World Journal of Pharmaceutical and Life Sciences
WJPLS
www.wjpls.org
SJIF Impact Factor: 7.409

CASSIA DIDIMOBOTRYA FREZEN. - A PLANT WITH MASSIVE BIODIVERSITY

Aishwarya S. Kabra[1], Jyotsna D. Patil[2], Upendra B. Gandagule[3], Rohit R. Sawant[4]* and Yogesh D. Pawar[5]

[1,4]Assistant Professor Shri Gulabrao Deokar College of Pharmacy Jalgaon, MS (India).
[2]Lecturer Shri Gulabrao Deokar College of Pharmacy Jalgaon, MS (India).
[3]Professor Shri Gulabrao Deokar College of Pharmacy Jalgaon, MS (India).
[5]Principal Shri Gulabrao Deokar College of Pharmacy Jalgaon, MS (India).

***Corresponding Author: Rohit R. Sawant**
Assistant Professor Shri Gulabrao Deokar College of Pharmacy Jalgaon, MS (India).

Article Received on 04/04/2024 **Article Revised on 24/04/2024** **Article Accepted on 14/05/2024**

ABSTRACT
Currently, the demand for herbal medicines and products is increasing globally and these medicines are being used traditionally as well as in modern systems for the treatment of various ailments and diseases. *Cassia didimobotrya* is found throughout India and Kenya. It is popular in indigenous systems of medicine. In the traditional system of medicine, various plant parts such as bark, root, and leaves, are used in purgative, laxative, cathartic, and antibacterial qualities, etc. The present review is, therefore, an effort to give a detailed survey of the literature on its pharmacognosy, phytochemistry, and traditional and pharmacological uses.

KEYWORDS: Senna didimobotrya, Popcorn Cassia, Biological activities.

INTRODUCTION

Since there has been life on Earth, herbal medicines have been utilized.(Sinidu, M. W., 2016)

The presence of natural goods with medical characteristics has been linked to the widespread usage of herbal treatments and healthcare preparations, such as those found in ancient texts like the Vedas and Bible, and made from commonly used traditional herbs and medicinal plants. (Singh, S. A., & Singh, N. R. 2010).

Even in the present era, where herbal medicines are used by nearly 80% of the global population, they continue to play a vital role in meeting people's basic healthcare needs. This is primarily ascribed to financial limitations or the general public's inability to obtain current medications. (Chawla et al., 2013), (Sinidu, M. W., 2016) In some African nations, up to 90% of the populace still only uses plants for medical purposes. (Musau, J., & Wanjiru)

The present popular perception that "green medicine" is more dependable and safe than expensive synthetic medications, many of which have unfavorable side effects, is the primary cause of the resurgence of interest in plant-derived medications. (Singh, S. A., & Singh, N. R. 2010)

The genus Cassia is well-known for its therapeutic applications, and several herbal remedies have been brought to the public's attention. The official Senna is one of these species that has attained widespread acceptance. The Fabaceae family's Cassia didymobotrya is widely distributed in Tamil Nadu's Nilgiris district. Eastern and Central Africa is home to the shaggy shrub C. didymobotrya (Alemayehu et al., 1989), (Sinidu, M. W., 2016) Popcorn Cassia and Peanut Butter Senna are some more names for it. (Singh, S. A., & Singh, N. R. 2010)The plant can also be used to produce lactation, cause uterine contractions and abortions, cure fungal and bacterial infections, hypertension, hemorrhoids, sickle cell anemia, and a variety of women's ailments including fibroids, backache, and inflammation of the fallopian tubes.(Nyamwamu, B. L., et al 2012).

Synonyms

Cassia didymobotrya Fres. is known by common names like African senna (French), candelabra tree (English), and peanut butter cassia, wild senna and grondboontjiebotter kassia in Afrikaans. In Mozambique, it is referred to as mudlayanhoka, nyocanyokani whereas in South Africa among the Vha - Vendas, it is called Tshiduwana. (Musau, J., & Wanjiru)

It is also called popcorn bush, popcorn cassia, or popcorn *Senna* because it smells like freshly cooked buttered popcorn when fingers are run through the leaves. (Singh,

S. A., & Singh, N. R. 2010) (Jeruto, P., Arama, P.,et.al 2017)

Vernacular names

Table no. 1: Different vernacular names are used by different ethnic communities in kenya.

