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Review

# Ethnobotanical uses, phytochemical and pharmacological profiles, and toxicity of Cassia alata L. An overview.

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**There are very ancient references for utilization of herbs, plants and other natural substances in clinical treatments. This knowledge is common among the people living in rural areas of developing countries. *Cassia alata* is one of these plants largely used by traditional health practitioners with a proved effectiveness. In the folkloric medicine, this plant is involved in curing asthma, constipation, haemorrhoids, intestinal parasitosis, skin problems, jaundice and hepatitis, typhoid, diabetes and breast cancers. Pharmacological tests undertaken on this plant's extracts have showed its antimalarial, anti-cancer and antitumor, anti-inflammatory, anthelmintic, antioxidant, hepatoprotective and hepatocurative, antibacterial and antifungal, cardioprotective, anti-diabetic and antihyperlipidemic, bronchorelaxant and antiviral activities. Some bioactive components such as quinones and anthraquinones, tannins, flavonoids, saponins, alkaloids, steroids, cardenolides, resins, phenols and triterpenoid, significantly present in the plant's extracts support its pharmacological profile and its uses in traditional medicine. More interesting yet, it has been scientifically proved that Cassia alata extract is safe till a dose of 16875 mg/kg body weight. This review study is an effort to give a detailed survey of the literature on the ethnobotanical uses, phytochemical and pharmacological profiles, as well as the toxicity of *Cassia alata*.**

**Keywords:** Cassia alata, ethnobotanical uses, phytochemical, pharmacological, toxicity

## INTRODUCTION

Since immemorial times, natural source products, especially plants and herbs have played a crucial role in the management of health problems, both for human being and animals. Therefore, Indiscriminate use of medicinal plants for the treatment of various diseases has attracted the interest of many researchers in science and medicine to undertake studies that will significantly unfold the phytochemical profile, medical importance, mechanism of action as well as toxic effect (if any) of these medicinal plants (Akinsanya 1973). *Cassia alata* L. is one of those plants currently used in the traditional system of medicine for clinical treatment. It is categorized under the family

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Fabaceae, a pan tropical ornamental shrub. The shrub stands 2-3 m tall, with leaves 50–80cm long. The inflorescence looks like a yellow candle. The fruit, shaped like a straight pod is up to 25 cm long. The seed pods are nearly straight, dark brown or nearly black, about 15cm long and 15 mm wide. On both sides of the pods there is a wing that runs the length of the pod. Pods contain 50 to 60 flattened, triangular seeds (Ibrahim and Osman 1995; Martin and Bindanda 2008). These seeds are distributed by water or animals (Martin and Bindanda 2008). The tree is native to South America, but has been planted widely for medicinal and ornamental purposes and is now pan-tropical. In many countries, including most countries of tropical Africa, it has become naturalized and is often considered as a weed (Bosch 2007). Cassia alata is often called the “Ringworm Bush” because of its very effective fungicidal properties, for treating ringworm and other fungal infections of the skin (Martin and Bindanda 2008). Its other common names include: senna alata, amana-putiri, bajagua, bois artre, candlebush, candlesticks, Christmas-candle, daoen koepang, dartres, dates jaunes, emperor's candlesticks, empress-candleplant, fleur a dartres, fleur St Christophe, fleur dartre, fleur palmiste, gelenggang, guacamaya francesa, herbe a dattes, ketepeng kebo, ketepeng tijna, ketepeng, ketepeng badak, ki manila, ludanggan, mata-pasto, matupa, mocot retama, ringworm senna, ringworm shrub, seven-golden-candlesticks, Herpetica alata, Cassia bracteata, Cassia herpetica, dartrier... Cassia alata grows aggressively in areas where there is high water table. It prefers open areas and sunlight (Khare 2007). All parts of this medicinal plant including, leaf, stem bark, flower, seed and root have been mentioned in many ethnobotanical and pharmacological studies, although the leaf remains the most used part.

