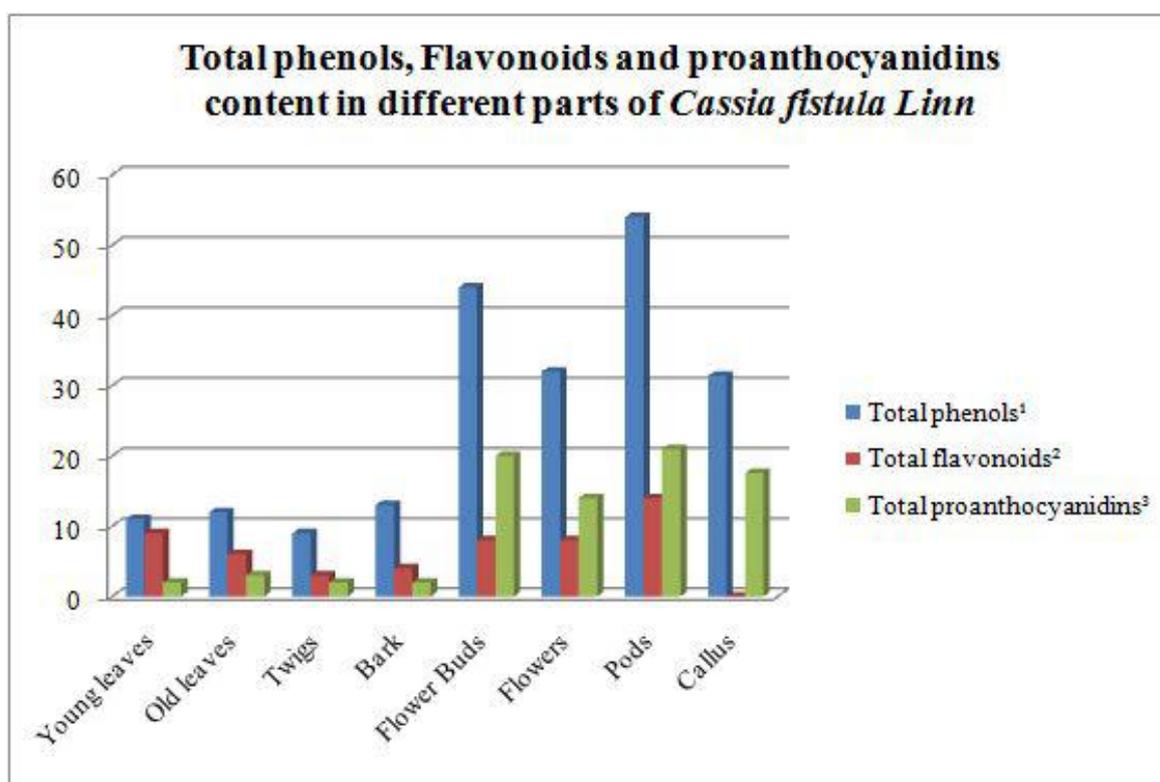


Figure 1: Graphical representation of Total phenols, flavonoids and proanthocyanidins contents in different parts of *Cassia fistula* Linn. Concentration of phenols, flavonoids and proanthocyanidins was found maximum in pods.

¹ = mg gallic acid equivalent/g dry weight

² = mg quercetin equivalent/g dry weight

³ = mg cyaniding chloride equivalent/g dry weight

PHARMACOLOGICAL ACTIVITIES:

Anti oxidant activity:

Cassia fistula (Linn) flowers showed excellent antioxidant activity when its

aqueous extract was used in alloxan induced diabetic Albino rats. It not only decreased the levels of harmful free radicals like peroxides, hydroperoxides but also normalized low

levels of catalase, glutathione reductase and superoxide dismutase which are key antioxidant enzymes [24]. These reactive oxygen species can cause mitochondrial damage and inhibition of energy producing cycle [25].

A comparison of antioxidant activity was done between sexual and asexual parts of *Cassia fistula* Linn. Antioxidant activity is strongly associated with presence of phenols and flavonoids contents. It was reported that sexual parts of *Cassia fistula* Linn showed good antioxidant activity than asexual parts as the former had higher levels of phenol and flavonoids contents [26].

