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Cassia auriculata Linn." A Phytopharmacological Review

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ABSTRACT

Cassia auriculata is a shrub with large bright yellow colored flowers. The plant can be seen throughout south India. Tribals of various states of south India are using different parts of this plant due to its various medicinal properties. This review gives an account of updated information on its Pharmacognostical, phytochemical and pharmacological activities which will be a valuable information to researchers in getting advanced knowledge about the plant

Key words: Cassia auriculata, Phytochemistry and Pharmacology

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INTRODUCTION

Traditional herbal remedies have always been valued since time immemorial and they are well known to cure everything, right from spasms to heart diseases and that too without any post medication blues. A number of special ethano pharmacological survey programmes conducted in the forests, villages and tribals of various parts of South India, which have yielded useful and satisfactory results in identifying the medicinal plant wealth of these regions. There are several pharmacological uses to the genus Cassia but some of these species, though promising have not been subjected to scientific study.

Cassia auriculata is a shrub with large bright yellow coloured flowers, which grows wild in the Central Province and Western Peninsula, and is cultivated in other parts of India. The plant is used in treating skin diseases, asthma, conjunctivitis, and also considered as a remedy for many diseases associated with kidney. The plant is also reported with many constituents like flavonoids, poly saccharides and tannins etc., (Rao et.al., 2000) which possibly contributes to its diverse uses in folk lore medicines.

Phytochemical review

Secondary metabolites or Phytoconstituents are the compounds which are responsible for a particular therapeutic activity There are several such compounds isolated from the different morphological parts of the plant which shows several pharmacological activity. This part of the review comprises of certain important phytoconstituents which are isolated from the plant and possess particular pharmacological activity.

Important Phytoconstituents Isolated from various parts of Cassia auriculata

Nonacosane and Nonacosan and Nonacosan-6-one were isolated from the benzene extract of the pods of the plant.[1] The seeds of the plant contains 4.8% of light yellow oil. It is low in unsaponifiable content and is non drying oil. Major components of fatty acids are palmitic, oleic and linoleic acids. Oil has about 75% of unsaturated fatty acid content.[2]

The phytochemical examination of the root of the plant resulted in the isolation of a new flavone glycoside which has been identified as 7, 4'-dihydroxy flavone-5-O-beta-D-galactopyranoside; on the basis of chemical studies and spectral UV, IR, PMR and mass data.[3]The isolation, purification and preliminary analysis of the seeds yielded water soluble polysacharides comprising of D-galactose and D-mannose in a molar ratio of 1:3 on acid hydrolysis. IR-spectral data of the polysacharides in KBr indicated alpha and beta linkages in the D-galactopyranose and D-mannopyranose units respectively.[5]

Water soluble galactomannan from the seed of the plant furnished beta-D-mannopyranosyl-(1to4)-O-beta-D-mannopyranosyl (1to4)-O-beta-D-mannopyranose by partial hydrolysis.[6]

The isolation of structural elucidation of new anthraquinone glycoside, 3hydroxy, 6,8,-dimethoxy-2-methyl anthraquinone 1-0-beta-D-galactonide from the heart wood of the plant was also reported.[4] The chemical investigation of the stem bark of the plant yielded two new triterpenoid glycosides.[7]

Pharmacological review

A particular pharmacological action of a plant is mainly due to the presence of particular phyto constituent. This part of the review comprises of various pharmacological actions exhibited by various morphological part of the plant because of the presence of such constituents.

Anti bacterial activity

Antibacterial potential of methanolic extract of dry flowers of Cassia auriculata was conducted using agar disc diffusion method. The microorganisms used include Staphylococcus aureus, Bacillus subtilis, Salmonella typhi, Escherichia coli. The maximum activity was observed against all microorganisms the minimum inhibitory concentration was determined depending on microorganisms. Cassia auriculata was observed to have antibacterial activity and can be used to combat against vast flora of microorganisms. [8]

The antibacterial properties of the Cassia auriculata were tested against ten human pathogens by using five different solvent namely, hexane, chloroform, ethyl acetate, acetone and methanol. The maximum antibacterial activity recorded in methanol extracts against Vibrio cholorae and Staphylococcus aureus. Minimum activity was noted in chloroform extracts against Pseudomonas aeruginosa, no inhibition zone present in chloroform extract against E. coli. Total anti oxidant level, total phenolic compounds and total flavonoid content was higher in ethyl acetate extract. In separation of compounds, ethyl acetate extract were more spots in (TLC) plate[9].

