



Costus Igneus: Traditional Remedy For Diabetes Mellitus

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ABSTRACT:

Costus igneus Nak and *Costus pictus* D. Don, commonly known as Spiral flag, is a member of Costaceae and a newly introduced plant in India from South and Central America. It is a perennial, upright, spreading plant reaching about two feet tall, with spirally arranged leaves and attractive flowers. In southern India, it usually grows as an ornamental plant and its leaves are used as a dietary supplement in the treatment of diabetes mellitus. Recently, a number of researches have been carried out to evaluate the anti-diabetic potential of this plant. Besides, it has been proven to possess various pharmacological activities like hypolipidemic, diuretic, antioxidant, anti-microbial, anti-cancerous. Further, various phytochemical investigations reveal the presence of carbohydrates, triterpenoids, proteins, alkaloids, tannins, saponins, flavonoids, steroid, and appreciable amounts of trace elements. This work is an attempt to compile and explore the different pharmacological and phytochemical studies reported till date.

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

INTRODUCTION:

Costus igneus Nak (syn. *Costus pictus* D. Don, *Costus mexicanus* Liebm ex Petersen or *Costus congenitus* Rowle), commonly known as fiery costus, Step ladder or Spiral flag or Insulin plant, is native to

South and Central America. This is a recent introduction to India from America as an herbal cure for diabetes and hence commonly called as ‘insulin plant.’⁽¹⁾ It is widely grown in gardens as ornamental plant in South India and also run wild in many places. ⁽²⁾ It is used in India to control diabetes, and it is known that diabetic people eat one leaf daily to keep their blood glucose low.⁽³⁾ Leaves of *C. igneus* were one among the plants known to be effectively used for treating diabetes by the tribal people of Kolli hills of Namakkal district, Tamilnadu.⁽⁴⁾ In Mexican folk medicine, the aerial part of *C. pictus* D. Don is used as an infusion in the treatment of renal disorders. ⁽⁵⁾ The plant belongs to the family Costaceae. The Costaceae was first raised to the rank of family by Nakai on the basis of spirally arranged leaves and rhizomes being free from aromatic essential oils. Before the elevation to family status, Engler and Prantl recognized Costoideae as a subfamily under Zingiberaceae. Several anatomical and morphological features support this isolated position including well developed aerial shoot with distinct, rigid, and commonly branched stems. The genus *Costus* is the largest in the family with about 150 species that are mainly tropical in distribution. ^(2,6) The present review deals with the recent research carried out in the area of phytochemistry, pharmacological, biological activities, and safety of *Costus igneus* Nak.

Taxonomy:

Botanical name: *Costus igneus* N.E.Br Domain: Eukaryota
 Kingdom: Plantae Subkingdom: Viridiplantae Phylum: Tracheophyta Subphylum: Euphyllophytina
 Infraphylum: Radiatopses Class: Liliopsida
 Subclass: Commelinidae Superorder: Zingiberanae Order: Zingiberales Family: Costaceae Subfamily:
 Asteroideae Tribe: Coreoideae Genus: *Costus*
 Specific epithet: *igneus*

Morphology: It is a perennial, upright, spreading plant reaching about two feet tall, with the tallest stems falling over and lying on the ground. Leaves are simple, alternate, entire, oblong, evergreen, 4-8 inches in length with parallel venation. The large, smooth, dark green leaves of this tropical evergreen have light purple undersides and are spirally arranged around stems, forming attractive, arching clumps arising from underground rootstocks. Beautiful, 1.5-inch diameter, orange flowers are produced in the warm months, appearing on cone-like heads at the tips of branches. ⁽⁸⁾ Fruits are inconspicuous, not showy, less than 0.5 inch, and green-colored.





Fig. 2. Leaves of Insulin plant



Fig. 3. Flower of Insulin



Fig. 4. Fruit of Insulin

Growth and propagation: Spiral flag grows in either full sun or partial shade. It needs fertile soil and ample moisture, and is often planted near water. Propagation is by division of the clumps, cuttings, or by separating the offsets or plantlets that form below the flower heads. Mites and nematodes can be a problem, especially on light, sandy soil. The plant has no diseases are of major concern. ⁽⁸⁾

Consuming *Costus igneus* may come with side effects, including:

- upset stomach
- diarrhea
- dizziness

- low blood sugar levels, especially if you take insulin
- increased risk of diabetes-related coma (from hypoglycemia)

➤ Always check with your doctor before starting any herbal supplements to manage blood sugar levels, especially if you're insulin-dependent.

➤ Additionally, taking herbal *Costus igneus* may interact with other medications you're taking, so be sure to ask your doctor if anything will be contraindicated (reason why you should not consume *Costus igneus*) if you wish to start taking this supplement.

➤ The longer-term side effects of this plant are largely unknown. More research is needed.

Insulin Plant Benefits:

1. Blood sugar regulation:

The insulin plant has been traditionally used for its potential in regulating blood sugar levels. It is believed to stimulate insulin production and improve insulin sensitivity, making it beneficial for individuals with diabetes.