Cassia fistula Linn bark also possesses significant antioxidant and anti-inflammatory activities. Aqueous and methanolic extracts of plant bark manifested excellent anti-inflammatory activity both *in vitro* (Hydroxyl and nitric acid) and *in vivo* (CCl₄ and FeSO₄) models. Experiments also showed that *Cassia fistula* Linn bark is non toxic even at higher doses [27].

Alcoholic extracts of *Cassia fistula* Linn pulp, leaves, flowers and stem bark also exhibit good antioxidant activity. Significant antioxidant activity was reported in stem bark followed by leaves and flowers while pulp showed minor activity as level of

phenolic constituents was found low in pulp [28].

Cough Suppressant Activity:

Cassia fistula Linn leaves were tested for antitussive activity by developing induced cough model in mice. Findings showed that methanolic extracts of leaves manifested excellent activity and results were equivalent to other commercially available cough suppressant drugs [29].

CNS Depressant and Analgesic Activity:

Cassia fistula Linn seeds also possess various pharmacological activities. Among these most prominent is central nervous system depressant activity. It exerts its CNS depressant action by acting synergistically with benzodiazepines and other sedatives. Moreover methanolic extract of seeds also intensify analgesic actions of drugs [30].

Antipyretic Activity:

Cassia fistula methanolic extracts has ability to alleviate high body temperature. Its temperature alleviating effect was tested on two groups of rats. In one group effect on normal body temperature was measured. In second group pyrexia was instigated by yeast. Results showed that *Cassia fistula* Linn shoot methanolic extract decrease normal body temperature up to 3hrs at dose of 200mg/kg whereas at dose of 400mg/kg antipyretic effects was observed up to 6hrs.

In yeast instigated fever group it was observed that decrease in elevated temperature is correlated with dose of extract.

Purgative activity:

Laxative and purgative effects of *Cassia fistula* Linn was evaluated on guinea pig intestine. It was reported that *Cassia fistula* Linn pods infusion show excellent purgative action and it can be comparable with Senna leaves. Toxicity profile of *Cassia fistula* pods was also analyzed and findings showed that it does not possess any toxic effects even at high dose of 6600mg/kg [8].

Anti Hepatotoxic Activity:

Leaves of *Cassia fistula* were found to be effective in treatment of liver damage. In order to investigate hepatoprotective activity, *in vivo* model consisting of Albino rats was developed. Liver toxicity in these rats was induced using diethyl nitrosamine. To these rats ethanolic extracts of *Cassia fistula* Linn leaves were administered orally for 30 days. Results proved that *Cassia fistula* leaves are indeed beneficial to cure liver damage and liver injuries [31].

Antineoplastic Activity:

Seeds of *Cassia fistula* Linn possess variety of pharmacological activities. Methanolic extract of *Cassia fistula* Linn seeds demonstrated remarkable anticancer

properties especially against ascites tumor in mice (this tumor is commonly known as Ehrlich cell carcinoma) by decreasing number of cancerous cells. Its exact mechanism of action is unknown. But it is believed that it exerts is Antineoplastic action by formation of membrane vesicles and by declining the rate of cell division of cancerous cells. Antineoplastic studies were also performed on cancer inflicted mice by administering doses of *Cassia fistula* Linn seed extract. It was observed that at dose of 100mg/kg not only hematological profile of these rats improved but also they lived longer comparative to other cancer bearing rats that were not treated with *Cassia fistula* Linn seeds [32].

Apart from seeds, *Cassia fistula* Linn bark also manifested excellent Antineoplastic and anti cancer activities. To investigate these effects animals were treated with a strong carcinogen and powerful immunosuppressant, dimethyl benzanthracene that provoked Hamster Buccal Pouch Cancer in animals. These animals after induction of cancer were treated with oral doses of *Cassia fistula* Linn bark extracts. Results revealed that bark extracts inhibit the development of skin cancer specially epidermis squamous cell carcinoma. It is thought that *Cassia fistula*

Linn bark exerted this action through its antioxidant and toxin removing action [8].

Antifungal activity:

Cassia fistula Linn found to possess promising antifungal properties as well. Leaves of *Cassia fistula* has been tested against various fungal species including *Candida albicans*. *Cassia fistula Linn* leaves extracts were prepared by using solvents of different polarity namely methanol, acetone and diethyl ether. Among all these extracts methanolic extract of *Cassia fistula Linn* leaves manifested excellent antifungal activity and its effect was similar to that of commercially available antifungal agents [33].

