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Review Article

CASSIA AURICULATA: A COMPREHENSIVE REVIEW OF THE NUTRITIONAL, PHYTOCHEMICAL AND PHARMACOLOGICAL PROPERTIES

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ABSTRACT

Cassia auriculata, a notable medicinal plant deeply rooted in traditional medicine, plays a significant role in the Ayurvedic systems of India and Sri Lanka. The different parts of the plant including flowers, leaves, barks, roots, and seeds were revealing substantial quantities of essential nutrients, including carbohydrates, proteins, lipids, crude fiber, and total soluble sugars, along with minor amounts of calcium, zinc, sodium, magnesium, copper, iron, and vitamins. Beyond its nutritional attributes, C. auriculata exhibits a diverse phytochemical profile, encompassing alkaloids, phenols, glycosides, flavonoids, tannins, saponins, emodin, and anthraquinone derivatives, each contributing to a spectrum of health benefits. The rich phytochemical composition imparts a broad range of pharmacological activities, including antioxidant, antidiabetic, anticancer, and anti-inflammatory properties. In traditional medicinal practices, C. auriculata has been effectively employed to alleviate various ailments such as type II diabetes, skin disorders, eye conditions, liver maladies, and urinary tract disorders. The current review seeks to provide updated insights into the nutritional, phytochemical, and pharmacological aspects of C. auriculata, with special emphasis on its clinical implications for managing a range of health issues, thereby offering valuable information for researchers, and healthcare professionals.

Keywords: Cassia auriculata, nutrients, phytochemicals, pharmacological properties

INTRODUCTION

The value of traditional medical practices and medicinal plants in resolving global health issues is becoming more and more well-known every day. The majority of developing countries have included traditional medicine in their cultural fabric. Although they are found throughout the world, tropical nations have the greatest abundance of medicinal plants. Pharmaceutical corporations are keenly interested in using the extensive knowledge bases of nations like China, India, and Sri Lanka about medicinal plants and health care as a resource for research and development initiatives aimed at finding novel medications (Krishnaraju et al., 2005). *Cassia auriculata* is one of the extraordinarily commonly used medicinal plants in traditional medicine especially in Sri Lankan and Indian Ayurvedic systems. Belonging to the genus Cassia and the family Caesalpiniaceae, *C. auriculata*, also known as tanner's cassia, holds cultural significance, identified as "avaram" in Tamil and "Ranawara" in Sri Lanka. Its distribution spans tropical countries, including America, India, Fiji, Indonesia, Malaysia, Brazil, and Africa (Deshpande & Bhalsing, 2013; Juan-Badaturuge et al., 2011; Meenupriya et al., n.d.-a). The plant has been reported to contain a diverse array of phytochemical constituents, such as alkaloids,

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phenols, glycosides, flavonoids, tannins, saponins, emodin, and anthraquinone derivatives, each contributing to various health benefits (DAISY & Feril Jeeva Kani, n.d.; Meenupriya et al., n.d.-a).

Traditional medicinal practices widely employ various parts of the *C. auriculata* plant to treat a range of ailments, including helminth infections, eye diseases, diabetes, skin conditions, conjunctivitis, and ophthalmia (Deshpande & Bhalsing, 2013; Juan-Badaturuge et al., 2011; Meenupriya et al., n.d.-a). The herb is especially famous for its attractive yellow flowers which are used to treat urinary discharges, nocturnal emissions, diabetes and throat irritation. The dried flower bud powder serves as a tea substitute. Leaves and seeds find utility in addressing leprosy, ringworm, flatulence, colic, dyspepsia, constipation, cough, bronchitis, and cardiac disorders. The seeds of Cassia species have been used in Chinese medicine as aperients, antiasthma, diuretic agents and also to treat eye troubles. The bark acts as an astringent, while the roots are used to cure skin diseases, ulcers, leprosy, and liver diseases. *C. auriculata* is a significant component of 'kalpa herbal tea,' widely consumed by individuals dealing with diabetes mellitus, constipation, and urinary tract diseases (Thabrew et al., 2005). Furthermore, adding an equal amount of dried powdered leaves, roots, flowers, bark and unripe fruits of *C. auriculata* plant in traditional medicine produce a drink called ‘‘avarai panchaga choornam” and it’s most famous for cure diabetic (Deshpande & Bhalsing, 2013; Pari & Latha, 2002).

