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COSTUS SPECIOSUS: TRADITIONAL MEDICINAL REMEDIES FOR DIABETES AND OTHER PHARMACOLOGICAL ACTIVITIES.

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Abstract
Costus speciosus, also referred to as crepe ginger, is an herbaceous perennial shrub that has a widespread acknowledgment of its remarkable ethnobotanical and pharmacological uses. With its varied tradition in indigenous systems of medicine, the herb contains high concentration of varied phytochemicals such as diosgenin, flavonoids, saponins, and essential oils. The current review delves into the taxonomy, botanical characteristics, geographical location, traditional applications, chemical composition, and pharmacological activities of C. speciosus. It also reports on recent scientific studies, safety assessments, and therapeutic prospects. Moreover, the article is discussing difficulties in clinical translation and proposing avenues for future research. Through the integration of available data, this review seeks to achieve an overall picture of Costus speciosus as a potential pharmaceutical resource for future pharmaceutical development

Keywords: Costus speciosus, crepe ginger, phytochemicals, diosgenin, ethnomedicine, pharmacological activity, traditional medicine, therapeutic potential, drug development, herbal medicine.

Introduction
Nature has long served as a rich source of medicinal compounds, with plants offering a vast repository of bioactive molecules that have been harnessed for therapeutic purposes. Among these is Costus speciosus (Koenig) Sm., commonly referred to as crepe ginger, a plant belonging to the family Costaceae [1, 2]. Indigenous to Southeast Asia and the Indian subcontinent, this plant has been extensively utilized in traditional medicine systems such as Ayurveda, Unani, and Siddha. The increasing global demand for plant-based remedies and natural health products has revived scientific interest in underexplored species like C. speciosus. Its tuberous rhizomes and aerial parts are reputed for their anti-diabetic, anti-inflammatory, antioxidant, antimicrobial, and hepatoprotective properties [3]. Pharmacologically active constituents such as diosgenin and costunolide have drawn considerable attention from researchers for their potential therapeutic implications. Despite its promising medicinal profile, C. speciosus remains relatively underrepresented in mainstream pharmaceutical research. A thorough analysis of its phytochemistry, mechanisms of action, and clinical potential is essential for advancing its application in evidence-based medicine[4-6]. This review aims to compile and synthesize the current body of knowledge surrounding Costus speciosus, focusing on its taxonomy, botanical description, traditional uses, phytochemical composition, and pharmacological effects. It also explores contemporary research advancements, challenges in clinical validation, and future prospects in drug development.

Botanical Description
Costus speciosus is a perennial, rhizomatous herbaceous plant characterized by its elegant and striking appearance. It typically grows to a height of 1.5 to 3 meters and is distinguished by its spirally arranged leaves and vibrant, showy flowers. The plant exhibits a robust morphology, which contributes to its adaptability across tropical and subtropical regions. The stem of C. speciosus is erect, cylindrical, and succulent, often unbranched, with a tendency to form dense clumps. Its leaves are simple,

ovate to elliptic in shape, and arranged alternately in a helical pattern around the stem. The leaf surface is smooth, with a glossy dark green appearance on the upper side and a lighter green on the underside. The venation is prominent and pinnate, contributing to the structural integrity of the foliage [7,8].

The rhizomes of the plant are thick, fleshy, and aromatic. They serve as the primary reservoir of bioactive compounds and are widely harvested for medicinal purposes. The rhizomes grow horizontally underground and display nodal regions from which new shoots arise. Flowering usually occurs during the rainy season. The flowers are large, white, and trumpet-shaped with a crimson throat, borne on cone-shaped inflorescences at the terminal end of the stem. Each flower is ephemeral, typically lasting for a single day. The inflorescence bracts are bright red, providing a vibrant contrast to the white petals. The overall floral arrangement is both ornamental and functionally adapted for pollination by insects. The fruit is a small capsule, which contains numerous tiny seeds. Although seed propagation is possible, C. speciosus is predominantly propagated via rhizomes, which allows for faster and more uniform cultivation. Due to its attractive morphology and medicinal importance, Costus speciosus is cultivated not only for therapeutic use but also as an ornamental plant in tropical gardens [9, 10].

Taxonomy and Nomenclature

The classification of Costus speciosus is as follows:

- Kingdom: Plantae
- Subkingdom: Tracheobionta
- Division: Magnoliophyta
- Class: Liliopsida
- Order: Zingiberales
- Family: Costaceae
- Genus: Costus
- Species: Costus speciosus (Koenig) Sm.

