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CASSIA TORA: A PHYTO-PHARMACOLOGICAL OVERVIEW

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ABSTRACT
Cassia tora, a popular Indian medicinal plant, has long been used in Ayurvedic system of medicine. The plant has been found to possess diverse number of pharmacological activities. The present paper gives an account of updated information on its phytochemical and pharmacological activities. The review reveals that wide range of phytochemical constituents have been isolated from the plant and it possess important activities like laxative, skin diseases, ringworm, eye diseases, liver complaint, dysentery and anthelmentic. Various other activities like antioxidant, hypoglycemic, hypolipidemic, antinociceptive, antiplasmodial, antifungal & antimicrobial, hyperlipemia & hypotensive have also been reported. These reports are very encouraging and indicate that herb should be studied more extensively for its therapeutic benefits.
Keywords: *Cassia tora*, ethnobotanical, phytoconstituents & pharmacological activities.

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INTRODUCTION

A small plant growing on dry soil in Bengal and throughout the tropical parts of India. An annual herb fetid herb 30-90 cm high. Leaves 7.5-10 cm long; rachis grooved, more or less pubescent, with a conical gland between each of the 2 lowest pairs of leaflets; stipules 1.3-2 cm. long, linear-subulate, caducous. Leaflets 3 pairs, opposite, 2.5-4.5 by 1.3-2.5 cm. (the lowest pair the smallest), obovate-oblong, glaucous, membranous, glabrous or more or less pubescent, base somewhat oblique, usually rounded; main nerves 8-10 pairs; petiolules 2.5 mm. long, pubescent. Flowers usually in subsessile pairs in the axils of the leaves, the upper crowded; commom peduncle in fruit not exceeding 4 mm. long; pedicels in fruit rarely exceeding 8 mm. long. Calyx glabrous, divided to the base; segments 5 mm. long, ovate, acute, spreading. Petals 5, pale yellow, subequal, 8 by 2.5 mm., oblong, obtuse, spreading, the upper petal (standard) 2-lobed, the entires. Stamens 10, the 3 upper reduced to minute staminodes, the remaining 7 perfect, subequal. Pods 12.5-20 cm. by 4-5 mm., subtetragonous, much curved when young, obliquely septate, puberulous, not reticulate, the sutures very broad. Seeds 25-30, rhombohedral, with the long axis in the direction of the pods.

The leaves are used as laxatives in the form of decoction. Both leaves and seeds constitute a valuable remedy in skin diseases, chiefly for ringworm and itch. In China, the seeds are used externally for all sorts of eye diseases; preparations are also given for liver complaints and boils. In Indo China, the pods are used in dysentery and diseases of the eye. In Nigeria, the leaves are as a mild laxative. The weed is used in various Gold Coast medicines, chiefly as a purgative. In Madagascar and La Reunion, the root is considered bitter, tonic, stomachic. The leaves are used as an antiperiodic, aperient, anthelmintic; they are given to children with intestinal troubles. The root is not an antidote to either snake-venom or scorpion-venom[1].

PHARMACOLOGICAL STUDY

Antioxidant property

In the present study *C. tora* methanolic leaf extract (CTME) was evaluated for its nitric oxide scavenging activity and reducing power assays using Rutin and BHT as standards. Preliminary phytochemical analysis of leaf showed the presence of polyphenols (3.7 mg gallic acid equivalent per gram dried leaves). The presence of phenolic compound prompted us to evaluate its antioxidant and antiproliferative potential. The extract was studied for its lipid peroxidation inhibition assay

using rat liver and brain. In all assays, a correlation existed between concentration of extract and percentage inhibition of free radical, reducing power and inhibition of lipid peroxidation. The antiproliferative activity of CTME with Cisplatin, anticancer drug was studied using human cervical cancer cells (HeLa). Proliferation of HeLa was measured by MTT assay, cell DNA content by modified diphenylamine method and apoptosis by Caspase 3 activity. The plant extract induced a marked concentration dependent inhibition on proliferation, reduced DNA content and apoptosis in HeLa. These results clearly indicate that *C. tora* is effective against free radical mediated diseases[2].

In the search for the regulatory basis of biochemical response to Al, cell wall-bound peroxidases, including lignin-generated peroxidases and NADH oxidases, were investigated in the root tips of *C. tora*. Activities of both types of peroxidases significantly increased with Al concentrations. Analysis with native PAGE also demonstrated the strong induction of cell wall peroxidases by Al. The Al-induced increasing activities of peroxidases were closely correlated with lignin accumulation and H_2O_2 production. The biochemical effect of exogenous nitric oxide (NO) and methyl jasmonic acid (MJ) was examined to investigate signal properties and lignin synthesis under Al stress. Application of MJ at 10 microM promoted root sensitivity to Al by activating apoplastic peroxidase activity and accumulating H_2O_2 and lignin, whereas the opposite action was found for NO. The sensitivity of apoplastic peroxidases under Al stress was associated with the cross-talk of MJ and NO signals. The analysis reveals that the activity of lipoxygenase (an enzyme for MJ biosynthesis), with its transcripts increased in Al-exposed roots, was depressed by NO exposure. The effect of MJ on intracellular NO production was also investigated. It is shown that NO staining with 4,5-diaminofluorescein diacetate fluorescence was intensified by Al but was suppressed by MJ. These results suggest that NO and MJ may interplay in signaling the cell wall peroxidase activity and lignin synthesis in the roots exposed to Al[3].

In the present study the effect of NO on *Cassia tora* L. plants exposed to aluminum (Al) was investigated. Plants pre-treated for 12 h with 0.4 mM sodium nitroprusside (SNP), an NO donor, and subsequently exposed to 10 microM Al treatment for 24 h exhibited significantly greater root elongation as compared with the plants without SNP treatment. The NO-promoted root elongation was correlated with a decrease in Al accumulation in root apexes. Furthermore, oxidative stress associated with Al treatment increased lipid peroxidation and reactive oxygen species, and the activation of lipoxygenase and antioxidant enzymes was reduced by NO. Such effects were confirmed by the histochemical staining for the detection of peroxidation of lipids and loss of membrane integrity in roots. The ameliorating effect of NO was specific, because the NO scavenger cPTIO [2-(4-carboxy-2-phenyl)-4,4,5,5-tetramethylinidazoline-1-oxyl-3-oxide] completely reversed the effect of NO on root growth in the presence of Al. These results indicate that NO plays an important role in protecting the plant against Al-induced oxidative stress[4].

In the present study the various plant extracts were tested for their ONOO- scavenging activity. Among them, extract from *Cassia tora*, which is well known as an oriental herb in traditional medicine, showed potent ONOO- scavenging activity. Further analysis identified the phenolic active components, alaternin and nor-rubrofusarin glucose, as potent ONOO- scavengers. Spectrophotometric analysis demonstrated that alaternin and nor-rubrofusarin glucose led to a decrease in the ONOO- -mediated nitration of tyrosine through electron donation. In bovine serum albumin, alaternin, but not nor-rubrofusarin glucose, showed significant inhibition of ONOO- -mediated nitration in a dose-dependent manner. We believe alaternin can be developed as an effective ONOO- scavenger for the prevention of ONOO- -associated diseases[5].

