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Review Article

Recent Advances in Nanoparticle Preparation from *Cassia auriculata*: Pharmacognostical and Biological Perspectives

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ABSTRACT

This review provides a comprehensive overview of *Cassia auriculata* Linn., focusing on its morphological traits and the synthesis of nanoparticles from its leaf and flower extracts. With a rich phytochemical composition, including alkaloids, amino acids, terpenoids, and polyphenols, the plant emerges as a promising source for medicinal applications. Nanoparticles (silver, zinc oxide, copper oxide, and gold) synthesized from the plant exhibit properties beneficial for wound healing, anticancer, antidiabetic, and antimicrobial activities. Traditional uses of *Cassia auriculata* in treating conditions like cancer, diabetes, arthritis, and infections are explored, highlighting its multifaceted therapeutic potential. The review also discusses the plant's role in formulating skin-whitening cream. Overall, *Cassia auriculata* Lin proves to be a versatile medicinal shrub with significant pharmacological potential. The synthesized nanoparticles show enhanced pharmacological activities compared to conventional extracts, suggesting promising applications in both medical and industrial contexts. This abstract underscore the plant's importance in traditional medicine and nanoparticle-based drug development.

Keywords: *Cassia auriculata* (L.), Nanoparticles, Anticancer Activity, Antidiabetic Activity, Antioxidant Activity.

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INTRODUCTION

The oldest kind of medicine is derived from medicinal plants, which have been historically utilized for thousands of years in traditional medicine throughout different countries (Nagaraj *et al*., 2025). Over thousands of years, the empirical knowledge of their medicinal properties influences human communities. Medicinal herbs have been used for a very long time (Jenila *et al*., 2022). In less wealthy countries, treatments made from plants are becoming an increasingly popular form of treatment. India is among the nations in which the use of herbal medicine is most widespread. Because natural herbs are thought to be less dangerous and safer than synthetic drugs, the pharmaceutical sector has been growing quickly in order to create new drugs using herbs (Thirumurthy, 2020). The discovery of novel molecule leads for both medical care and prevention of illnesses largely depend on natural products (Mohan, 2017).

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There is no doubt that humans were thinking about medicinal plants since the beginning of time. People have been utilizing homemade remedies for recovering themselves since ancient times. Different kinds of seeds, roots, leaves, fruits, flowers, and even the entire plant are among the parts of medicinal plants that can be employed (Jamshidi-Kia *et al*., 2018).

In developed nations, high-throughput screening tests are utilized for bioassay-guided fractionation, leading to the isolation of active principles. These can be developed into clinical agents as natural products, synthetic modifications, or synthesized analogues with improved clinical efficacy or minimized adverse effects (Phillipson J. D, 2001).

Cassia auriculata (Figure 1) was a promising traditional plant belonging to the family Caesalpiniaceae. It is mainly adopted (used) in the Siddha and Ayurvedic systems of medicine (Jenila *et al*., 2022). *Cassia auriculata* (Tanner's Cassia or Tanner's Senna) commonly called as Avartaki. Plant is environmentally sensitive to a broad range of temperatures and climates, while it prefers warmth (Dk *et al*., 2022; Swamivelmanickam, 2014). *Cassia auriculata* plant were widely distributed in tropical Africa, the southwest of the People's Republic of China, India, Sri Lanka, Malaysia, Indonesia, Japan, Vietnam, and Australia (Thirumal *et al*., 2021, n.d.). In India, the plant was widely found in desert areas

and high-temperature areas like Rajasthan, Tamil Nadu, Madhya Pradesh, and also other regions of India (Janarny *et al.*, 2022).

The whole part of the plant *Cassia auriculata* is efficient for biological activity. The plant is composed of leaves, flowers, bark, twigs, pods, roots and seeds (Purushotham *et al.*, 2014).

Morphology of *Cassia auriculata*

Cassia auriculata, commonly known as Tanner's Cassia or Avaram Senna, is a shrub belonging to the Fabaceae family (Ramesh *et al.*, 2021). It typically grows up to 2 m in height and is characterized by slender, branched stems with smooth bark. The leaves are alternate, compound, and paripinnate, with 4-6 pairs of leaflets that are oblong, smooth, and light green in colour. Each leaflet measures approximately 1-2 cm in length and is pointed at both ends.

