

A REVIEW ON ANTIDIABETIC ACTIVITY OF COSTUS SPECIES

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Abstract: Diabetes mellitus is a chronic metabolic disorder characterized by impaired glucose metabolism, which leads to hyperglycemia and associated complications. The increasing prevalence of diabetes worldwide has intensified the search for safer and more effective therapeutic alternatives. Medicinal plants have long served as a valuable source of bioactive compounds with antidiabetic potential. Among them, species of the genus *Costus*—notably *Costus pictus*, *Costus speciosus*, and *Costus spicatus* have shown promising hypoglycemic and antioxidant properties. Phytochemical analyses reveal the presence of flavonoids, alkaloids, terpenoids, saponins, and phenolic compounds responsible for their pharmacological activities. Experimental studies demonstrate that extracts from the leaves and rhizomes of *Costus* species can enhance insulin secretion, improve glucose tolerance, and mitigate oxidative stress. Biotechnological methods like tissue culture also help these important plants grow and stay alive on a large scale. This review highlights the pharmacological significance, bioactive constituents, and potential therapeutic applications of *Costus* species as natural antidiabetic agents, emphasizing the need for further clinical and toxicological validation.

Index Terms - *Costus* species, *Costus pictus*, *Costus speciosus*, *Costus spicatus*, antidiabetic activity, medicinal plants, phytochemicals, flavonoids, antioxidants, diabetes mellitus, hypoglycemic effect, natural products, tissue culture.

INTRODUCTION

The global prevalence of diabetes is rising rapidly, with projections suggesting 472.6 million affected individuals by 2045, including nearly 80 million in India by 2030. This chronic metabolic disorder causes persistent hyperglycemia, leading to the formation of Advanced Glycation End Products (AGEs) that damage vital organs. To combat this, research has turned to ethnopharmacology and plants like *Costus speciosus* (Crepe Ginger). Rich in the bioactive compound diosgenin and various secondary metabolites like phenolics and alkaloids, the rhizome of this plant has demonstrated significant hypoglycemic effects. By targeting enzymes like α -amylase and α -glucosidase, such plant-derived treatments offer a natural pathway to managing blood glucose and reducing the global burden of the disease.

TYPES

Type 1 Diabetes

Type 1 diabetes is a chronic autoimmune disorder in which the immune system destroys pancreatic β -cells, leading to absolute insulin deficiency and elevated blood glucose levels. Patients require lifelong insulin therapy, delivered through injections or pumps, along with regular blood sugar monitoring to prevent complications.

Common Symptoms:

- Increased thirst and frequent urination (polydipsia and polyuria)
- Persistent fatigue and lack of energy
- Blurred vision due to elevated blood sugar
- Unexplained weight loss from fat breakdown when glucose is unavailable

Treatment and Management:

- ❖ **Insulin delivery** – Daily injections or continuous pump therapy are required due to autoimmune destruction of β -cells and complete insulin deficiency.
- ❖ **Blood sugar monitoring** – Regular testing is essential for effective management.
- ❖ **Healthy lifestyle** – A balanced diet and regular exercise help in controlling blood glucose levels.

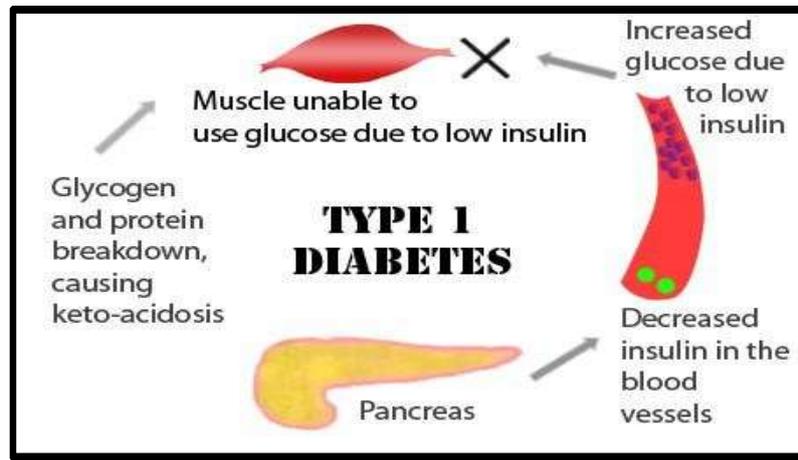


Figure 1: Type I Diabetes (Insulin Dependent Diabetes Mellitus (IDDM)).

