In the present scenario of increasing environmental pollution globally, health of people living in developed as well as developing countries is always at risk giving rise to chronic and infectious diseases alarmingly. Even, the number of multi-drug resistant microbial strains and the appearance of strains with reduced susceptibility to antibiotics are continuously increasing which is a big threat to health of living community throughout the world. The drugs presently available in modern system of medicine have not been able to provide affordable and lasting remedies to treat diseases especially refractory diseases due to their adverse reactions in patients. This has necessitated continued research efforts to address the health issues adequately. Medicinal plants as a source of therapeutically important compounds have continued to play a prominent role in the maintenance of human health since ancient times. Traditional use of natural products in folk medicine for treating ailments is the basis of many modern day medicines all over the world. Medicinal herbs can provide eco-friendly sustainable strategy for health care of ailing humanity as these herbs have been found to modulate immune system of the body thereby making the body more capable to fight against complex diseases. Among medicinal plants, Cassia fistula Linn. (Cassia) has been extensively used in Ayurvedic system of medicine for the treatment of various ailments. It is widely used in traditional medicinal system of India. Almost all parts of this medicinal plant have been found to exhibit different pharmacological properties such as anti-diabetic, anti-fertility, anti-tumor, hepato-protective, cholesterol lowering, astrigent, febrifugal, purgative, anti-inflammatory, anti-oxidant, antibacterial, anti-viral, analgesic, anti-dysenteric, antibacterial, antifungal, anti-leishmaniac, larvicidal and ovicidal, wound healing, laxative, clastogenic, antipyretic, leukotriene inhibition, antitussive, CNS etc. Cassia fistula is well known for its traditional uses. Among its traditional uses, few are: it reduces fever, cold, swelling of throat, asthma symptoms; it has ability to subside gas, flatulence and acidity; it reduces the colic pain; it eases the discomfort of piles, stops bleeding from different parts of the body and benefit in heart diseases; it cleanses the blood and eradicates skin problems like itching, inflammation and suppuration. The present review is an attempt to highlight significant pharmacological properties of Cassia fistula and its phytoconstituents which may have immense potential in developing effective medicinal herbal products based on Cassia fistula in addressing the present health challenges of ailing humanity. Extensive multidisciplinary research efforts on the efficacy of medicinal plants/herbs to treat diseases followed by animal studies and clinical trials on human subjects are urgently needed to finding remedies for the so called Refractory Diseases for which modern medicine has not been able to offer, so far, a satisfactory or lasting remedy and as supplementary measures to well-established chemotherapy.

**Keywords:** Cassia fistula Linn. (Cassia); Phytoconstituents; Traditional Uses; Ayurvedic Preparations; Pharmacological Activities

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**ABSTRACT**

In the present scenario of increasing environmental pollution globally, health of people living in developed as well as developing countries is always at risk giving rise to chronic and infectious diseases alarmingly. Even, the number of multi-drug resistant microbial strains and the appearance of strains with reduced susceptibility to antibiotics are continuously increasing which is a big threat to health of living community throughout the world. The drugs presently available in modern system of medicine have not been able to provide affordable and lasting remedies to treat diseases especially refractory diseases due to their adverse reactions in patients. This has necessitated continued research efforts to address the health issues adequately. Medicinal plants as a source of therapeutically important compounds have continued to play a prominent role in the maintenance of human health since ancient times. Traditional use of natural products in folk medicine for treating ailments is the basis of many modern day medicines all over the world. Medicinal herbs can provide eco-friendly sustainable strategy for health care of ailing humanity as these herbs have been found to modulate immune system of the body thereby making the body more capable to fight against complex diseases. Among medicinal plants, Cassia fistula Linn. (Cassia) has been extensively used in Ayurvedic system of medicine for the treatment of various ailments. It is widely used in traditional medicinal system of India. Almost all parts of this medicinal plant have been found to exhibit different pharmacological properties such as anti-diabetic, anti-fertility, anti-tumor, hepato-protective, cholesterol lowering, astrigent, febrifugal, purgative, anti-inflammatory, anti-oxidant, antibacterial, anti-viral, analgesic, anti-dysenteric, antibacterial, antifungal, anti-leishmaniac, larvicidal and ovicidal, wound healing, laxative, clastogenic, antipyretic, leukotriene inhibition, antitussive, CNS etc. Cassia fistula is well known for its traditional uses. Among its traditional uses, few are: it reduces fever, cold, swelling of throat, asthma symptoms; it has ability to subside gas, flatulence and acidity; it reduces the colic pain; it eases the discomfort of piles, stops bleeding from different parts of the body and benefit in heart diseases; it cleanses the blood and eradicates skin problems like itching, inflammation and suppuration. The present review is an attempt to highlight significant pharmacological properties of Cassia fistula and its phytoconstituents which may have immense potential in developing effective medicinal herbal products based on Cassia fistula in addressing the present health challenges of ailing humanity. Extensive multidisciplinary research efforts on the efficacy of medicinal plants/herbs to treat diseases followed by animal studies and clinical trials on human subjects are urgently needed to finding remedies for the so called Refractory Diseases for which modern medicine has not been able to offer, so far, a satisfactory or lasting remedy and as supplementary measures to well-established chemotherapy.

