

A Detailed Review on *Costus Igneous* and Its Pharmacological Activities

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Abstract

A member of the Costaceae family, *Costus igneus* better known by their popular name, "Spiral flag," is a recently introduced plant from South and Central America to India. With spiral-arranged leaves and eye-catching blossoms, this perennial grows erect and spreading to a height of around two feet. It often grows as an attractive plant in southern India, and its leaves are supplemented with food to cure diabetes mellitus. Many studies have been conducted recently to assess this plant's potential as an anti-diabetic agent. It has also been shown to possess various pharmacological properties, such as antioxidant, diuretic, hypolipidemic, antimicrobial, and anticancer effects. Furthermore, multiple phytochemical analyses have revealed the presence of proteins, carbohydrates, triterpenoids, alkaloids, tannins, saponins, flavonoids, steroids, and other compounds.

Keywords: Anti-diabetic activity, *Costus igneus* Nak, *Costus pictus* D. Don, diabetes mellitus, insulin plant

1. Introduction

Native to South and Central America, *Costus igneus* is also known by several names, including flaming costus, step ladder, spiral flag, and insulin plant. Known as the "insulin plant," it was brought to India from America as a natural remedy for diabetes relatively recently[1]. In South India, it is commonly planted as a decorative plant in gardens and is also allowed to roam freely in many areas[2]. People with diabetes are known to consume one leaf per day to maintain low blood glucose levels. It is utilized as a diabetes treatment in India[3]. Among the plants that the Kolli tribal people are known to utilize successfully to cure diabetes are the leaves of *C. igneus*[4]. The portion in aerial part this plant is used as an infusion to treat renal diseases in traditional Mexican medicine[5]. The plant belongs to the Costaceae family. Nakai was the first to elevate Costaceae to the family level, distinguishing it by its spirally arranged leaves and the absence of fragrant essential oils in its rhizomes. Before its elevation to family status, Engler and Prantl identified Costaceae as a subfamily of Zingiberaceae. This unique classification is supported by several anatomical and morphological traits, such as a well-developed aerial shoot with distinct, stiff, and often branching stems. The largest genus in the family, *Costus*, includes over 150 species, most of which are found in tropical regions[2,6]. The current review addresses contemporary studies conducted on *Costus igneus* Nak in the fields of phytochemistry, pharmacology, biological activity, and safety.

2. Taxonomy

Botanical Name	:	<i>Costus igneus</i>
Domain	:	Eukaryota
Kingdom	:	Plantae
Subkingdom	:	Viridae plantae
Phylum	:	Tracheophyta
Subphylum	:	Euphyllophytina
Infraphylum	:	Radiatopses
Class	:	Liliopsida
Subclass	:	Commelinidae
Superorder	:	Zingiberanae
Order	:	Zingiberales
Family	:	Costaceae
Subfamily	:	Asteroideae
Tribe	:	Coreoideae
Genus	:	<i>Costus</i>
Specific Epithet	:	<i>Igneus</i>

3. Morphology

The tallest stems of *Costus igneus* eventually topple over and lie on the ground. This tropical evergreen grows to about two feet in height, with alternating, simple, oblong green leaves featuring parallel venation, measuring 4 to 8 inches in length. It forms attractive, arching clusters from subterranean rootstocks, characterized by large, smooth, dark green leaves with light purple undersides. During the summer months, beautiful orange flowers, 1.5 inches in diameter, emerge on cone-shaped heads at the tops of the branches[7,8]. It has green coloured fruits, smaller than 0.5 inches, unassuming, and unshowy.



Figure 1: Insulin Plant

4. Growth & Propagation

Spiral flags thrive in either direct sunlight or partial shade. They are typically grown near water sources and require rich soil with plenty of moisture. Propagation methods include dividing the clumps, using cuttings, or separating the offsets that grow beneath the flower heads. Nematodes and mites can pose problems, especially in light, sandy soil. However, the plant is not significantly affected by serious diseases[8].

5. Consuming *Costus igneus* may Come with Side Effects Including

- Upset stomach
- Diarrhea
- Dizziness
- Low blood sugar levels, especially if you take insulin
- Higher chance of hypoglycemia-induced coma associated with diabetes
- Before beginning any herbal supplement regimen to control blood sugar levels, always see your doctor, particularly if you are insulin-dependent.
- Furthermore, using herbal *Costus igneus* may interact negatively with other prescriptions you are taking. whether you would want to start taking this supplement, make sure to ask your doctor whether there are any contraindications, or reasons why you should not drink *Costus igneus*.
- There is limited knowledge about this plant's long-term adverse effects. Further investigation is required.