The genus Costus includes over 100 species, most of which are native to tropical climates in Africa, Asia, and the Americas. The species name “speciosus” is derived from Latin, meaning “showy” or “beautiful,” reflecting the plant’s ornamental value due to its attractive flowers and striking foliage [10,11].

Common vernacular names of Costus speciosus vary by region and language:

- Hindi: Keukand or Kust
- Sanskrit: Pushkarmool
- Tamil: Chengaluneer
- Malayalam: Channakizhangu
- English: Crepe Ginger or Spiral Ginger
- Ayurvedic Name: Kustha

The plant was first described by the botanist Johann Gerhard Koenig and later classified by James Edward Smith, hence the botanical citation “(Koenig) Sm.” It has been historically associated with the Zingiberaceae family due to morphological similarities, but advances in molecular taxonomy have confirmed its placement in the distinct family Costaceae. Nomenclature discrepancies have occurred due to regional variations and synonymic references in ethnobotanical texts. However, Costus speciosus remains the most widely accepted scientific name, recognized in modern pharmacognosy and botanical literature [12, 13].

Geographical Distribution

Costus speciosus is indigenous to Southeast Asia and the Indian subcontinent, but due to its adaptability and ornamental appeal, it has spread across many tropical and subtropical regions worldwide. Its presence has been documented in countries including India, Sri Lanka, Myanmar, Thailand, Malaysia, Indonesia, the Philippines, China (particularly Yunnan and Guangxi provinces), and even extending to some Pacific islands [14].

In India, the plant is commonly found in the Western Ghats, Northeastern states, and parts of Central and Eastern India. It grows naturally in moist deciduous forests, along riverbanks, in shaded valleys, and on hill slopes. The climatic preference of C. speciosus includes warm temperatures and high humidity, with an annual rainfall range of 1500–3000 mm. Beyond Asia, Costus speciosus has been introduced and naturalized in parts of Africa, the Caribbean, and South America. It has also gained popularity in tropical gardens in countries such as Brazil, Kenya, and Hawaii due to its striking flowers and spiraling leaf arrangement [15].

The plant thrives best in well-drained, loamy soils rich in organic matter and slightly acidic to neutral pH conditions. Although it can tolerate partial shade, optimal growth occurs under full sunlight with adequate water availability. In cultivation, it is propagated mainly through rhizomes and is often planted during the pre-monsoon season to take advantage of natural rainfall. Given its ecological adaptability, C. speciosus has the potential to be cultivated more widely, both for its medicinal value and ornamental use. However, overharvesting from the wild, especially for pharmaceutical and ethnomedicinal purposes, poses a threat to its natural populations in certain region [16, 17]

Traditional and Ethnobotanical Uses

Costus speciosus holds a prominent place in the traditional medicinal systems of South and Southeast Asia. For centuries, various parts of the plant-especially the rhizomes-have been used in indigenous healing practices to treat a range of ailments (Table 1) [18-20].

Table 1: Traditional and Ethnobotanical Uses

System/Region	Part Used	Traditional Uses
Ayurvedic Medicine	Rhizome	Treats asthma, bronchitis, cough; acts as laxative, diuretic, anti-inflammatory, blood purifier; balances Kapha and Vata doshas
Siddha Medicine	Rhizome	Used for fever, skin diseases, rheumatism; considered aphrodisiac; included in rejuvenation therapies
Tribal/Folk Medicine (India)	Rhizome (chewed/paste)	Applied for boils, skin infections, scabies; decoction used for diabetes, jaundice, digestion; hair tonic and anti-dandruff
Malaysia & Indonesia	Rhizome	Prescribed for dysentery, helminthic infections, joint pain, menstrual irregularities, and post-partum recovery
Cosmetic Uses	Rhizome extract	Used in skin cleansers and anti-aging formulations
Culinary Uses	Young shoots, rhizomes	Occasionally cooked as vegetables in traditional cuisines
Aromatherapy	Essential oil	Used in traditional massage and relaxation practices
Spiritual Practices	Whole plant	Planted around homes to ward off evil spirits and for protection

Phytochemical Composition

The therapeutic efficacy of Costus speciosus is largely attributed to its rich and diverse phytochemical profile, particularly concentrated in the rhizomes. Modern phytochemical analyses have identified a wide range of bioactive compounds belonging to various chemical classes such as steroidal saponins, flavonoids, alkaloids, glycosides, tannins, phenolics, and essential oils (Table 2) [20-24].