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INTRODUCTION

Living in a world of inadequately controlled environmental pollution and expanding therapy with potent drugs, the important organs of complex human system are continually exposed to a variety of xenobiotics and therapeutic agents. Thus, the disorders associated with important organs of the human body are numerous and varied. In such a scenario, an unexpected increase in water born diseases like diarrhoea, dysentery, hepatitis, jaundice, cholera; air borne diseases like bronchial asthma, lung cancer, dyspnea; food borne diseases like liver cirrhosis, chronic hepatitis, immunosuppression, endocrine and reproductive disorders; radiation induced disorders like sun burn, cataracts, skin cancer; heat induced syndromes like heat cramps, heat exhaustion, heat stroke have been observed in developed as well as developing countries. Although significant efforts have been made in our modern system of medicine for the treatment of various diseases, but the drugs available in this system have not able to provide permanent cure in complex chronic diseases. Further, the continuous use of potent drugs is associated with gradual decay of the body’s resistance mechanism and this, as well as, the harmful side effects of these medicines have led to prescription of many standard remedies in recent years. This has been realized both in affluent west as well as in the poor east and there is now a growing tendency towards the use of herbal remedies.

Medicinal plants as a source of therapeutically important compounds have continued to play a prominent role in the maintenance of human health since ancient times. Traditional use of natural products in folk medicine for treating ailments is the basis of many modern day medicines all over the world. According to the World Health Organization (WHO), plant extracts or their active constituents are used as folk medicine in traditional therapies of 80% of the world’s population. Medicinal herbs can provide eco-friendly sustainable strategy for health care of ailing humanity as these herbs have been found to modulate immune system of the body thereby making the body more capable to fight against complex diseases. India’s century old heritage of traditional medical systems using natural products have been utilized for addressing preventive as well as curative aspects of health care in the country.

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 the treatment of various ailments. It is widely used in traditional medicinal system of India. It is 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. The plant is cultivated as an ornamental throughout India. Several studies have been made on the morphology of the plant.

The plant Cassia fistula Linn. has been reported to possess diverse pharmacological properties such as hepatoprotective, anti-inflammatory, antitussive, antifungal, antibacterial and wounds healing. Scientific studies have demonstrated that the plant has anti-diabetics, anti-fertility, anti-tumor, hepatoprotective, cholesterol lowering, astringent, febrifugal, purgative, anti inflammatory, anti-oxidant, antibacterial, anti-viral, analgesic, anti-dysenteric properties. The plant reduces fever, cold, swelling of throat, asthma symptoms. The plant subsides gas, flatulence and acidity. It reduces the colic pain, eases the discomfort of piles, stops bleeding from different parts of the body and benefit in heart diseases. It cleanses the blood and eradicates skins problems like itching, inflammation and suppuration. It is helpful in treating piles. The diverse pharmacological properties possessed by this medicinal plant prompted us to review its therapeutic properties which may be useful in developing effective herbal drugs based on Cassia fistula Linn. for treatment of various diseases.