The antioxidant properties of water extracts from *Cassia tora* L. (WECT) prepared under different degrees of roasting were investigated. The water extracts of unroasted *C. tora* L. (WEUCT) showed 94% inhibition of peroxidation of linoleic acid at a dose of 0.2 mg/mL, which was higher than that of alpha-tocopherol (82%). Water extracts prepared from *C. tora* L. roasted at 175 °C for 5 min and at 200 °C for 5 min exhibited 83% and 82%, respectively, inhibition of linoleic acid peroxidation. This result indicated that the antioxidant activities of WECT decreased with longer roasting time or higher roasting temperature. The IC_{50} of WEUCT in liposome oxidation induced by the Fenton reaction was 0.41 mg/mL, which was higher than that of alpha-tocopherol (IC_{50} = 0.55 mg/mL). WEUCT also exhibited good antioxidant activity in enzymatic and nonenzymatic microsome oxidative systems. The water extracts of roasted *C. tora* L. increased in the degree of browning and produced chemiluminescence when compared with the unroasted sample. However, the total polyphenolic compounds of WECT decreased after the roasting process finished. In conclusion, the decrease in the antioxidant activity of water extracts from roasted *C. tora* L. might have been due to the degradation of

Maillard reaction products and the decrease of polyphenolic compounds[6].

The effects of water extracts from *Cassia tora* L. (WECT) treated with different degrees of roasting (unroasted and roasted at 150, 200, and 250 °C) on the oxidative damage to deoxyribose, DNA, and DNA base in vitro were investigated. It was found that WECT alone induced a slight strand breaking of DNA. In the presence of Fe(3+)/H(2)O(2), WECT accelerated the strand breaking of DNA at a concentration of 2 microg/mL; however, it decreased with increasing concentrations (>5 microg/mL) of WECT. WECT also accelerated the oxidation of deoxyribose induced by Fe(3+)-EDTA/H(2)O(2) at a concentration of 0.2 mg/mL but inhibited the oxidation of deoxyribose induced by Fe(3+)-EDTA/H(2)O(2)/ascorbic acid. Furthermore, WECT accelerated the oxidation of 2'-deoxyguanosine (2'-dG) to form 8-OH-2'-dG induced by Fe(3+)-EDTA/H(2)O(2). The prooxidant action of WECT on the oxidation of 2'-dG was in the order of unroasted > roasted at 150 degrees C > roasted at 200 degrees C > roasted at 250 °C. The decrease in the prooxidant activity of the roasted sample might be due to the reduction in its anthraquinone glycoside content or the formation of antioxidant Maillard reaction products after roasting. Thus, WECT exhibited either a prooxidant or an antioxidant property in the model system that was dependent on the activities of the reducing metal ions, scavenging hydroxyl radical, and chelating ferrous ion[7].

Hepatoprotective activity

Ononitol monohydrate, structurally similar to glycoside was isolated from *Cassia tora* L. leaves. Fifty Male rats were divided into five groups. Group I served as normal control. Group II, III and IV rats were induced hepatotoxicity by CCl_4 administering single dose of CCl_4 on 8th day only. Group III was treated with ononitol monohydrate (20mg/kg body weight) and group IV was treated with reference drug silymarin (20mg/kg body weight) both dissolved in corn oil and administering for 8 days. Ononitol monohydrate with corn oil alone was given for 8 days (group V). At the end of the experimental period all the animals were sacrificed and analyzed for biochemical parameters to assess the effect of ononitol monohydrate treatment in CCl_4 induced hepatotoxicity. In in vivo study, ononitol monohydrate decreased the levels of serum transaminase, lipid peroxidation and TNF-alpha but increased the levels of antioxidant and hepatic glutathione enzyme activities. Compared with reference drug silymarin ononitol monohydrate possessed high hepatoprotective activity. Histopathological results also suggested the hepatoprotective activity of ononitol monohydrate with no adverse effect. Hence we conclude that ononitol monohydrate is a potent hepatoprotective agent[8].

Inhibitory properties

Bioactivity of seeds from raw and roasted *Cassia tora* via angiotensin converting enzyme (ACE) inhibitory assays was screened. It was found that both of the MeOH extracts from the raw and roasted *C. tora* exhibited significant inhibitory properties against ACE, demonstrating more than 50% inhibition at a concentration of 163.93 microg/mL. Emodin (3), alaternin (4), gluco-obtusifolin (5), cassiaside (6), gluco-aurantioobtusin (7), cassitoroside (8), toralactone gentiobioside (9), and chrysophanol triglucoside (10) had been previously isolated; however, questin (1) and 2-hydroxyemodin 1-methylether (2) were isolated from *C. tora* for the first time in this study. Among them, only anthraquinone glycoside (7) demonstrated marked inhibitory activity against ACE, with an IC_{50} value of 30.24 +/- 0.20 microM. Conversely, aurantioobtusin (7a), obtained from the acid hydrolysis of 7, showed no activity. Further inhibitory kinetics analyzed from Lineweaver-Burk plots showed 7 to be a competitive inhibitor with a Ki value of 8.3 x 10(-5) M. Moreover, compound 7 showed marked inhibitory and scavenging activities with an IC_{50} value of 49.64 +/- 0.37 microM (positive control; trolox: 26.07 +/- 1.05 microM) for total reactive oxygen species generation, and 4.60 +/- 1.12 microM (positive control; penicillamine: 0.24 +/- 0.04 microM) for ONOO(-). [9]

The effects of water extracts from *Cassia tora L.* (WECT) treated with different degrees of roasting on benzo[a]pyrene (B[a]P)-induced DNA damage in human hepatoma cell line HepG2 were investigated via the comet assay without exogenous activation mixtures, such as S9 mix. WECT alone, at concentrations of 0.1-2 mg/mL, showed neither cytotoxic nor genotoxic effect toward HepG2 cells. B[a]P-induced DNA damage in HepG2 cells could be reduced by WECT in a dose-dependent manner ($P < 0.05$). At a concentration of 1 mg/mL, the inhibitory effects of WECT on DNA damage were in the order unroasted (72%) > roasted at 150 degrees C (60%) > roasted at 250 degrees C (23%). Ethoxyresorufin-O-dealkylase activity of HepG2 cells was effectively inhibited by WECT, and a similar trend of inhibition was observed in the order unroasted (64%) > roasted at 150 degrees C (42%) > roasted at 250 degrees C (18%). The activity of NADPH cytochrome P-450 reductase was also decreased by unroasted and 150 degrees C-roasted samples (50% and 38%, respectively). Furthermore, glutathione S-transferase activity was increased by treatment with unroasted (1.26-fold) and 150 degrees C-roasted (1.35-fold) samples at 1 mg/mL.