Table 2: Phytochemical Compositionof Costus speciosus

Phytochemical Class	Key Constituents	Reported Biological/Pharmacological Activities
Steroidal Saponins	Diosgenin, Costusosides, Tigogenin	Anti-inflammatory, hypoglycemic, anti-cancer, antimicrobial, cholesterol-lowering, hormonal precursor
Flavonoids	Quercetin, Kaempferol, Apigenin	Antioxidant, anti-inflammatory, hepatoprotective, anti-diabetic
Phenolic Compounds	Gallic acid, Ferulic acid	Antioxidant, cardioprotective, anti-diabetic, anti-aging
Alkaloids	(Unspecified minor alkaloids)	Antispasmodic, analgesic
Glycosides	(Unspecified types)	Cardiac stimulation, diuretic effects
Essential Oils	α-Pinene, β-Caryophyllene, Eugenol	Antimicrobial, anti-inflammatory, aromatic applications (aromatherapy)
Tannins	Hydrolyzable and condensed tannins	Astringent, antimicrobial
Resins and Mucilage	(Unspecified types)	Soothing, anti-irritant effects on GI tract and skin
Proteins & Carbohydrates	Basic macronutrients (non-medicinal)	Nutritional support, energy metabolism

Pharmacological Activities

Numerous preclinical studies have validated the wide spectrum of pharmacological activities of Costus speciosus, confirming its traditional uses and revealing new therapeutic avenues (Table 3). These effects are primarily linked to its phytochemical constituents [25, 26].

Table 3: Pharmacological activities of Costus speciosus

Pharmacological Activity	Key Constituents Involved	Mechanism/Effects
Antidiabetic	Diosgenin, steroidal saponins	Enhances insulin secretion, improves glucose uptake, inhibits gluconeogenesis; improves lipid profile
Antioxidant	Flavonoids (quercetin, kaempferol), phenolics	Scavenges free radicals, reduces oxidative stress, protects against aging, inflammation, and neurotoxicity
Anti-inflammatory & Analgesic	Rhizome extract, saponins, essential oils	Inhibits prostaglandins and inflammatory mediators; analgesic via peripheral and central mechanisms
Antimicrobial & Antifungal	Essential oils (α-pinene, eugenol), phenolic acids	Effective against Gram-positive/negative bacteria and fungi (e.g., *Candida albicans*)
Anticancer	Diosgenin, costunolide	Induces apoptosis, cell cycle arrest, inhibits angiogenesis in cancer cell lines (breast, colon, liver)
Hepatoprotective	Rhizome extract, flavonoids, saponins	Restores liver enzymes, improves liver histology in hepatotoxin-induced models
Diuretic & Laxative	Saponins, alkaloids	Promotes urine output and bowel movement; modulates electrolyte balance and GI motility
Wound Healing & Dermatological	Rhizome paste, tannins, phenolics	Promotes tissue regeneration, reduces inflammation, prevents microbial infection

Mechanism of Action of Active Compounds

The pharmacological effectiveness of Costus speciosus is mediated through a variety of molecular and cellular mechanisms, primarily attributed to its bioactive phytochemicals such as diosgenin, flavonoids, phenolics, and essential oils [27,28]. These compounds interact with specific biological targets, producing therapeutic effects through well-defined pathways (Table 4 & Figure 1).

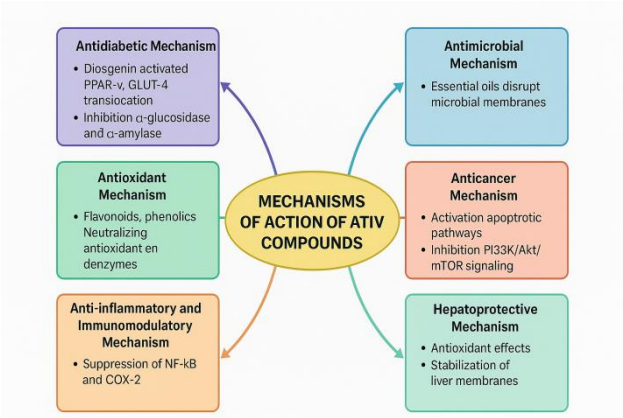

Fig.1: Schematic representation Mechanism of Action of Active Compounds in Costus speciosus

Table 4: Mechanism of Action of Active Compounds in *Costus speciosus*

Pharmacological Action	Active Compounds	Mechanism
Antidiabetic	Diosgenin, Polyphenols	- Activates PPAR-γ to improve insulin sensitivity - Enhances GLUT-4 translocation - Inhibits α-glucosidase & α-amylase, reducing postprandial hyperglycemia
Antioxidant	Flavonoids, Phenolic acids	- Scavenges ROS by electron donation - Upregulates antioxidant enzymes: SOD, CAT, GPx