TRADITIONAL USES

All parts of the plant Cassia fistula Linn. have medical uses and are used in different disease conditions. The root of Cassia fistula Linn. is prescribed as a tonic, astringent, febrifuge and strong purgative. The extract of leaves of the plant has been found to reduce mutagenicity in E. coli. The extract of the root bark of the plant with alcohol can be used for back wart fever. Its leaves are laxative and are used externally as emollient, a poultice is used for chilblains, in insect bites, swelling, rheumatism and facial paralysis. Leaves of the plant possess 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. The roots of the plant are used in chest pain, joint pain, migraine and blood dysentery.
The extract of the root of the plant has been found to lower the blood sugar level up to 30 % [13]. Leaves and flowers of the plant 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 [9]. Root of the plant is useful in fever, heart diseases, retained excretions and biliousness [9]. Fruits are used as cathartic and in snake bite. Juice of leaves of the plant is used in skin diseases [10,12]. Flowers and pods of the plant are used as purgative, febrifugal, biliousness and astringent. The ethanolic (50%) extract of pods has been found to show antifertility activity in female albino rats. The heated pods are applied to swellings on the neck due to cold. The fruits of the plant are reported to be used for asthma [3,11]. Pulp of the plant is given in disorders of liver. The plant is used as analgesic and antipyretic, it is a remedy for malaria and fever. It is also applied in blood poisoning, anthrax and leprosy. It also works as anti-dysenteric and anti-diabetic, it is used for the removal of abdominal obstruction [10]. 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]. The fruits of the plant are antipyretic, abortifacient, demulcent, lessen inflammation and heat of the body; useful in chest complaints, throat troubles, liver complaints, diseases of eye and gripping [13]. Juice of leaves is useful as dressing for ringworm, relieving irritation and relief of dropical swelling. The pulp of the fruit around the seeds is a mild purgative [3,7,9,11]. 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 [3,9,10,11,12]. The seeds are slightly sweet, laxative, carminative, cooling and they improve the appetite [3,11] and possess antipyretic activity. They are useful in jaundice, biliousness, skin disease and in swollen throat. A seed dried produce marked hypoglycaemic activity [10]. Seed powder is used in amoebiasis [4,11]. The fruit pulp is used for constipation, colic, chlorosis and urinary disorders [4]. The bark of the plant possesses tonic and anti-dysenteric 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, hemorrhages, wounds, ulcers and boils and various skin diseases [11,14]. The stem bark of the plant is used against amenorrhea, chest pain and swellings [6].

**Ayurvedic Preparations**

The plant Cassia fistula Linn. is used in Ayurvedic preparations also. It is one of the ingredients of the preparation known as Constivac (Lupine Herbal), a bowel regulator, which 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].