Cassia fistula Linn flowers are found effective not only against fungi but also against a variety of gram negative and gram positive bacteria. Assay of different extracts of *Cassia fistula Linn* were analyzed for its anti microbial activity. All extracts especially of chloroform, methanol and water showed good activity. *Pseudomonas aeruginosa* was found very liable to these extracts. In ethyl acetate crude extract, compound responsible for anti microbial activity was 4-hydroxy benzoic acid; its structure was elucidated using X-ray crystallography X-ray crystallography techniques. This compound was effective against various pathogenic

species of fungus *Trichophyton* and *Epidermophyton* [10].

Antileukotriene Activity:

Cassia fistula Linn also exhibit anti allergic activities by inhibiting production and secretion of leukotrienes. Mechanism behind this anti allergic activity was oxidation reduction reactions causing inactivation of 5-lipoxygenase that ultimately leads to inhibition of leukotrienes production [34].

Anti-inflammatory Activity:

Cassia fistula leaves also demonstrate outstanding effects to alleviate inflammation such as gout which have negative impact on patient quality of life [35, 36]. *In vivo* model of albino rats were used to evaluate anti inflammatory activity of leaves extracts. Oedema was induced in these rats using carrageenan and dextran. *Cassia fistula Linn* leaves extract showed significant anti inflammatory activity [37].

Cassia fistula Linn bark was analyzed for its antioxidant and inflammation alleviating activity *in vivo* using two groups of Albino rats' namely acute and chronic groups. Inflammation is induced in these two groups using carbon tetrachloride and ferrous sulphate. Methanolic and water extracts demonstrated excellent anti inflammatory activity. This activity is due to suppressing peroxidation of lipids. Factors that affect the

anti inflammatory activity include dose/ conc. of extracts and production of oxidative specie. Toxicity studies of bark extracts were also performed. It was found out that bark extracts have very low levels of toxicity even at higher doses [27].

Another study demonstrated anti inflammatory action of *Cassia fistula Linn* bark. To analyze these effect acute inflammatory models of albino rats were used using aqueous and methanolic extracts. Both extracts show outstanding anti inflammatory activity especially against granuloma induced by implantation of cotton ball. Mode of action involves decrease in concentration of serum enzymes like alkaline phosphatase and acid phosphatase. Anti inflammatory activity produced by these extracts was equivalent to effect produced by commercially available standard anti inflammatory agent like Diclofenac [8].

Antimicrobial Activity:

Antimicrobial activities of *Cassia fistula Linn* were compared with other herbal extracts like *M. ferrea*. It was found out that *Cassia fistula* demonstrated more promising antimicrobial activities including both antifungal and antibacterial properties. Compounds responsible for this activity were isolated and found effective against various gram positive and gram negative bacteria.

Different proteins were isolated from seeds of *Cassia fistula Linn*. After purification these proteins they were employed against various streptococcus species and were found effective against most of strains [38].

Cassia fistula Linn extracts also exhibit pesticidal activity as it is found useful against a variety of parasitic nematodes. Death rate of nematodes was reported 100%, 48hours and 72 hours after administration of *Cassia fistula Linn* extracts. Encouraging results were not obtained after 24 hours as death rate of parasite was reported minimum [39].

Stem bark of *Cassia fistula Linn* possess outstanding antimicrobial properties. Alcoholic and aqueous extracts were found most effective. Both extracts showed excellent activity against *Streptococcus aureus*. Although alcoholic extract show better antibacterial activity than aqueous extract. Even *S. aureus* that were unaffected by chloramphenicol were also liable to alcoholic extract of *Cassia fistula Linn* stem bark extract [40].

Larvicidal and Ovicidal Activity:

Leaves of *Cassia fistula Linn* also found to possess pesticidal activity. When leave extract of varying concentrations applied topically, they not only inhibit hatching of eggs but also makes them non functional to produce any disease [8].

In another study larvicidal activity of *Cassia fistula* Linn leaves methanolic extract was tested against *Culex quinquefasciatus* and *Anopheles stephensi*. The methanolic leaf extract show more activity against *A. stephensi* at larvae stage. Less larvicidal activity was reported against *C. quinquefasciatus*. Thus it was proved that *Cassia fistula* Linn does possess good larvicidal activity [41].