Type 2 Diabetes:

Type 2 diabetes is a chronic condition characterized by persistently high blood sugar levels due to insulin resistance. This occurs when the body either does not produce enough insulin or cannot use it effectively. As a result, glucose the body's main source of energy cannot enter the cells and instead builds up in the bloodstream. This excess glucose leads to various health complications over time. The risk of developing type 2 diabetes increases with factors such as ageing, genetic predisposition, obesity, and physical inactivity. Although it is more common in adults, this condition can also occur in children, particularly with rising rates of childhood obesity and sedentary lifestyles.

Causes and Risk Factors:

- ✓ **Weight and Physical Activity:** Major risk factors for type 2 diabetes include being overweight or obese and engaging in little or no physical activity.
- ✓ **Genetics:** Having a family history of type 2 diabetes increases the risk of developing the condition.
- ✓ **Age:** The risk of type 2 diabetes increases after the age of 45.
- ✓ **Prediabetes:** Individuals with prediabetes—where blood sugar levels are higher than normal but not yet high enough to be classified as diabetes—have an increased risk of developing type 2 diabetes.

Symptoms:

- A delayed diagnosis may occur because symptoms often develop gradually. Be alert for the following signs:
- Frequent urination and increased thirst
- Increased appetite and fatigue
- The slow healing of wounds or cuts
- Recurrent infections, such as thrush
- Unexplained weight loss as universe of the study.

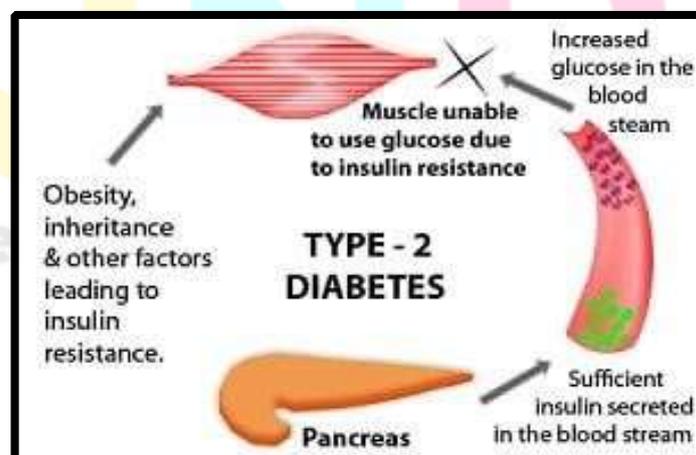


Figure 2: Type II Diabetes (Noninsulin Dependent Diabetes Mellitus (NDDM)).

Botany of Costus Pictus:

Taxonomy

Kingdom: Plantae

Phylum: Tracheophyta

Class: Liliopsida

Order: Zingiberales

Family: Costaceae

Genus: Costus

Species: C. Pictus

Originally classified under the ginger family (Zingiberaceae), Costaceae was elevated to its own distinct family due to its unique root structures and monostichous spiral phyllotaxy (a specific spiral leaf arrangement). While historically centred around the genus Costus, modern phylogenetic analysis revealed the group was polyphyletic. This led to a taxonomic revision that established three new genera—Paracostus, Cheilocostus, and Chamaecostus—to better reflect their evolutionary lineages.

Gestational Diabetes Mellitus:

Gestational diabetes mellitus (GDM) is a condition characterized by elevated blood glucose levels that develop during pregnancy due to the influence of placental hormones, which cause insulin resistance and reduce the body's ability to effectively use insulin for glucose transport into cells. Although many women with GDM show no noticeable symptoms, some may experience increased thirst and frequent urination. The condition typically occurs in women who have never had diabetes before pregnancy, and while it can often be managed through a combination of diet, exercise, and medication, failure to control blood sugar levels can pose serious risks to both mother and baby. Uncontrolled GDM increases the likelihood of complications during pregnancy and delivery and significantly raises the mother's risk of developing type 2 diabetes later in life.



Figure 3: Gestational diabetes mellitus.