Anti-inflammatory & Immunomodulatory	Flavonoids, Saponins	- Inhibits NF-κB and COX-2 - Suppresses TNF-α, IL-1β, and IL-6 production
Antimicrobial	Eugenol, β-Caryophyllene (essential oils)	Disrupts microbial membranes - Inhibits microbial enzymes and metabolism
Anticancer	Diosgenin, Costunolide	- Induces apoptosis via Bax, Caspase-3/9 - Reduces Bcl-2 - Inhibits PI3K/Akt/mTOR pathway - Cell cycle arrest (G1/S, G2/M)
Hepatoprotective	Antioxidants, Saponins	- Prevents lipid peroxidation - Stabilizes hepatocyte membranes - Normalizes ALT, AST, ALP

Toxicity and Safety Evaluation

While Costus speciosus has a long history of traditional use and is generally regarded as safe, recent pharmacological research has begun to explore its toxicological profile to ensure its safety for modern therapeutic use[29] (Table 5).

Table 5: Toxicity and Safety Evaluation of *Costus speciosus*

Toxicity Category	Findings
Acute Toxicity	LD_{50} > 2000 mg/kg (rodents)
Sub-chronic/Chronic Toxicity	No significant hepatic, renal, or hematological changes over 28–90 days of administration
Reproductive/Developmental	Limited data; possible hormonal influence due to diosgenin
Allergenicity & Irritation	Generally safe; rare cases of contact dermatitis
Herb–Drug Interactions	May interact with antidiabetics, NSAIDs, anticoagulants, hormonal drugs

Current Research Trends

In recent years, Costus speciosus has become a focus of interdisciplinary research, spanning phytochemistry, pharmacology, biotechnology, and nanomedicine. These studies aim to validate traditional uses, identify novel compounds, and explore innovative applications of this promising medicinal plant [30].

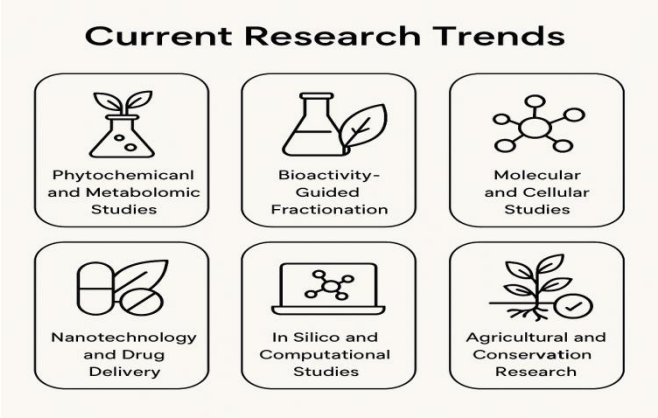

Fig.2: Current Research Trends

Conclusion

Costus speciosus (crepe ginger) is a plant of significant medicinal and ethnobotanical importance, traditionally revered across various cultural and healing systems for its wide range of therapeutic applications. Its rich phytochemical composition-particularly steroidal saponins like diosgenin, along with flavonoids, alkaloids, and essential oils-forms the biochemical foundation for its diverse pharmacological activities. These include antidiabetic, antioxidant, anti-inflammatory, antimicrobial, hepatoprotective, and anticancer properties, among others.Clinical investigations have supported many of these historical assertions with in vivo and in vitro research. Mechanistic understanding has disclosed the

plant's activation or inhibition of core molecular pathways including NF-κB, PI3K/Akt, COX-2, and PPAR-γ. However, the complete therapeutic possibilities of C. speciosus are still uncultivated in clinical settings, with few human trials as yet having been performed. Obstacles of irregular extract standardization, sparse safety information, and regulatory impediments have held it back from gaining a foothold within contemporary medical practice. Looking ahead, Costus speciosus offers tremendous potential as a source of novel plant-based therapeutics. Standardization of bioactive compounds, application of nanotechnology in drug delivery, and execution of high-quality clinical trials will be crucial in transforming this traditional remedy into a scientifically validated and globally accepted medicinal resource. Furthermore, sustainable cultivation and conservation strategies are essential to safeguard this valuable plant for future generations.

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Conflict of Interest
Authors are declared that no conflict of interest.

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Bingi Kumar, Arshiya Aqsa Syed, Umme Kulsum, Nandi Mukesh, and Silam Vishnupriyacontributed to literature collection and drafting the manuscript. A. Suneetha provided support in organizing and refining the content. Patibandla Jahnavi conceptualized, supervised, and finalized the manuscript for submission.

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