**PHYTOCONSTITUENTS**

A large number of phytochemical compounds have been found to be present in the plant Cassia fistula Linn. Pulp of the pod has been found to contain 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 of the plant have been found to give galactomannan free sugars and free amino acids; flowers have been reported to give ceryl alcohol, kaempferol, rhein and a bianthraquinone glycoside, fistulin; leaves have been found to give 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, oxyzanthraquinone, rhein and volatile oils [5,10]. Pulp of the plant consists of sugar, gum, astringent matter, gluten, coloring matter and water [9,12]. Root bark besides tannins contains phlobaphenes and oxyzanthraquinone compounds [10,12]. The plant contains rhein glucoside, rhein, fistulic acid, sennoside A & B [13]. Aurantiamide acetate (0.011), βsitosterol (0.006) and its βD glucoside (0.02%) have been isolated from flowers of the plant [15]. The roots of the plant contain 7-methylphyscion, betulinic acid and βsitosterol [13,15,16]. The stem bark of the plant has been found to contain two flavonol glycosides, 5,7,3',4'-tetrahydroxy-6, 8-dimethoxyflavone-3-O-α-arabinopyranoside (C_{22}H_{22}O_{13}, m.p.285°c.), 5,7,4'-trihydroxy-6,8,3'-trimethoxyflavone-3-O-α-L-rhamnosyl (1→2)-O-β-D-glucopyranoside (C_{30}H_{30}O_{15}, m.p.210°c) and a xanthone glycoside, 1,8-dihydroxy-3, 7-dimethoxyxanthone-4-O-α-L-rhamnosyl(1→2)-O-β-D-glucopyranoside (C_{32}H_{32}O_{15}, m.p.217°c). The cuticular wax of leaves of the plant has been reported to contain hentriacontanoic, tricontaonic, nonacosanoic and heptacosanoic acids. The seed oil contains cyclopropeonoid fatty acids viz. vernolic, malvatic and stetulic 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, triacontane, 16-hentriacontanone and beta-sitosterol have been isolated from the hexane fraction. In addition to these compounds, Misra et al. reported that the hexane fraction of fruits (collected from India) has been isolated from the pulp and beta-sitosterol have been isolated from the hexane fraction. In addition to above compounds, twenty-seven compounds including eight long-chain hydrocarbons, isocapreterol, dihydrokaempferol and 18-dihydroxy-3-methylanthraquinone and its structure was determined [17]. The studies conducted by Mahesh et al. on the plant revealed the presence of chrysophanol, rhein, physcion, and kaempferol. The identities of the compounds were confirmed by spectrometry (NMR, MS, IR) and direct comparison (Co-TLC, MMP) with authentic samples [19]. 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 have been reported in the plant [5, 13]. It has been observed from the studies conducted by Barthakur et al. that the fruit of the plant is a good source of Fe and Mn, and their concentrations are 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]. The results of the study conducted by Vaishnav et al. confirmed that Rhamnetin 3-O-gentiobioside is isolated from the roots of the plant [17, 21]. Misra et al. reported that the hexane fraction of fruits (collected from India) exhibited activity against Klebsiella sp. The compounds 5-Nonatetracontanone, 2-hentriacontanone, triacontane, 16-hentriacontanone and beta-sitosterol have been isolated from the hexane fraction [22]. In addition to these compounds, Misra et al. isolated a new diterpene, 3-beta hydroxy-17-norpimar-8(9)-en-15-one from the pods of Cassia fistula [21]. An anthraquinone derivative, characterized as 3-formyl-1-hydroxy-8-methoxy-anthraquinone has been isolated by Rani et al. (1998) [24]. It has been reported by Sayeed et al. that Cassia fistula seeds grown under different soil and climatic conditions of Bangladesh contain 3% golden colored oil which was fractionated into mono-, di-, and tri-glycerides by silicic acid column chromatography. The triglycerides varied from 89.16% to 91.01%, diglycerides from 2.51% to 3.32% and mono-glycerides from 90.1% to 9.98% depending on the areas from which the seeds were collected. Fractionation of lipids into three major lipid groups such as neutral lipids, glycolipids and phospholipids was carried out by silicic acid column chromatography where the neutral lipids accounted for over 89.80% of the total weight of the lipid employed. Saturated and unsaturated fatty acids present in the oil have been 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 analyzed by gas liquid chromatography (GLC) and 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 [22]. In addition to above compounds, twenty-seven compounds including eight long-chain hydrocarbons, 1-hexacosanol, 1-octacosanol, palmitic acid, stearic acid, oleic acid, linoleic acid, heptacosyl eicosanate, glyceryl-1-tetraecicosanoate; three sterols, beta-sitosterol, stigmasterol, beta-sitosteryl-3-O-D-glucopyranoside; one triterpene, lupeol; eight anthraquinones, chrysophanol, emodin, physcion, citreorosein, rhein, rhein methyl ester, zigeanein, 1,4,5-trihydroxyanthraquinone; two coumarins, isoscopoletin, scopoletin; two chromones, 2,5-dimethyl-7-hydroxychromone, 2,5-dimethyl-7methoxychromone; three aromatic compounds, isovanillic acid, vanillic acid and 2,4-dihydroxybenzaldehyde were isolated and identified from the aril of Cassia fistula and their structures have been determined on the basis of spectral data according to the studies conducted by Lee et al. [24]. The studies conducted by Kuo et al. have shown 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-glucopyranosyl-3,6-dimethoxybenzoate, together with four known compounds, 5-hydroxymethylfurfural, 2′′-7-hydroxy-2-(2′-hydroxypropyl)-5-methylchromone, and two oxyanthraquinones, chrysophanol and chrysophanein, were isolated and identified from the seeds of Cassia fistula and the structures were determined on the basis of spectral data. A new bioactive flavones glycoside (m.p. 252-254 C, C28H32O16 [M]+ 624 (EIMS)) has been isolated from the acetone soluble fraction of the defatted seeds of Cassia fistula by Yadav et al. It was characterized as a new bioactive flavone glycoside 5,3′,4′-trihydroxy-6-methoxy-7-O-alpha-L-rhamnopyranosyl-(1 -> 2)-O-beta-D-galactopyranoside by several colour reactions, spectral analysis and chemical degradations. Ali et al. 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. 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. Sartorelli et al. examined the bio-guided fractionation which resulted in the isolation of a sterol, clerosterol, which was further analyzed in different models. Tzakou et al. examined the chemical compositions of the flower and leaf essential oil of Cassia fistula by GC and GC/MS where 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%).