The flowers of *Cassia auriculata* are bright yellow and bloom in dense, axillary clusters. They are characterized by five petals, with the uppermost petal often having a dark reddish spot at its base (Mohan, 2017). The plant produces cylindrical, slightly curved pods that are about 5-7 cm long and contain numerous seeds.

Microscopically, the leaf anatomy of *Cassia auriculata* reveals dorsiventral mesophyll with prominent palisade and spongy layers. The epidermis is covered with a thick cuticle and contains numerous stomata, facilitating gas exchange. The vascular bundles are collateral, arranged in a circular pattern within the stem. The seeds are ovoid and smooth, enclosed within the pods.

Overall, *Cassia auriculata* is distinguished by its distinctive yellow flowers, compound leaves, and slender pods, making it easily identifiable both macroscopically in its natural habitat and microscopically through anatomical features under a microscope.

In recent years nanoparticles were newly discovered in drug development due to their self-targeting, and because of their small size, they bind it binds to particular sites of infected area (Sakshi *et al.*, n.d.). Nanoparticles are eco-friendly, have good conductivity, are cost effective and chemically stable (Muthu and Priya, 2017; Parveen and Rao, 2015).

The plant material was synthesized with nanoparticles like Silver Nanoparticles (Ag NPs) (Thirumal *et al.*, 2021,), Zinc Oxide Nanoparticles (ZnONPs) Copper Oxide Nanoparticles (CuO NPs) (Sharmila and Thirumarimurugan, 2017), and gold nanoparticles (Tharishini, 2014). Since nanotechnology and nanoscience offer novel solutions to problems in electronics, materials science, and medicine, researchers have been giving close attention to those areas of research in recent years. Nanomaterials are crucial due to their superior physicochemical and biological properties compared to bulk phase materials (Prasad *et al.*, 2020).

Zinc oxide nanoparticles, or ZnONPs, have several advantages over other materials: they are simpler to produce, safe, environmentally benign, and compatible with biological systems (Seshadri, 2021). Silver nanoparticles are used in dye preparation, having potent pharmacological screening activity such as wound healing, antimicrobial, antidiabetic, and anticancer activity (Dk *et al.*, 2022).

The *Cassia auriculata* plant has potential in medicine for the treatment of cancer, diabetes mellitus, rheumatoid arthritis, snake bites, stress, and obesity. In addition, it has various applications such as anthelmintic activity, hepatoprotective, anti-obesity, immunomodulatory potential, antioxidant activity, skin disorders, body odour analgesic and anti-inflammatory activity, and antimicrobial property against anaerobic periodontal pathogens. For antimicrobial activity, microorganisms that were employed *Bacillus subtilis, Salmonella typhi, Salmonella paratyphi* A, *Escherichia coli, Proteus mirabilis, Vibrio cholerae*, and *Shigella dysentrae. C. auriculata* extract and a few anthraquinones exhibit promising effective antibacterial agents. Crude extracts of ethanol solvents dosage drastically reduced blood sugar levels (Jenila *et al.*, 2022). *Cassia auriculata* flower ethyl acetate extract minimizes glycation-related diabetic complication issues (Prasad *et al.*, 2020; Sreeram *et al.*, 2021). Comparing *C. auriculata* silver nanoparticles with other formulations, they exhibited potential wound-healing capacity. The medical profession could make use of the biologically synthesized *C. auriculata* Ag NPs because of its successful wound - healing properties (Bandawane *et al.*, 2014).

Cassia auriculata plant extract showed potential for urinary tract infection (Nawaz *et al.*, 2022). *In vitro* anticancer activity and strong antibacterial properties against MG-63 cells are exhibited by the prepared AS-ZnO NPs. When it comes to osteosarcoma, AS-ZnO NP's may be an effective chemotherapy drug (Sreeram *et al.*, 2021). This article examines how medicinal plants, such as *Cassia auriculata*, which are utilized in traditional medicine, may be able to treat a range of illnesses. This shrub, often called Tanner's Cassia, is widely distributed in tropical areas and is used in Ayurveda and Siddha medicine to treat conditions like diabetes, cancer, and infections. *Cassia auriculata* contains chemical constituents such as flavonoids, anthraquinones, triterpenoids, phenolic acids, tannins, and amino acids (Table 1). Its bioactive substances have antibacterial, antioxidant, and anticancer qualities. These include nanoparticles like silver and zinc oxide. The plant's extracts have the ability to treat diabetic problems, reduce inflammation, and promote wound healing. Because of its improved therapeutic efficacy thanks to nanoparticle formulations, *Cassia auriculata* is a top contender for contemporary medication development (Chanderraj *et al.*, 2021).