2. Antioxidant properties:

The leaves of the insulin plant are rich in antioxidants, such as flavonoids and phenolic compounds. These antioxidants help combat oxidative stress, reduce inflammation, and protect the body against various diseases.

3. Digestive health:

Consuming insulin plant leaves may aid in digestion, relieve stomach discomfort, and improve bowel movements. It is often used to alleviate digestive disorders such as constipation and indigestion.

4. Anti-inflammatory effects:

The insulin plant possesses anti-inflammatory properties, which can help reduce inflammation in the body. This property makes it potentially useful in managing conditions like arthritis and inflammatory bowel disease.

5. Immune system support:

Regular consumption of insulin plant leaves may strengthen the immune system, thanks to its high vitamin C content. It helps boost the body's defenses against infections and illnesses.

Varieties of Insulin Plant:

Costus igneus var. spiralis:

This variety is known for its spiraling leaves, which add an intriguing visual appeal to the plant. It shares similar health benefits with the common insulin plant variety.

Costus igneus var. compactus:

This compact variety of insulin plant features smaller leaves and a more compact growth habit. It is a suitable option for those with limited space.

Costus igneus var. Albus:

Unlike the traditional green leaves of insulin plants, this variety has white leaves. It possesses the same medicinal properties and can be a captivating addition to any garden.

Phytochemical study: Sequential screening for phytochemicals of *C. igneus* leaves revealed that it is rich in protein, iron, and antioxidant components such as ascorbic acid, α -tocopherol, β -carotene, terpenoids, steroids, and flavonoids. ^(9,10) It was revealed in another study that methanolic extract was found to contain the highest number of phytochemicals such as carbohydrates, triterpenoids, proteins, alkaloids, tannins, saponins, and flavonoids. ⁽¹¹⁾ Preliminary phytochemical evaluation of Insulin plant (*C. pictus*) revealed that the leaves contain 21.2% fibers. Successive extracts gave 5.2% extractives in petroleum ether, 1.06% in cyclohexane, 1.33% in acetone, and 2.95% in ethanol. Analysis of successive extracts showed presence of steroids in all extracts. The ethanol extract contained alkaloid also. The major component of the ether fraction was bis (2'-ethylhexyl)-1,2-benzenedicarboxylate (59.04%) apart from α -tocopherol and a steroid, ergastanol. ⁽¹²⁾ Stem showed the presence of a terpenoid compound lupeol and a steroid compound stigmasterol. ⁽¹³⁾ Bioactive compounds quercetin and diosgenin, a steroidal saponin, were isolated from *C. igneus* rhizome. ⁽¹⁴⁾ Trace elemental analysis showed that the leaves and rhizomes of *C. pictus* contains appreciable amounts of the elements K, Ca, Cr, Mn, Cu, and Zn. ⁽¹⁵⁾ Steam distillation of stems, leaves, and rhizomes of *C. pictus* D. Don yielded clear and yellowish essential oils. The major constituents identified in the essential oil are enlisted in Table 1

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)	A- Lonone (8.01)	α -terpineol (4.44)
7.	Υ - eudesmol (3.21) 4-ethoxy phenol (3.06)	-	-

Traditional Uses:

In Ayurveda, *Costus speciosus* is used to subdue vata and kapha and promotes complexion. It is reported to cure dyspepsia, fever, cough and other respiratory disorders. It is one of the constituent of indigenous drug “amber mezhugu” useful in rheumatism (Chopra et al., 1956). The rhizome also possesses antifertility, anticholinesterase, antiinflammatory and anthelmintic activities (Hussain et al., 2009).

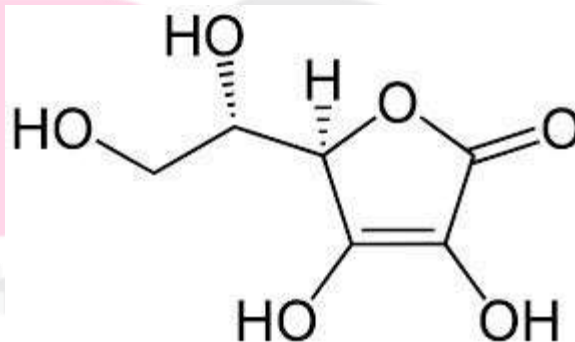
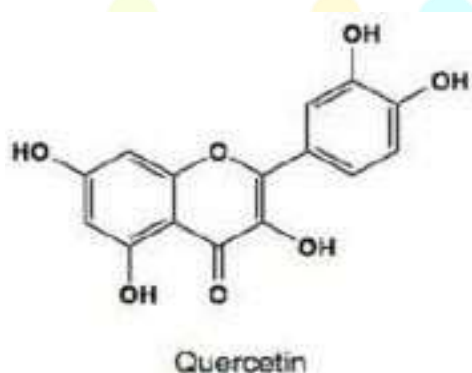
Essential oil from rhizomes showed antimicrobial activity (Asolkar et al., 1992). Steroid saponins and sapogenins from *Costus speciosus* were reported to possess antifungal activity (Singh and Srivastava, 1992). *Costus pictus* is traditionally used as a medicinal herb mainly for its tonic, stimulant, carminative, diuretic, digestive and antiseptic properties. The rhizome is used internally in the treatment of abdominal pain, chest pains, liver problems, jaundice, gall bladder pain etc (Sivarajan and Balachandran, 1994).