Ethnic communities	Vernacular names
Kamba	Ithaa, Muthaa
Luhya	Lubino, Luvino
Meru	Kilao, Murao
Taita	Mshua, Mbinu
Kik	Mwino, Mwinu
Gusii	Omovenyu
Luo	Owinu, Ovino, Obino
Mas	Ol-senetoi
Nandi and Kipsigis	Senetwet
Pokot	Senetwo
Maasai	Osenetoi, Esletoi

(Jeruto, P., Arama, P.,et.al (2017), (Madureira *et al*., 2012)

Biological source

Scientific classification (Jeruto, P., Arama, P.,et.al 2017)

Kingdom: Plantae
Division: Spermatophyta / Angiospermae
Class: Magnoliopsida
Order: Magnoliopsidales / Fabales
Family: *Caesalpiniaceae / Fabaceae*
Sub - family: *Caesalpiniodeae*
Tribe: *Cassieae*
Sub tribe: *Cassiinae*
Genus: *Senna*
Species: *Senna didymobotrya* (Fresen.) H. S. Irwin & Barneby

The genus Senna comprises mostly flowering plants (shrubs, herbs, and trees) Cassia is a large genus in the family Fabaceae (Leguminosae), subfamily - Caesalpiniaceae (Musau, J., & Wanjiru), (Singh, S. A., & Singh, N. R. 2010), (Oladeji, O. S., Adelowo, F. E., & Oluyori, A. P. 2021)

Morphology

Fig. 1: Cassia didymobotrya.

A unique floral morphology and the presence of extrafloral nectaries (EFNs) in many species define the genus Senna. It has effectively colonized a wide range of habitats in diverse temperatures and latitudes and has demonstrated a remarkable diversity of behaviors, including herbs, shrubs, trees, tall trees, and lianas (Marazzi et al., 2006), (Jeruto, P., Arama, P., et.al., 2017).

The deciduous shrub or small tree Cassia didymobotrya can grow up to 4.5 meters in height. (Sinidu, M. W., 2016) A few species of S. didymobotrya, a shrub that is native to the tropics, can be found in temperate climates. Eastern and Central Africa are where it originated (Jeruto, P., Arama, P., et.al., 2017). (Orwa et al., 2009). It was brought to India as a garden plant and green manure, and it is widely found by the sides of the highways in the Imphal Valley. (Singh, S. A., & Singh, N. R., 2010)

Fruit: According to Orwa et al. (2009), the fruit is a flat, 9–16 seeded pod that is linear-oblong, 7–12 cm x 1.5–2.5 cm, glabrescent, short-beaked, dehiscent when dry or indehiscent when wet, with elevated sutures and a blackish–brown color. The seed is smooth, pale brown, flattened, oblong, and apiculate, measuring 8–9 mm by 4–5 mm by 2.5 mm. The areole is elliptical, measuring 3–4 mm by 0.7–1.5 mm.(Jeruto, P., Arama, P., et.al., 2017), (Singh, S. A., & Singh, N. R., 2010) (Botta, B., G. Dall'Olio, et al., 1989)

Leaves: This graceful shrub boasts compound leaves on arching branches. Evergreen, leaves open from brown buds and range in length from 14 to 50 cm (Singh, S. A., & Singh, N. R., 2010). They are pinnate, having 8–18 opposing paired leaflets (Oladeji, O. S., Adelowo, F. E., & Oluyori, A. P. 2021). The leaves are simply paripinnate, narrowly oblong to elliptical in outline, and measure between 10 and 50 cm in length. The stipules are broadly ovate-cordate, measuring 6 to 17 mm x 8 to 10 mm, acuminate (Botta, B., G. Dall'Olio, et al., 1989), palmately veined, reflexed, and tardily caducous. The petiole is terete, measuring between 1 and 8 cm in length, and the rachis can reach 40 cm in length, both pubescent and glandular; the petioles are up to 3 mm long. The leaflets are arranged in 8 to 18 pairs, chartaceous, elliptical - oblong, measuring 2 to 6.5 cm x 0.5 to 2.5 cm, twice as long as wide, with an oblique base, rounded but mucronate apex, pubescent to glabrescent, and distinct marginal vein. (Jeruto, P., Arama, P., et.al., 2017)