6. Insulin Plant Benefits

6.1 Blood sugar regulation: Because it can help control blood sugar levels, the insulin plant has long been employed. It is thought to increase insulin sensitivity and boost insulin production, which makes it advantageous for those who have diabetes.

6.2 Antioxidant properties: The insulin plant produces a lot of flavonoids and phenolic chemicals, which are important sources of antioxidants. These antioxidants aid in the body's defense against numerous illnesses, lessen inflammation, and fight oxidative stress.

6.3 Digestive health: Eating the leaves of the insulin plant may facilitate better bowel motions, ease stomach discomfort, and aid in digestion. It is frequently used to treat digestive issues like indigestion and constipation.

6.4 Anti-inflammatory effects: The anti-inflammatory qualities of the insulin plant may aid in lowering bodily inflammation. It may be helpful in treating diseases like inflammatory bowel disease and arthritis because of this characteristic.

6.5 Immune system support: Because insulin plant leaves have a significant amount of vitamin C, regular eating of them may enhance the immune system. It strengthens the body's defenses against diseases and infections.

7. Insulin Plant Varieties

7.1 *Costus igneus* var. *spiralis*: The swirling leaves of this species are well-known for giving the plant an eye-catching visual appeal. Its health benefits are comparable to those of the common plant version of insulin.

7.2 *Costus igneus* var. *compactus*: This smaller leafed form of insulin plant has a more compact growing habit. It is an excellent choice for those with limited space.

7.3 *Costus igneus* var. *Albus*: This type of insulin plant features white leaves instead of the typical green ones. It can be an interesting addition to any garden and has the same medical qualities.

8. Phytochemical Study

Ascorbic acid, α -tocopherol, β -carotene, terpinoids, steroids, and flavonoids are among the antioxidant components found in *C. igneus* leaves, which were shown to be rich in protein and iron through sequential screening for phytochemicals[9,10]. Another study demonstrated that the greatest concentration of phytochemicals, including proteins, carbohydrates, triterpenoids, alkaloids, tannins, saponins, and flavonoids, was present in methanolic extract[11]. According to a preliminary phytochemical analysis, 21.2% of the leaves of the insulin plant (*C. pictus*) are made of fiber. Steroids were found in every extract after a series of extracts were analyzed. There were alkaloids in the ethanol extract as well. Apart from α -tocopherol and ergastanol, a steroid, the main constituent of the ether fraction was bis (2'-ethylhexyl)-1,2-benzenedicarboxylate (59.04%)[12]. Stem revealed the presence of the steroid molecule stigmasterol and the terpenoid compound lupeol[13]. The rhizome of *C. igneus* has yielded bioactive chemicals such as quercetin, diosgenin, and sapogenin. Analysis revealed that the leaves and rhizomes of *C. pictus* contain significant concentrations of potassium, calcium, manganese, zinc, copper, and chromium. Clear, yellowish essential oils were obtained by steam distilling the stems, leaves, and rhizomes of *C. pictus* D. Don[14,15].

Table 1: Essential Oils Present in Insulin Plant

Sr. No.	Stem Oil (%)	Leaf Oil (%)	Rhizome Oil (%)
1.	Hexadecanoic Acid (28.3%)	Hexadecanoic Acid (24.51%)	Hexadecanoic Acid (25.26%)
2.	9,12-octadecadienoic Acid (18.33%)	2-pentanol (22.48%)	9,12-octadecadienoic Acid (7.74%)
3.	Dodecanoic Acid (5.62%)	Dodecanoic Acid (3.96%)	Dodecanoic Acid (16.56%)
4.	Linalyl propanoate (6.03%)	β - Ionone (8.69%)	Tetradecanoic Acid (10.20%)
5.	Tetradecanoic Acid (4.82%)	Famesyl acetone (7.04%)	Linalool (8.48%)
6.	A- eudesmol (3.55%)	Lonone (8.01%)	α -terpineol (4.44%)
7.	Υ - eudesmol (3.2%) 4-ethoxy phenol (3.06%)	-	-

9. Traditional Uses

Costus speciosus is used in Ayurveda to enhance complexion and balance vata and kapha. It is said to treat cough, fever, dyspepsia, and other respiratory conditions. It is a component of the traditional medicine "amber mezhugu," which treats rheumatism (Chopra et al., 1956). According to Hussain et al. (2009), the rhizome also has anticholinesterase, antifertility, anti-inflammatory, and anthelmintic properties. Rhizome essential oil exhibited antibacterial properties (Asolkar et al., 1992). It has been discovered that *Costus speciosus* contains steroid saponins and sapogenins with antifungal properties (Singh and Srivastava, 1992). The ancient uses of *costus pictus* as a medical herb are attributed to its stimulant, tonic, carminative, diuretic, digestive, and antiseptic qualities. According to Sivarajan and Balachandran (1994), the rhizome is taken internally to cure a variety of ailments, including gallbladder discomfort, liver issues, jaundice, and abdominal and chest pain.