In addition, the contents of anthraquinones (AQs) in WECT, including chrysophanol, emodin, and rhein, was decreased with increasing roasting temperature. Each of these AQs also demonstrated significant antigenotoxic activity in the comet assay. The inhibitory effects of chrysophanol, emodin, and rhein on B[a]P-mediated DNA damage in HepG2 cells were 78, 86, and 71%, respectively, at 100 microM. These findings suggested that the decreased antigenotoxicity of the roasted samples might be due to a reduction in their AQs content.[10]

Hypoglycemic activity

In the present study, the effects of *Cassia tora L*. seed butanol fraction (CATO) were studied on postprandial glucose control and insulin secretion from the pancreas of the normal and diabetic rats. Diabetes was induced by an i.p. injection of Streptozotocin (55 mg/kg BW) into the male Sprague-Dawley rats. The postprandial glucose control was monitored during a 240 min-period using a maltose loading test. In normal rats, rats fed CATO (20 mg/100 g BW/d) showed lower postprandial glucose levels in all the levels from 30 min up to 180 min than those in the control rats without CATO ($p<0.05$). In diabetic rats, those levels in the CATO group seemed to be lower during the 30~180 min, but only glucose level at 30 min showed significant difference compared to that in the control group. Moreover, CATO delayed the peak time of the glucose rise in both normal and diabetic rats in the glucose curves. On the other hand, when CATO was administered orally to the diabetic rats for 5 days, 12 hr fasting serum glucose level was decreased in the diabetic rats ($p<0.05$). Degree of a decrease in 12 hr fasting serum insulin levels was significantly less in the diabetic CATO rats as compared to diabetic control rats. On the last day of feeding, beta cells of the pancreas were stimulated by 200 mg/dL glucose through a 40 min-pancreas perfusion. Amounts of the insulin secreted from the pancreas during the first phase (11~20 min) and the second phase (21~40 min) in the CATO fed diabetic rats were significantly greater than those in the diabetic control group ($p<0.05$). These findings indicated that constituents of *Cassia tora* L. seeds have beneficial effect on postprandial blood glucose control which may be partially mediated by stimulated insulin secretion from the pancreas of the diabetic rats.[11]

Cassia tora fiber supplement consisting of 2 g of soluble fiber extracted from *Cassia semen* (*C. tora* L.), 200 mg of alpha-tocopherol, 500 mg of ascorbic acid, and 300 mg of maltodextrin was formulated in a pack, and given to 15 type II diabetic subjects (seven men and eight women 57.1 +/- 2.9 years old) with instructions to take two packs per day for 2 months. Placebo contained maltodextrin only with a little brown caramel color. Lifestyle factors and dietary intakes of the subjects were not altered during the 2-month period. Serum total cholesterol was moderately ($P < .1$) decreased in the *C. tora* group compared with the age- and gender-matched placebo group, as was the ratio of apolipoprotein B to apolipoprotein A1 ($P < .1$). Levels of serum triglycerides and low-density lipoprotein-cholesterol tended to decrease more in the *C. tora*-supplemented group than in the placebo group. Serum alpha-tocopherol was increased ($P < .01$) but lipid peroxides were not significantly lower in the *C. tora* group. Fasting blood glucose, hemoglobin A1c, blood urea nitrogen, creatinine, and activities of serum aspartate aminotransferase and alanine aminotransferase were not changed by the fiber supplement. We concluded that *C. tora* supplements can help improve serum lipid status in type II diabetic subjects without serious adverse effects.[12]

Estrogenic activity

Through an estrogenic activity bioassay-guided fractionation of the 70% ethanolic extract of *Cassia tora* seeds two new phenolic triglucosides, torachrysone 8-O-[beta-D-glucopyranosyl(1-->3)-O-beta-D-glucopyranosyl(1-->6)-O-beta-D-glucopyranoside] (1) and toralactone 9-O-[beta-D-glucopyranosyl-(1-->3)-O-beta-D-glucopyranosyl-(1-->6)-O-beta-D-glucopyranoside] (2), along with seven known compounds were isolated. The estrogenic activity of the fractions and the isolated compounds were investigated using the estrogen-dependent proliferation of MCF-7 cells. In addition, the yeast two hybrid assay expressing estrogen receptor alpha (ERalpha) and beta (ERbeta) and the ERalpha competitor screening assay (ligand binding screen) were used to verify the binding affinities of the isolated compounds to ER. Furthermore, a naringinase pre-treatment of the 70% alcoholic extract of *Cassia tora* seeds resulted in a significant increase in its estrogenic activity. From the naringinase pre-treated extract six compounds were isolated, among which 6-hydroxymusizin and aurantio-obtusin showed the most potent estrogenic activity, while torachrysone, rubrofusarin and toralactone showed a significant anti-estrogenic activity. Finally, the structure requirements responsible for the estrogenic activity of the isolated compounds were studied by investigating the activity of several synthetic compounds and chemically modifying the isolated compounds. The basic nucleus 1,3,8-trihyroxynaphthalene (T(3)HN) was found to play a principal role in the binding affinity of these compounds to ER.[13]

Citrate synthase activity

In the present study, a protein-synthesis inhibitor, cycloheximide (CHM), was used to investigate its effect on Al-induced organic acid secretion in a pattern I (rapid exudation of organic acids under Al stress) plant buckwheat (*Fagopyrum esculentum* Moench) and a pattern II (exudation of organic acids was delayed by several hours under Al stress) plant *Cassia tora* L. A dose-response experiment showed that the secretion of oxalate by buckwheat roots was not affected by CHM when added in the range from 0 to 50 microM, with or without exposure to 100 microM Al, but the secretion of citrate was completely inhibited by 30 microM CHM in *C. tora*. A time-course experiment showed that even prolonged exposure to 20 microM CHM did not affect oxalate secretion in buckwheat, but significantly inhibited citrate secretion in *C. tora*. However, citrate synthase (CS) activity in *C. tora* was not affected during 12 h exposure to 100 microM Al when compared with that in control roots, although CHM can inhibit CS activity effectively. These results indicated that CS activity was not related to Al-regulated citrate efflux in *C. tora*. The total protein was decreased by 14.0% and 32.3% in *C. tora* and buckwheat root tip, respectively, after 3-h treatment with 20 microM CHM. A 3-h pulse with 20 microM CHM completely inhibited citrate efflux in *C. tora* during the next 6-h exposure to Al, although a small amount of citrate was exuded after 9-h exposure. However, oxalate efflux in buckwheat was not influenced by a similar treatment. In buckwheat, a 3-h pulse with 100 microM Al maintained oxalate secretion at a high level during the next 9 h, with or without CHM treatment. Conversely, in *C. tora* a 6-h pulse with 100 microM Al induced significant secretion of citrate which was inhibited by the CHM. Taken together, these findings suggest that both de novo synthesis and activation of an anion channel are needed for Al-induced secretion of citrate in *C. tora*, but in buckwheat the plasma membrane protein responsible for oxalate secretion pre-exists.[14]