Table 1: Phytochemical constituents present in *Cassia auriculata* (Bhuvaneswari *et al.*, 2019; Jeysiha *et al.*, 2022; Nawaz M P *et al.*, 2018; Thirumal S *et al.*, 2021, Venkatachalam *et al.*, 2013).

Chemical Constituents	Compounds
Flavonoids	Kaempferol, quercetin, glycosides
Anthraquinones	Auriculatin, emodin, and chrysophanol.
Triterpenoids	Triterpenoid saponins
Phenolic Acids	Caffeic acid, ferulic acid,
Tannins	Phenolic compounds
Amino acids	Arginine and glycine

Figure 1: *Cassia auriculata* plant.

Preparation of Nanoparticles using leaves and flower extract of plant

Green Synthesis of Silver Nanoparticles Using Aqueous Extracts from Flowers and Leaves of Cassia auriculata: An Eco-Friendly Approach

Silver nanoparticles were prepared from silver ions by using reducing agents (Figure 2) of triple distilled water fraction. First, 100 mg of separated paste (plant extract was separated by using polar solvent containing triple distilled water) was taken in a 10 mL measuring flask to dissolve and made up using triple distilled water (AS). The required quantity of AS solution was added to 1 mM $AgNO_3$ and kept at room temperature in a dark condition (Parveen and Rao, 2015). The reduction of Ag+ ions to Ag nanocrystals was monitored by the change in the colour of the reaction mixture from yellowish to dark brown (Nawaz *et al.*, 2022).

Green Synthesis of Zinc Oxide Nanoparticles Using Aqueous Extracts from Flowers and Leaves of *Cassia auriculata*: A Sustainable and Eco-Friendly Approach

0.1 M of zinc acetate was dissolved in 100 mL of distilled water. It was mixed by continuous stirring for 10 min at room temperature. To this, 2 g of sodium hydroxide was added slowly. This mixture was titrated with aqueous extract of *Cassia auriculata* flower (Sreeram *et al.*, 2021) or leaf was stirred for 2 hr continuously. The solution pH maintained to 12. The solution was centrifuged at 6000 RPM for 30 min (Figure 3). The aqueous solution was boiled until its colour changed from watery to light white paste. This indicates the presence of zinc oxide nanoparticles (Ramesh *et al.*, 2021).

Phyto fabrication of Copper Oxide Nanoparticles Using Aqueous Leaf Extracts from *Cassia auriculata*: A Green and Sustainable Approach

To 30 mL of aqueous *C. auriculata* extract, 0.01 M $CuSO_4$ (10 mL) solution was added and mixed by mechanical shaking. Then the mixture was heated in a water bath for 1 hr at 80°C. Slowly the reaction colour changed from brownish yellow to dark brown (Figure 4), indicating the formation of copper oxide nanoparticles (Shi *et al.*, 2017).

Synthesis of gold nanoparticles from aqueous leaf extract of plant *Cassia auriculata*

1 mL of aqueous leaf extract was combined with 1 mM $HAuCl_4$ (Chloroauric acid), then diluted to 10 mL with glass-distilled water. The solution was examined for colour change from yellow to ruby red within 1 hr, indicating gold nanoparticle synthesis (Prasad *et al.*, 2020).

Exploring Pharmacological Characteristics across Nanoparticle Formulations Derived from Diverse Biological Sources

Wound Healing Activity

Wound - healing activity on *Cassia auriculata* using synthesized silver nanoparticles. Aqueous extract of aerial parts of plants with AgNPs subjected to wound healing on Wistar rat's dorsal thoracic region. Povidone iodine was used as standard, and 1% *Cassia auriculata* AgNP's were applied on the wound area and observed. *C. auriculata with* AgNPs demonstrated significantly better performance in both models, indicating a more potent effect. The fact that AgNPs outperformed this standard treatment in wound contraction and tensile strength suggests they may offer superior healing properties (Swamivelmanickam, 2014).