This review article aims to consolidate the existing knowledge on the nutritional, phytochemical and pharmacological properties of *C. auriculata*, shedding light on its potential health benefits.

NUTRITIONAL VALUE

The different parts of *C. auriculata* including flower, leaves, roots and seed were reported to investigate using various analytical methods and have found various nutrient compounds like carbohydrate, protein, lipids, crude fiber, total soluble sugars and energy value. The flowers of *C. auriculata* represent a significant carbohydrate source, comprising more than 64.45/100 g of dry weight (DW). Furthermore, these flowers contain substantial amounts of protein (>9 g/100 g), fiber (ranging from 1.89 to 7.82 g/100g), and fat (>3 g/100 g), thereby contributing to their diverse nutritional profile. Based on prior studies, the nutrient composition analysis of *C. auriculata* flowers reveals the presence of calcium (10 mg/100 mg), phosphorus (4.8 mg/100 mg), iron (2.5 mg/100 mg), and vitamin C (0.0072 mg/100 mg). Additionally, the reported energy value is approximately 324 kcal (Rao et al., 2000; Sahoo et al., 2020) (Table 1).

The seeds of the *C. auriculata* plant are documented to contain essential nutrients such as protein (23.83 g/100 g), lipids (6.68 g/100 g), crude fiber (8.93 g/100 g), and total sugars (53.4 g/100 g). Furthermore, a comprehensive mineral analysis revealed that nitrogen, potassium, and phosphorus are the primary elements present in substantial amounts. Additionally, minor quantities of calcium, zinc, sodium, magnesium, copper, and iron were detected. Examining the fatty acid composition, the seeds exhibit prominent saturated fatty acids, with palmitic acid (14.01 %) and stearic acid (5.12 %) taking the lead. In contrast, arachidic acid (2.17 %), oleic acid (21.31 %), and linoleic acid (51.52 %) are the dominant unsaturated fatty acids in the seed extracts. The energy value of the seeds is reported to be 412.6 Kcal/100 g (Senthil Kumar et al., 2002).

PHYTOCHEMICAL COMPOSITION

Phytochemicals, compounds present in plants, play a crucial role in providing various health benefits. While plants produce these chemicals as part of their defence mechanism, research indicates that phytochemicals can also confer protective effects against non-communicable diseases in humans (Yadav & Agarwala, 2011). *C. auriculata* is recognized as an herb rich in phytochemical content across its various plant parts, including fruits, leaves, and roots. Polyphenols, as outlined in Table 2), are one of the most abundant categories of secondary metabolites. Numerous studies have reported various compounds within this category, encompassing phenolic acids, flavonoids, tannins, and other phenolics, highlighting the diverse array of phytochemicals present in *C. auriculata*.

Flower: Cassia flowers have been documented to encompass a spectrum of main phytochemical constituents, including total phenols, flavonoids, tannins, phytates, saponins, quinines, coumarins, and oxalates (Meena et al., 2019; Ramachandra Reddy, 2016b; S et al., 2022; Sahoo et al., 2020).

Leaves: The leaves of the Cassia plant have been documented to contain a rich array of major phytochemical constituents, including alkaloids, flavonoids, phenols, saponins, tannins, terpenoids, and glycosides (B & V, 2015; Chaudhary & Kumar, n.d.; Kalaivani et al., 2008; S et al., 2022; Sahoo et al., 2020). In a quantitative analysis conducted by (Meena et al., 2019) the bioactive compounds were specifically identified, revealing the

presence of α-Tocopherol-β-D-mannoside (14.22%), Resorcinol (11.80%), and 1, 2, 3, 4-Tetrahydroisoquinolin-6-ol-1-carboxylic acid (1.98%) in the leaf extract.