Aluminum-induced exudation of organic acids from roots has been proposed as a mechanism for Al tolerance in plants. To better understand the regulatory process leading to efflux of organic acids, the possible involvement of salicylic acid (SA) in regulating Al-induced citrate release in *Cassia tora* L. was identified. The response of citrate efflux to exogenous SA was concentration-dependent. Application of SA at 5 microM in solution containing 20 microM Al increased citrate efflux to levels 1.76-fold higher than in controls (20 microM Al alone). However, inhibition of citrate release was observed when SA concentrations increased to more than 20 microM. Increased citrate efflux due to the SA treatment was associated with decreased inhibition of root growth and Al content in root tips, suggesting that exogenous SA could confer Al tolerance by increasing citrate efflux. Citrate synthase activities (EC 4.1.3.7) and citrate concentrations in root tips exposed to Al and/or SA was examined. However, both citrate synthase activities and citrate accumulation remained unaffected. These results indicate that SA-promotion of Al-induced citrate efflux is not correlated with increase in citrate production. Total endogenous SA concentrations were measured in root tips and the SA concentrations were significantly enhanced by Al at levels of 10-50 microM.[15]

Antigenotoxic properties

Antigenotoxic properties and the possible mechanisms of water extracts from *Cassia tora* L. (WECT) treated with different degrees of roasting (unroasted and roasted at 150 and 250 degrees C) were evaluated by the Ames Salmonella/microsome test and the Comet assay. Results indicated that WECT, especially unroasted *C. tora* (WEUCT), markedly suppressed the mutagenicity of 2-amino-6-methyldipyrido(1,2-a:3':2'-d)imidazole (Glu-P-1) and 3-amino-1,4-dimethyl-5H-pyrido(4,3-b)indole (Trp-P-1). In the Comet assay performed on human lymphocytes, WECT exhibited significant protective effect on Trp-P-1-mediated DNA damage followed the order of unroasted (55%) > roasted at 150 degrees C (42%) > roasted at 250 degrees C (29%). Pre-treatment of the lymphocytes with WEUCT resulted in 30% repression of DNA damage. However, no significant effect on excision-repair system was found during DNA damage expression time in post-treatment scheme ($p>0.05$). WEUCT showed 84% scavenging effect on oxygen free radicals generated in the activation process of mutagen detected by electron paramagentic resonance system. Two possible mechanisms were considered: (1) neutralization the reactive intermediate of Trp-P-1; and (2) protecting cells directly as an antioxidant that scavenge the oxygen radicals from the activation process of mutagen. The individual anthraquinone content in extracts of *C. tora* was measured by HPLC. Three anthraquinones, chrysophanol, emodin and rhein, have been detected under experimental conditions. The anthraquinone content decreased with increased roasting temperature. Each of these anthraquinones demonstrated significant antigenotoxicity against Trp-P-1 in the Comet assay. In conclusion, our data suggest that the decrease in antigenotoxic potency of roasted *C. tora* was related to the reduction in their anthraquinones.[16]

Hypolipidemic activity

Ethanolic extract of seeds of *Cassia tora* L. and its fractions were investigated for hypolipidemic activity on triton induced hyperlipidemic profile. Ethanolic extract and its ether soluble and water soluble fraction decreased serum level of total cholesterol by 42.07, 40.77 and 71.25%, respectively. On the other hand ethanolic extract, ether soluble fraction and water soluble fraction increased the serum HDL-cholesterol level by 6.72, 17.20 and 19.18%, respectively. Ethanolic extract, ether fraction and water fraction decreased triglyceride level by 26.84, 35.74 and 38.46%, respectively. The reduction in LDL-cholesterol level by ethanolic extract, ether soluble fraction and water soluble fraction were 69.25, 72.06 and 76.12%, respectively.[17]

Larvicidal activity

Larvicidal activity of methanol extracts of 26 leguminous seeds and 20 grains against early 4th-stage larvae of *Aedes aegypti* and *Culex pipiens* pallens was examined. At 200 ppm of the extracts from *Cassia obtusifolia, Cassia tora*, and *Vicia tetrasperma*, more than 90% mortality was obtained in larvae of Ae. aegypti and Cx. pipiens pallens. Extract of *C. tora* gave 86.7 and 100% mortality in the larvae of Ae. aegypti and Cx. pipiens pallens at 40 ppm but 59.2 and 78.3% mortality against larvae of Ae. aegypti and Cx. pipiens pallens at 20 ppm, respectively. At 40 ppm, extract of *C. obtusifolia* caused 51.4 and 68.5% mortality of the 4th-stage larvae of Ae. aegypti and Cx. pipiens pallens, respectively. Larvicidal activity of extract of *C obtusifolia* was significantly reduced when used at 20 ppm. Further studies of these plants as possible agents for mosquito control are warranted.[18]

Antinociceptive activity

The leaves of *Cassia tora* Linn. (Family: Caesalpiniaceae) were soxhlet extracted with methanol. The spasmogenic effects of the extract were evaluated on guinea pig ileum, rabbit jejunum and mice intestinal transit. Antinociceptive activity of the extract was also evaluated in the mice. The LD_{50} values of the extract in mice were >2000 mg/kg i.p. and p.o. The extract contracted smooth muscles of guinea pig ileum and rabbit jejunum in a concentration-dependent manner. Atropine reversibly blocked this activity. Mepyramine also reduced the contractile amplitude due to the extract in a concentration-dependent manner. The extract increased intestinal transit in mice dose dependently. *C. tora* extract significantly ($P<0.05$) reduced the number of acetic acid induced abdominal constrictions in mice and the effect was comparable to that of aspirin (150 mg/kg i.p.). The extract also significantly ($P<0.05$) reduced the nociceptive response of mice to increased force (g). The effects were dose-dependent. The studies suggest that the use of *C. tora*, traditionally, as a purgative and in the treatment of other ailments is justifiable.[19]

Pesticidal properties

Eleven sesquiterpene lactone derivatives of parthenin (1), obtained from wild feverfew, Parthenium hysterophorus, were prepared by chemical and photochemical transformations. The compounds tested were a pyrazoline adduct (2) of parthenin, its cyclopropyl (3) and propenyl (4) derivatives, anhydroparthenin (5), a dihydro-deoxygenated product (6), a formate (7) and its corresponding alcohol (8) and acetate (9), a rearranged product (10), lactone (11) and hemiacetal (12). All these derivatives, along with parthenin, were tried for their antifeedant action against sixth-instar larvae of Spodoptera litura, for insecticidal activity against the adults of store grain pest Callosobruchus maculatus, for phytotoxic activity against *Cassia tora*, and for nematicidal activity against the juvenile stage-II (J2) of the root knot nematode Meloidogyne incognita. Antifeedent bioassay revealed that parthenin is moderately antifeedant. Among the derivatives, the saturated lactone (11) was found to be about 2.25 times more active than parthenin. The pyrazoline adduct (2) was found to be the most effective as an insecticide, with LC_{50} values after 24, 48 and 72 h of 96, 43 and 32 mg litre-1, respectively, which are comparable with neem extract. Compound 4 was found to be the most effective inhibitor of germination and seedling growth of *C tora*, with ID_{50} values for germination, plumule length and radicle length of 136, 326 and 172 compared with 364, 738 and 427 mg litre-1, respectively, for parthenin. Compound 10 was found to be the most effective in terms of nematicidal activity. The LC_{50} values for this compound were 273 and 104 mg litre-1, respectively, after 48 and 72 h compared with 862 and 512 mg litre-1 observed for parthenin after 48 and 72 h.[20]