The present study was conducted to evaluate the phytochemical profile and antibacterial activities of flower extracts of Cassia auriculata. Studies on the antibacterial activity of ethanol, methanol and aqueous extracts of dry flower and ethanol, methanol and acetone extracts of fresh flower of Cassia auriculata was conducted using agar disc diffusion method. The microorganisms used include Staphylococcus aureus, Enterococcus faecalis, Bacillus subtilis, Salmonella typhi, Salmonella paratyphi A, Escherichia coli, Proteus mirabilis, Pseudomonas aeruginosa, Klebsiella pneumoniae, Vibrio cholerae and Shigella dysentrae. The maximum activity was observed against all organisms except Pseudomonas aeruginosa and Klebsiella

pneumoniae. The minimum inhibitory concentration ranged between 12.5mg/mL and 75mg/mL depending on microorganism and various extract. Presence of phytochemicals such as terpenoids, tannins, flavonoids, saponin, cardiac glycosides and steroids were observed. Cassia auriculata was observed to have antibacterial activity and can be used for medicinal purposes. [10]

The present study was undertaken to evaluate its efficacy against gram positive and gram negative microorganisms. Antibacterial activity of methanolic extract of Cassia auriculata roots was conducted using agar disc diffusion method. The microorganisms used include Staphylococcus aureus, Bacillus subtilis, Salmonella typhi, Escherichia coli. The maximum activity was observed against all microorganisms the minimum inhibitory concentration was determined depending on microorganisms. Cassia auriculata was observed to have profound antibacterial potential against vast flora of microorganisms. [11]

Antimicrobial activity

The synthesis of metals and nanoparticles is an expanding research area due to the potential applications for the development of novel technologies. Biosynthesis of silver nanoparticles was investigated by reducing sliver nitrate with Cassia auriculata leaf extract at room temperature. The plant belongs to family Ceasalpiniaceae and the plant is having promising medicinal properties for a wide range of human diseases. The synthesized nanoparticles characterized by the UV-Vis spectroscopy, revealed the formation of silver nanoparticles by exhibiting the typical surface plasmon absorption maxima at 420-435 nm.The peaks in the X ray Diffraction pattern are in good agreement with the standard values of the face-centered-cubic form of metallic silver. Fourier transform infrared spectroscopy indicates that the compounds attached with silver nanoparticles could be polyphenols with aromatic ring and bound amide region and transmission electron microscope reveals that the particles are spherical and polydispersed. The antimicrobial activity of synthesized nanoparticles were evaluated against E.coli, Sarratiamarcascence, Bacillus subtilis ,Aspergillusniger and Aspergillusflavus. Fungi were most susceptible to silver nanoparticles followed by bacteria. [12]

The current study is aimed at evaluating the antibacterial and antifungal activity of two different medicinal plants such as Cassia auriculata. L. and Tylophora indica (Burm.f.) Merrill., using two different solvents ethanol and methanol against three different bacterial strains Streptococcus aureus, Escherichia coli, Pseudomonas aeroginosa and four different fungal strains Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus and Candida albicans. The antibacterial and antifungal activity was determined by agar well diffusion method. Cassia auriculata showed very good inhibition in both ethanol and methanol extracts in all the concentration gradients used

against the organisms. Methanol extract of Cassia auriculata showed maximum inhibition with S.aureus, E. coli, P. aeruginosa and minimum inhibition with ethanol extract. In case of antifungal activity, maximum inhibition was against A.fumigatus when compared to all other organisms. Tylophora indica showed maximum inhibition in ethanol extract against the organisms S. aureus. In case of antifungal activity, methanol extract showed good inhibition at 50µg/ml against the microbes A .niger, A. fumigatus, and A. flavus. [13]

The study aimed at evaluating the in vitro antimicrobial effect of crude extract of locally available plants, Cassia auriculata L and Morinda tinctoria Roxb on bacteria (Escherichia coli Staphylococcus aureus, Bacillus subtilis, Pseudomonas aeruginosa) and fungi (Candida albicans, Candida tropicalis, Aspergillus niger). The agar disc diffusion method was used to determine the inhibitory effect of both the test plants. Both the plants extract showed inhibitory effect on test organisms. The extract of Cassia auriculata L produced wider zones of inhibition against Candida spp. than the crude extract of Morinda tinctoria Roxb. The minimum inhibitory concentration was also evaluated for the extracts. [14]

In the present investigation, the saponins rich fraction of roots of Cassia auriculata L. was evaluated for antimicrobial activity against P. vesicularis, Streptococcus faecalis, Aeromonas hydrophilia, Salmonella typhae, Staphylococcus cohni, Serratia ficaria and E. coli at concentration of 12.5 mg/ml, 25 mg/ml, 37.5 mg/ml and 50 mg/ml. Antimicrobial activity of Cassia auriculata L. was carried out by well diffusion method. At maximum conc i.e. 50 mg/ml antimicrobial effect of Saponin rich extract can be arranged in sequence of - P. vesicularis > Serratia ficaria > Streptococcus cohni > Aeromonas hydrophilic>, Salmonella typhae > Sterptococcus faecalis > E. coli. The results indicate the saponins rich fraction of roots of Cassia auriculata L. might be exploited as natural drug for the treatment of several infectious diseases caused by these organisms. Cassia auriculata L. was observed to have antibacterial activity and can be used for medicinal purposes. [15]