Seeds: The seeds of the Cassia plant have been noted for their rich phytochemical composition, encompassing alkaloids, phenols, flavonoids, tannins, phytosterols and anthraquinones as highlighted by various studies (B & V, 2015; Ramachandra Reddy, 2016a; S et al., 2022). A quantitative analysis conducted by (Meena et al., 2019) further unveiled specific bioactive constituents in the seed extract. Notably, benzoic acid, 2- hydroxyl methyl ester (0.07%), 1- methylbutyl ester (0.10%), 2,3 dihydro-3,5 dihydroxy- 6 methyl-4H-pyran-4-one (0.12%), Capric acid ethyl ester (0.16%), Resorcinol (0.21%) were identified as prominent beneficial compounds present in the seeds of the Cassia plant.

Root: Comprehensive studies conducted by (Meena et al., 2019; S et al., 2022) identified key bioactive constituents in the root extract. Notably, the studies revealed that significant amounts of 7, 4-dihydroxy flavone-5-o-beta-d-galactopyranoside, 1,3-dihydroxy-2 methyl-anthraquinone, 1,3,8- trihydroxy- 6methoxy -2 methyl-anthraquinone and rutinoside as prominent phytochemicals contained in roots.

PHARMACOLOGICAL PROPERTIES

Antioxidant activity

The oxidation process is one of the most important routs for producing free radicals and they are contributed to occur high number of disorders in the human body including cancers, atherosclerosis, arthritis, reperfusion injury of many tissues, central nervous system injury, etc. *C. auriculata* plants are enriched with a plethora of bioactive compounds known for their capacity to scavenge free radicals and protect the human body (Choi et al., n.d.). Previous researchers have found the antioxidant activity of this plant using in vitro, in vivo, and human studies. The antioxidant potential of *C. auriculata* leaves was explored using various organic solvents, namely n-hexane, ethyl acetate, and methanol. Interestingly, the methanol and ethyl acetate extracts exhibited identical and significantly stronger antioxidant activity compared to the n-hexane extract (Girme et al., 2018).

In evaluating the antioxidant potential of *C. auriculata* flowers, ethanol and methanol extracts were employed, using 2,2′-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) and 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging methods. (Kumaran & Karunakaran, 2007; Meenupriya et al., n.d.-b).The methanolic extract of *C. auriculata* flower buds exhibited heightened free radical scavenging activity, primarily attributed to the abundant bioactive compounds of flavonol and Quercetin (Meenupriya et al., n.d.-a). Utilizing the phosphor molybdenum assay, the flower extracts demonstrated a notable antioxidant capacity, quantified at 63.8 mg AAE/g. Furthermore, the flower extracts displayed significant ferrous ion chelating ability, reaching 90.05% (Kolar et al., 2018).

In another study carried out by (Rajagopal et al., 2003), the antioxidant activity of leaves of *C. auriculata* extract was observed in mice subjected to alcohol-induced oxidative stress. The study indicated that *C. auriculata* leaf extract has an ability to react against alcohol induced oxidative stress (Rajagopal et al., 2003) (Table 3).

Antidiabetic Property

The hypoglycemic properties of the ethanol extract from both *C. auriculata* leaves and flowers were investigated in alloxan-induced diabetic rats over 15 days, administered at doses of 120 mg/kg. The results revealed a significant reduction in blood glucose levels, suggesting a potential mechanism involving stimulated insulin secretion from β cells or regeneration of β cells. Furthermore, the antidiabetic efficacy of *C. auriculata* bark was evaluated in streptozotocin (STZ)-induced diabetic rats. Various extracts of *C. auriculata*, administered orally at 250 mg/kg body weight, exhibited a gradual reduction in plasma glucose levels. After a 90-day treatment period, the glucose levels approached normal, with the methanol extract demonstrating superior efficacy (DAISY & Feril Jeeva Kani, n.d.).

Protein tyrosine phosphatase 1B (PTP 1B) holds promise as a therapeutic target, especially in the context of type-2 diabetes treatment. PTP 1B is known to dephosphorylate the insulin receptor in intact cells, acting as a negative regulator of insulin signaling. Inhibition of PTP 1B for managing type-2 diabetes has garnered significant interest, leading to the investigation of the hydro-methanolic flower extract of *C. auriculata* for its potential PTP 1B inhibitory activity. The study revealed IC_{50} values of 96.27 and 35.5 μg/mL for the ethyl acetate and n-butanol fractions of *C. auriculata* flower extracts, respectively (Singaravelu & Ahn, n.d.).