Lipid Lowering and Hypoglycemic Activity:

Studies have revealed that *Cassia fistula* Linn posses outstanding lipid lowering and antidiabetic activities. To evaluate its antidiabetic activity, n-hexane extract of bark was administered in varying doses (0.15, 0.30, 0.45g /kg of body weight) to albino rats for one month. Diabetes was induced in these rats by intraperitoneal injection of streptozotocin. Results showed that blood glucose level of those diabetic rats was remarkably reduced. Lipid profile of these diabetic rats was also evaluated. It was reported that lipid profile remarkably improved at dose of 0.45g/kg body weight. It is thought that hypoglycemic and hypocholesterolemic action of *Cassia fistula* Linn was due to presence of ployphenols and antioxidant constituents [42].

Wound Alleviating Activity:

Wound healing potential of *Cassia fistula* Linn was explored by using its methanolic leaves extract in different *in vivo* wound models in rats. Leaves extract in 5 and 10% w/w concentration was incorporated in ointment base. In these concentrations the ointment was found to be effective in treating both types of wounds. The wound healing effect was equivalent to standard control drug nitrofurazone in every aspect [29].

Wound healing activity of *Cassia fistula* Linn was demonstrated in another study using albino rat model. Ointment base formulation of alcohol leaves extract was prepared and wound healing effect was analyzed on wounds infected with *Staphylococcus aureus* and *Pseudomonas aeruginosa*. It was observed that wounds treated with *Cassia fistula* Linn ointment showed faster healing, better tissue reanimation and rapid wound reduction rate. These findings provided a scientific proof of traditional use of *Cassia fistula* Linn in wound management [43].

Antidiabetic Activity:

A study was conducted to explore antidiabetic effects of *Cassia fistula* Linn and to identify its mechanism of action. For this purpose hydroalcoholic extract of *Cassia fistula* Linn was used in *in vivo* model of alloxan induced diabetic rats. The antidiabetic effect was analyzed at dose

levels, 200 and 400mg/kg. Glibenclamide was used as standard control. In parallel antioxidant (*in vitro* model) and lipid profile (*in vivo* model) of this extract was also evaluated. It was reported that the extract showed marked decrease in blood glucose level in fasting rats. Extract also decrease the level of free radical species lipid profile of diabetic rats was also improved [44].

Antidiabetic potential of *Cassia fistula Linn* roots was evaluated using alpha amylase inhibition and glucose diffusion assay as *in vitro* models. For this purpose root extracts of n-hexane, ethanol and ethyl acetate were prepared. Among this ethanol root extract showed outstanding results in inhibiting the activity of alpha amylase. Ethanol root extracts also manifested significant antidiabetic potential in glucose diffusion assay as compare to ethyl acetate and n-hexane extracts [45].

Different parts of *Cassia fistula Linn* plant were subjected to comparative analysis of antidiabetic potential. For this purpose, aqueous extracts of all parts of plant were prepared. An *in vivo* model of streptozotocin induced diabetic rats was developed. These diabetic rats were treated for 21 days with extracts of different plant parts at dose levels of 250 and 500mg/kg. It was reported that bark and leaves methanolic extract showed

significant decrease in blood glucose levels than other plant parts [46].

Hypoglycemic and pain reducing potential of ethanolic extract of *Cassia fistula Linn* stem bark was evaluated using *in vivo* models of rats and mice. For hypoglycemic activity albino rat model was selected and for analgesic activity *in vivo* model of mice was chosen. Writhing test method was adopted to evaluate analgesic effect. In this method, body contortions movements of rats like twisting and squirming were observed using Diclofenac as standard control. For evaluation of hypoglycemic potential, diabetes was induced by alloxan and glucose tolerance test was adopted using Metformin as standard control. Results revealed that ethanolic extract of *Cassia fistula Linn* stem bark appreciably reduced blood glucose levels in alloxan induced diabetic rats. Contrarily, for analgesic effect, ethanolic extract reduced contortions movement of rats up to 60% but results were not comparable to the standard control [47].

Antidiabetic potential of *Cassia fistula Linn* whole fruit was determined using its petroleum ether extract in *in vivo* rat model. Toxic profile of *Cassia fistula Linn* fruit petroleum ether extract was evaluated and it was found out that extract was safe and did not produce any signs of toxicity. Diabetes

was induced using Streptozotocin. It was reported that petroleum ether extract of *Cassia fistula* Linn fruit significantly reduced blood glucose levels in diabetic rats [48].