II. ANTIDIABETIC EFFECT:

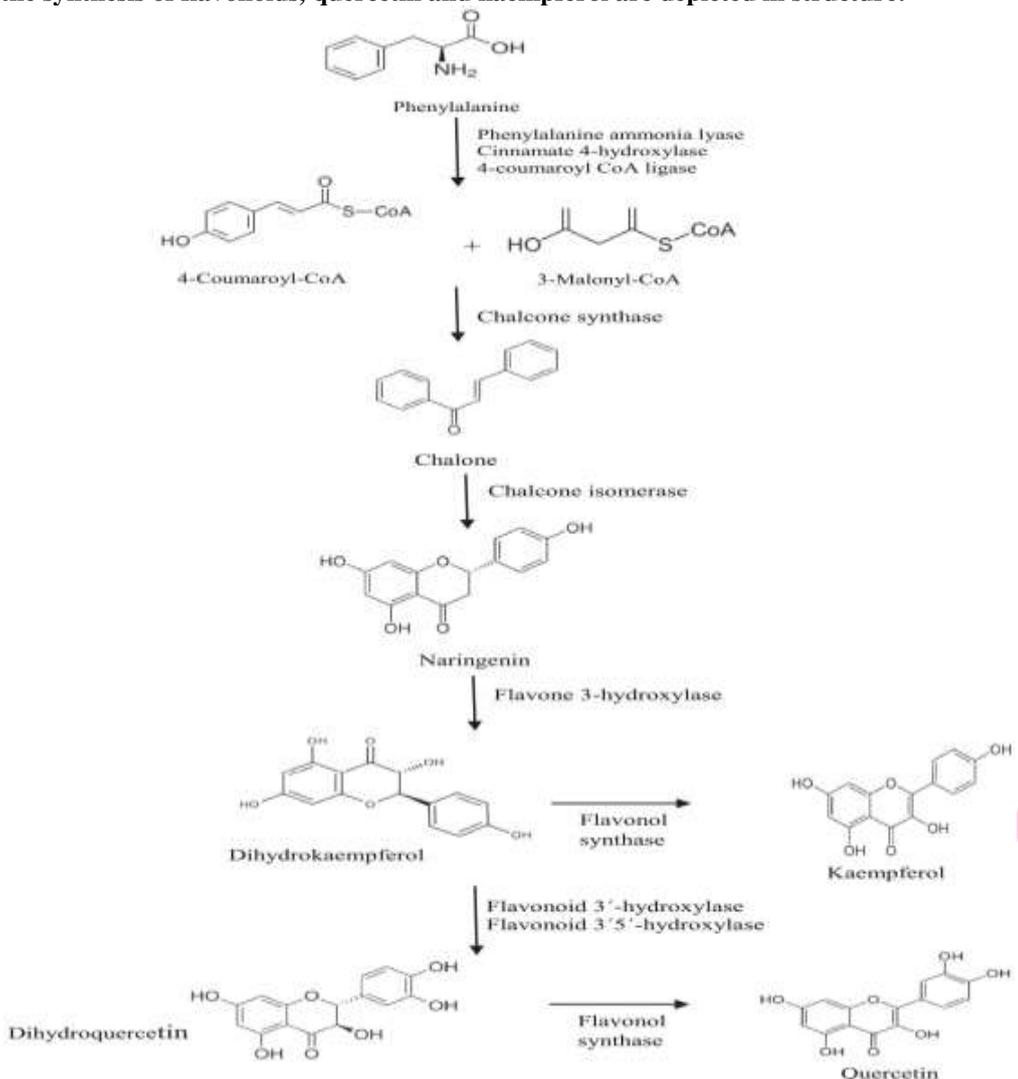
Medicinal plants are vital traditional treatments for Diabetes Mellitus, a disorder caused by insufficient insulin or impaired insulin activity. Research highlights species like *Costus igneus*, where daily consumption of a single leaf or dried powder has shown clinical success in regulating blood glucose. However, the varying results of other species, such as *C. spicatus*, emphasize that a plant's effectiveness often depends on the specific dosage and preparation used.

In India, *Costus pictus* (the "insulin plant") is a popular natural alternative for managing diabetes, which currently affects over 285 million people worldwide. Because synthetic treatments can be costly or inaccessible, many rely on *Costus* species to manage hyperglycemia and prevent severe complications like kidney failure or blindness. These plants offer a promising, less toxic approach to balancing the metabolic disruptions seen in Type 1, Type 2, and gestational diabetes.