## Scientific Classification

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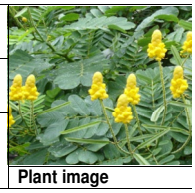
|---|---|---|
| **Kingdom:** Plantae | **Species**: alata |  |
| **Genus:** Cassia L. | **Family:** Fabaceae | |
| **Class:** Magnoliopsida | **Scientific name**: Cassia alata Linn.<br>Senna alata Linn. | |
| **Order:** Fabales | | **Plant image** |

## Traditional uses

Leaf extract of *Cassia alata* is credited for the treatment of constipation, inguinal hernia, intestinal parasitosis, syphilis and diabetes (Dutta et al., 2012; Kochar 1981). The juice of the fresh leaf of the plant is universally recognised as a remedy for parasitic skin diseases, and is used in many eruptive and pustular skin infections by simply rubbing the crushed leaves alone or mixed with lime juice or oil [10]. In Sierra Leone, the leaves in form of an infusion are used as a purgative, and a strong decoction is sometimes given as an abortifacent or during labour to hasten delivery. The juice expressed from the fresh leaves is taken along with lime juice for worms (Dalziel 1937). The bark has been recommended as a tanning material. The juice of the root is rubbed into cuts for tattooing or tribal markings. The plant is highly decorative and of unusual and interesting appearance (Dalziel 1937). The leaves of *Cassia alata* have been reported to be useful in treating convulsion, gonorrhoea, heart failure, abdominal pains, oedema and it’s also used as a purgative (Ogunti and Elujoba 1993; Oguntoye et al., 2005). Skin problems treated with *Cassia alata* include ringworm, favus and other mycoses, impetigo, syphilis sores, psoriasis, herpes, chronic lichen planus, scabies, shingles, eczema, rash and itching. In veterinary medicine too, a range of skin problems in livestock is treated with leaf decoctions. Such decoctions are also used against external parasites such as mites and ticks (Bosch 2007). Other ailments treated in tropical Africa with *Cassia alata* include stomach pain during pregnancy, dysentery, haemorrhoids, blood in the urine (schistosomiasis, gonorrhoea), jaundice, headache, hernia, one-sided weakness or paralysis (Bosch 2007). The seeds of cassia species have been used in Chinese medicine as aperients, antiasthma, diuretic agent and also improve the visual activity (Chauhan 1999). Whole plant is employed in the treatment of impetigo, ulcers, helmenthiasis and as a purgative (Manojlovic et al., 2006). Leaf’s extract of *Casia alata* has been found to lower the blood sugar level (Morrison and West 1982). The plant is traditionally acclaimed to be effective in treating skin infections in man (Igoli et al., 2005) and animals. It is also used for treating digestive tract infections, intestinal worms, typhoid fever, poison, hepatitis, yellow fever (Adjanohoun et al., 1996), wounds and viral infections (Agyare et al., 2009). The utilization of plants against diseases such as cancer, parasitic infection, rheumatism, arthritis, wound treatment, tumor growth, stroke, jaundice, typhoid, fibroid, syphilis and gonorrhea have been well documented (Reezal et al., 2002). The leaves are ground in a mortar to obtain a kind of "green cotton wool". This is mixed with the same amount of vegetable oil and then rubbed on the affected area 2-3 times a day to cure skin diseases (Martin and Bindanda 2008). *Cassia alata* is common in Cameroon and is traditionally acclaimed to be effective in treating skin infections, intestinal worms, asthma, typhoid fever, jaundice and hepatitis, diabetes, cancers (mostly breast cancers), and is used as a purgative.

## Reported phytoconstituents

Many researchers have undertaken scientific works in order to determine the phytochemical profile of *Cassia alata.* Almost all parts of the plant are concerned by these works, but leaf is the most studied. The results showed the presence of volatile oil and bioactive components in the plant’s extract.