Flower: S. didymobotrya produces copious amounts of blooms twice a year; in temperate climates, the flowers last all summer (Botta, B., G. Dall'Olio, et al., 1989). Bright yellow blooms with darker veins are arranged in groups of 10 to 20 on tall flower stalks. The tall, axillary, spike-like raceme with 20–30 flowers is known as an inflorescence. The peduncle is terete, 5–8 cm long, and glabrous. The broad, ovate, black-green, 8–27 mm x 5–

15 mm bracts are initially imbricate and enclose the flower buds. Bracteoles are missing; sepals 5 are subequal, oblong-obovate, 9–14 mm long, puberulous, and green; pedicel is thin, 3–10 mm long, and densely pubescent. Five petals measure 17 - 27 mm x 10 - 16 mm, with a slender, glabrous, bright yellow, delicately veined claw. The stamen count is 10, filaments shorter than the anthers, with two lower stamens measuring 9 - 11 mm long, three upper stamens staminodial, and five median stamens measuring approximately 5 mm long. The ovary and stipe are velvety pubescent, and the style is slender, glabrous, and recurved, measuring approximately 1 cm long. The stigma is punctiform (Kokwaro, 2009), (Jeruto, P., Arama, P., et.al., 2017)

Geographical source

It is a potentially therapeutic herb, and traditional healers have thoroughly investigated its medicinal properties throughout much of the world.

Consists of over 250–300 recognized species that are widely distributed throughout tropical and subtropical areas.

Senna species are widely utilized in Australia, Africa, Asia, Europe, and Latin America. (Oladeji, O. S., Adelowo, F. E., & Oluyori, A. P. 2021)

Kenya, Ethiopia (Congo East), Mozambique, Sudan, Angola, Uganda, Tanzania, Namibia, Zimbabwe, and Mozambique are native habitats for Cassia didymobotrya. Nagappan, R. (2012) and grown all over the world in tropical climates.(Jeruto, P., Arama, P., et.al., 2017)

Senna didymobotrya can be found in a range of environments in South Africa, including riparian zones, riverine forests, wastelands, riverbanks, woodlands, grasslands, coastal scrublands, and roadside areas (Nyaberi et al., 2013),. (Jeruto, P., Arama, P., et.al., 2017)

According to Brunmitt et al. (2007), the species is found in its natural environment, which includes marshes, seasonal rivers, roadsides, rocky slopes, grasslands, disturbed areas, and waste places. It is not commonly found in moist habitats, mostly in tropical seasonal vegetation but sometimes in forests. (Randell 1990; EWA 2016).

It is known that only the Senna and Cassia species are pollinated by the female carpenter bee, Xylocopa pubescens Spinola (Dulberger, 1981).

Numerous tropical nations, including the Comoros, Madagascar, Mauritius, and South Africa, received it as an ornamental plant introduction (Sunarno, 1997), (Jeruto, P., Arama, P., et.al., 2017)

Chemical constituents

Through phytochemical screening, the secondary metabolites that give plants their therapeutic properties can be found.

These include, among many other things, enzymes like papain, alkaloids like morphine, phenols like capsaicin, flavonoids like hesperidin, glycosides like sennoside B, C, and D, emodin, chrysophanol, physcion, knipholone, aloe-emodin, rhein, catechin tannins, dianthrone emodin, dianthrone aloe-emodin, and aloe-emodin B-glucoside, anthraquinones, steroids, terpenoids, saponins, and volatile oils, among many others. (Singh, S. A., & Singh, N. R., 2010), (Musau, J., & Wanjiru)

Arachidonic acid, chrysophanic acid, kaempferol, lauric acid, myristic acid, myristoleic acid, oleic acid, palmitic acid, rhein, glycoside, β sitosterol, and stearic There have been reports of 5, 1,4-anthraquinone, daucosterol, physcion, knipholone, and numerous anthraquinone derivatives from the plant.(Mahadevan, N., Upendra, B. G., et al., 2002)

According to Mining et al. (2014) to increase grain production in Kenya, the root bark of S. didymobotrya, which contains anthraquinone and triterpenoids, can be used as a biopesticide against the bean weevil beetle (Acanthoscelides obtectus Say).

Uses

Within its natural habitat, Senna didymobotrya is a widely used medicinal plant. It is used to cure jaundice and other fevers, and it also has purgative, laxative, cathartic, and antibacterial qualities.