Antiplasmodial activity

Twenty-two plant organs from eleven plants comprising five families were extracted and screened for antiplasmodial activity in vitro against *Plasmodium falciparum* 3D7 (chloroquine sensitive) and Dd2 (chloroquine resistant and pyrimethamine sensitive). Fifty nine percent of plant extracts from 22 extracts exerted activity on P. falciparum strain 3D7 with an IC_{50} less than 50 microg/mL, whereas 43% of plant extracts showed an IC IC_{50} value within 50 microg/mL on Dd2 strains. Plant extracts from *Gardenia lutea, Haplophyllum tuberculatum, Cassia tora, Acacia nilotica* and *Aristolochia bracteolata* possessed IC_{50} values less than 5 microg/mL on both tested strains. Bioassay guided fractionation of A. nilotica revealed that the ethyl acetate

extract possessed the highest activity (IC_{50} = 1.5 microg/mL). Fraction 2 R_f = 0.75) prepared by preparative chromatography showed the highest activity on P. falciparum (IC_{50} = 1.7 microg/mL). Phytochemical analysis indicated that the most active phase contained terpenoids and tannins and was devoid of alkaloids and saponins. The effect of plant extracts on lymphocyte proliferation showed low toxicity to the human cells. This plant has been subjected to long term clinical trials in folk medicine and is a promising plant.[21]

Antimutagenic activity

The antimutagenic activity of a methanol extract of *Cassia tora* seeds against aflatoxin B1(AFB1) was demonstrated with the Salmonella typhimurium assay. The numbers of revertants per plate decreased significantly when this extract was added to the assay system using Salmonella typhimurium TA100 and/or TA98. The MeOH extract was then sequentially partitioned with CH_2Cl_2, n-BuOH and H_2O. The CH_2Cl_2 and n-BuOH fractions possessed antimutagenic activity but the H_2O fraction was inactive. Neither the MeOH extract nor its fractions were capable of inhibiting the direct-acting mutagen N-methyl-N'-nitro-N-nitrosoguanidine suggesting that these fractions may prevent the metabolic activation of AFB1 or scavenge the electrophilic intermediate capable of inducing mutations. Column chromatography using silica gel yielded pure chrysophanol, chryso-obtusin, and aurantio-obtusin from the CH_2Cl_2 fraction and cassiaside and rubro-fusarin gentiobioside from the n-BuOH fraction. Each of these compounds demonstrated significant antimutagenic activity.[22]

Antifungal & antimocrobial activity

Antifungal activities of extracts of sixteen plants were tested against Ceratocystis paradoxa which causes soft rot of pineapples. *Xanthium strumarium* was the most effective followed by *Allium sativum*. The effectiveness of various extracts against *C. paradoxa* was in the decreasing order of *Meriandra bengalensis, Mentha piperita, Curcuma longa, Phlogacanthus thyrsiflorus, Toona ciliata, Vitex negundo, Azadirachta indica, Eupatorium birmanicum, Ocimum sanctum* and *Leucas aspera*. Extracts of *Cassia tora, Gynura cusimba, Calotropis gigantea* and *Ocimum canum* showed poor fungitoxicity. Ethanol was suitable for extraction of the inhibitory substance from *X. strumarium*. Acetonitrile was highly toxic to this fungus. Millipore filter-sterilized extracts had a more inhibitory effect on the fungus than the autoclaved samples. Treatment of pineapple fruits infested with *C. paradoxa* by *X. strumarium* extract reduced the severity of the disease.[23]

Hyperlipemia activity

Yishoujiangzhi (de-blood-lipid) tablets (composed of *Radix Polygori Multiflori, Rhizoma Polygonati, Fructus Lycii, Crataegus Pinnatifida* and *Cassia Tora*) were used in the treatment of 130 cases of hyperlipemia, achieving an effective rate of 87.0% in lowering serum cholesterol and 80.8% in lowering triglyceride.[24]

Hypotensive effect

In pentobarbital anesthetized rats, the medial portion of the medullary reticular formation has been identified to be directly involved in the hypotensive effect of extracts from the seeds of *Cassia tora*. This conclusion was drawn from the observed decrease in arterial blood pressure following local injection of extracts of this herb into this reticular site and from its inability to promote hypotension when the same reticular site has been electrolytically lesioned. The role of the medullary reticular formation in the *Cassia tora*-induced hypotension was suggested to be one which modulates the basic cardiovascular reflexes, favoring a decrease in vasomotor tone.[25]

The Chinese medicinal herb Chueh-ming-tzu, seeds of *Cassia tora* (Leguminosae) Linn., elicits hypotensive effects in anesthetized rats. Experimental results indicate that the hypotensive effect of the *Cassia tora* extract possibly involves a vagal reflex which reciprocally alters the vasomotor tone of the centrally emanating sympathetic nervous system. It is shown that the capacity of the *Cassia tora* extract to reduce blood pressure is significantly reduced in vagotomized rats and that hypotensive effects are greatly antagonized in rats whose sympathetic nervous systems are interrupted by transaction of the spinal cord.[26]

PHYTOCHEMICAL STUDY

Non-enzymatic glycation reactions between reducing sugar and free reactive amino groups of protein lead to the formation of advanced glycation end products, which increase under conditions of aging or diabetes. A previous study showed that extracts of *Cassiae Semen* (CS), the seed of *Cassia tora*, had inhibitory activity on advanced glycation end products formation in vitro. To examine the pharmacological effects of a butanol-soluble extract of CS under conditions of diabetic nephropathy, we evaluated the expression of transforming growth factor-beta1 (TGF-beta1) and fibronectin, key mediators of diabetic nephropathy, in mouse glomerular mesangial cells cultured in the presence of S100b (a specific ligand for receptor of advanced glycation end products). CS inhibited S100b-induced TGF-beta1 and fibronectin expression in mouse mesangial cells by suppressing activation of Smad2/3, extracellular signal-regulated kinase (ERK)/mitogen-activated protein kinase (MAPK),

and oxidative stress. Moreover, CS suppressed nuclear factor-kappa B (NF-kappaB) activation in S100b-stimulated mouse mesangial cells. To identify the active compounds of CS, three major compounds, rubrofusarin-6-O-beta-d-gentiobioside (CS-A), toralactone-9-O-beta-d-gentiobioside (CS-B), and cassiaside (CS-C), were tested in cells. Of these compounds, CS-A significantly decreased the expression of TGF-beta1 and fibronectin and NF-kappaB DNA binding activity. These findings suggest that CS, especially CS-A, has potential as a preventive agent for advanced glycation end products-related diabetic complications.[27]