**Volatile components:** Igwe *et al* conducted a study aimed to characterize the chemical constituents of the essential oil (extracted with isopropanol) from the leaves of *Cassia alata*, using Gas Chromatography-Mass Spectrometry (GC/MS) technique (Igwe and Onwu 2015). In this oil, seven compounds were identified which include two sesquiterpenes [(6Z)-7,11-dimethyl-3-methylidenedodeca-1,6,10-triene(2.42%) and 4a,8-dimethyl-2-(prop-1-en-2-yl)-1,2,3,4,4a,5,6,8a-octahydronaphthalene (3.80%)]; two monoterpenes [ 4,4,7a-trimethyl-5,6,7,7a-tetrahydro-1-benzofuran-2(4H)-one (2.91 %) and 3,7-dimethylocta-1,6-diene (3.94%)] and three Fatty acids [hexadecanoic acid methyl ester (8.59%), hexadecanoic acid (3.31%) and octadecanoic acid methyl ester (75.03%)]. In another study, Ogunwande *et al* provide information on the chemical constituents of the volatile oils of the leaves of *Cassia alata* growing in Nigeria (Ogunwande et al., 2010). The oil samples were obtained from the plant's leaves by hydrodistillation. The quantitatively significant constituents of that oil were 1, 8-cineole (39.8%), β-caryophyllene (19.1%) and caryophyllene oxide (12.7%). Limonene (5.2%), germacrene D (5.5%) and α-selinene (5.4%) constituted the other significant compounds present in the oil.

**Qualitative and quantitative analysis of bioactive components:** The plant is known to be a source carbohydrates and cardiac glycosides (Jyothirmai et al., 2015), quinones and Anthraquinones, tannins, flavonoids, saponins, alkaloids, steroids, cardenolides, resins, phenols and triterpenoid (Pieme et al., 2008; Archana et al., 2012). Some purified compounds isolated from this shrub are sesquiterpene lactone, Helivypolide G (Macías et al., 2004), bisnorsesquiterpenes annuionones A-C and the helinorbisabone (Macías et al., 1998), 24α-Methyl-5α-cholest-7-en-3β-ol (Matsumoto et al., 1984), the germacranolide, Annuithrin (Spring et al., 1981), the heliangolide, niveusin B and its ethoxy derivative (Spring et al., 1982). It also contains chrysoeriol, kaempferol, quercetin, 5,7,4'-trihydroflavanone, kaempferol-3-O-β-D-glucopyranoside, kaempferol-3-O-β -D-lucopyranosyl-(1->6)-β-D-glucopyranoside, 17-hydrotetratriacontane, n-dotriacontanol, n-triacontanol, palmitic acid cerylester, stearic acid, palmitic acid (Liu et al., 2009). The ethyl acetate and n-butanol fractions contain predominantly kaempferol and kaempferol 3-O-gentiobioside (Varghese et al., 2013).

Alkaloids possess a lot of pharmaceutical activities which includes antihypertensive, antiarrhythmic, antimalarial and anti-cancer functions (Wink et al., 1998). The presence of alkaloids also indicates that the plant extract can be useful as a muscle relaxant in clinics as reported by Doughari [36]. Anthraquinones and steroids constituents promote the plant in the treatment and therapeutic applications as arrow poisons or cardiac drugs and as laxatives (Doughari 2012). Anthraquinones was also reported to have anti-oxidant, antimicrobial, anti-viral, anti-malaria and anti-tumor activities (Demirezer et al., 2001). The presence of flavonoids in a plant indicates its anti-allergic, anti-inflammatory (De Sousa et al., 2007), anti-cancer (Yamamoto and Gaynor 2001; Cushnie and Lamb 2011), anti-oxidant (Essiett et al., 2010) and hypo-lipidemic effects. Tannin rich medicinal plants are used to heal a lot of illnesses; such as leucorrhoea, rhinorrhea and diarrhea. More recently, tannins have gained medical interest, because of the high prevalence of deadly ailments such as AIDS and numerous cancers (Blytt et al., 1998). Saponins are responsible for antimicrobial, antifungal, anti-inflammatory, anti-yeast and antidote activates. The function of saponins in plants generally serves as anti-feedant and to protect the plant against microbes and fungi (Matsumoto et al., 1984). From these studies, *Cassia alata* leaves stand as a potential source for pharmaceutical exploitation. This gives credence to the medicinal benefits that this plant has been used for in the past years.