While some produce lumber, tannins, and seeds, others are producers of polysaccharides, anthraquinones, mucilage, and flavonoids. It is used to treat gonorrhea, malaria, abscesses, ringworms, headaches, stomachaches, colds, and the flu.(Musau, J., & Wanjiru)

Many nations, including Rwanda, Tanzania, East Africa, and Kenya, employ the leaves of Cassia didymobotrya to treat a range of illnesses, including pneumonia, gastrointestinal issues, and malaria. (Mahadevan, N., Upendra, B. G., et al., 2002)

It has also been used to treat infections in livestock and human skin diseases. Additionally, the plant can be used to treat bacterial, fungal, hypertensive, hemorrhagic, sickle cell anemia, and a variety of women's conditions including fibroids, back pain, and fallopian tube inflammation. It can also be used to promote lactation, produce uterine contractions, and cause abortions (Nyamwamu, B. L., et al., 2012).

Many in vitro and in vivo pharmacological activities, including those of the genus Senna that are antidiabetic, anti-gonorrhea, antimicrobial, antioxidant, antipyretic, antinociceptive, antidepressant, and anti-inflammatory,

were demonstrated by the crude extracts and isolated metabolites from Senna.

Hexane extract's antibacterial properties have the potential to be larvicidal, ovicidal, and repellent against a variety of adult and immature mosquito vector species. (Nagappan, R. 2012)

Additional applications

Other applications for Senna didymobotrya include covering firewood, providing shade, dying, and using it in residential and ornamental gardens.(Musau, J., & Wanjiru)

It is applied to fruits, vegetables, and colors.

These plants were first brought to tropical Asia and America as a cover crop, insecticidal, and fodder.

By covering the inside of the milk storage container with the ash from burned twigs, this species is also used to preserve milk for longer periods—up to a year.

Wood is used in the craft business to create handicrafts. Beyond its natural habitat (such as tropical Asia or America).

Parts	Methods	Uses
Leaves (Mahadevan, N., Upendra, B. G., et al., 2002)	Decoction	Malaria, Gastrointestinal problems, Pneumonia and Purgative
	-	Treat external parasites such as ticks.
Root (Nyamwamu, B. L., et al., 2012)	Decoction	Malaria, jaundice, and intestinal worm
Stem Bark (Nagappan, R. 2012)	Aqueous extract (1%, 0.1% or 0.01% W/V solution)	Potential larvicidal activity.
Root + Leaves (Nyamwamu, B. L., et al., 2012)	Decoction with water	Abscess of the skeletal muscle and venereal diseases.
Leaves , Stems and Roots (Singh, S. A., & Singh, N. R.,2010)	Decoction or Infusion	Laxative and purgative
		Abdominal pains, diarrhea,
		In large quantities it is taken as an emetic to expel intestinal worms and to treat ringworms.
Leaves and Stem barks (Nagappan, R., 2012)	-	Lethal effect to early stages on Malarial vector

Table no. 2: Parts of plant used, its Method and Uses.

Young Leaves of Cassia didymobotrya + Banana Leaves	Cooked	In children lower toxicity levels are given orally.

Screening of biological activities

1. Purgative activity

The purgative activity was conducted using the methodology outlined by Akah et al.1997.

At a dosage of 100 mg/kg body weight, the purgative and activity of cassia didymobotraya extracts were studied in albino mice and rats, respectively. Senna (20 mg/kg) should be taken as usual. Divide the 20–30 gm mice of both sexes into four groups of six mice each. It was noticed how many wet feces there were overall.

Senna (20 mg/kg) should be taken as usual. The purgative effect of the ethanol extract (41.75) was greater than that of the aqueous extract (37.50).)(Mahadevan, N., Upendra, B. G., et al., 2002)

2. *Anti-inflammatory* activity

The anti-inflammatory properties of Cassia didymobotrya's aqueous and ethanol extract were tested on albino rats by inducing paw edema with 1% carrageenan 8. The animals used in this procedure were split up into four groups, each with six animals. The animals were split up into four groups, each with six members. The animals in groups I and II were given fine suspensions of aqueous and ethanol extracts at a dose of 100 mg/kg body weight, respectively, in 0.3% w/v carboxymethyl cellulose. Groups III and IV were given indomethacin (20 mg/kg) and saline water (1 ml/kg), respectively, to act as positive control and solvent control. Every therapy was administered orally. At the fourth hour, the protection % was computed using the following formula.