Anticancer Activity

The anticancer activity of *C. auriculata* products of ZnO NPs with aqueous flower extract was tested on the MG-63 cell lines for their inhibitory activity. The percentage feasibility of the cell line was determined using Trypan blue colour prohibition technique. The cytotoxic properties of prepared formulated compound (Ca-ZnO nanoparticles 15 and 20 µg) against MG-63 cells are inspected via MTT assay. Ca-ZnO nanoparticles remarkably inhibit cell viability and MMP and inhibit apoptosis in OS MG-63 cells (Sreeram *et al.*, 2021).

The tumoricidal activity of *C. auriculata* products of ZnO NPs with aqueous leaf extract performed on MCF-12A and

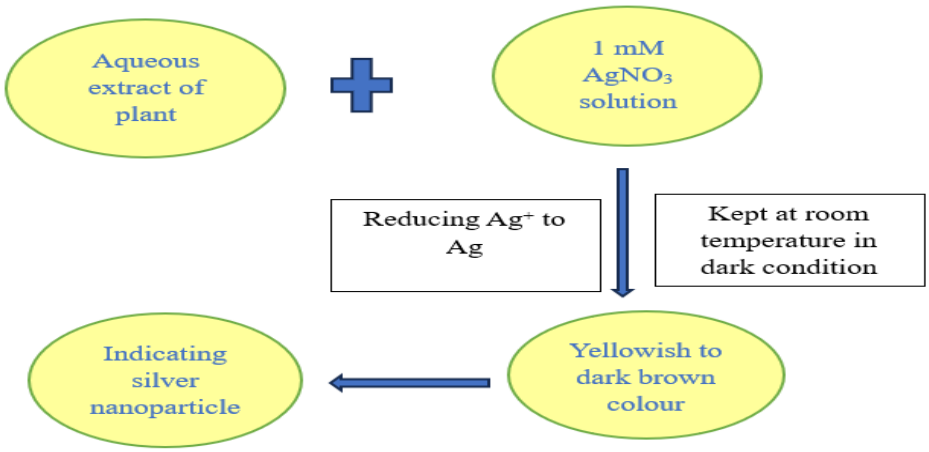

Figure 2: Schematic representation of green synthesis of silver nanoparticles.

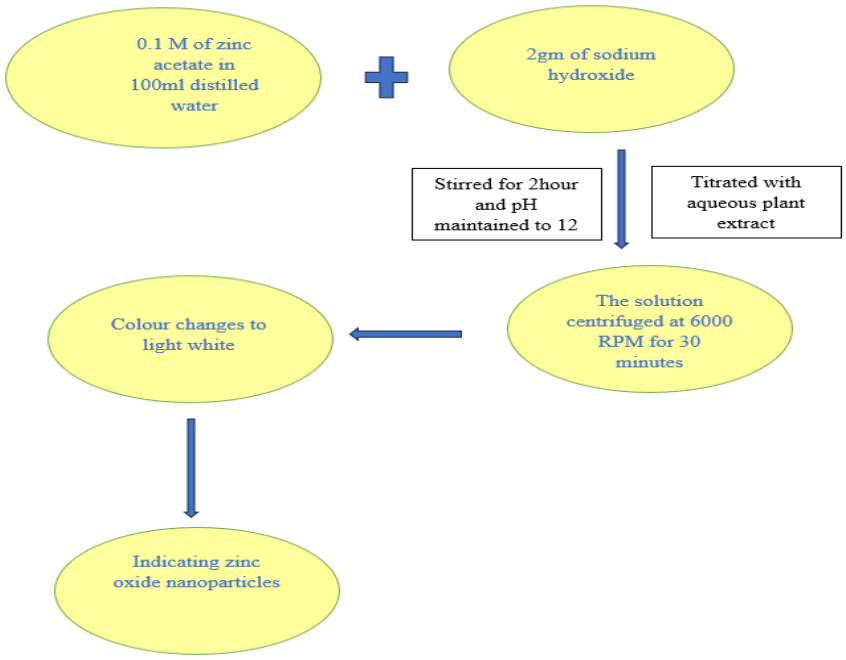

Figure 3: Schematic representation of green synthesis of zinc oxide nanoparticles.

MCF-7 cell strains for their inhibitory activity. The obtained formulation was analysed using UV absorption and emission spectroscopy, XRD, TGA-TDA, SEM, TEM. ZnO nanoparticle and *C. auriculata* extract cytotoxic effects were assessed utilising 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium assay method. Ca-ZnO NP remarkably inhibit cell viability and apoptosis in MCF-7 cells, with no significant inhibition on MCF-12A cell lines (Seshadri, 2021).