The aim of the present study was to evaluate the invitro antimicrobial and antioxidant activity of flavonoid rich fraction of C. auriculata petals. The invitro antimicrobial activity was performed by disc diffusion and MIC method against Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Pseudomonas aeruginosa and Proteus vulgaris. The antioxidant activity of rich flavonoid rich fraction from the petals of C. auriculata was tested using antioxidant assay techniques. The flavonoid rich fraction of C. auriculata petals exhibited antibacterial activity on P. vulgaris and E. coli significantly than the others. The flavonoid rich fraction of C. auriculata also showed effective antioxidant activity in all assay techniques. The present study indicated the

petals of C. auriculata as a potential novel source with free radical scavenging compound and antibacterial properties. [16]

A study was performed to evaluate the antimicrobial activity of aerial parts of chloroform extract of Cassia auriculata L. The chloroform extract of C. auriculata were shown to possess an antimicrobial activity against two gram positive and two gram negative human pathogenic bacteria and fungi, viz. Bacillus subtilis, Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli and fungus cultures Candida albicans and Aspergillus niger by using disc diffusion method. The extract showed antibacterial activity at all concentrations selected, but only the extract with the concentration of 300µg/ml showed maximum antibacterial activity against all the organisms except Pseudomonas aeruginosa which are comparable with the standard control, amikacin. The anti fungal activity of chloroform extract of C. auriculata revealed significant effect against Candida albicans and Aspergillus niger with the net inhibition zone of 14 and 14 mm, respectively at 300µg/ml concentration, which is almost comparable with standard control, ketokonazole used as an antifungal agent. The phytochemical analysis showed the presence of alkaloids, carbohydrates, fixed oils, fats, tannins, gum & mucilage, flavonoids, saponins, terpenoids, lignin and sterols. It is concluded that the antimicrobial activity showed by the plant was due to the presence of these phytochemicals. Further studies are highly needed for future drug development. [17]

Antidiabetic and Hypolipidimic activity

An aqueous leaf extract of Cassia auriculata was found to lower the serum glucose level in normal rats. Maximum reduction in serum glucose level was observed after 4 h at a dose levels of 100, 200, 400 mg/kg body weight of the extract. In normal rats the serum glucose level reduction at 4th h was 23% by 100 mg/kg body weight and 31% by 200 mg/kg body weight. In alloxan induced diabetic rats, chronic administration of the extract significantly reduced the serum glucose level from third day to till the end of the experiment. The extract was also found to inhibit the body weight reduction induced by alloxan administration. Glucose uptake and glycogen deposition studies suggest that C. auriculata leaf extract probably has no direct insulin like effect which can enhance the peripheral utilization of glucose. [18]

The ethanolic extract of Cassia auriculata L. flower were tested for type 2 anti-diabetic activity using streptazotocin - nicotinamide induced diabetic rats and compared with standard. The result expressed that ethanolic extract had shown significant protection and maximum reduction in blood glucose was observed in streptazotocin - nicotinamide induced diabetic rats ($p>0.05$). The

result of this comprehensive study reveals that Cassia auriculata flower shown statistically significant type 2 anti-diabetic activity in comparison to the standard glibenclamide. [19]

In the present study, the seeds of Cassia auriculata were screened for antidiabetic activity. The seeds of Cassia auriculata were subjected to hot continuous extraction with ethanol as universal solvent, and fractionation was carried out to obtained pet. ether and chloroform fraction. Aqueous extract was prepared by cold maceration. After qualitative phytochemical investigations, all the extracts and fractions were subjected for antidiabetic activity in streptozotocin induced diabetes in rats. All the extracts and fractions were given orally at a dose of 300mg/kg body weight. Metformin was used as standard drug (250mg/kg body weight p.o.). Result: The alcoholic as well as aqueous showed significant antidiabetic activity as compared to streptozotocin induced diabetes in rats. [20]