Percentage protection of edema = $\frac{C-T}{C} \times 100$

At four hours, both extracts exhibited strong anti-inflammatory action that was on par with indomethacin. It was discovered that whereas ethanol extract reduced edema in the first, second, and fourth hours, the aqueous extract treatment group did not demonstrate any reduction in edema at that point. At the fourth hour, the percentage of protection for the aqueous extract, ethanol extract, and indomethacin was computed and found to be 35.29, 37.25, and 43.13, respectively.(Mahadevan, N., Upendra, B. G., et al., 2002)

3. Antibacterial activity

The agar well diffusion method was used to screen the

methanolic and aqueous extracts for antibacterial activity. Staphylococcus aureus (ATCC29213) was the gram-positive bacterial strain, and Pseudomonas aeruginosa (ATCC27853) and Escherichia coli (ATCC25922) were the gram-negative bacterial strains.

Culture medium preparation and inoculation
Mueller-Hinton Agar was ready. To ensure sterility before usage, the plates were then incubated for a whole night. The microorganisms were suspended in peptone water and calibrated to 0.5 Macfarland standards, which correspond to 108 CFU/ml (NCCLS, 2000). An inoculation loop was used to evenly inoculate each labeled medium plate with a test organism.

50 µl of the methanolic and aqueous extract serial dilutions were added to these wells. After allowing the extracts to permeate into the agar, the plates were chilled for one hour. Thereafter, they were incubated for twenty-four hours at 370C. The conventional control medications for the gram-positive and gram-negative bacterial strains were ampicillin and gentamicin, respectively. Using a ruler, the diameter of the clear zones (zones of inhibition) formed after incubation was measured to estimate the antibacterial activity (mm).

It demonstrates that there was little difference between the methanolic and aqueous stem bark extracts' zones of inhibition. E. Coli and P. aerogenosa demonstrated the lowest and highest susceptibilities, respectively. Given that many herbalists extract the plant using water as a solvent, this supports their use of the plant. Even though there were no alkaloids present, the leaf extract was more active than the stem bark extract. This might be because tannins are present because they have been demonstrated to have antimicrobial activity through molecular inhibitions, which primarily affect the integrity of the cell membrane of microorganisms by inhibiting the formation of complexes that cause malformations and increased permeability. (Musau, J. K. 2011), (Musau, J., & Wanjiru), (Botelho, M. A., et al 2007)

4. Pupicidal activity
According to the WHO standard technique, the plant extract's wide and narrow range concentrations were examined for the fatality rate of immature mosquitoes. The pupa that had just emerged was used for pupicidal activities. After a 24-hour exposure period, 25 freshly emerged pupae were released one at a time for each concentration, and the percentage of mortality was noted. Abbott's formula was utilized to quantify the proportion of death after the experiment was replicated five times. In the current investigation, concentrations within the tight range of 50, 100, 150, 200, and 250 mg/L were examined, and concentrations within the large range of 10,000, 1000, 100, 10, and 1 mg/L.

The findings showed that juvenile mosquitoes subjected to 100 mg/L, 1000 mg/L, and 1000 mg/L (aqueous extract) caused 100% mortality in the second, third, fourth, and pupa larvae and pupa, respectively.

A limited range of concentration was produced and evaluated in light of this outcome. After a 24-hour exposure period, 100% mortality was seen at a 250 mg/L concentration in the aqueous extract for all examined immature stages. The findings unequivocally show that the insects' stage and the plant extract dosage determined the fatality rate. (Nagappan, R. 2012)

5. Antimicrobial activity
Using the Agar disc diffusion method, the in vitro antibacterial activity of leaf extracts from Cassia didymobotrya was investigated against a selection of 6 bacterial and 2 fungus species.

Methanol, ethyl acetate, and distilled water were used to extract the leaves. For every extract, three distinct concentrations (100µg, 250µg, and 500µg/disc) were put into the disk. There was a negative control set of discs containing ethyl acetate, methanol, and water. For comparison and control, 30 mg of kanamycin and 50 mg of fluconazole per disc were utilized as antibacterial and antifungal standards. The mean values were displayed after the tests were conducted three times. The antibacterial activity of the methanol and ethyl acetate extracts was found to be greater than that of the aqueous extract. (Singh, S. A., & Singh, N. R., 2010)