The cytotoxic activity of *C. auriculata*-Ag nanoparticle products with ethanol leaf extract was performed on MCF-7 cell lines. *C. auriculata*-Ag nanoparticle against MCF-7 cell line was compared with 5-fluorouracil (standard) as determined by the MTT assay method. The maximum cell inhibition and minimum cell viability were observed in ethanolic extract of *C. auriculata* - AgNP with different concentrations. Highest cell inhibition was 74.80% and minimum cell inhibition was 16.56% was observed with change in Ag nanoparticle concentration (Nawaz *et al.*, 2022).

The cytotoxicity activity of *C. auriculata* AgNP product with aqueous leaf extract was tested on HeLa and VERO cell lines. The 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide assay was utilized to decide the cytotoxicity of *C. auriculata* on HeLa and VERO cell lines. The gold nanoparticles are safe to humans at 10 µg/m concentration, from the result of cytotoxicity tests on HeLa and VERO cell lines (Prasad *et al.*, 2020).

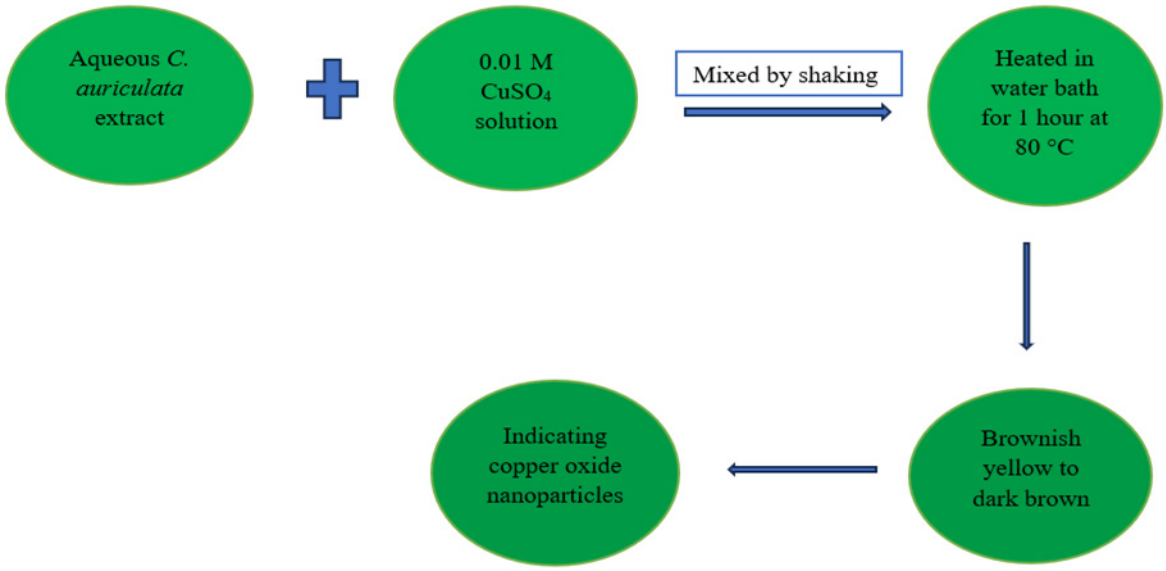

Figure 4: Schematic representation of synthesis of copper oxide nanoparticles.

Rheumatoid Arthritis

The CuO nanoparticles derived from *C. auriculata* leaf extract were tested for cytotoxicity using the MTT assay on RAW 264.7 macrophages. The experiment was designed to test the effects of CuO nanoparticles specifically on macrophages associated with rheumatoid arthritis. This suggests a potential interest in the therapeutic or harmful effects of the nanoparticles in inflammatory conditions. At a concentration of 200 µg/mL, the CuO nanoparticles showed less toxicity, suggesting a potentially safe threshold for further investigation, especially in the context of rheumatoid arthritis (Shi *et al.*, 2017).