Emodin from the seed of *Cassia tora* and baicalin from Scutellariae radix showed potent inhibitory effects (IC_{50} = 4.9 and 9.0 microM, respectively) on the phosphorylation of Kit. Emodin also blocked other receptor tyrosine kinase activities, such as epithelial growth factor receptor (EGFR), vascular endothelial growth factor receptor 2 (VEGFR-2), fibroblast growth factor receptor 1 (FGFR-1), platelet-derived growth factor receptor b (PDGFR-b). In contrast to emodin, aloe-emodin did not inhibit Kit activity at all. Emodin also blocked the cellular kinase activities of Kit and its down-stream p44/42 mitogen activated protein kinase (MAPK) in MO7e cells and human primary melanocytes. Emodin strongly suppressed the melanin synthesis triggered by stem cell factor (SCF) treatment. Also, emodin showed almost no toxicity up to 10 microM on cultured melanocytes as reported previously by other researchers. The results indicate that emodin is a good candidate for the development of antipigmentation agents since it can radically block the differentiation and proliferation of pigment cells by reducing Kit signaling.[28]

Cassiae Semen (seeds of *Cassia tora*) showed a remarkably different HPLC chromatogram after being treated with a crude enzyme extract from *Aspergillus usamii*. Increased and decreased compounds were identified as aurantio-obtusin and glucoaurantio-obtusin, respectively. The aurantio-obtusin content reached its maximum level (133.58 +/- 0.39 microg/mg extract) after being incubated for 50 min at 37 degrees C, whereas the inactivated crude enzyme-treated control remained unchanged (54.13 +/- 1.33 microg/mg). On the other hand, the glucoaurantio-obtusin content decreased by less than one-third (51.09 +/- 1.63 microg/ mg) of the untreated control (143.19 +/- 2.12 microg/mg), suggesting that an increase in aurantio-obtusin content originated from the enzymatic cleavage of its glucoside glucoaurantio-obtusin.[29]

Nine anthraquinones, aurantio-obtusin (1), chryso-obtusin (2), obtusin (3), chryso-obtusin-2-O-beta-D-glucoside (4), physcion (5), emodin (6), chrysophanol (7), obtusifolin (8), and obtusifolin-2-O-beta-D-glucoside (9), isolated from an EtOAc-soluble extract of the seeds of *Cassia tora*, were subjected to in vitro bioassays to evaluate their inhibitory activity against advanced glycation end products (AGEs) formation and rat lens aldose reductase (RLAR). Among the isolates, compounds 6 and 8 exhibited a significant inhibitory activity on AGEs formation with observed IC_{50} values of 118 and 28.9 microM, respectively, in an AGEs-bovine serum albumin (BSA) assay by specific fluorescence. Furthermore, compounds 6 and 8 inhibited AGEs-BSA formation more effectively than aminoguanidine, an AGEs inhibitor, by indirect AGEs-ELISA. N (epsilon)-Carboxymethyllysine (CML)-BSA formation was also inhibited by compounds 6 and 8. Whereas compounds 1, 4, and 6 showed a significant inhibitory activity on RLAR with IC_{50} values of 13.6, 8.8, and 15.9 microM, respectively.[30]

Soluble fibers isolated from the seeds of *Cassia tora* Linn. (SFC) have attracted considerable attention in recent years due to their phenomenal rheological behavior. In this study were investigated the effects of SFC on lipid metabolism. Male Sprague-Dawley rats were fed one of three experimental diets, a normal diet, a high-cholesterol diet, or a high-cholesterol diet with 5% SFC, for 5 weeks. The serum concentration of total cholesterol in rats fed SFC was 27% lower ($p < 0.05$) compared to that of the control group, but the serum high-density lipoprotein cholesterol level was increased in the SFC group. Liver total cholesterol and triglyceride levels were reduced significantly ($p < 0.05$) in rats fed the SFC diet. In addition, fecal bile acid and lipid excretion was significantly increased by SFC consumption. These results indicate that SFC enhances fecal lipid excretion and may cause a reduction in serum and hepatic lipid concentrations in rats.[31]

Three naphthopyrone glucosides, cassiaside (1), rubrofusarin-6-O-beta-D-gentiobioside (2), and toralactone-9-O-beta-D-gentiobioside (3), were isolated from the BuOH-soluble extract of the seeds of *Cassia tora* as active constituents, using an in vitro bioassay based on the inhibition of advanced glycation end products (AGEs) to monitor chromatographic fractionation. The structures of 1-3 were determined by spectroscopic data interpretation, particularly by extensive 1D and 2D NMR studies. All the isolates (1-3) were evaluated for the inhibitory activity on AGEs formation in vitro.[32]

The fungicidal activities of *Cassia tora* extracts and their active principles were determined against *Botrytis cineria, Erysiphe graminis, Phytophthora infestans,*

Puccinia recondita, Pyricularia grisea, and *Rhizoctonia solani* using a whole plant method in vivo and were compared with synthetic fungicides and three commercially available anthraquinones. The responses varied with the plant pathogen tested. At 1 g/L, the chloroform fraction of *C. tora* showed a strong fungicidal activity against *B. cinerea, E. graminis, P. infestans,* and *R. solani*. Emodin, physcion, and rhein were isolated from the chloroform fraction using chromatographic techniques and showed strong and moderate fungicidal activities against *B. cinerea, E. graminis, P. infestans,* and *R. solani*. Furthermore, aloe-emodin showed strong and moderate fungicidal activities against *B. cinerea* and *R. solani*, respectively, but did not inhibit the growth of *E. graminis, P. infestans, P. recondita,* and *Py. grisea*. Little or no activity was observed for anthraquinone and anthraquinone-2-carboxylic acid when tested at 1 g/L. Chlorothalonil and dichlofluanid as synthetic fungicides were active against *P. infestans* and *B. cinerea* at 0.05 g/L, respectively. Our results demonstrate the fungicidal actions of emodin, physcion and rhein from *C. tora*.[33]

The simultaneous separation and determination of the major anthraquinones, emodin, chrysophanol, and their glucosides, of Rumex japonicus HOUTT., and emodin and emodin glucoside, of *Cassia tora* L., *Rhamnus purshiana* DC., *Polygonum multiflorum* THUNB., and *P. cuspidatum* SIEB. et ZUCC., were achieved by cyclodextrin modified capillary zone electrophoresis. The running electrolyte used in this method was 0.005 M alpha-cyclodextrin in 0.03 M borate buffer (pH 10.5) containing 10% acetonitrile, with an applied voltage of 20 kV.[34]

Cassia tora is a well known plant of India. Aloe-emodin was isolated from the leaves of this plant and its metabolism pattern was studied. The results showed that about 15.4% of the administered aloe-emodin was excreted and the rest was probably bound or metabolized in the system.[35]

Thirteen phenolic glycosides including six new compounds were isolated from seeds of *Cassia tora* (Leguminosae). The structures of the new compounds, rubrofusarin triglucoside (7), nor-rubrofusarin gentiobioside (9), demethylflavasperone gentiobioside (10), torachrysone gentiobioside (11), torachrysone tetraglucoside (12) and torachrysone apioglucoside (13), were elucidated on the basis of spectroscopic and chemical evidence. The effects of the phenolic glycosides, their aglycones and several other compounds structurally related to them on *Escherichia coli* K12, *Pseudomonas aeruginosa* PAO1 and some strains of *Staphylococcus aureus* were then examined. Among them, torachrysone (15), toralactone (16), aloe-emodin (18), rhein (19) and emodin (20) showed noticeable antibacterial effects on four strains of methicillin-resistant *Staphylococcus aureus* with a minimum inhibitory concentration of 2-64 micrograms/ml. On the other hand, the phenolic compounds tested did not show strong antibacterial effects on *E. coli* and *P. aeruginosa*.[36]