Costus pictus rhizomes are used in India to treat rheumatism, pneumonia, and colds. It is used to cure diarrhoea, headaches, nausea, ear, eye, and nose pain, and to halt vomiting in Southeast Asia. Rhizome extract was utilized by the Japanese to treat syphilis (Khare, 2007). It has been claimed that *Costus pictus* leaves and rhizomes contain the steroid diosgenin, which has anti-diabetic properties and is used to treat diabetes mellitus. Rats with diabetes mellitus are treated with an aqueous leaf extract of *Costus pictus* at a dose of 2 gm/kg body weight (Jayasri et al, 2008). The pharmaceutical formulation further demonstrates the potentiating effect of insulin in addition to lowering blood sugar. In a similar vein, *Costus speciosus* leaves are reported to possess hypoglycemic qualities (Eliza et al., 2009). The rhizome has been used to treat conditions of the eyes, neck, jaws, tongue, and mouth as well as bronchitis, intestinal worms, dermatitis, and asthma. Additionally, it is used to treat spermaturia, hemorrhoids, edema, and wheezing (dyspnea). *C. igneus* root has been utilized as an oil, decoction, and powder in the siddha medical system. According to reports, *C. igneus* contains resinoids, an alkaloid called saussurine, inulin, and resin, as well as essential oil (Arun et al., 2011).

This plant contains quercetin as a phytochemical. It belongs to the flavonoid family. From the *chamaecostus cuspidatus* methanol extract, it was separated as the active principle. In addition to flavonoids, other phytochemical studies suggest the presence of proteins, carbohydrates, terpenoids, alkaloids, tannins, and trace levels of elements. Protein, iron, and antioxidants such flavonoids, terpenoids, steroids, β -carotene.

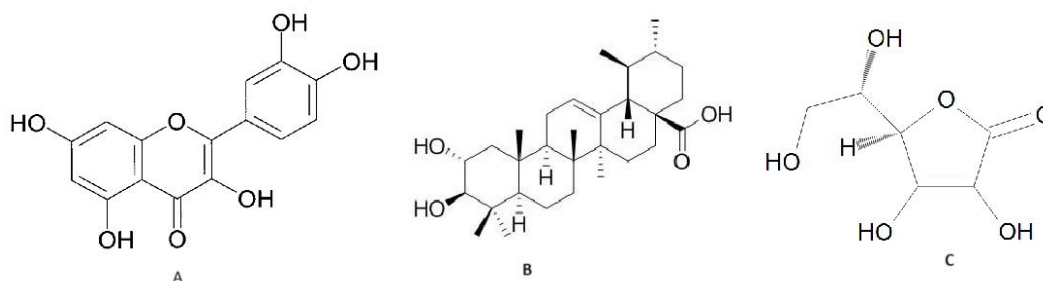


Figure 2: Some chemical constituents A) Coroscolic acid, B) Quercetin and C) Ascorbic acid

10. Major Pharmacological Activities

10.1 Anti-diabetic Activity

Patients who consumed one fresh leaf or one teaspoon of *C. igneus* powder per day, together with other treatment modalities, efficiently produced glycemic control in diabetics, according to a cross-sectional clinical trial[16]. To investigate GLUT4 translocation and glucose uptake activity, an in vitro investigation using an ethanolic extract of *C. pictus* leaf was conducted; however, at a dose of 300 µg/ml, which is comparable to that of insulin and metformin, there was no direct peripheral effect observed[17]. Using C57BLKS/J (KS) db/db mice—a model of obesity-induced hyperglycemia—a study assessed the effect of a tea prepared from the leaves of *C. spicatus* on glucose homeostasis and beta-cell depletion. After the 10-week trial period, intraperitoneal (IP) insulin tolerance tests revealed that drinking *C. spicatus* tea did not change insulin sensitivity. This finding suggested that tea brewed from *C. spicatus* leaves was ineffective at treating obesity-induced hyperglycemia at the provided dose[18].