Table 1. Summary of the major Bioactive Properties of Flavonoids and Phenolic Compounds associated with *C. pictus* leaves.

Compounds	Properties
FLAVONOIDS Quercetin	Anti-diabetic effects Antioxidant property
Astragalin	Antioxidant property
Kaempferol	Anti-cancer property
Isovitexin	Antioxidant property
CHALCONES Lico chalcone A	Anti-cancer property
PHENOLIC ACIDS Gentisic acid	Antioxidant property
Cis- and trans-p-coumaric acid	Antioxidant property
α -Resor cyclic acid	Antioxidant property

The pathway for the synthesis of flavonoids, quercetin and kaempferol are depicted in structure:



III. PHARMACOLOGICAL ACTIVITIES:

Crepe ginger (*Costus speciosus*) is a versatile medicinal plant used traditionally to treat everything from asthma and fever to digestive and skin disorders. Ethnopharmacology validates these uses by studying the plant's bioactive compounds—such as alkaloids, flavonoids, and terpenoids—which provide therapeutic effects. With over 800 antidiabetic plants identified globally, countries like Brazil have even officially integrated medicinal plants into their public health systems to develop safe, natural therapies. Brazil possesses immense biodiversity, yet 99.6% of its medicinal plants remain chemically unexplored. Despite the dominance of modern medicine, there is a renewed focus on plants like *Costus speciosus*, which contain bioactive compounds capable of neutralizing toxins and managing Diabetes Mellitus. This global health crisis—encompassing Type I, Type II, and Gestational diabetes—disrupts the metabolism of vital nutrients, making the study of these untapped natural resources essential for future therapies.



Figure 4: Insulin Plant (*Costus spicatus*)



Figure 5: Rhizomes with stem



Figure 7: Leaf of Insulin plant.



Figure 8: Powder of Rhizome.

The pancreas contains beta cells essential for producing insulin; their dysfunction leads to the severe complications of diabetes, such as renal and heart failure. *Costus pictus* helps protect these cells through its potent antioxidant properties, with methanolic extracts showing up to 90% activity—surpassing standard synthetic antioxidants like BHT. By boosting internal enzymes (like catalase and superoxide dismutase) and essential vitamins, the plant neutralizes free radicals and reduces the oxidative stress that drives diabetic damage.

IV. ANTIOXIDANT ACTIVITY:

Modern lifestyle disruptions to circadian rhythms can impair glucose regulation, raising the risk of Type 2 Diabetes. While common sleep medications (like GABA agonists) are used for treatment, their effect on blood sugar must be carefully monitored. Medicinal plants remain a massive economic and therapeutic resource—historically providing 25% of Brazil's pharmaceutical income—though researchers must continue to screen these traditional remedies for potential side effects like toxicity or mutagenicity.

Costus species are perennial rhizomatous herbs characterized by upright or spreading stems and simple, smooth, evergreen leaves arranged in an elegant spiral pattern. The leaves are subsessile, elliptic to obovate, and dark green on the upper surface, varying among species in texture and color. For instance, the underside of *C. igneus* leaves is bright purple, while *C. speciosus* leaves have a smooth underside. [16] The inflorescence of *Costus* plants is typically a subterminal spike about 10 cm long, with large, cone-shaped bracts that vary in color and form. *C. pictus* bears green bracts with yellow flowers streaked with red, *C. igneus* has green bracts with orange flowers, and *C. speciosus* displays striking red bracts with white, cup shaped flowers and golden stamens. The fruit is an ellipsoidal capsule containing five dark seeds surrounded by a fleshy white aril. Many species from related genera such as *Alpinia*, *Amomum*, *Curcuma*, *Costus*, *Kaempferol*, and *Zingier* are commercially available as herbal mixtures used as tonics and

traditional remedies. These preparations are often employed for their diuretic and detoxifying properties, helping in the treatment of kidney stones, urinary infections, diabetes, sore throats, colds, diarrhea, and other ailments, reflecting the broad medicinal utility of the *Costus* genus

Table 2. Summary of the major bioactive properties of the compounds associated with *C. pictus* rhizomes.