PHARMACOLOGICAL ACTIVITIES

Antitussive Activity
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 and 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 confirming its antitussive potential.

CNS Activities
The methanol extract of seeds of C. fistula was tested for different pharmacological actions in mice and the extract significantly potentiated the sedative actions of sodium pentobarbitone, diazepam, mepromabate and chlorpromazine. It also potentiated analgesia induced by morphine and pethidine in a dose-dependent manner. The extract also influenced behaviour in mice. These studies have shown that the methanol extract of seeds of C. fistula possesses significant CNS activities.

Leukotriene Inhibition Activity
Studies have shown that the methanol extract of fruits of C. fistula inhibited the 5-lipoxygenase catalysed formation of leukotriene B4 in bovine polymorphonuclear leukocytes (IC50 value of 38 micro g/ml). Lipid peroxidation in bovine brain phospholipid liposomes induced with 2,2'-azo-bis-(2-amidinopropane) dihydrochloride (AAPH) was inhibited (IC50 of 40 micro g/ml). A linear correlation was obtained between the effects of the extract in the two assays suggesting a redox-based mechanism for the inhibition of the 5-lipoxygenase enzyme.

Clastogenic Effect
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 of the study 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.
Antipyretic Activity
The methanol extract of buds of C. fistula was investigated 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.

Antioxidant Activity
The antioxidant properties of 90% ethanol extracts of leaves and 90% methanol extracts of stem bark, pulp and flowers from Cassia fistula were investigated. The antioxidant activity was found 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 pro-oxidants 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. In another study, 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 \(\text{mmol/g dry weight}\); FRAP) 811 (23 \(\text{mmol/g dry weight}\)). The 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 antioxidant activity in alloxan diabetic rats.

Laxative Activity
The in-vitro effect of Cassia fistula infusion on isolated guinea-pig ileum was studied where 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. 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. Thus, C. fistula pod infusion could be safely utilized as laxative drug and as a substitute for the official Senna.

Anti-inflammatory Activity
The extract of leaves of C. fistula has been evaluated for anti-inflammatory activity using carrageenan-, histamine- and dextran- induced paw oedema assays in rats and the activity was compared with that of phenylbutazone. It has been noted that the extract exhibited potent anti-inflammatory activity against all phlogistic agents. In another study, the aqueous (CFA) and methanolic extracts (CFM) of the Cassia fistula bark were assayed for anti-inflammatory and antioxidant activities 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 \(\text{CCl}_4\) and \(\text{FeSO}_4\) 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. The studies revealed that Cassia fistula bark extracts (CFA & CFM) possess significant anti-inflammatory and antioxidant properties.
Rajeswari et al. 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. 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**

The methanolic extract of C. fistula leaves was studied 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\(^{[45]}\). Kumar et al. 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. In this study, 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. It has been observed that 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, hypcholesterolaemic, 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**

The hepatoprotective and antioxidant effect of Cassia fistula leaf extract on liver injury induced by diethyl nitrosamine (DEN) was investigated using animal model Wistar rats. In the experimental animal study, *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. The results of the study revealed that ELE of C. fistula protects the liver against DEN induced hepatic injury in rats\(^{[47]}\). In another study, the hepatoprotective activity of the n-heptane extract of Cassia fistula leaves was investigated where the extract at a dose of 400 mg/kg body weight has been found to exhibit significant protective effect by lowering serum levels of transaminase (serum glutamic-oxaloacetate transaminase [aspartate aminotransferase] and serum glutamic-pyruvic transaminase [alanine aminotransferase]), bilirubin and alkaline phosphatase. The protective effect was found to be comparable to that of a standard hepatoprotective agent\(^{[48,49]}\).