In vitro antihypertensive activity of *Cassia fistula* Linn was also tested using alpha amylase inhibition assay. The enzyme alpha amylase cause hydrolysis of starch and glycogen and convert them into monomers like maltose and glucose. So, alpha amylase inhibition is very effective criteria to measure antidiabetic potential of any sample. Results of this assay showed that *Cassia fistula* Linn possessed excellent antidiabetic potential [49].

Cassia fistula Linn bark also exhibit outstanding antidiabetic potential. To evaluate antihyperglycemic activity of *Cassia fistula* Linn bark, its extracts were prepared in alcohol and ethyl acetate. *In vivo* albino rat's model was developed and diabetes was induced by using alloxan. Results revealed that there was marked reduction in blood glucose levels of ethyl acetate extract treated diabetic rats. Moreover *Cassia fistula* Linn bark also improved lipid profile of these diabetic rats [50].

In another study antidiabetic potential of *Cassia fistula* Linn bark was reported. To evaluate its antihyperglycemic activity aqueous and alcoholic extracts of *Cassia*

fistula Linn bark (400mg/kg) was administered to alloxan induced diabetic rat model. The study revealed that both aqueous and alcoholic extracts of *Cassia fistula* Linn bark tremendously reduced blood glucose levels of diabetic rats. These findings provide scientific proof of traditional use of *Cassia fistula* Linn for treatment of diabetes related ailments [51].

Due to threatening increase in prevalence of type 2 diabetes, use of medicinal plants is gaining popularity in treatment of type 2 diabetes. For this purpose, a study was carried out to evaluate antidiabetic potential of stem bark of *Cassia fistula* Linn stem bark against type 2 diabetes. Results showed that *Cassia fistula* Linn stem bark significantly decrease blood glucose level without having any harmful effects on urea and creatinine levels [52].

CONCLUSION:

For centuries herbal remedies have been used for prevention and management of diseases. In rural areas people still rely on medicinal herbs for treatment of their ailments. In this regard *Cassia fistula* is considered one of the most important herbs and it is widely used in traditional medicinal systems of India, China and Japan. It is also found to possess antibacterial, antipyretic, anti-inflammatory, antidiabetic, antioxidant, antitussive, wound

healing and antifungal properties. Phytochemical profile of *Cassia fistula* Linn showed that it is rich source of primary and secondary metabolites such as lipids, proteins, carbohydrates, tannins, phenols, flavonoids, glycosides, volatile oils and essential oils. The current review has summarized pharmacological activities and phytochemical constituents of almost all parts of *Cassia fistula* Linn including leaves, stem, stem bark, roots, seeds and flowers. It was found that less attention has been paid on fruit wall of plant. No study has been conducted to explore phytochemical and pharmacological potential of fruit wall of *Cassia fistula* Linn. Moreover there is need to standardize herbal medicines to ensure safety and efficacy.

Acknowledgement:

The authors are thankful to University College of Pharmacy, University of the Punjab, Lahore, Pakistan and Superior University Lahore, Pakistan for providing literature review facility to carry out the work.

REFERENCES:

- [1] Joe, M. M., Benson, A., Ayyanar, M., & Sa, T., Bioactive compounds and medical significance of some endangered medicinal plants from the Western Ghats region of India, *Biotechnology of bioactive compounds*. John Wiley & Sons, Ltd, Chichester, 2015, 163-193.
- [2] Kumar, S., Dobos, G. J., & Rampp, T., The significance of ayurvedic medicinal plants, *Journal of evidence-based complementary & alternative medicine*, 22(3), 2017, 494-501.
- [3] Mishra, A., Seth, A., & Maurya, S. K., Therapeutic significance and pharmacological activities of antidiarrheal medicinal plants mention in Ayurveda: A review, *Journal of intercultural ethnopharmacology*, 5(3), 2016, 290.
- [4] Mulholland, D. A., Thuerig, B., Langat, M. K., Tamm, L., Nawrot, D. A., James, E. E., ... & Hokkanen, H., Efficacy of extracts from eight economically important forestry species against grapevine downy mildew (*Plasmopara viticola*) and identification of active constituents, *Crop protection*, 102, 2017, 104-109
- [5] Saini, R. K., Sivanesan, I., & Keum, Y. S., Phytochemicals of *Moringa oleifera*: a review of their nutritional, therapeutic and industrial significance, *3 Biotech*, 6(2), 2016, 203.