## Pharmacological activities

The research data indicate that *Cassia alata*, possesses enormous pharmacological values which support its various traditional uses for the management of health problems. The most important are:

**Antimalarial activity:** Kayembe *et al* conducted a study aimed to evaluate in vitro anti-malarial activities of 20 quinones isolated from these four plants: Cassia alata (4), Cassia occidentalis(6), Garcinia Kola seeds (5) and Ocimum basillicum(5), on their ability to inhibit Plasmodium falciparum growth on RPMI 1640 medium, using the micro dilution test of Desjardin by a visual evaluation on thin blood smears (Kayembe et al., 2010).The six quinones isolated from C. occidentalis, three from C. alata and three from O. basilicum were found to be the most active with an IC50 value of below 1µg/ml. This result was later confirmed by the same author in a research work, where four terpenes extracted from Cassia alata leaves exhibited in vitro antimalarial activities against Plasmodium falciparum in ethylene Glycol-water 3:7 solvent, with IC50 values below 1µg/ml (Kayembe et al., 2012). In another study, aqueous decoction of two plants (stem bark of Afzelia Africana and the leaves of Cassia alata) were investigated for their antimalarial activities against the 3D7 strain of the Plasmodium falciparum parasite (Vigbedor et al., 2015). The results indicated that, Afzelia africana was the most active with an IC50 value of 2.954µg/ml and Cassia alata had an IC50 value of 17.270µg/ml. The antimalarial activity of this plant is doubtless due to its alkaloids, quinones and terpenes. In fact, in the chemotherapy of malaria, most molecules belong to the class of alkaloids (Federicci et al., 2000), terpenes (Li and Rieckmann 1992) and quinones (Fowler et al., 1994). These studies have provided scientific evidence for traditional usage of Cassia Alata as effective remedy for the treatment of malaria in many African countries.

**Anti-cancer and antitumor activity:** Pieme *et al* conducted a study designed to investigate the sub **acute toxicity**, *in vivo* antioxidant and antitumor activity of aqueous ethanol extract of *Cassia alata* on bearing carcinomaous cells on Nude mice (Pieme et al., 2008). The results of *in vivo* antitumor activity of extract of *Cassia alata* showed that after treatment with the extract at 100 and 200 mg $kg^{-1}$ body weight, the levels of MDA decreased significantly (3.44 ± 0.76 to 1.97 ± 0.48) while the concentration of glutathione and the activities of CAT and SOD increased significantly. The results suggest that the aqueous-ethanol extract of the plant exhibits significant antitumor and antioxidant effects on bearing carcinomatous cells. This phenomenon can be attributed to different bioactive compounds present in the extract such as tannins, flavonoids and polyphenol. Polyphenol have been reported to reduce lipid peroxidation by free radical scavenging and antioxidant activity (Sasikumar and Devi 2000). These antioxidant properties of aqueous-EtOH extract of *Cassia alata* might have anticancer activity on bearing carcinomatous cells. In another study, Pamulaparthi and Nanna investigated the anticancer activity of aqueous leaf extract of *Cassia alata* on human Breast Cancer (MCF-7) cell lines, using MTT assay (Pamulaparthi and Nanna 2015). After treating the MCF-7 cells with the standard and test drugs and subsequent incubations, OD of Tamoxifen (STD) was compared to that of the test extract at 492 nm and percentage of inhibition of cell proliferation was calculated. The results of the study showed that an increase in the inhibition of cell proliferation was concentration dependent and even at lower concentrations the test extracts effectively regulated cell proliferation. As the concentration of the test extract increased from 6.25-200µg/ml, an increase in the percentage of cell inhibition was observed and at highest concentration (200µg/ml) of the leaf extract the maximum percentage of cell inhibition (99.92%) was observed. Hence, the leaf extract of *Cassia alata* can be used to cure the breast cancer. Olarte *et al* evaluated leaf extracts of Cassia alata for their potential antitumor properties in vitro (Olarte et al., 2013). MTT assays were used to examine the cytotoxic effects of crude extracts on five human cancer cell lines, namely MCF-7, derived from a breast carcinoma, SK-BR-3, another breast carcinoma, T24 a bladder carcinoma, Col 2, a colorectal carcinoma, and A549, a non- small cell lung adenocarcinoma. Hexane extracts showed remarkable cytotoxicity against MCF-7, T24, and Col 2 in a dose-dependent manner. This plant extract had also proved its effectiveness against Leukemia cells (L1210) (Pieme et al., 2009).