Compounds	Properties
Quercetin	Anti-diabetic effects
	Antioxidant property
	Anti-cancer property
	Anti-inflammatory effects
	Hepatoprotective property
Diosgenin	Anti-diabetic effects
	Antioxidant property

V. BIOTECHNOLOGICAL APPROACHES:

Tissue culture is essential for the conservation and mass production of *Costus* species. By using methods like micropropagation from pseudo stem explants and callus cultures, researchers can generate disease-free, high-yield plants without damaging the original source. These lab-grown cultures consistently produce diosgenin, a valuable pharmaceutical compound. With the help of growth regulators like triacontanol, these techniques ensure the sustainable, large-scale cultivation of this economically vital medicinal species.

VI. APPLICATION:

Costus pictus has emerged as an important medicinal plant of high therapeutic value due to its remarkable biological properties and diverse pharmacological potential. With a long history of traditional medicinal use, this species has attracted growing scientific interest across various disciplines, including biotechnology and nanotechnology, where its bioactive compounds are being explored for innovative therapeutic and industrial applications. The integration of *C. pictus* into these advanced research fields not only broadens its scope of use but also enhances its global significance by ensuring sustainable utilization and worldwide availability. As a result, *Costus pictus* continues to gain recognition as a valuable natural resource with promising prospects for future medical and technological advancements.

VII. ANTIDIABETIC AGENT FROM MEDICINAL PLANT:

Phytochemical analysis of *Costus spicatus* rhizomes reveals a rich profile of flavonoids, saponins, and sapogenins, which provide diuretic, anti-inflammatory, and antibacterial benefits. While its ability to lower blood sugar is still being studied, the plant is officially recognized in Brazil's Renisus list for its medicinal importance. Research has isolated specific flavonoid diglycosides (like quercetin and kaempferol derivatives) from its aerial parts. These secondary metabolites are crucial for plant defense and human therapy, specifically for their potential to scavenge Reactive Oxygen Species (ROS)—unstable molecules that damage DNA and proteins. By neutralizing these free radicals, *C. spicatus* compounds help protect vital cellular components from oxidative stress.

VIII. NATURAL PRODUCT AND TREATMENT OF DIABETES:

Natural products offer safer, low-side-effect alternatives for managing Type 2 diabetes. To isolate these therapeutic phytochemicals, researchers utilize advanced analytical tools like TLC, NMR, and GC-MS for precise identification with nearly 800 plant species identified for their antidiabetic potential, these natural defenses—originally evolved for plant protection—are now being optimized through modern extraction techniques to promote human metabolic health. *Costus pictus*, commonly known as “pancake ginger,” displays striking ornamental and biological characteristics. The plant produces attractive flowers in late summer to early autumn, resembling delicate pancake paper, while the cone-shaped bracts remain prominent after the flowers wither. The stems typically emerge in April, bloom from July to September, and reach full maturity by mid-November, after which the leaves fall and the stems begin to dry out. During the dormant period from December to March or April, the underground rhizomes remain viable. *Costus pictus* is a hardy tropical evergreen herb with upright or spreading stems that can grow up to two feet tall. It bears simple, alternate, elliptical leaves, 4–8 inches long, with a dark green upper surface and light purple underside, arranged spirally around the stems to form graceful, arching clusters. The plant's bright orange flowers, about 1.5 inches across, appear on cone-shaped inflorescences at the branch tips throughout the summer, adding both aesthetic appeal and medicinal value to this important species.

IX. CONCLUSION:

The *Costus* species, particularly *Costus pictus*, *Costus speciosus*, and *Costus spicatus*, possess remarkable pharmacological potential, especially in the management of diabetes mellitus. Their rich content of bioactive compounds such as flavonoids, alkaloids, terpenoids, saponins, and phenolics contributes to significant antioxidant and antidiabetic activities. Traditional medicinal practices and modern phytochemical investigations collectively highlight the importance of these plants in regulating blood glucose levels, improving insulin sensitivity, and reducing oxidative stress. Tissue culture and biotechnological advancements have further supported large-scale propagation and conservation of these valuable species. Despite their traditional use and promising experimental results, more extensive clinical trials, toxicity evaluations, and standardization studies are essential to confirm their safety, efficacy, and mechanism of action. Overall, *Costus* species represent a natural, sustainable, and promising source for developing novel plant-based antidiabetic agents.

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