- [6] Guaadaoui, A., Benaicha, S., Elmajdoub, N., Bellaoui, M., & Hamal, A., What is a bioactive compound? A combined definition for a preliminary consensus. *International Journal of Nutrition and Food Sciences*, 3(3), 2014, 174-179.
- [7] Wijaya, R., Neumann, G. M., Condron, R., Hughes, A. B., & Polya, G. M., Defense proteins from seed of Cassia fistula include a lipid transfer protein homologue and a protease inhibitory plant defensin, *Plant Science*, 159(2), 2000, 243-255.
- [8] Danish, M., Singh, P., Mishra, G., Srivastava, S., Jha, K. K., & Khosa, R. L., Cassia fistula Linn.(Amulthus)-An important medicinal plant: A review of its traditional uses, phytochemistry and pharmacological properties, *Journal of Natural Product and Plant Resources*, 1(1), 2011, 101-118.
- [9] Hanif, M. A., Nadeem, R., Bhatti, H. N., Ahmad, N. R., & Ansari, T. M., Ni (II) biosorption by Cassia fistula (Golden Shower) biomass., *Journal of Hazardous Materials*, 139(2), 2007, 345-355.
- [10] Duraipandiyan, V., & Ignacimuthu, S., Antibacterial and antifungal activity of Cassia fistula L.: An ethnomedicinal plant. *Journal of ethnopharmacology*, 112(3), 2007, 590-594.
- [11] Seasotiya, L., Siwach, P., Malik, A., Bai, S., Bharti, P., & Dalal, S., Phytochemical evaluation and HPTLC fingerprint profile of Cassia fistula. *International Journal of Advances in Pharmacy, Biology and Chemistry*, 3(3), 2014, 604-611.
- [12] Bhakta, T., Banerjee, S., Mandal, S. C., Maity, T. K., Saha, B. P., & Pal, M., Hepatoprotective activity of Cassia fistula leaf extract, *Phytomedicine*, 8(3), 2001, 220-224.
- [13] Tanveer, S., Ashfaq, M., Parveen, R., Ashiq, K., Qayyum, M., Bajwa, M., & Arshad, A., Assessment of the risk factors and various patient related attributes influencing hemodialysis, *International Journal of Biosciences*, 14(4), 2019, 238-247.
- [14] Joshi, T., Agarwal, M., & Singh, T., Anti-diabetic and other pharmacological activities of cassia fistula, *International Journal of*

- advance Technology Engineering and Sciences*,4(6), 2016, 1-8.
- [15] Bahorun, T., Neergheen, V. S., & Aruoma, O. I., Phytochemical constituents of Cassia fistula. *African journal of Biotechnology*, 4(13), 2005, 1530-1540.
- [16] Mahmood, K. T., Ghafoor, S., & Tanveer, S., Risk Factors Contributing to Hirsutism, *Journal of Biomedical Sciences and Research*, 3(1), 2011, 347-52.
- [17] Zhao, W., Zeng, X., Zhang, T., Wang, L., Yang, G., Chen, Y. K., ... & Miao, M., Flavonoids from the bark and stems of Cassia fistula and their anti-tobacco mosaic virus activities. *Phytochemistry letters*, 6(2), 2013, 179-182.
- [18] Durairandiyan, V., Baskar, A. A., Ignacimuthu, S., Muthukumar, C., & Al-Harbi, N. A. , Anticancer activity of Rhein isolated from Cassia fistula L. flower, *Asian Pacific Journal of Tropical Disease*, 2, 2012, S517-S523.
- [19] Sartorelli, P., Carvalho, C. S., Reimao, J. Q., Ferreira, M. J. P., & Tempone, A. G., Antiparasitic activity of biochanin A, an isolated isoflavone from fruits of Cassia fistula (Leguminosae), *Parasitology Research*, 104(2), 2009, 311-314.
- [20] Panda, S. K., Padhi, L. P., & Mohanty, G., Antibacterial activities and phytochemical analysis of Cassia fistula (Linn.) leaf, *Journal of Advanced Pharmaceutical Technology & Research*, 2(1), 2011,62.
- [21] Bhalodia, N. R., & Shukla, V. J., Antibacterial and antifungal activities from leaf extracts of Cassia fistula l.: An ethnomedicinal plant. *Journal of Advanced Pharmaceutical Technology & Research*, 2(2), 2011,104.
- [22] Sakulpanich, A., & Gritsanapan, W., Determination of anthraquinone glycoside content in Cassia fistula leaf extracts for alternative source of laxative drug. *International Journal of Biomedical and Pharmaceutical Sciences*, 3(1), 2009, 42-45.
- [23] Irshad, M., Mehdi, S. J., Al-Fatlawi, A. A., Zafaryab, M., Ali, A., Ahmad, I., ... & Rizvi, M. M. A., Phytochemical composition of Cassia fistula fruit extracts and its anticancer activity against human cancer cell lines, *Journal of*