**Antifungal Activity**

The leaf extract of Cassia fistula was evaluated for antifungal activity against *Candida albicans* where extracts of the leaves of Cassia fistula were prepared in acetone, diethyl ether and methanol for testing and the antifungal activity was performed by paper disc diffusion assay. The results of the study indicated that the methanol extract showed highest activity i.e., up to 21 mm which was comparable with the standard antifungal antibiotic, clotrimazole\(^{[50]}\). The hexane, chloroform, ethyl acetate, methanol and water extracts from the flower of Cassia fistula were tested against bacteria and fungi where 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 and 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

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*. The results of the study have shown that 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\(^{[52]}\). In another study, 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 found to be 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 of the study show that the leaf extract of *C. fistula* is a promising larvicidal and ovicidal agent against *C. quinquefasciatus* and *A. stephensi*\(^{[53]}\).

### Antibacterial Activity

A compound isolated from *C. fistula* has been found to possess antimicrobial activity against *Staphylococcus aureus*, *Bacillus subtilis*, *Klebsiella pneumoniae*, *Escherichia coli*, *Aspergillus niger* and *Fusarium oxysporum*\(^{[28]}\). In a study, 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*\(^{[46]}\). Sundararaju et al. have 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. In this study, the mortality rate was found 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*\(^{[55]}\). In another study, three lectins 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*. Further, it has been observed that 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)\(^{[46]}\). In another study, the antibacterial activity of the aqueous and alcoholic extract of stem bark of *C. fistula* was evaluated and it has been found that 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\(^{[55]}\).

### Hypocholesterolemic and Hypoglycaemic Activity

The hypocholesterolemic and hypoglycemic effects of the hexane extract of stem bark of *C. fistula*, were found 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.
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.

**Antitumor Activity**
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 where it has been found that 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 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. Studies have been to investigate the chemopreventive efficacy of Cassia fistula bark extracts in 7,12-dimethyl Benzo(a)anthracene (DMBA) induced hamster buccal pouchcarcinogenesis. The results of this study have revealed that 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 anti-lipid peroxidative, antioxidative and modulation of detoxification agents during DMBA induced oral carcinogenesis.

**Antiparasitic Activity**
The fractionation through bio-guided antileishmanial activity of the dichloromethane extract of Cassia fistula fruits (Leguminosae) led to the isolation of the active isoflavone biochanin A, identified by spectroscopic methods. This compound showed 50% effective concentration (EC₅₀) value of 18.96 micro g/mL against promastigotes of Leishmania (L.) chagasi. The cytotoxicity of this substance against peritoneal macrophages resulted in an EC₅₀ value of 42.58 micro g/mL. Additionally, biochanin A presented an anti-Trypanosoma-brucei activity, resulting in an EC₅₀ value of 18.32 micro g/mL and a 2.4-fold more effectiveness than benznidazole.

**Hypolipidemic Activity**
The effect of 50% ethanolic extract of Cassia fistula legume was investigated on serum lipid metabolism in cholesterol fed rats where 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.

**Antifertility Activity**
Research studies have demonstrated that petroleum ether extract of seeds of Cassia fistula, as screened for antifertility activity in proven fertile female albino rats at the doses 100, 200 and 500 mg/kg b.wt./day, produced significant antifertility activity. The results of the study have revealed that 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 fetuses 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 administered along with estradiol valerate (0.1 mg/kg b.wt.). In this experimental animal study, 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.
Anti-leishmanial activity

Research studies have shown that the hexane extract from the fruits of Cassia fistula possesses significant antileishmanial activity against the promastigote form of Leishmania chagasi. It has been found that the bio-guided fractionation resulted in the isolation of a sterol, clerosterol, which was further analyzed 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\(^\[64\]\). Jaffary et al. evaluated the effectiveness of Cassia fistula in the treatment of leishmaniasis, where 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 clinical study, 63.6% of patients were treated with the concentrated boiled extract, 52.7% of patients were treated with the hydroalcoholic extract and 45.5% of patients were treated with Glucantime. In total, 22 patients (40%) were given the concentrated boiled extract of C. fistula, 20 patients (36.4%) were given the hydroalcoholic extract of C. fistula, and 36 patients (65.5%) of the Glucantime group showed complete cure. The results of the study revealed that 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\(^\[61\]\). In addition to these studies, Jaffary et al. also conducted the studies to evaluate the potential of Cassia fistula boiled extract in the treatment of cutaneous leishmaniasis, to evaluate the efficacy of intralosomal meglumine antimonate-C. Fistula fruit gel combination for the treatment of cutaneous leishmaniasis. In this clinical study, a total of 140 patients with cutaneous leishmaniasis were taken, one group received intralosomal meglumine antimonate injection and C. fistula fruit gel, and the second group (control) was treated with intralosomal meglumine antimonite plus placebo gel. Improvement was defined as complete cure, partial cure and treatment failure. At week 12, forty-seven (67.1%) patients in the experimental group achieved complete cure, compared to 29 (41.4%) patients in the control group (P<0.001). Results of this clinical study indicate that the C. fistula fruit gel increases the efficacy of intralosomal meglumine antimonate for the treatment of cutaneous leishmaniasis. Thus, combination therapy with intralesional meglumine antimonite and C. fistula fruit gel may be considered for the treatment of acute cutaneous leishmaniasis\(^\[65\]\).