**Anti-inflammatory activity:** The anti-inflammatory mechanism of a hexane extract of *Cassia alata* was investigated in Complete Freund's Adjuvant (CFA) arthritis, as a chronic model of inflammation (Lewis and Levy 2011). The extract was prepared and administered to CFA arthritic animals at 500mg/kg. Controls received corn oil (2 ml, n = 6). The CFA model was created by the injection of 0.5ml CFA into the synovial cavity of the right knee joint of hind leg of rats. Changes in knee joint swelling, cartilage integrity and synovial fluid leukocyte counts were assessed in response to *Cassia alata* treatment. Assessment of the reduction in knee joint swelling was performed by obtaining the circumference of the knee joint. Histological analysis was done to assess the cartilage erosion. *Cassia alata* significantly ($p = 0.009$) reduced knee joint swelling and provided protection against cartilage degradation. The migration of leukocytes to the blood ($p= 0.002$) and synovial cavity ($p=0.019$, 0.012, 0.028 and 0.002) was also significantly reduced. These results suggest potent anti-inflammatory activities for *Cassia alata* that could be potentially exploited for arthritis therapy.

**Anthelmintic activity:** Alcohol extract from the leaves of Cassia alata and Typha angustifolia were investigated for their anthelmintic activity against Pheretima posthuma and Ascardia galli (Anbu et al., 2013). Various concentrations (10-100 mg/ml) of each extract were tested in the bioassay, which involved determination of time of paralysis and time of death of the worms. Both the extracts exhibited significant anthelmintic activity at highest concentration of 100 mg/ml. Piperazine citrate (10 mg/ml) was included as standard reference and distilled water as control. **I**n conclusion, the traditional claim of leaves of *Cassia alata* as anthelmintic have been confirmed as the leaf extracts displayed activity against the worms used in the study.

**Antioxidant activity:** Sarkar *et al* carried out a study to evaluate *in vivo* the antioxidant and antitumor activity of the aqueous-EtOH extract of leaves of *Cassia alata* (Sarkar et al., 2014). Antioxidant potential was found to be more in extract as compared to control. The results of this study clearly indicated that the extracts of *Cassia alata* could be used as a potential source of natural antioxidant agents. The antioxidant activity of crude methanol extracts from the leaves, flowers and pods of *Cassia alata* was also investigated by Panichayupakaranant et al, using DPPH radical scavenging assay (Panichayupakaranant and Kaewsuwan 2004). The leaf extract exhibited a stronger antioxidant activity than the extracts from the flowers and pods. The active compound in this extract was identified as kaempferol. This compound exhibited antioxidant activity (ED509.99 µM) that was six times stronger than that of a synthetic antioxidant, BHT (ED5057.41 µM). In another study, kaempferol showed an antioxidative activity against metal-induced lipid peroxidation (Sugihara et al., 1999). It also prevented protein glycosylation (Asgary et al., 1999). The antioxidant active compound that was purified by DPPH radical scavenging assay-guided isolation was also identified. Plants that contain kaempferol can therefore be used to prevent or lower the risk of chronic diseases such as cerebrovascular disease and diabetes (Asgary et al., 1999).

**Hepatoprotective and hepatocurative activities:** Hepatoprotective activity of the Infusion of the dried leaves

of *Cassia alata* (ICA) was studied against Paracetamol induced hepatic injury in albino rats (Anandan et al., 2009). Pretreatment of the Infusion (ICA) reduced the biochemical markers of hepatic injury like serum glutamate pyruvate transaminase (SGPT), serum oxaloacetate transaminase (SGOT), alkaline phosphatase (ALP), total bilirubin and gamma glutamate transpeptidase (GGTP). Histopathological observations also revealed that pretreatment with ICA protected the animals from paracetamol induced liver damage. The results indicate that the leaves of *Cassia alata* possess the hepatoprotective activity. This property may be attributed to the flavonoids present in the leaves of this plant. The effect of oral administration of aqueous extract of leaves of Cassia alata in various doses (2.5-20.0 mg/kg) for seven days, on hepatic induced damage by administration of 45% of ethanol (20ml/kg) and $CCl_4$ (0.1 ml/kg) in rats has been investigated (Effraim et al., 1999). Biochemical parameter including level of serum transaminase (GOT and GPT), serum bilirubin and plasma prothrombin time has been determine to assess liver cell damage and liver function. Significant increases in the levels of serum transaminase 88.14±29.89 U/L, ($P<0.01$) GOP and 76.00±31.19 U/L ($P<0.05$) GPT were reduced by 22.7% and 32.9% respectively. In addition, prothrombin time, 19.97± 2.02 sec ($P<0.005$) was reduced by 48.75% and bilirubin contents (0.31±0.10mg/dl, direct and 1.38±0.98 mg/dl total) were decreased by 44.2% and 58.1 respectively. The results showed that the levels of serum transaminases (GOT and GPT), serum bilirubin and plasma prothrombin time raised by the ethanol/$CCL_4$ treatment were dose-dependently reduced by oral administration of the extract. The observed hepatocurative activity confirms this aspect of the use of *Cassia alata* in the traditional medicine for the treatment of cirrhosis and hepatitis.