- Biologically Active Products from Nature*, 4(3), 2014, 158-170.
- [24] Manonmani, G., Bhavapriya, V., Kalpana, S., Govindasamy, S., & Apparantham, T., Antioxidant activity of *Cassia fistula* (Linn.) flowers in alloxan induced diabetic rats, *Journal of Ethnopharmacology*, 97(1), 2005, 39-42.
- [25] Tanveer, S., Farrukh, M. A., Ali, S., Khaleeq-ur-Rahman, M., & Imtiaz, A., In vitro Toxicological Study of Metal Oxides Nanoparticles on Oxidation of Succinate in Krebs Cycle and Their Resultant Effect in Metabolic Pathways, *Journal of the Chinese Chemical Society*, 61(5), 2014, 525-532.
- [26] Luximon-Ramma, A., Bahorun, T., Soobrattee, M. A., & Aruoma, O. I., Antioxidant activities of phenolic, proanthocyanidin, and flavonoid components in extracts of *Cassia fistula*, *Journal of Agricultural and Food Chemistry*, 50(18), 2002, 5042-5047.
- [27] Ilavarasan, R., Malika, M., & Venkataraman, S., Anti-inflammatory and antioxidant activities of *Cassia fistula* Linn bark extracts, *African Journal of Traditional, Complementary and Alternative Medicines*, 2(1), 2005, 70-85.
- [28] Siddhuraju, P., Mohan, P. S., & Becker, K., Studies on the antioxidant activity of Indian Laburnum (*Cassia fistula* L.): a preliminary assessment of crude extracts from stem bark, leaves, flowers and fruit pulp, *Food chemistry*, 79(1), 2002, 61-67.
- [29] Bhakta, T., Mukherjee, P. K., Mukherjee, K., & Pal, M. (1998). Studies on in vivo wound healing activity of *Cassia fistula* linn. Leaves (Leguminosae) in rats. *Natural Product Sciences*, 4(2), 1998, 84-87.
- [30] Barthakur, N. N., Arnold, N. P., & Alli, I., The Indian laburnum (*Cassia fistula* L.) fruit: an analysis of its chemical constituents, *Plant Foods for Human Nutrition*, 47(1), 1995, 55-62.
- [31] Pradeep, K., Mohan, C. V. R., Gobianand, K., & Karthikeyan, S., Effect of *Cassia fistula* Linn. leaf extract on diethylnitrosamine induced hepatic injury in

- rats, *Chemico-Biological Interactions*, 167(1), 2007, 12-18.
- [32] Bhalerao, S. A., & Kelkar, T. S., Traditional medicinal uses, phytochemical profile and pharmacological activities of *Cassia fistula* Linn, *International Research Journal of Biological Sciences*, 1(5), 2012, 79-84.
- [33] Singh, P., & Karnwal, P. P., Antifungal activity of *Cassia fistula* leaf extract against *Candida albicans*, *Indian Journal of Microbiology*, 46(2), 2006, 169.
- [34] Müller, T. S., Sun, Z., Kumar, G., Itoh, K., & Murabayashi, M., The combination of photocatalysis and ozonolysis as a new approach for cleaning 2, 4-dichlorophenoxyacetic acid polluted water, *Chemosphere*, 36(9), 1998, 2043-2055.
- [35] Kanwal, A., Abida, L., Sana, A., & Ahlam, S., A systematic review on the prevalence, pathophysiology, diagnosis, management and treatment of gout (2007-2018), *GSC Biological and Pharmaceutical Sciences*, 05(01), 2018, 050-055.
- [36] Kanwal, A., Khurram, R., Sana, A., & Ahlam, S., Influence of osteoporosis on quality of life and current strategies for its management and treatment, *GSC Biological and Pharmaceutical Sciences*, 1(2), 2017, 34-40.
- [37] Bhakta, T., Mukherjee, P. K., Saha, K., Pal, M., Saha, B. P., & Mandal, S. C., Evaluation of anti-inflammatory effects of *Cassia fistula* (Leguminosae) leaf extract on rats, *Journal of Herbs, Spices & Medicinal Plants*, 6(4), 2000, 67-72.
- [38] Singh, S., Singh, S. K., & Yadav, A., A review on *Cassia* species: Pharmacological, traditional and medicinal aspects in various countries, *American Journal of Phytomedicine and Clinical Therapeutics*, 1(3), 2013, 291-312.
- [39] Sundararaju, P., & Saritha, V., Effect of leaf extracts of *Acalypha indica*, *Cassia fistula* and *Solanum torvum* on *Pratylenchus coffeae*, *Indian Journal of Nematology*, 36(1), 2006, 144-145.
- [40] Vimalraj, T. R., Kumar, S. S., Vadivel, S., Ramesh, S., & Thejomoorthy, P., Antibacterial effect of *Cassia fistula* extract on pathogenic bacteria of veterinary importance, *Tamilnadu Journal of*