6. Amoebiasis Activity
Studies were conducted on the anti-amoebic properties of crude root extracts of Senna didymobotrya against Entamoeba histolytica-infected mice's caecum. S. didymobotrya extracts and a pill of metronidazole, the usual medication, were suspended in distilled water. Every therapy was given orally, through a feeding tube, every day for five days in a row, starting 24 hours after the E. histolytica infection. For the plant extracts, daily dosages of 1 and 500 mg/g body weight were utilized. Metronidazole (125 mg/g) and normal saline (5 ml/g body weight) were administered daily to the control animals. There were six animals used for every treatment. They offered sacrifices to the animals on the sixth day. Using an inverted light microscope, the caecum was found to contain E. histolytica trophozoites. (Nyamwamu, B. L., et al., 2012), (Sohni, Y. R., Kaimal, P., & Bhatt, R. M. 1995), (Ghoshal, S., et al., 1996)

CONCLUSION
This review provides valuable sources of traditional uses, and pharmacological, and phytochemical perspectives of different plant parts of *Cassia didimobotrya* and it will help other researchers in further investigation and exploring properties present in this plant.

ACKNOWLEDGEMENT
The authors are thankful to the Principal of SGDCOP College of Pharmacy, Jalgaon -425001, Maharashtra for their help and support in completing the review work.