**Antibacterial and antifungal activities:** Antimicrobial studies showed that the isolated compound from cassia *alata* seeds successfully inhibited Pseudomonas aeruginosa, Klebsiella pneumonia, Escherichia coli, Staphylococcus aureus Candida albicans and Aspergillus niger. Chemical investigation of the bioactive constituents from the seeds of *Cassia alata* resulted in the isolation of a new cannabinoid alkaloid (4-butylamine 10-methyl-6-hydroxy cannabinoid dronabinol) (Okwu and Nnamdi 2011). The antimicrobial observation of the above compound against these pathogens showed that the bioactive compound could be responsible for the activity of the plant and its use in traditional medicine. These findings also justify the use of *Cassia alata* in the treatment of skin infections such as eczemas, ringworms, boils, carbuncles, breast abscess, infantile impetigo, sores and wound in herbal medicine and its use as an ingredient in the formulation of medicated and antiseptic soaps. Sule *et al* conducted another study aimed to evaluate the *in vitro* antifungal activity of *Cassia alata* leaf extracts on clinical test Dermatophytes (Sule et al., 2010). The test was conducted on Dermatophytes which included Dermatophytes of the genera *Trichophyton*, *Microsporum* and *Epidermophyton*. The results obtained showed that the leaf exudates and the ethanol extract of the leaf of the plant had marked antifungal effects on *Microsporum canis*, *Trichophyton jirrucosum*, *Trichophyton mentagrophytes* and *Epidermophyton jlorrcosum*. The ethanolic extract showed the highest inhibition on *trinchophyton verrucosuf* and *Epidermophyton jloccosum* with 20.50 and 20.00 mm zone of inhibition, respectively. The Minimum Inhibitory Concentration (MIC) was also performed and the result showed that the MIC of *Cassia alata* on all the tested Dermatophytes was 5.0 mg $mL^{-1}$. The EtOH extract of *Cassia alata* have been also reported to inhibit the growth of *D. congolensis* while its aqueous-MeOH extract have shown higher antifungal on fungi (*Microsporum canis*, *Blastomyces dermatitidis*, *Trichophyton mentagrophyte*, *Candida albicans*, *Aspergillus flavus***)** and weak inhibition property on bacteria (*Dermatophilus congolensis*, *Proteus vulgaris*, *Staphylococcus aureus***,** *Corynebacterium parvum*, *Actinomycesbovis*, *Nocardia asteroids*, *Clostridium septicum*, *Bacillus* (Ali-Emmanuel et al., 2003; Makinde et al., 2007).

**Cardioprotective activity**: Neharkar *et al* carried out a research work designed to evaluate the cardioprotective potential of the Cassia alata leaves against doxorubicin-induced cardiac toxicity in rats (Vishnu et al., 2016). Administration of doxorubicin (15 mg/kg i.p.) induced cardiomyopathy by significant elevation in serum creatine kinase MB (Ck-MB), lactate dehydrogenase (LDH), triglycerides & cholesterol activities with a corresponding decrease in SOD, CAT, GSH level in tissue homogenate. Oral administration of Cassia alata leaves methanolic extract (100, 200 & 400mg/kg) prior to doxorubicin produced a significant reduction in mortality & restoration of altered cardiac marker enzymes. The histopathological studies also supported the protective properties of *Cassia alata* leaves. In fact animals pre-treated with *Cassia alata* leaves extract showed a marked protective effect with decreased necrotic zones and revealed normal cardiac muscle bundles. This study showed that *Cassia alata* leaves extract significantly restores most of the the biochemical and histopathological parameters. These results indicate that *Cassia alata* leaves methanolic extract has significant cardioprotective activity. Preliminary phytochemical investigation of cassia alata leaves methanolic extracts shows presence of flavonoids, tannins, glycosides. Thus, the strong antioxidant and cardioprotective effect of the extract could be attributed to the presence of bioactive constituents present in the extract.