Administration of *C. auriculata* flower extract at doses of 0.45 g/kg body weight for 30 days demonstrated the suppression of elevated blood glucose levels in diabetic rats, comparable to the effect of glibenclamide (Pari & Latha, 2002). Additionally, the methanolic extract of Cassia flowers exhibited a significant decrease in blood glucose levels in response to maltose ingestion, concurrently suppressing insulin activity in Sprague Dawley rats (B & V, 2015). The hypoglycaemic properties of *C. auriculata* leaves and flower extracts were reported in alloxan-induced diabetic rats at doses of 120 mg/kg for 15 days. The results indicated that *C. auriculata* leaves and flower extracts stimulated insulin secretion from beta cells in alloxan-induced diabetic rats (Kalaivani et al., 2008) (Table 3).

Anticancer activity

C. auriculata was also evaluated for its anticancer activity using numerous *in vivo* and *in vitro* methods. In a previous study, the in vitro anti-cancer effect of *C. auriculata* leaf extract was evaluated in human breast adenocarcinoma MCF-7 and human larynx carcinoma Hep-2 cell lines and IC_{50} values reported as 400 and 500 mg respectively. The observed nuclear fragmentation and condensation, coupled with apoptosis-mediated inhibition of both cell lines' proliferation, were identified as key contributors to the growth inhibition induced by the extract (Prasanna et al., 2009).

Moreover, a compound isolated from the leaves of *C. auriculata*, identified as 4-(4-chlorobenzyl)-2,3,4,5,6,7-hexahydro-7-(2-ethoxyphenyl) benzo[h] [1,4,7] triazecin-8(1H)-one, demonstrated significant anticancer activity. It exhibited a 50 % inhibition of human colon cancer cells (HCT 15) at a concentration of 25 µg/mL within 48 hours. The study indicated that the compound's high lipophilicity led to the loss of membrane integrity in cancer cells due to its cytotoxic effects. Moreover, the isolated compound was found to induce membrane disintegration, confirmed by a notable release of lactate dehydrogenase (LDH) from damaged cell membranes, reflecting the occurrence of apoptosis Therefore, that isolated compound from *C. auriculata* has potential to prevent colon cancer cell line (Esakkirajan et al., 2014).

However, it is still too early to draw any firm conclusions about *C. auriculata* potential therapeutic benefits for cancer patients, as there have been relatively few studies conducted to determine the plant's cytotoxic effect (

Table 3).

Anti-inflammatory activity

In an investigation using carrageenan-induced paw edema rats, the methanolic extract from C. auriculata leaves showcased notable anti-inflammatory properties, with percentage inhibitions of 37 % at 250 mg/kg and 31.63 % at 500 mg/kg. The presence of alkaloids, flavonoids, tannins, and steroids was implicated in this observed effect (Prasanna et al., 2009).

Furthermore, previous studies highlighted specific compounds isolated from the alcoholic extract of *C. auriculata* leaves, namely DL-α-tocopheryl-α-D-mannopyranoside and DL-α-tocopheryl-β-D-galactopyranoside, which were reported for their anti-inflammatory effects (Pari & Latha, 2002). Another investigation conducted by (Manogaran & Sulochana, n.d.) reported that the 50 % acetone extract from *C. auriculata* flowers exhibited significant anti-inflammatory activity (56 %) at 100mg/kg in carrageenin-induced edema in rats (

Table 3).

Table 1: **Nutrition composition of different parts of *C. auriculata***

Plant part	Protein	Carbohydrate	Fat	Crude Fiber	Energy	Reference
Flowers	9.54-9.76 g/100 g	64.45g/100 g	3.03 g/100 g	1.89-7.82 g/100 g	324.87 Kcal/100 g	(Rao et al., 2000; Sahoo et al., 2020)
Seeds	23.83 g/100 g	53.4 g/100 g	6.68 g/100 g	8/93 g/100 g	412.6 Kcal/100 g	(Senthil Kumar et al., 2002)

Table 2: Phytochemical composition of different parts of *C. auriculata*.