Radical scavenging principles on 1,1-diphenyl-2-picrylhydrazyl(DPPH) radical were isolated from the seeds of *Cassia tora* L. Assignments of the 1H- and 13C-NMR data showed the active components to be an anthraquinone, alaternin and two naphthopyrone glycosides, nor-rubrofusarin-6-beta-D-glucoside(cassiaside) and rubrofusarin-6- -D-gentiobioside. Alaternin showed more potent radical scavenging effect than the others.[37]

Two new naphtho-pyrone glycosides, 9-[(beta-D-glucopyranosyl-(1----6)-O-beta-D-glucopyranosyl)oxy]-10- hydroxy-7-methoxy-3-methyl-1H-naphtho[2,3-c]pyran-1 -one (5) and 6-[(alpha-apiofuranosyl-(1----6)-O-beta-D-glucopyranosyl)oxy]- rubrofusarin (6), together with cassiaside (3) and rubrofusarin-6-beta-gentiobioside (4) were isolated from the seeds of *Cassia tora* L. Their structures were elucidated on the basis of chemical and spectral data. The naphtho-gamma-pyrone glycosides (3, 4, and 6) were found to have significant hepato-protective effects against galactosamine damage, which were higher than that of silybin from *Silybum marianum*.[38]

Preliminary phytochemical screening of *Bauhinia variegata, Cassia fistula, Cassia tora* and *Tamarindus indica* did not reveal alkaloids and unbound anthraquinones while glycosides as well as flavonoids were present in all the four species of the family caesalpiniaceae. Cardiac glycosides were absent only in *C. tora* and saponins were present only in *T. indica*, *B. variegata* and *T. indica* were devoid of bound anthraquinones while bound anthraquinones were present in *C. fistula* and *C. tora*. Paper chromatography revealed 6 spots in solvent system I, and 5 spots in solvent system 2, showing different Rf values. The per cent yield of crude glycosides was 3.18 in *B. variegata*, 4.03 in *C. fistula*, 4.45 in *C. tora* and 4.14 in T. indica.[39]

Seeds of *Cassia tora* Linn. (Leguminosae) are known in Chinese medicinal herbal practice as Chueh-ming-tzu. Aqueous and methanol extracts from these seeds elicit hypotensive effects on anesthetized rats. Preliminary phytochemical studies show that the active hypotensive principles are derived from the kernel of the seed and consist of mainly glycosides.[40]

An antifungal principle of defatted seed power of *Cassia tora* Linn. was isolated by extraction of an aqueous paste of the powder with benzene, followed by column chromatography over activated silica gel C using chloroform as the developing solvent. Besides chrysophanic acid and other hydroxyanthraquinone derivatives, the major antifungal compound was identified as chrysophanic acid-9-anthrone, the structure of which was assigned on the basis of its chemical properties and UV, IR, NMR and mass spectral analysis. The compound was active against *Trichophyton rubrum, T. mentagrophytes, Microsporum canis, M. gypseum* and *Geotrichum candidum* in broth in the presence of 100 mug/ml L-ascorbic acid as antioxidant.[41]

MISCELLANEOUS

A review has been made of the ethnobotanical and pharmacological data of 43 medicinal plants of the tree-savannah used by the Diola against infectious diseases. The traditional use of ten plants can be explained by pharmacologically active principles: *Adansonia digitata, Azadirachta indica, Carica papaya, Cassia tora, Fagara leprieurii, Guiera senegalensis, Khaya senegalensis, Mangifera indica, Psidium guajava* and *Voacanga africana*. Four of these herbs are recommended for use in Primary Health Care. The therapeutic value of the other plants discussed is not absolutely clear. It is, however, obvious that herbal medicine has a large potential, which is still insufficiently explored, for utilization in Primary Health Care.[42]

Aluminum-induced secretion of organic acids from the root apex has been demonstrated to be one major Al resistance mechanism in plants. However, whether the organic acid concentration is high enough to detoxify Al in the growth medium is frequently questioned. The genotypes of Al-resistant wheat, *Cassia tora* L. and buckwheat secrete malate, citrate and oxalate, respectively. In the present study we found that at a 35% inhibition of root elongation, the Al activities in the solution were 10, 20, and 50 muM with the corresponding malate, citrate, and oxalate exudation at the rates of 15, 20 and 21 nmol/cm(2) per 12 h, respectively, for the above three plant species. When exogenous organic acids were added to ameliorate Al toxicity, twofold and eightfold higher oxalate and malate concentrations were required to produce the equal effect by citrate. After the root apical cell walls were isolated and preincubated in 1 mM malate, oxalate or citrate solution overnight, the total amount of Al adsorbed to the cell walls all decreased significantly to a similar level, implying that these organic acids own an equal ability to protect the cell walls from binding Al. These findings suggest that protection of cell walls from binding Al by organic acids may contribute significantly to Al resistance.[43]

In this study herbal cosmetic creams was prepared and evaluated for their improvement of skin viscoelastic and hydration properties. The cosmetic cream formulations were designed by using ethanolic extracts of *Glycyrriza glabra, Curcuma longa* (roots), seeds of *Psorolea corlifolia*, *Cassia tora, Areca catechu, Punica granatum,* fruits of *Embelica officinale*, leaves of *Centella asiatica*, dried bark of *Cinnamon zeylanicum* and fresh gel of *Aloe vera* in varied concentrations (0.12-0.9%w/w) and characterized using physicochemical and physiological measurements. The ethanolic extracts of herbs were incorporated in a cream base that is prepared by a phase inversion emulsification technique. The cream base was prepared by utilizing oil of *Prunus amagdalus, Sesamum indicum*, honey, cetyl alcohol, stearic acid, polysorbate monoleate, sorbitan monostearate, propylene glycol and glycerin. Physicochemical assessments and microbiological testing were completed for all formulations according to the methods of the Indian Standard Bureau. The studies were carried out for 6 weeks on normal subjects (6 males and 12 females, between 22 and 50 years) on the back of their volar forearm for evaluation of viscoelastic properties in terms of extensibility via a suction measurement, firmness using laboratory fabricated instruments such as ball bouncing and skin hydration using electric (resistance) measurement methods. The physicochemical parameters of formulations CAA1-CAA6, i.e. pH, acid value, saponification value, viscosity, spreadability, layer thickness microbial count and skin sensitivity were found to be in the range of 5.01 +/- 0.4-6.07 +/- 0.6, 3.3-5.1 +/- 0.2, 20-32, 5900-6755 cps, 60-99%, 25-50 mum, 31-46 colony-forming units (CFU) and a 0-1 erythema score. The formulations, CAA4 and CAA5, showed an increase in percentage extensibility (32.27 +/- 1.7% and 29.89 +/- 1.64%, respectively), firmness (28.86 +/- 0.86% and 29.89 +/- 2.8%, respectively) and improved skin hydration (15.97 +/- 0.55 and 18.27 +/- 0.99%, respectively) and were found more effective compared with the control product (C7) after the 6- week study.[44]