DISCUSSION

Medicinal plants have been used as remedies for human diseases for centuries. The use of medicinal plants to heal chronic complex diseases, including infectious ones, has been extensively applied by people worldwide. Interestingly, over 50% of all modern clinical drugs are of natural product origin\(^\[66\]\). Cassia fistula has occupied a significant position in herbal medicine due to its therapeutic potential in prevention and treatment of varieties of diseases. Almost all parts of this medicinal plant have been found to exhibit different pharmacological properties such as anti-diabetic, anti-fertility, anti-tumor, hepatoprotective, cholesterol lowering, astringent, febrifugal, purgative, anti-inflammatory, anti-oxidant, antibacterial, anti-viral, analgesic, anti-dysenteric, antibacterial, antifungal, anti-leishmanial properties, larvicidal and ovicidal activity, wound healing activity, laxative activity, clastogenic activity, antipyretic activity, leukotriene inhibition activity, antitussive activity, CNS activity etc. The plant is well known for its traditional uses. Among its traditional uses, few are Cassia fistula reduces fever, cold, swelling of throat, asthma symptoms; it has ability to subside gas, flatulence and acidity; it reduces the colic pain; it eases the discomfort of piles, stops bleeding from different parts of the body and benefit in heart diseases; it cleanses the blood and eradicates skins problems like itching, inflammation and suppuration. The pharmacological actions exhibited by Cassia fistula in treatment of several ailments have attracted interest of pharmaceutical companies in preparation of herbal formulations based on Cassia fistula. It is one of the ingredients of the Ayurvedic preparation known as Constivac (Lupin Herbal), a bowel regulator, which relieves constipation. It is also one of the ingredients of the preparations known as Pilex, Purian (Himalaya Drug Company) for piles and detoxifier respectively.
A large number of biomolecules / phytoconstituents present in Cassia fistula may be responsible for its diverse nature of therapeutic response in disease conditions. It has been observed from research studies that most of the antimicrobial effects of *C. fistula* be related to their components and secondary metabolites like phenolic compounds. Phytochemical studies have shown that this plant contains components like saponin, triterpenoids, glycosides, anthraquinone, steroids and flavonoids which may inhibit the growth of the bacterial strains. The antimicrobial activity depends on the contents of phenolic components of the plant extracts. High amounts of phenolic group in the aerial parts of *C. fistula* have been reported suggesting that these components may be the active compounds, which may be responsible for the antibacterial activity. It has been found that *Cassia* species had a significant activity against Gram positive microorganisms which may be due to the presence of some substances like flavonoids and polysaccharides. Research studies have shown that methanolic extracts inhibited Gram positive bacteria more than Gram negative species thus *C. fistula* extracts can be useful to treat infectious diseases and may be considered as a new source of antibacterial agents. The *C. fistula* extracts can be used as Complementary or Alternative Medicine in various disease conditions. Although *C. fistula* exhibits significant therapeutic actions in treatment of varieties of chronic and infectious diseases, multidisciplinary research studies on this clinically significant plant and its constituents is needed in order to develop effective herbal drugs for mankind.

Several microorganism- derived antibiotics are currently in use to treat variety of infectious diseases. Many of them have, however, a limited anti-microbial spectrum due to frequent evolution of drug-resistant mutant strain of the pathogen; some even lead to serious side effects. Further, situation is alarming in developing as well as developed countries due to indiscriminate use of antibiotics. The number of multi-drug-resistant microbial strains and the appearance of strains with reduced susceptibility to antibiotics are continuously increasing. This increase has been attributed to indiscriminate use of broad-spectrum antibiotics, immunosuppressive agent, intravenous catheters, organ transplantation and ongoing epidemics of HIV infection. In addition, in developing countries, synthetic drugs are not only expensive and inadequate for the treatment of diseases but also often with adulterations and side effects. Therefore, there is need to search new infection-fighting strategies to control microbial infections.