10.2 Toxicity Study

Studies on the acute toxicity of varying dosages of *C. pictus* aqueous extract (5, 10, 20, and 40 g/kg body weight) were conducted. This extract did not result in any behavioral abnormalities or death at any of the doses tested[19,20]. According to acute toxicity experiments, all of the animals survived the test period and there was no influence on their general behavior after receiving 1 g/kg b.w./day of aqueous extract for 30 days[21]. The drug was found to be safe at the tested dose level of 5000 mg/kg b.wt. Administration of an ethanolic extract of *C. igneus* leaves, ranging from 50 mg/kg b.w. to 5000 mg/kg b.w., did not show significant toxicity signs during the first four hours and was observed daily for 14 days. Additionally, no mortality was observed[22]. However, results from a study on *C. igneus's* methanolic extract showed toxicity at 250 mg/kg body weight[23]. Furthermore, it was discovered in a different study that the main ingredient in the oils detected on the stem, leaves, and rhizomes of *C. pictus* was palmitic acid. It has been discovered that palmitic acid increases the ratio of LDL to HDL cholesterol, causes myofibrils to degenerate in healthy adult rat cardiomyocytes, and is a key precursor to the development of coronary heart disease. Therefore, it is not advised to cure diabetes by continuously using *C. pictus* leaves since this could result in significant cardiac illnesses[24].

10.3 Hypolipidemic Activity

Rats with diabetes-induced hyperlipidemia were used in the study to compare the effects of *C. igneus* methanolic and aqueous extracts. According to the study, hyperlipidemia brought on by diabetes was corrected by methanolic and aqueous extracts at a level of 200 mg/kg body weight[25,26]. In rats treated with Triton-induced hyperlipidemia, an alcoholic extract of *C. igneus* at a dose of 400 mg/kg (p. o.) dramatically reduced the levels of blood cholesterol, triglycerides, and LDL[27].

10.4 Diuretic Effect

A study was conducted to evaluate the diuretic effect of furosemide at 4 mg/kg with that of an aqueous extract of *C. pictus* D. Don at doses of 100 and 200 mg/kg body weight. The findings showed that *C. pictus* had a natriuretic effect that was comparable to that of furosemide. Similar to the increase in potassium and sodium clearance brought about by furosemide, the aqueous extract may indicate severe diuresis[28].

Table 2: Pharmacological Activities of Different Parts of *Costus Igneous*

Plant Part	Reported Biological Activity	Result
Leaf	Hypoglycemic	75.70% decrease in blood sugar levels
	Hypolipidemic	Notable increases in HDL and significant decreases in total cholesterol, LDL, VLDL, phospholipids, and triglyceride levels
	Antioxidant	The noticeable increase in SOD, CAT, and GSH levels among other enzymes. Enzyme level fully recovered at 600 mg/kg, the highest dose. Additionally, a notable decline in the MDA level has been reported
	Antiuro lithiatic	A maximum reduction in the nucleation rate and development of CHPD crystals could be achieved with 1.00% of leaf aqueous extract. Still, the focus was mostly on stem and root extracts.
	Antiproliferative	The methanolic extract demonstrated 97.46% cytotoxicity and was able to shrink the tumor.
	Anti-inflammatory	Isolated compound β -amyirin has shown 97% inhibition of paw edema at a dose of 100 μ g.
	Prevent learning and memory deficit	Diabetic rats treated with <i>Costus igneus</i> showed improvement in their learning tendency while maintaining their natural behavior. demonstrated a significant improvement in both the entry delay and the amount of time spent in the dark room.
Stem	Antiuro lithiatic	A weight drop of 98.25% in CHPD crystals has been noted.
	Antioxidant	demonstrated a strong antioxidant capacity.
	Antimicrobial	Methanolic extract exhibited strong antibacterial properties.
Root	Antibacterial	Significant action against both gram positive and gram-negative bacteria was shown by the methanolic extract.
	Antioxidant	Maximum activity because the greatest phenol content is present
	Hypoglycemic	68.26% decrease in blood glucose levels
Rhizome	Antioxidant	increased SOD, CAT, and GSH levels

	Hepatoprotective	The restoration of AST and ALT to normal levels is indicative of hepatoprotective capability.
	Hypolipidemic	Decrease in serum HDL levels and significant reduction in TC, TG, LDL, and VLDL values
	Antiuro lithiatic	It is possible to reduce the weight of CHPD crystals by 97.125%.
Whole Plant	Hypoglycemic	50.46% decrease in blood glucose levels