Antimicrobial Activity

Aqueous extract of *C. auriculata* flower with silver nanoparticles was subjected to antibacterial and antifungal activity by the well diffusion method against fungal strains *Candida albicans* and *Trichophyton megnini* and bacterial strains *Pseudomonas aeruginosa*, and *Staphylococcus aureus*. Standard used for the antimicrobial and antifungal studies were Chloramphenicol and Nystatin respectively. The results revealed that the aqueous *C. auriculata* - silver nanoparticles exhibited more or less same zone of inhibition against the tested organism as the standard for bacterial strains but for fungal strain the standard exhibited a little bit more result (Bhuvaneswari *et al.*, 2019).

Aqueous extract of *C. auriculata* flower with silver nanoparticles was introduced to antimicrobial activity by the disk diffusion method against 4 bacterial strains *P. aeruginosa, E. coli, S. epidermidi*, and *S. aureus.* The formulated AgNP's with Aqueous flower extract cream showed potent zone of inhibition (11 mm, 14 mm, 16 mm, 12 mm) against to gram positive and gram-negative bacterial strains compared to flower extract. Further studies are needed to formulate bactericidal cold cream based on animal studies and to make the formulation cost-effective and patent an affordable cream (Sahana *et al.*, 2014).

The antimicrobial properties of *Cassia auriculata* flower aqueous extract with silver nanoparticles using the Kirby-Bauer well diffusion method. The synthesized AgNPs exhibited potent inhibitory effects against *Enterococcus faecalis, Klebsiella pneumoniae, Salmonella typhi, Escherichia coli*, and *Staphylococcus aureus*, surpassing the efficacy of the flower extract alone. Characterization techniques including UV-visible spectroscopy, TEM, EDS, XRD, and FTIR were employed for the synthesized AgNPs (Sahana *et al.*, 2014).

Antidiabetic activity

The antidiabetic potential of *Cassia auriculata* flower with gold nanoparticles. In diabetic rats induced by alloxan monohydrate and fed a commercial rat diet, *C. auriculata* flower with gold nanoparticles exhibited significant antidiabetic effects. Compared to flower extract alone, gold nanoparticles synthesized using *C. auriculata* showed enhanced hypoglycaemic activity (Venkatachalam *et al.*, 2013).

Different Biological Sources' Pharmacological Characteristics of Plant Extract

Antidiabetic activity

Antidiabetic activity of *Cassia auriculata* ethanolic extracts was performed on streptozotocin and nicotinamide induced diabetic rats. By inhibiting the glucose oxidase enzyme utilising glucose estimation, *in vivo* anti-diabetic screening was investigated. Glibenclamide is used as standard. Ethanol extract of *Cassia auriculata* crude product (200 and 400 mg/kg) showed greater reduction in blood glucose level in diabetic rats and prevente loss of body weight in rats. To control diabetes mellitus, the *C.*

auriculata Linn. plant can be utilised as an alternative supplement (Jenila *et al.*, 2022).

Clinical Trials

Some clinical trials have explored the efficacy of *Cassia auriculata* in managing diabetes, with promising results indicating its potential as an adjunct therapy or alternative treatment option.

Antitubercular

An organic solvent extract of *Cassia auriculata* bark was used for the antitubercular screening. The phytochemicals present in ethanol and benzene extract are terpenoids, alkaloids, phenols, and steroids. Molecular docking was performed on 5HKF protein and *Mycobacterium tuberculosis* (H37Rv) to check the ligand and protein interaction by using autodock. ADMET study was performed using smiles. Isoniazid used as standard. N-methyl-N-nitrosoadenosine, simarenol, 4-Acetyl-5-(2-fluorophenyl)-3-hydroxy-1-methyl-1,5-dihydro-2H-pyrrol-2-one and 6,7,8,14-tetradehydro- 3-methoxy-17-methylmorphinan, are significant potent suppressors of *Mycobacterium tuberculosis* strain (H37Rv) protein ID (5HKF) as compared to the standard. Four phytocompounds were subjected to ADMET profiling, which verified their human absorption capacity, lack of cytochrome P450 inhibition, non-carcinogenicity, and non-hERG inhibition (Jeysiha *et al.*, 2022).