- Veterinary and Animal Sciences*, 5(3), 2009, 109-113.
- [41] Govindarajan, M., Jebanesan, A., & Pushpanathan, T., Larvicidal and ovicidal activity of Cassia fistula Linn. leaf extract against filarial and malarial vector mosquitoes, *Parasitology Research*, 102(2), 2008, 289-292.
- [42] Nirmala, A., Eliza, J., Rajalakshmi, M., Priya, E., & Daisy, P., Effect of hexane extract of Cassia fistula barks on blood glucose and lipid profile in streptozotocin diabetic rats, *International Journal of Pharmacology*, 4(4), 2008, 292-296.
- [43] Kumar, M. S., Sripriya, R., Raghavan, H. V., & Sehgal, P. K., Wound healing potential of Cassia fistula on infected albino rat model, *Journal of Surgical Research*, 131(2), 2006, 283-289.
- [44] Silawat, N., Jarald, E. E., Jain, N., Yadav, A., & Deshmukh, P. T., The mechanism of hypoglycemic and antidiabetic action of hydroalcoholic extract of Cassia fistula Linn. in rats, *Journal of Pharma Research*, 1, 2009, 82-92.
- [45] Balraj, S., Indumathy, R., Jayshree, N., & Abirami, M. S., Evaluation of invitro anti-diabetic activity of various root extract of Cassia fistula L, *Imperial Journal of Interdisciplinary Research*, 2(6), 2016, 758-61.
- [46] Einstein, J. W., Mohd Rais, M., & Mohd, M. A., Comparative evaluation of the antidiabetic effects of different parts of Cassia fistula Linn, a Southeast Asian Plant, *Journal of Chemistry*, 2012, 10.
- [47] Ali, M. A., Sagar, H. A., Khatun, M. C. S., Azad, A. K., Begum, K., & Wahed, M. I. I., Antihyperglycemic and analgesic activities of ethanolic extract of Cassia fistula (L.) stem bark, *International Journal of Pharmaceutical Sciences and Research*, 3(2), 2012, 416.
- [48] Akhila, S., & Aleykutty, N. A., Anti-diabetic activity studies on Cassia fistula fruits, *Advanced Journal of Pharmaceutical and Life science Research*, 3, 2015, 1-8.
- [49] Fathima, H. M., Thangavelu, L., & Roy, A., Anti-diabetic activity of cassia fistula (alpha amylase-inhibitory effect), *Journal of Advanced Pharmacy Education & Research*, 8(2), 2018, 13.

-
- [50] Malpani, S. N., Manjunath, K. P., Sholapur, H., Savadi, R. V., Akki, K. S., & Darade, S. S., Antidiabetic activity of *Cassia fistula* Linn. bark in alloxan induced diabetic rats. *International Journal of Pharmaceutical Science and Research*, 2(1), 2010, 382-385.
- [51] Vijayalakshmi., Deepa. N., & Jayakumari.S., Hypoglycemic antidiabetic screening of *Cassia fistula* Linn. bark, *NPIJ*,5(4), 2009, 157-161.
- [52] Mangai.S.A., & Laxmy.S.M., Anti diabetic effect of cassia fistula among selected type 2 diabetes, *International Journal of Food Science and Nutrition*, 7(1), 2018, 2-7.