The present study was designed to assess in vitro and in vivo antioxidant and antidiabetic efficiency of Cassia auriculata L. flowers and its phytochemical analysis. In vitro antioxidant competence was screened for scavenging DPPH, superoxide, nitric oxide, hydroxyl, H O and lipid peroxides in addition to reducing power and metal ion chelating capabilities. The inhibitory effect on carbohydrate digestive enzymes -amylase and -glucosidase was studied with reference to acarbose. In vivo, parameters such as fasting blood glucose, glycosylated hemoglobin, plasma insulin, reduced glutathione and activities of antioxidant enzymes were studied with reference to glibenclamide. The methanolic extract showed higher antilipid peroxide and DPPH radical scavenging ability. The potent inhibitory effect was observed on activities of -amylase and -glucosidase. The marked decrease in the glucose level in the extract treated streptozotocin induced diabetic rats was due to elevated levels of insulin. The increased activity of antioxidant enzymes and glutathione, accounts the antiradical activity of the extract. RP-HPLC analysis indicated the presence of mixed catechins, caffeine and quercetin. These bioactive constituents validate antioxidative ability and provides scientific basis for the usage of Cassia auriculata L. flowers in ayurvedic formulations in the treatment of diabetes and other related inflammatory diseases. [21]

The current investigation focuses on the serum insulin augmentation, anti-hyperglycemic and anti-hyperlipidemic property of a combined aqueous extracts of C. auriculata and A. marmelos on streptozotocin induced diabetic rats. The diabetes induced animals were fed with plant extracts at the increasing dosage of 250mg, 350mg and 450mg of body wt. The combined plant extracts administrated animals revealed a significant ($P<0.001$) increment of serum insulin levels, higher reduction in hyperglycemia and hyperlipidemia when compared to the diabetic

control rats (P<0.001). The histological studies of the endocrine region of pancreas of diabetic animals revealed that shrinkage of β cells of islets of langerhans. The combined plant extracts treated animals revealed restoration of β-cells. The restoration of β cells was evident at higher dose level i.e. 450mg/by wt extracts fed groups. [22]

Antibacterial properties of methanol extract of Cassia auriculata flower was studied on three Gram positive and seven Gram negative bacteria by disc diffusion method. The extract showed zone of inhibition against Gram positive bacteria (Bacillus cereus, B. subtilis and B. megaterium) and Gram negative bacteria [Streptococcus aureus, E. Coli, Salmonella typhae, S. paratyphae, Pseudomonous sp (I), Pseudomonous sp (II) and Shigella sonnei [23]

In this study the antidiabetic potential of aqueous and ethanol extract of Cassia auriculata L. flowers was assessed in alloxan-induced diabetic rats. The phytochemical screening and antioxidant activity were made in these extracts. Antidiabetic agents (Flavonoids and phenolic acids) and free radical scavenging activity in water-soluble fraction of the ethanol extract was higher compared to that of aqueous extract. Diabetic rats showed increase in blood glucose ($p<0.01$) and decrease in plasma insulin ($p<0.01$) levels after 48 hrs of alloxan administration. The oral administration of water-soluble fraction of the ethanol extract at a dose of 0.25 and 0.5g/kg of body of weight, for 30 days exhibited a significant ($p<0.001$) reduction in the blood glucose level and a remarkable increase in plasma insulin level compared to the aqueous extract-treated rats and diabetic control. The level of serum triglycerides and total cholesterol were significantly ($p<0.01$) increased in diabetic rats. The marker enzymes of liver toxicity such as serum alanine transaminase (ALT), serum aspartate transaminase (AST), serum acid phosphatase (ACP), and serum alkaline phosphatase (ALP) were elevated significantly ($p<0.01$) in diabetic control. The liver glycogen and glycogen synthase levels were also increased significantly ($p<0.01$) in alloxan-induced diabetic rats. In addition changes in the body weight and food intake were also analyzed in diabetic and the extracts-treated rats. Treatment with water soluble fraction of ethanol extract and aqueous extract of C. auriculata flowers restored the above altered parameters significantly in diabetic animals. The water soluble fraction of the ethanol extract showed a more efficient antihyperglycemic effect compared to the aqueous extract. [24]

The present study is an attempt to investigate the pharmacodynamic and pharmacokinetic interactions of Cassia auriculata with Metfornin. Though Cassia auriculata's antihyperglycemic activity has been proved but no work till date has been done to study its Pharmacodynamics and Pharmacokinetic interactions with other oral Hypoglycemics (OH). A single dose of 55 mg/kg streptozotocin prepared in citrate buffer (pH 4.4, 0.1 M) was injected intraperitoneally to

overnight fasted animals to induce diabetes. The control rats received an equal volume of citrate buffer and used along with diabetic animals. The One Touch Glucometer Accu Check is used for quantitative in vitro determination of glucose in various samples. Each day after administering drug to the animals after 3 hours a drop of blood was applied on the AccuCheck strip and the blood glucose reading was measured. Diabetes was confirmed after 48 hr of streptozotocin injection, the blood sample were collected through retro-orbital puncture and plasma glucose levels were estimated by one touch Glucometer. The rats having fasting plasma glucose levels more than 250 mg/dL were selected and used for the present study. Cassia auriculata extract was administered for 21 days at single dose level 500 mg/kg made in aqueous and given orally along with the standard drug combinations. The Blood was collected by terminal tail vein puncture and retro orbital puncture. Blood glucose levels were measured using one touch glucometer. Blood was centrifuged at 4000 rpm for 7 minutes. Body weight and blood glucose levels was analyzed every day were analyzed after 21 days. Pharmacokinetically Cassia auriculata and 90 mg/kg Metformin combination increased the t1/2, tmax of Metformin, decreased the Cmax and AUC0-t was similar to Metformin control. These results suggest that Cassia auriculata and 90 mg/kg Metformin combination is potentiating Metformin's action by decreasing its elimination, but this may lead to Metformins toxicity. As Cassia auriculata extract itself has antidiabetic activity. [25]