In this paper, the high-charge-density (3.0 mEq/g) cassia hydroxypropyltrimonium chloride (cassia HPTC), a quaternized galactomannan from the endosperm of *Cassia tora* and *Cassia obtusifolia* was describe. Cassia HPTC is shown to participate in the coacervate phase of conditioning shampoos, from which it is deposited onto hair to provide conditioning benefits. Cryo-scanning electron microscopy and time-of-flight secondary ion mass spectrometry were used to observe and characterize the cassia HPTC deposits left on hair. The high-charge-

density cassia HPTC resulted in improved deposition efficiency compared with a quaternized guar-containing formula. Cassia HPTC offers benefits as an alternative to traditional cationic polymers as conditioning agents or as an adjunct conditioner to decrease the amount of cationic polymer needed to achieve the desired conditioning performance.[45]

Present study is focused on the decontamination and/or revegetation of fly ash dykes through naturally growing plants, namely *Calotropis procera, Cassia tora, Chenopodium album, Sida cardifolia, Blumea lacera*. The results of sequential extraction study showed that maximum amount of metals (Na, K, Fe, Mn, Cr, Pb, Ni, Cd) were associated with residual and Fe-Mn fractions. Diethylenetriamine penta acetic acid (DTPA)-triethanolamine (TEA) extraction assessed the bioavailability of the metals. The total metal accumulation in tested plants was found in the order; *C. album>S. cardifolia>C. tora>C. procera>B. lacera*. The maximum bioconcentration factor (BCF) was recorded in *S. cardifolia* for the metals (Na, Fe, Zn, Cd), in *C. procera* for the metals (Mn, Cu, Ni, Cr) and in *C. album* for the metals (Co, Pb). However, the translocation factor (TF) of most of the metals was found more in *S. cardifolia* followed by *C. album* than other plants. Among all the plants, *C. album* have shown high BCF and low TF values for toxic metals (Pb, Cd) and suitable for phytostabilization of these metals. Principal component analysis was used to predict translocation behavior of the metals in different parts of the plants which was found similar for the metals (Cu, Zn, Mn, Cr). All examined plants are suitable for revegetation (naturally grows on fly ash dykes) and *S. cardifolia* and *C. album* may be used for decontamination purposes.[46]

Six non-conventional leafy vegetables consumed largely by the rural populace of Nigeria were analyzed for mineral composition. Mineral contents appeared to be dependent on the type of vegetables. *Amaranthus spinosus* and *Adansonia digitata* leaves contained the highest level of iron (38.4 mg/100 g and 30.6 mg/100 g dw, respectively). These values are low compared to those for common Nigerian vegetables but higher than those for other food sources. All the vegetables contained high levels of calcium compared to common vegetables, thus they could be a rich source of this mineral. Microelement content of the leaves varied appreciably. Zinc content was highest in *Moringa oleifera, Adansonia digitata* and *Cassia tora* leaves (25.5 mg/100 g, 22.4 mg/100 g and 20.9 mg/100 g dw, respectively) while the manganese content was comparatively higher in *Colocasia esculenta*. The concentrations of the mineral elements in the vegetables per serving portion are presented and these values indicate that the local vegetables could be valuable and important contributors in the diets of the rural and urban people of Nigeria. The mean daily intake of P, Mg, Ca, Fe, Cu and Zn were lower than their recommended dietary allowances (RDAs). However, the manganese daily intake was found not to differ significantly ($p = 0.05$) from the RDA value.[47]

The influence of temperature on the chemical constituents and pharmacological effects of seeds of *Cassia tora* was examined. As the baking temperature was raised, the contents of free chrysophanol increased. The contents of antihepatotoxic constituents in the samples baked at different temperatures were compared. They decreased as the temperature rose. The pharmacological results basically accorded with the contents of the constituents.[48]

Xiphidorus amazonensis n. sp. was found in the rhizospheres of *Jatropha curcas, Musa* sp., *Anona muricata, Cassia tora, Panicum laxum, Paspalum fasciculatum, Aeschynomene sensitiva, Saccharum officinarum, Manihot esculenta, Abelmoschus esculentus, Tamarindus indica, Mangifera indica, Vigna unguiculata, Zea mays, Commelina* sp., *Cyperus rotundus, Fimbristylis miliacea, Citrus sinensis,* and *Eichhornia crassipes* on the Amazon River island of Xiborena, approximately 40 km southeast of Manaus, capital of the State of Amazonas. The type habitat is flooded annually for about 6 months by the Amazon River. *Xiphidorus amazonensis* n. sp. differs from the closely related species *Xiphidorus yepesara* Monteiro, 1976 by the larger size, by a, b, and c values, and by the rounded tail terminus. It also resembles *Xiphidorus tucumanensis* Chaves and Coomans, 1984, but can be distinguished by its larger size, larger a, b, and c values, more conical female tail, bilobed amphidial pouch, and the presence of a spermatheca full of sperm.[49]

Callus cultures were extablished from the seedlings of *Cassia tora* on a chemically defined medium supplemented with 2, 4-D and kinetin. A phytochemical investigation of callus tissues demonstrated the presence of chrysophanol, emodin, physcion, and an unidentified pigment, all of which are contained in the seeds of the original plant. The maximum content of antraquinones on a fresh weight basis was 0.334 percent, which is higher than the content of total anthraquinones in the dry seeds. Furthermore, it was shown that the production of these compounds is influenced by the concentrations of auxin and cytokinin supplied to the culture medium.[50]

The present ethnomedicine survey covers the Dharwad district of Karnataka in southern India. It was revealed that 35 plants belonging to 26 families are being used to

treat different types of oral ailments like toothache, plaque and caries, pyorrhea and aphthae. Sixteen of these plants were new claims for the treatment of oral ailments not previously reported in the ethnomedicinal literature of India. *Basella alba, Blepharis repens*, *Capparis sepiaria, Oxalis corniculata* and *Ricinus communis* are used for the treatment of aphthae; *Azima tetracantha, Caesalpinia coriaria, Cleome gynandra, Gossypium herbacium, Leucas aspera, Merremia chryseides, Pergularia daemia, Prosopis juliflora* and *Solanum nigrum* are used to treat tooth ache and *Cassia hirsuta* and *Cassia tora* are used in the treatment of plaque and caries.[51]

CONCLUSION

The pharmacological studies reported in the present review confirm the therapeutic value of *Cassia tora*. Thus, activity guided phytochemical and pharmacological studies may lead to development of novel agents for various disorders. The available literature regarding the chemical constituents and pharmacological properties appeared to be impressive. The standardization of the extracts, identification and isolation of active principles and pharmacological studies of isolated principles may be considered for detailed studies. Further, synthesis of the active principle can lead to development of promising pharmacological action.

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