Plant part	Phytochemical	Amount	Reference
Flower	total phenols	249.13 mg GAE/100 gm	(Sahoo et al., 2020)
	flavonoid content	304 mg of QE/100 gm	(Sahoo et al., 2020)
	alkaloids		(Meena et al., 2019)
	glycosides		(Sahoo et al., 2020)
	saponins		(Rao et al., 2000)
	sitosterols		(Rao et al., 2000)
	terpenoids		(S et al., 2022)
	tannins		(Ramachandra Reddy, 2016a)
	triterpenes		(Pari & Latha, 2002)
	anthraquinone		(Deshpande & Bhalsing, 2013)
Leaves	13-Octadecenal	2.18 %	(Meena et al., 2019)
	3-0-Methyl-Dglucose	48.50 %	(Meena et al., 2019)
	1, 2, 3, 4-Tetra hydro isoquinolin-6-ol-1-carboxylic acid	1.98 %	(Meena et al., 2019)
	Hexadecanoic acid	3.21 %	(Meena et al., 2019)
	Resorcinol	11.80 %	(Meena et al., 2019)
	α- Tocopherol-β-D-mannoside	14.22 %	(Meena et al., 2019)
Seeds	benzoic acid 2-hydroxyl methyl ester	0.07 %	(Meena et al., 2019; Nille et al., 2021)
	glycine, n- (trifluroacetyl), 1-methybutul ester,	0.15 %	(Meena et al., 2019; Nille et al., 2021)
	resorcinol	0.21 %	(Meena et al., 2019; Nille et al., 2021)
	cupric acid	0.16 %	(Meena et al., 2019; Nille et al.,

			2021)
	epicatechin	6-14 %	(Meena et al., 2019; Puranik et al., 2011)
	catechin	4.5-20 %	(Meena et al., 2019; Puranik et al., 2011)
	procyanidin B1	1 %	(Puranik et al., 2011)
Roots	anthraquinone glycosides		(Meena et al., 2019)
	leucoanthocyanins		(Meena et al., 2019)
	flavone glycoside,		(Meena et al., 2019)

Table 3: Pharmacological properties of different parts of *C. auriculata.*

Pharmacological property	**Plant part**	**Method**	**Amount**	**Reference**
Antioxidants	Flower	Folin Ciocalteu method	249.13 mg of GAE/100gm	(Sahoo et al., 2020)
		Aluminium chloride method	304 mg QE/100 gm	(Sahoo et al., 2020)
		Phospho-molybdenum assay	63.8 mg AAE/g	(Kolar et al., 2018)
		Ferric reducing antioxidant power (FRAP)	161.5 mg AAE/g	(Kolar et al., 2018)
		DPPH	86.09 %	(Kolar et al., 2018)
		Hydroxyl radical scavenging activity	89.28 %	(Kolar et al., 2018)
		Deoxyribose assay	89.57 %	(Kolar et al., 2018)
Anticancer	Leaves	MCF-7 cell line	IC_{50} = 400 µg/mL	(Prasanna et al., 2009)
		Hep-2 cell line	IC_{50}= 500 µg/mL	(Prasanna et al., 2009)
		Human colon cancer cell line HCT	IC_{50} =25 mg/mL	(Esakkirajan et al., 2014)
Antidiabetic	Leaves	O-toluidine method (alloxan induced diabetic rats	Reduced fasting blood glucose level at 86.11 mg/dL	(Kalaivani et al., 2008)
	Flower	Protein tyrosine phosphatase assay method	IC_{50}= 96.27 µg/ mL (ethyl acetate extract) IC_{50}= 35.5 µg/mL (n-butanol extract)	(Singaravelu & Ahn, n.d.)

		O-toluidine method (using streptozotocin induced diabetes rats)	Reduced fastin blood glucose level at 0.45 g/kg body weight	(Pari & Latha, 2002)
		O-toluidine method (alloxan induced diabetic rats)	Reduced fasting blood glucose level at 98.49 mg/dL	(Kalaivani et al., 2008)
Anti-inflammatory	Flowers	carrageenin induced oedema in rats	56 % at 100 mg/kg	(Manogaran & Suloc hana, n.d.)
	Leaves	carrageenan-induced paw edema rats	37 % at 250 mg/kg 31.63 % at 500 mg/kg	(Esakkirajan et al., 2014)

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