In the present scenario of emergence of multiple drug resistance to human pathogenic organisms, there is a necessity to search for new antimicrobial substances from other sources including plants which may be useful in developing safe, long acting antimicrobial drugs based on medicinal plants / herbs as alternative and complementary medicine for mankind in treatment and prevention of infectious diseases. The potential for developing antimicrobials from medicinal plants appears to be more appropriate as it may lead to the development of a phytomedicine to act against microbes. Plant based antimicrobials represent a vast untapped source of medicine. Plant based antimicrobials have enormous therapeutic potential as they can serve the purpose without any side effects that are often associated with synthetic antimicrobials.

Since, most modern drug discovery attempts to use one single compound to hit one target for combating the related disease, targeted single compound usually fails to cure multi-genic diseases adequately as human body is an extremely complex network and the pathogenesis of most of diseases involves multiple factors. Further, a single target drug can exert unexpected side effects due to the breaking of the balance of the network. Traditional systems of medicines are still in place today because of their organizational strengths and as they focus primarily on multi-component mixtures. They contain enormous number of compounds to fight the disease at various aspects. Biological activity of crude drug is mainly due to the active chemical constituents like saponins, flavonoids, triterpenoids, sterols, tannins, steroids etc.

It is believed that the medicinal value of plants lies in some chemical substances (usually secondary metabolites) producing a definite physiological action on the human body. Saponins are glycosides occurring widely in plants and are abundant in many foods consumed by animals and man. In medicine, it is used as antibiotic, antiviral, anti-inflammatory and anti-ulcer. Flavonoids are a group of polyphenolic compounds with known properties which include free radical scavenging, inhibition of hydrolytic and oxidative enzymes and anti-inflammatory action. Triterpenoids and sterols from plants and fungi possess antitumor-promoting and anti-inflammatory activities. Tannins are known to possess general antimicrobial and antioxidant activities. Recent reports show that tannins may have potential value as cytotoxic and antineoplastic agents.
Other compounds like saponins also have antifungal properties. Plant derived natural products such as flavonoids, terpenoids and steroids etc. have received considerable attention in recent years due to their diverse pharmacological properties including antioxidant and antitumor activity. The herbal medicinal preparations may exert synergistic effects due to multi-constituents and multi-targets and these formulations can explore a wider biological space with less expense. These herbal formulations have ability to modulate the biological networks modestly and thus may be efficient in controlling complex disease systems. The herbal preparations exert effects at lower concentration of individual constituents, thus are safer than single component drugs and these can deal with drug resistance that becomes more and more severe with antibiotics, antimalarial and anticancer drugs. Thus, there is a need of exploring new faces of drug discovery based on herbal formulations. In order to achieve results within reasonably short period it would be desirable to have a need based approach to research on herbal/traditional drugs including screening of medicinal plants and herbs for biological activity. Extensive multi-disciplinary research efforts on the efficacy of medicinal plants/herbs to treat diseases followed by animal studies and clinical trials on human subjects are urgently needed to finding remedies for the so called Refractory Diseases for which modern medicine has not been able to offer, so far, a satisfactory or lasting remedy and as supplementary measures to well-established chemotherapy. Further, scientific studies on the effect of agroclimatic conditions, seasonal variations, soil conditions, cultivation practices, geographical variations, environmental factors on the growth of these plants and quality of their phytoconstituents along with the studies on organic nature of the medicinal plants/herbs i.e. free from toxic metals, pesticides, herbicides and environmental harmful toxins using modern biotechnological techniques may enhance the therapeutic potential of these medicinal plants/herbs. Considering the innumerable side and ill effects of modern medicine and deaths caused by adverse drug reactions recorded in developed countries, it has become imperative to look for Holistic Herbal Medicines of the oriental Indian Medical systems as an Alternative and Complimentary Medicine. This is necessary because these are time tested remedies used by humans for millennia with minimal adverse reactions. These herbs are specially needed to treatment of chronic diseases. Thus, the usefulness of medicinal plants/herbs in the treatment of many chronic diseases and infectious diseases appears to be of great benefits for ailing humanity.

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