The present study was designed to evaluate the effect of coadministration of Cassia auriculata and pioglitazone in alloxan induced diabetic rats. Different groups of diabetic animals were treated with pioglitazone (10 mg/kg, p.o.; 100%), C. auriculata (450 mg/kg, p.o.; 100%); and 50:50 and 25:75 combinations of both pioglitazone and C. auriculata, respectively for a period of 28 days. Biochemical parameters like SGPT, SGOT, alkaline phosphatase, total bilirubin, BUN, serum creatinine and LDH were estimated weekly up to 28 days of treatment. The results proved a prominent positive effect of 25:75 combination of pioglitazone and C. auriculata; suggesting that a reduction of 75% of the conventional dose of pioglitazone, supplemented/ combined with 75% dose of C. auriculata (25% reduction in conventional dose), produced protective effects which were comparable to that of 100% pioglitazone (10 mg/kg) with restoration of levels of renal, cardiac and hepatic parameters. The study concluded that coadministration of pioglitazone and C.auriculata may prove to be more beneficial in diabetes than pioglitazone alone; but the clinical appropriateness of the combination has still to be confirmed. [26]

The antidiabetic activity of flowers of Cassia auriculata Linn against alloxan induced diabetes in rats and to isolate the bioactive constituents from the activity guided fraction. The ethanol & aqueous extracts of flowers of Cassia auriculata were obtained by continuous soxhlet extraction

& cold maceration respectively. Each extract was assessed for antidiabetic activity by estimating serum glucose level in diabetic rats. The active ethanol extract was subjected to qualitative chemical analysis to identify the active phytoconstituents. The sterol was isolated from ethanol extract by column chromatography. In alloxan-induced diabetic rats the ethanol extract (250 mg / kg, p.o.) showed significant ($P<0.001$) antidiabetic activity as observed from serum glucose level in diabetic rats. However, the aqueous extract (250 mg / kg, p.o.) did not significantly reduce the serum glucose level in diabetic rats. The ethanol extract showed the presence of sterols, triterpenoids,flavonoids and tannins. Thus from the results, it is revealed that, the active ethanol extract of Cassia auriculata flowers is worthwhile to develop the bioactive principle for diabetes mellitus and it is also concluded that the isolated sterol could be attributed for antidiabetic activity. [27]

The effects of Cassia auriculata flowers on blood glucose and lipid levels in experimental diabetic rats were evaluated. Aqueous extract of Cassia auriculata flowers was administered orally and different doses of the extract on blood glucose, haemoglobin, glycosylated haemoglobin, serum and tissue lipids, hexokinase and glucose-6-phosphatase in streptozotocin-induced diabetic rats were studied. Glibenclamide was used as standard reference drug. Cassia auriculata flower extract (CFEt), at doses of 0.15, 0.30 and 0.45 g/kg body weight for 30 days, suppressed the elevated blood glucose and lipid levels in diabetic rats. Cassia auriculata at 0.45 g/kg was found to be comparable to glibenclamide. The results indicate that the Cassia auriculata flowers possess antihyperlipidaemic effect in addition to antidiabetic activity. [28]

Oxidative stress occurs in diabetic patients and experimental models of diabetes. The present study investigated the effects of leaves and flowers parts of Cassia auriculata ethanolic extract on alloxan induced diabetic rats by measuring fasting blood glucose, lipid peroxidation and liver antioxidant enzymes including superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx). Treatment to diabetic rats with oral administration of Cassia auriculata at a dose of 120 mg/kg body weight for 15 days resulted in a significant alterations in comparison with diabetic control group. This results indicating that the underlying mechanism of the plants pharmacological action seems to be independent of insulin secretion. The result of the present study proved that the Cassia auriculata leaves and flowers possess significant anti-diabetic activity along with potent antioxidant potential in diabetic conditions. [29]