**Anti-diabetic and antihyperlipidemic activities:** A study aimed to depict the therapeutic effect of *Cassia alata* leaf aqueous extract on oxidative stress in aorta as well as heart of streptozotoc in hyperglycemic rats was undertaken by (Reezal et al., 2015). Two days after diabetes induction,

Cassia alata leaf aqueous extract was administered orally for 20 days (200mg/kg rat's weight). In the aorta and heart of hyperglycemic rats, there was a significant increase in lipid peroxidation, decreased in total antioxidant activity (DPPH free radical scavenging activity) as well as decrease in antioxidant catalase activity. The administration of *Cassia alata* leaf aqueous extract to hyperglycemic rats has reduced lipid peroxidation (MDA levels), increased in total antioxidant activity (DPPH free radical scavenging activity) and antioxidant catalase activity as well as reduced in the blood glucose level. Cassia alata leaf aqueous extract provide a competent antioxidative mechanism to attack against the oxidative stress in the aorta and heart of hyperglycemic rats. This study suggests that *Cassia alata* may be a useful therapeutic alternative in the reversal of oxidative stress induced cardiac dysfunction in hyperglycemic condition as well as capable to act as antidiabetic agent. Nanna *et al* carried out a study aimed to evaluate the antidiabetic activity attributed to *Cassia alata* and also to evaluate the antihyperlipidemic potential of the species using various standard experimental models available (Nanna et al., 2015). Acute toxicity studies of aqueous leaf extracts of the plant were performed up to a dose of 2500mg/kg body weight of rats and a dose of 200mg/kg was selected for the present study. Its Aqueous leaf extracts showed a significant ($P<0.01$) anti diabetic and anti hyperlipedimic potential in alloxan induced diabetic rats within 15 days of induction of diabetes and the antidiabetic potential of the species may be due to the presence of flavonoids. From the results presented in this study, it can be concluded that aqueous leaf extracts of this shrub showed a gradual decrease in the diabetes from 5$^{th}$ day of administration of the test extract. The blood glucose levels returned to normal by the 15$^{th}$ day indicating that the aqueous leaf extracts possess a potent diabetic activity. The extracts also showed a reduction in the hyperlipidemic profile associated with diabetes. Thus, it can be suggested that the aqueous leaf extracts with optimal dose may be administered for human beings to cure type-I diabetes. Varghese *et al* identified the antidiabetic principles of *Cassia alata* extracts using an in vitro α-glucosidase inhibition study (Varghese et al., 2013). The methanol extract of leaves of the plant, which showed potent α-glucosidase inhibitory activity ($IC_{50}$, 63.75 ± 12.81 µg/ml), was fractionated. The α-glucosidase inhibitory effect of the crude extract was far better than the standard clinically used drug, acarbose ($IC_{50}$, 107.31 ± 12.31 µg/ml). A subsequent fractionation of the crude extract was made using solvents of ascending polarity (petroleum ether, chloroform, ethyl acetate, n-butanol and water). The ethyl acetate ($IC_{50}$, 2.95 ± 0.47 µg/ml) and n-butanol ($IC_{50}$, 25.80 ± 2.01 µg/ml) fractions of *Cassia alata*, which contained predominantly kaempferol (56.7 ± 7.7 µM) and kaempferol 3-O-gentiobioside (50.0 ± 8.5 µM), respectively, displayed the highest carbohydrate enzyme inhibitory effect. Thus, one of the possible antidiabetic mechanisms of action of C. alata is by inhibiting carbohydrate digestion.