REFERENCES

1. Akah, P. A., Oli, A. N., Enwerem, N. M., & Gamaniel, K. Preliminary studies on purgative effect of Carica papaya root extract, 1997.
2. Alemayehu, G., Abegaz, B., Snatzke, G., & Duddeck, H. Quinones of senna didymobotry a. Bulletin of the Chemical Society of Ethiopia, 1989; 3(1).
3. Botelho, M. A., Nogueira, N. A. P., Bastos, G. M., Fonseca, S. G. C., Lemos, T. L. G., Matos, F. J. A., ... & Brito, G. A. C. Antimicrobial activity of the essential oil from Lippia sidoides, carvacrol and thymol against oral pathogens. Brazilian Journal of Medical and Biological Research, 2007; 40: 349-356.
4. Botta, B., G. Dall'Olio, et al. Cell suspension cultures of Cassia didymobotrya: Optimization of growth and, 1989.
5. BRUMMITT, R.K., CHIKUNI, A.C., LOCK, J.M. & POLHILL, R.M. Leguminosae subfamily Caesalpinioideae. Flora zambesiaca, 2007; 3(2): 144–152.
6. Chawla, R., Thakur, P., Chowdhry, A., Jaiswal, S., Sharma, A., Goel, R., Sharma, J., Priyadarshi, S. S., Kumar, V., Sharma, R. K., & Arora, R. Evidence based herbal drug standardization approach in coping with challenges of holistic management of diabetes: A dreadful lifestyle disorder of 21st century. Journal of Diabetes and Metabolic Disorders, 2013; 12: 35-35. doi: 10.1186/2251-6581-12-35]
7. Delle Monache, G., De Rosa, M. C., Scurria, R., Monacelli, B., Pasqua, G., Dall'Olio, G., & Botta, B. Metabolites from in vitro cultures of Cassia didymobotrya. Phytochemistry, 1991; 30(6): 1849-1854.
8. Dulberger, R. The floral biology of Cassia didymobotrya and C. auriculata (Caesalpiniaceae). American Journal of Botany, 1981; 68(10): 1350-1360.
9. Ghoshal, S., Prasad, B. K., & Lakshmi, V. Antiamoebic activity of Piper longum fruits against Entamoeba histolytica in vitro and in vivo. Journal of ethnopharmacology, 1996; 50(3): 167-170.
10. Jeruto, P., Arama, P., Anyango, B., Nyunja, R. A., Taracha, C., & Opiyo, S. A. Morphometric study of Senna didymobotrya (Fresen.) HS Irwin and Barneby in Kenya, 2017.
11. Kokwaro, J. O. Medicinal plants of east Africa. University of Nairobi press, 2009.
12. Liberato, Z. A., Liberato, M. O., & De la Cruz, J. The Potential of Cassia Didymobotrya (Popcorn Cassia) and Cassia fistula L. Golden Shower) Leaf Extract as Organic Pesticides in Eggplant Production.
13. Madureira, A. M., Ramalhete, C., Mulhovo, S., Duarte, A., & Ferreira, M. J. U. Antibacterial activity of some African medicinal plants used traditionally against infectious diseases. Pharmaceutical Biology, 2012; 50(4): 481-489.
14. Mahadevan, N., Upendra, B. G., Subburaju, T., Elango, K., & Suresh, B. Purgative and anti-inflammatory activities of Cassia didymobotrya, Fresen. Ancient science of life, 2002; 22(1): 9.
15. Marazzi, B., Endress, P. K., De Queiroz, L. P., & Conti, E. Phylogenetic relationships within Senna (Leguminosae, Cassiinae) based on three chloroplast DNA regions: patterns in the evolution of floral symmetry and extrafloral nectaries. American journal of botany, 2006; 93(2): 288-303.
16. Mining, J., Lagat, Z. O., Akenga, T., Tarus, P., Imbuga, M., & Tsanuo, M. K. Bioactive metabolites of Senna didymobotrya used as biopesticide against Acanthoscelides obtectus in Bungoma, Kenya, 2014.
17. Musau, J. K. Antimicrobial activity, cytotoxicity and phytochemistry of selected medicinal plants in Meru central district, Kenya (Doctoral dissertation), 2011.
18. Musau, J., & Wanjiru, I. Phytochemical Screening and in vitro Antibacterial Activity of Cassia didymobotrya Fres. International Journal of Research and Review, 2011; 7(10): 36-37.
19. Nagappan, R. Evaluation of aqueous and ethanol extract of bioactive medicinal plant, Cassia didymobotrya (Fresenius) Irwin & Barneby against immature stages of filarial vector, Culex quinquefasciatus Say (Diptera: Culicidae). Asian Pacific journal of tropical biomedicine, 2012; 2(9): 707-711.
20. Nyaberi, M. O., Onyango, C. A., Mathoko, F. M., Maina, J. M., Makobe, M., & Mwaura, F. Bioactive fractions in the stem charcoal of Senna didymobotrya Freasen Irwin and Barney used by pastoral communities in West Pokot to preserve milk. Natural Resource Management, 2013; 16: 980-985.
21. Nyamwamu, B. L., Ngeiywa, M., Mulaa, M., Lelo, E. A., Ingonga, J., Kimutai, A., & Gicheru, M. Effects of crude roots extracts of senna didymobotrya on caecal amoebiasis in mice, 2012.
22. Nyamwamu, L. B., Moses, M., Ngeiywa, M. M., Agola, E. L., Johnstone, M. I., Albert, K., & Michael, M. G. Cytotoxicity and in vitro antiamoebic activity of senna didymobotrya crude root extracts in comparison with metronidazole against entamoeba histolytica, 2015.
23. Oladeji, O. S., Adelowo, F. E., & Oluyori, A. P. The genus Senna (Fabaceae): A review on its traditional uses, botany, phytochemistry, pharmacology and toxicology. South African Journal of Botany, 2021; 138: 1-32.
24. Orwa, C. Agroforestree Database: a tree reference and selection guide, version, 2009; 4.0. http://www. worldagroforestry. org/sites/treedbs/treedatabases. asp.
25. Randell, B. R. Revision of the Cassiinae in Australia. 3. Senna Miller Sect. Senna. Journal of the Adelaide Botanic Garden, 1990; 3: 1-16.
26. Secondary metabolite production by application of the orthogonal design method. Journal of Plant Physiology, 135(3).

27. Singh, S. A., & Singh, N. R. Antimicrobial activity of Cassia didymobotrya and Phlogacanthus thyrsiflorus. J. Chem. Pharm. Res, 2010; 2(4): 304-308.
28. Sinidu, M. W. Formulation of cassia didymobotrya leaf laxative tablets (Doctoral dissertation, University of Nairobi), 2016.
29. Sohni, Y. R., Kaimal, P., & Bhatt, R. M. The antiamoebic effect of a crude drug formulation of herbal extracts against Entamoeba histolytica in vitro and in vivo. Journal of ethnopharmacology, 1995; 45(1): 43-52.
30. Sunarno, B. Senna didymobotrya (Fresenianus) Irwin & Barneby. Plant Resources of South-East Asia, 1997; (11): 229-231.
31. Vitali, A., Pacini, L., Bordi, E., De Mori, P., Pucillo, L., Maras, B, & Giardina, B. Purification and characterization of an antifungal thaumatin-like protein from Cassia didymobotrya cell culture. Plant Physiology and Biochemistry, 2006; 44(10): 604-610.