Present work describes the potent antidiabetic fraction from flowers of Cassia auriculata Linn. Hydromethanolic extract along with its ethyl acetate and n-butanol fractions were evaluated for antidiabetic activity in alloxan-induced diabetes in rats. The n-butanol fraction exhibited

significant reduction ($p<0.001$) in blood glucose levels and was also found effective in restoring the blood lipids and proteins to normal level. The activity was found comparable with standard drug phenformin. The hydromethanolic extract and its fractions were subjected to preliminary qualitative chemical investigations which indicated the presence of phenolic compounds, carbohydrates, tannins, steroids and amino acids. [30]

The present study was to evaluate antihyperglycemic and hypolipidemic activity of aqueous extract of Cassia auriculata leaves (CLEt) in streptozotocin (STZ)-induced mild diabetic (MD)and severe diabetic (SD)rats. CLEt showed dosed dependent fall in fasting bloodsugar level at 400 mg/kg dose, FBG was reduced by 13.9% and 17.4% in MD and SD rats respectively. fter 3 weeks treatment, CLEt produced significant reduction in FBG and glycosylated haemoglobin (GH b) in both MD and SD rats. Serum lipid levels were reversed towards normal in extract fed MD and SD rats. [31]

Antioxidant activity

Comparative assay for the plant parts shows the leaves exhibit higher radical scavenging activity than stem and fruit. The semipolar to polar extracts of these plant parts were analysed further. All extracts of exhibit higher range of the radical scavenging activity but acetone extract shows highest radical scavenging activity among these three plant parts. It means these extracts are rich in flavonoids as well as phenolic compounds which along with other polyphenolics in the plant material may be responsible for the antioxidant activities of these extracts. Further work is under way to confirm the anti-oxidative effect of these promising plant extracts by using other methods. [32]

Comparative antioxidant studies were carried out for methanolic extract of Cassia auriculata flowers, leaves and roots for proving its utility in inflammation and healing mechanism. The methanolic extracts were screened for antioxidant activity by nitric oxide radical scavenging, lipid peroxidation inhibition and DPPH methods at different concentrations. Throughout the studies flowers extract showed marked antioxidant activity compared to leaves and roots extract. The antioxidant activity of the flower flowers extract may be due to stabilization of plasma membrane, thereby lowering the elevated levels of serum lysosomal enzymes. The antioxidant activity was found to be concentration dependent and may be attributed to the presence of high flavanoids and bioflavonoids content in the flowers of Cassia auriculata. [33]

A study was carried out in In-vitro antioxidant effects of the Petroleum Ether, Ethanol, and Methanolic flower extracts of Cassia auriculata L . The powder of flower of Cassia auriculata L was extracted sequentially with petroleum ether, ethanol and methanol using Soxhlet extractor

and it was subjected to preliminary phytochemical studies for the identification of phytoconstituents by chemical tests. Antioxidant activity of the extract was evaluated by using Diphenyl picryl hydrazyl (DPPH) radical scavenging, and reducing power methods. The extracts of Cassia auriculata L had shown good DPPH (1, 1-diphenyl-2-picryl-hydrazyl) radical scavenging activity. BHA was used as standard antioxidant and positive control. The DPPH radical scavenging activity of the extracts was increased with the increasing concentration, the reducing power of extracts was carried out with ascorbic acid as a standard reducing agent. The Methanolic extract of Cassia auriculata L exhibited higher scavenging and reducing power than the other extracts. All the analysis was made with the use of UV Visible Spectrophotometer. The observation suggest that the flower of Cassia auriculata L extracts has potent dose dependent anti oxidant activity, thus the Ethanobotanical claim of the plant being used in the cardio vascular disorder, muscle build up, nephro protection, anti inflammatory and as an aphrodisiac may be in part due to the antioxidant activity and also the presence of saponins and traces of Flavanoids ascertains that the Anti-oxidant activity. [34]

This study was undertaken to investigate the effect of Cassia auric ulata leaf extract on tissue lipid peroxidation and antioxidant status in experimental hepato toxicity. Administering ethanol to rats for 60 days resulted in significantly elevated levels of serum total bilirubin, aspartate transaminase (AST), alanine transaminase (ALT) and alkaline phosphatase (ALP) as compared with those of the experimental control rats. Significa ntly elevated levels of tissue thiobarbituric acid reactive substances (TBARS), hydro peroxides and lowered activities of superoxide dismutase (SOD), catalase (CAT) and redu ced glutathione e (GSH) were also observed on alcohol treatment as compared with those of experimental control rats. Concentration of serum non-enzymic antioxidants such as vitamin n E and vitamin C were also significantly lowered on alcohol supplementation. [35, 36]

In the present study, various extracts of Cassia auriculata leaves were evaluated by Hydrogen peroxide scavenging activity, Reducing power method, Nitric-oxide scavenging Activity and DPPH method. IC50 value was calculated and compared with standard Ascorbic acid. Ethyl acetate extract was found to be extremely effective in scavenging of nitric-oxide, hydrogen peroxide (IC50 232.56 µg/ml, 229.88µg/ml). In inhibition of DPPH Radical Scavenging activity (IC50222.2 µg/ml) and by using reducing method (IC50 212.76µg/ml).Ethyl acetate extract showed different levels of antioxidant activities in all tested models. [37]