10.5 Antioxidant Activity

A moderate level of antioxidant activity was observed in an in vitro investigation using an alcoholic extract of *C. mexicanus* leaves[29]. DPPH, β -carotene, Deoxyribose, superoxide anion, reducing power, and metal chelating test were among the models used to evaluate the antioxidant properties of leaves and rhizomes in methanol, water, ethanol, and ethyl acetate extracts at varying concentrations. When *C. pictus* leaves and rhizomes were compared to standard BHT (Butylated Hydroxy Toulene) (85%) at a concentration of 400 μ g/ml, they demonstrated good antioxidant activity of around 89.5% and 90.0%. The findings showed that, in comparison to other extracts, the methanolic extracts of *C. pictus*'s leaves and rhizomes had stronger antioxidant activity[30]. In a different investigation, the methanolic leaf extract of *C. pictus* D. Don significantly increased the levels of reduced glutathione, catalase, glutathione reductase, glutathione peroxidase, vitamin A, vitamin C, and vitamin E. As a result, it may be useful in lowering oxidative stress and diseases caused by free radicals. This plant's antioxidant properties might be attributed to the phenolic compounds it contains[31] *C. pictus* flower and stem methanolic preparations have antioxidant action against oxidative protein damage in vitro[32]. Of the extracts examined, the *C. pictus* D. Don bark chloroform extract had the highest level of antioxidant activity. ³³For 30 days, diabetic rats were given an oral ethanolic extract of *C. igneus* rhizome at a dose of 200 mg/kg body weight. This treatment significantly increased antioxidant levels in the animals. The plant's bioactive compounds, quercetin and diosgenin, demonstrated antioxidant activity that was adequate to stimulate glycolytic enzymes, regulate gluconeogenesis, and reverse oxidative stress in the liver, pancreas, and kidney of diabetic rats[34].

10.6 Ameliorative Effect

A study examined the protective effects of the ethanolic extract of rhizome (50 mg/kg b. wt, orally) on mitochondrial enzymes during alcohol-induced free radical toxicity in malnourished albino rats. After a 21-day treatment period, mitochondrial enzyme levels returned to normal, suggesting that *C. pictus* improved mitochondrial functions under alcohol-induced free radical stress[35].

10.7 Anti-microbial Activity

The methanolic extract of *C. igneus* exhibited maximum antibacterial activity against gram-negative strains such as *Salmonella typhimurium*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Enterobacter aerogenes*, and *Pseudomonas cerus*, as well as gram-positive strains like *Bacillus megaterium*, *Micrococcus leuteus*, *Staphylococcus aureus*, and *Streptococcus lactis*. Additionally, the isolated chemical from the ethanolic extract of *Costus igneus* demonstrated moderate antibacterial and antifungal activity against *Staphylococcus aureus*,

Escherichia coli, and Candida albicans. Among all the extracts from different parts of *C. pictus*, the methanolic extracts from the stem and flower displayed the most inhibitory activity at 150 µg/ml against various microorganisms including *Shigella flexneri*, *Klebsiella pneumonia*, *Bacillus subtilis*, and *Escherichia coli*[36,37].

10.8 Anti-cancer Effect

The anti-proliferative and anti-cancer properties of the ethanolic extract derived from *C. pictus* leaves were tested on in vitro mammalian fibrosarcoma (HT-1080) cells. Additionally, the powerful anti-cancer effects of various bark extracts were demonstrated on HT-29 and A549 cells[38,39]

10.9 Putative Activity

The potential activity of the aqueous extract of *Costus* stem and the isolated compounds stigmasterol and lupeol was confirmed by their promotion of calcium oxalate dihydrate (COD) crystal formation. This activity may be utilized to treat urinary stones by preventing the formation of calcium oxalate monohydrate (COM) crystals[40,41].

11. Conclusion

The review provides evidence in favor of the leaves' potential therapeutic use in diabetes. Clinical trials must, however, assess and validate these findings further. Its leaves are presently being investigated on diabetic patients for its anti-diabetic properties. Research reveals how it functions in a number of disorders, which creates new avenues for clinical study. It also opens up new possibilities for researching the substances causing these therapeutic effects and the manner in which they work.

12. Marketed Products

Table 3: Various Marketed products of *Costus igneus*

Plant Name	Product Name	Category	Manufacturer
<i>Costus igneus</i>	Insulin Plant Leaf powder 180g	Dietary supplement	TheInsulinPlant.com, USA
	Kostam Keerai (<i>Costus igneus</i>) Capsule 500mg	-	Agroline Mori tantraa
	Diabestop 500mg Capsule	Food supplement	Herbs & Nutri Pharma
	Glucobeet plus Capsule 500mg	Blood sugar supportive Supplement	Orange organic pharma
	Daun Insulin	20 Herbal tea bags	Tigadaun

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