**Bronchorelaxant activity:** Aqueous-ethanolic extract of Cassia alata (AECal) and its derived fractions obtained through liquid-liquid fractionation were evaluated for their bronchorelaxant effect (Ouédraogo et al., 2013). Contractile activity of rats' tracheas in the presence of tested materials, as well as its modifications with different inhibitors and blockers, was isometrically recorded. In animals pretreated with the extract, the percentage of CP-induced DNA damage decreased. The results suggest that (1) muscarinic receptors contribute at least in part to the relaxant effects of AECal; (2) AECal interferes with membrane polarization. Evaluation of isolated bioactive molecules from plant extract eliciting tracheorelaxant effect may give new investigational and treatment tools in bronchorespiratory pharmacology. This study provides sound mechanistic basis for the use of *Cassia alata* in asthma-induced bronchospasm.

**Antiviral activity:** Mohamed *et al* investigated the antiviral activity of five extracts (methanol, chloroform, ethyl acetate, n-butanol, and aqueous) from *Cassia alata* leaves against rotavirus (RV) infection in vitro and in vivo (Mohamed et al., 2015). In vitro, all extracts prevented the cytopathic effect (CPE) of RV, as demonstrated in an MTT colorimetric and karber methods, with therapeutic index (IT) ranged from 22.8 to 0.02 and reduction in virus titers ranged from 4.25 and 0.25 log10TCID50. The methanol extract was the stronger than the other extracts against RV replication. In vivo antiviral activity of the methanol extract against rotavirus was evaluated, using a mouse model. Orally administered methanol extract at 100 mg and 50 mg /kg body weight/day (once a day) significantly reduced virus yield in the small intestine as well as it reduced mortality, severity and duration of diarrhea after infection for 7 days. In addition to this, extract protects the intestinal tissues from damage resulted from RV infection when compared with the untreated infected control. These results clearly shows that in vitro and in vivo infection with RV can be effectively treated by the methanol extract of *Cassia alata* leaves. The antiviral activity of methanol extract of *Cassia alata* may be attributed to the presence of saponins. The anti-rotavirus activity of saponins has been well documented in vivo (Tam and Roner 2011). Thus, the present study has shown that the methanol extract of *Cassia alata* recovered the rotavirus gastroenteritis by coordinating antiviral and anti-inflammatory effects. Also, aqueous and 80% ethanolic extracts of aerial parts have shown slight inhibitory effect on HIV type 1 (Woradulayapinij et al., 2005).

**Reported toxicity:** Pieme *et al* investigated the acute and subacute toxicities of hydro-ethanolic extract of leaves of Cassia alata in Swiss mice and Wistar albino rats (Pieme et al., 2006). The mice were divided into 6 groups of 10 animals and each group received once by intra-gastric gavages 0, 4, 8, 12, 16, 20 times 1000 mg/kg dose

of extract. Distilled water served as the control. For the subacute toxicity, three groups of 10 rats (5 males and 5 females) were treated per os with distilled water (control), 500 or 1000 mg/kg of extract every 48 h for 26 days. At the end of treatment blood sample and 20% liver homogenates were collected for biochemical analyses. The results indicated that the medium lethal dose (LD50) was about 18.50 g/kg of body weight. Significant variation ($P<0.05$) of the body weight was observed after 26 days of treatment, in some biochemicals index of serum and 20% liver homogenates (glutathion , alkaline phosphatase (APL), aspartate aminotransferase (AST)), haematological parameters (platelet) also in the female relative weight of heart of rat. Some of parameter investigated in this study showed dose responsive. The histopatological study of the liver did not show any features after the treatment but, the extract seems to ameliorate the liver architecture. In another study, no death and no clinically significant changes were recorded in mice which consumed this plant extract. The maximum non-lethal dose was more than 16875 mg/kg in animals. No significant changes were observed in body weight, tissues morphology, biochemical and hematological parameters at doses above or equal to 2779.5 mg/kg body weight (Da et al., 2016).

## CONCLUSION

The use of medicinal plants to manage health problems has significantly increased worldwide over recent years as it is easily accessible, cheap and the strong belief that herbal remedies are natural and therefore non or less toxic than standard drugs. It has been proved in this study that *Cassia alata* extracts possess a lot of chemical compounds which support it traditional uses in curing some diseases, and justify its pharmacological profile. Moreover, it has been reported from many scientific studies that this plant's extract is safe for mice and rats till a dose of 16875 mg/kg body weight. In this review, we believe that we have provided a data base for proper evaluation of *Cassia alata* extracts which could lead to the discovery of new and more effective drugs.

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