In the present study evaluation of ethyl acetate extract of Cassia auriculata leaves with the help of two In-vitro antioxidant models were carried out for Nitric-oxide scavenging activity and

DPPH method. IC50 value was calculated and compared with standard Ascorbic acid. The ethyl acetate extract was found to be extremely effective in scavenging nitric-oxide (IC50 51.3µg/ml). In inhibition of DPPH Radical Scavenging activity (IC5096.6µgµg/l) Ethyl acetate extract showed different levels of antioxidant activities in tested models. [38]

Anti-inflammatory activity

Cassia auriculata is widely distributed even in poor soil in Sri Lanka, India, Burma and cultivated in tropics. Based on Physical and Chemical methods, the flower of C. auriculata was found to contain a flavonol glycoside 5-O-methylquercetin 7-O-glucoside. The 50% acetone extract of the flower of C. auriculata showed marked anti-inflammatory activity (56%) in carrageenan induced oedema in rats. [39]

Methanolic extract of Cassia auriculata flowers (MECA 80 %) was studied for anti-inflammatory activity using albumin induced paw edema and cotton pellet granuloma animal models. The MECA was evaluated using two different dose levels. The MECA was screened for acute toxicity and it did not show any toxic or deleterious effects indicating low toxicity of the extract even at high doses. In albumin induced paw edema a significant reduction in paw volume was observed as compared to control group whereas in cotton pellet granuloma model marked inhibition in granuloma formation, reduction in the elevated levels of serum lysosomal enzymes (SGPT, SGOT, and ALP) and lipid peroxidation was noted as compared to control group. The MECA exhibited profound anti-inflammatory activity in both acute and chronic animal models warranting further investigations to establish its anti-inflammatory potential. The activity was thought due to high content of flavonoids and bioflavonoids. [33]

A study was undertaken to evaluate the anti-inflammatory activity of aqueous, methanolic, ethyl acetate and hydroalcoholic extracts of Cassia auriculata leaves. The study was carried out using the pharmacological model of carrageenan induced rat paw edema. Among all extracts methanolic extract showed maximum anti-inflammatory potential. Indomethacin (10mg/kg) was used as reference compound in the present study. The anti-inflammatory activity of methanolic extract may be due to presence alkaloids, flavonoids, tannins and steroids. [40]

Nephroprotective activity

The ethanol extract of the roots of the plant were studied for its nephroprotective activity in cisplatin and gentamycin induced renal injury in male albino rats. In cisplatin model, the extract at doses of 300 and 600mg/kg body weight reduced elevated blood urea and serum creatinine and normalized the histopathological changes in the curative regimen. In the gentamycin model. The ethanol extract at a dose of 600mg/kg body weight reduced blood urea and serum creatinine

effectively in both the curative and preventive regimen. The extract had a marked nitric oxide free radical scavenging effect. The findings suggest that the probable mechanism of nephroprotective activity of the roots of the plant against cisplatin and gentamycin induced renal injury could be due to its anti oxidant and free radical scavenging activity. [41]

Immunomodulatory activity

The present study was aimed to evaluate the immunomodulatory activity of methanolic extract of Cassia auriculata in rats. Cassia auriculata was administered orally at doses of 100 and 200 mg/kg to healthy rats divided into five groups consisting of six animals each. The assessment of immunomodulatory activity was carried out by testing the humoral (antibody titre) and cellular (foot pad swelling) immune responses to the antigenic challenge by sheep RBCs and by neutrophil adhesion test. On oral administration of the extract, a significant increase in neutrophil adhesion and delayed type hypersensitivity response whereas the humoral response to sheep RBCs was unaffected. Thus Cassia auriculata significantly potentiated the cellular immunity by facilitating the foot pad thickness responses to the sheep RBCs in sensitized rats. With a dose of 50 and 100 mg/kg the DTH response (mean + S.D. % increase in paw volume). The responses were statistically significant when they were compared with the control. The study stated that Cassia auriculata shows a significant stimulation of the cell mediated immunity and no effects on the humoral immunity. [42]