In vitro Antimicrobial and *In vitro* Cytotoxic Activity

The phytochemical, antimicrobial, and anticancer activities of flower extract of *Cassia auriculata* were studied on methanol, ethanol, and aqueous extract. Methanol extract showed more phytochemicals compared to ethanol and aqueous. The flower extract of the plant was performed *in vitro* antimicrobial activity against three different pathogens, *Pseudomonas. Aeruginosa, S. aureus,* and *C. albicans.* Streptomycin is standard for *P. aeruginosa* and *S. aureus* and Fluconazole for C. albicans. Pseudomonas aeruginosa (19mm at 125 µg/mL) showed better zone of inhibitory activity compared to other microorganisms. *In vitro* cytotoxicity was performed on MCF-7 cell line by MTT assay. The MCF-7 cell lines were exposed to the crude extract, which exhibited good anticancer activity. Activity showed up in a dose-dependent manner. At 400 µg/mL, MCF-7 cell strain showed a low level of cell viability (9.48%), while at 3.125 µg/mL, MCF-7 cell lines demonstrated a low level of cell viability (89.80%). The compound's IC_{50} value against MCF-7 cell lines was 148.836 µg/mL (Thirumurthy *et al.*, 2020).

CONCLUSION

Cassia auriculata, a medicinal shrub deeply rooted in traditional medicine, has been extensively studied through literature research and experimental data analysis. The plant's phytochemical constituents, encompassing alkaloids, amino acids, proteins, terpenoids, saponin, flavonoids, tannins, carbohydrates, glycosides, and polyphenols, have paved the way for its integration into aqueous extractions with nanoparticles (AgNP's, ZnONP's, CuONP's, $HAuCl_4$NP's) from its leaves and flowers.

The incorporation of nanoparticles significantly amplifies the plant's therapeutic potential, notably in wound healing, antidiabetic, anticancer, and antimicrobial applications. Traditionally, *Cassia auriculata* has been employed for diverse medical purposes, including cancer and diabetes treatment, addressing fungal and bacterial infections, inflammation, rheumatoid arthritis, snake bites, stress, tuberculosis, cholesterol regulation, and dengue. Moreover, it plays a role in formulating skin-whitening cream.

This comprehensive review underscores the plant's immense promise, both in pharmacological practices and industrial applications. The nanoparticle formulations, when compared to conventional aqueous and organic solvent extracts, exhibit potent pharmacological activities, marking *Cassia auriculata* as a versatile and invaluable resource for future medicinal and industrial advancements. The study suggests a compelling future scope for the plant, further solidifying its position as a multifaceted contributor to health and industry.

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ABBREVIATIONS

CuONP: Copper oxide nanoparticle; **AgNP:** Silver nanoparticles; **ZnONP:** Zinc oxide nanoparticles; **$HAuCl_4$NP:** Chloroauric acid; **MCF-7:** Michigan Cancer Foundation-7; **MTT:** 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide; **$AgNO_3$:** Silver nitrate; **ADMET:** absorption, distribution, metabolism, elimination, toxicity. **AS:** Aqueous Solution; **OS:** Osteosarcoma; **UV:** Ultraviolet; **XRD:** X-ray Diffraction; **TGA-TDA:** Thermogravimetric Analysis-Differential Thermal Analysis; **SEM**: Scanning Electron Microscopy; **TEM:** Transmission Electron Microscopy; **MMP:** Mitochondrial Membrane Potential; **IC_{50}:** Half Maximal Inhibitory Concentration; **hERG:** Human Ether-à-go-go-Related Gene; **RAW 264.7:** Mouse Macrophage Cell Line; **HeLa:** Human Cervical Carcinoma Cell Line; **VERO:** African Green Monkey Kidney Cell Line.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

FUNDING SOURCES

The authors received no financial support for this work.

ETHICAL STATEMENTS

This study did not involve any human or animal subjects requiring ethical approval.

SUMMARY

Cassia auriculata is a medicinal shrub that is well-known in both traditional medicine and modern research for its important phytochemical content (i.e., alkaloids, flavonoids, terpenoids, and polyphenols). The recent research is indicating that this plant is more effective for treating or resolving health issues when combined with nanoparticles (AgNPs, ZnONPs, CuONPs, $HAuCl_4$NPs) upon application, which enhances the mechanism for use in areas such as wound healing, anticancer, antidiabetic, and antimicrobial applications. Although the medicinal shrub has been used for centuries to treat illnesses like diabetes, cancer, infection, and inflammation, among others, it is also found as an ingredient in cosmetics to treat skin. Overall, the nanoparticles-this may provide benefits for pharmaceutical as well as industrial purposes given the additional pharmacological efficacy obtained through the integration.

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