Anticancer activity

The in vitro anti-cancer effect of Cassia auriculata leaf extract (CALE) was evaluated in human breast adenocarcinoma MCF-7 and human larynx carcinoma Hep-2 cell lines. CALE pre ferentially inhibited the growth of both the cell lines in a dose-dependent manner with IC_{50} values of 400 and 500 µg for MCF-7 and Hep-2 cells, respectively. The results showed the anti-cancer action is due to nuclear fragmentation and condensation, associated with the appearance of A_0 peak in cell cycle analysis that is indicative of apoptosis. In addition, CALE treated MCF-7 and Hep-2 cells had decreased expression of anti-apopto tic Bcl-2 protein and increased expression of pro-apoptotic bax protein, eventually leading a decrease in the Bcl-2/Bax ratio. These results demonstrated that CALE inhibits the proliferation of MCF-7 and Hep-2 cells through induction of apoptosis, making CALE candidate as new anti-cancer drug. [43]

Hepatoprotective activity

The aqueous (10 mg/kg p.o.), methanolic (100 mg/kg p.o.) and petroleum ether (50 mg/kg p.o.) extracts of the flowers of Cassia auriculata linn, were tested for their hepatoprotective activity against paracetamol induced hepatotoxicity in albino rats. Silymarin at a dose of 25 mg/kg i.p.

was used as standard. The degree of protection was measured by using biochemical parameters like serum glutamic oxaloacetic transaminase (SGOT),serum glutamic pyruvate transaminase (SGPT), alkaline phosphatase (ALP), direct bilirubin and total bilirubin. The histopathological studies were also conducted. The aqueous and methanolic extracts of the flowers showed a significant hepatoprotective activity comparable with those of Silymarin. [44]

Anthelmintic activity

Three extracts viz. Petroleum ether, Methanol and Chloroform extracts of Cassia auriculata leaves were investigated for the anthelmintic activity against earthworms [Megascoplex konkanensis]. Three concentrations [20, 40, 60mg/ml] of each extract were studied which included the determination of time of paralysis and time of death of earthworms. Albendazole [10 mg/ml] was used as standard drug and distilled water containing 2% Tween 80 was used as control. All the extracts exhibited dose dependent anthelmintic activity. The decreasing order of activity of extracts was assessed to be Methanol, Petroleum ether, and Chloroform. [45]

Various extracts of Cassia auriculata roots at varied concentrations were investigated for their in vitro anthelmintic and antibacterial potential. Anthelmintic activity was evaluated by petri-dish method using Indian adult earthworms, Pheretima posthuma. Benzene extract was found potent among all showing comparable paralysis and death time to albendazole. The antibacterial activity was screened by cup-plate agar diffusion method against Staphylococcus aureus (NCIM-2079), Bacillus subtilis (NCIM-2063), Escherichia coli (NCIM-2089) and Proteus vulgaris (NCIM-2027) using streptomycin and ampicillin as standards. Chloroform extract was found potent among all showing comparable zone of inhibition to standard antibacterial drugs. [49]

Four extracts like Petroleum ether, Ethyl acetate, Ethanol and Aqueous extracts of Cassia auriculata leaves were investigated for the anthelmintic activity against earthworms [Eisenia foetida]. Three concentrations [20, 40, 60 mg/ml] of each extract were studied which included the determination of time of paralysis and time of death of earthworms. Piperazine citrate [10 mg/ml] was used as standard drug and distilled water containing 2% Tween 80 was used as control. All the extracts exhibited dose dependent anthelmintic activity. The decreasing order of activity of extracts was ethyl acetate, ethanol, petroleum ether and aqueous extracts. [46]

Cardioprotective activity

Cassia auriculata Linn., floral extract was examined against Isoproterenol induced Myocardial infarction in male albino rats. The oral administration of aqueous extract of Cassia auriculata, afforded protection against Isoproterenol induced alterations in Cholesterol, LDL, HDL, TG, Protein, AST, ALT, LDH, Catalase and GPx. The protective effect was further supported by the

histological observations. The results clearly demonstrate that Cassia auriculata flowers have potent cardioprotective effect. [47]

Anti-arthritic activity

The major objective of the present study is to evaluate the anti arthritic activity of Cassia auriculata by using different in vivo and in vitro models and give a scientific justification for use of Cassia auriculata in treatment of arthritis. in the in-vitro method anti arthritic activity by protein denaturation method and HRBC membrane stabilization methods were used and in vivo model adjuvant induced arthritis was done in male wister rats using complete freund's adjuvant(CFA) for paw swelling. From 8th day onwards with the administration of EECA (ethanolic extract of Cassia auriculata) orally the paw swelling was significantly reduced. In conclusion the obtained data indicates that the administration of EECA to rats at the doses 250mg/kg and 500mg/kg reduced the paw edema supporting the folklore information regarding anti arthritic activity of leaves of Cassia auriculata. [48]

CONCLUSION

The review reveals that Cassia auriculata contains a number of phytoconstituents which are used for treating many diseases and disorders in human being such as, diabetes, hepatic and nephro toxicity, fungal and microbial infection, inflammation. Hence it is necessary to investigate the mechanism of actions of these constituents in detail.

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