In India rhizomes of *Costus pictus* are used for cold, pneumonia and rheumatism. In Southeast Asia, it is used to treat diarrhoea, dizziness, headache, ear, eye, nose pain and to stop vomiting. Japanese used the rhizome extract for controlling of syphilis disease (Khare, 2007). The leaves and rhizomes of *Costus pictus* are reported to possess steroid - diosgenin, which is anti-diabetic in nature and is used in the treatment of diabetes mellitus. The aqueous leaf extract of *Costus pictus* is used to control diabetes mellitus in a dose of 2 gm/kg body weight in rats (Jayasri et al, 2008).

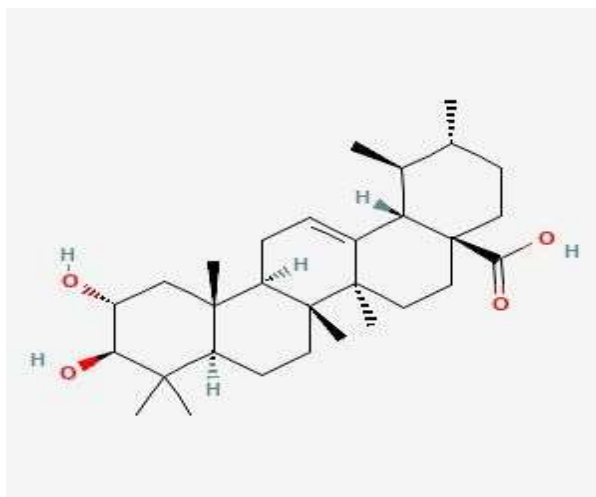
The medicinal preparation further shows insulin potentiating action in addition to decreasing blood glucose. Similarly, the leaves of *Costus speciosus* are known to have hypoglycemic properties (Eliza et al., 2009).

The rhizome has been used to treat asthma, rash, bronchitis, intestinal worms, ailments of eyes, neck, jaws, tongue and mouth. It is also used for curing edema, wheezing (dyspnoea), haemorrhoids and spermaturia. In siddha medicine system, *C. igneus* root has been used in the form of powder, decoction and oil. *C.igneus* has been reported to contain resinoids, essential oil and alkaloid named saussurine, inulin and resin (Arun et al., 2011).

- The phytochemical constituent of this plant is quercetin. It is a flavonoid. It was isolated as active principle from methanol extract of *chamaecostus cuspidatus*.



- The leave mainly contained Coroscolic acid



- Other components
- Various phytochemical investigations reveal the presence of carbohydrates, terpenoids, proteins, alkaloids, tannins and amounts of trace elements along with flavonoids.
- Leaves are rich in protein, iron, and antioxidant components such as ascorbic acid, α -tocopherol, β -carotene, terpenoids, steroids, and flavonoids.

Major pharmacological activities:

Anti-diabetic activity: In a cross-sectional clinical study, patients consuming either one fresh leaf or 1 teaspoon of shade-dried powder/day of *C. igneus* in conjunction with other modalities of treatment had effectively produced glycemic control in diabetics. ⁽¹⁶⁾ However, an *in vitro* study of ethanolic extract of *C. pictus* leaf was analyzed to study GLUT4 translocation and glucose uptake activity, which showed no direct peripheral action at 300 μ g/ml dose comparable with insulin and metformin. ⁽¹⁷⁾ A study evaluated the ability of a tea made from the leaves of *C. spicatus* to alter glucose homeostasis in C57BLKS/J (KS) *db/db* mice, a model of obesity-induced hyperglycemia, with progressive beta-cell depletion. Intraperitoneal (IP) insulin tolerance testing after the 10-week study period showed that *C. spicatus* tea consumption did not alter insulin sensitivity, which suggested that at the dose given, tea made from *C. spicatus* leaves had no efficacy in the treatment of obesity-induced hyperglycemia. ⁽¹⁸⁾

Toxicity study: Acute toxicity studies were studied with different doses of aqueous extract of *C. pictus* from 5, 10, 20, and 40 g/kg body weight. None of the doses of this extract produced mortality or any behavioral disorders. ^(19,20) Acute toxicity studies revealed that the administration of aqueous extract 1 g/kg b.w/day for 30 days produced no effect on the general behavior and all the animals survived the test period. ⁽²¹⁾ Administration of ethanolic extract of *C. igneus* leaves from 50 mg/kg b.w up to the dose of 5000 mg/kg b.w did not show significant toxicity signs during the first four hours and followed by daily observations for 14 days, and no mortality was also observed; the drug was found to be safe at the tested dose level of 5000 mg/kg b.wt. ⁽²²⁾ However, in a study carried out on the methanolic extract of *C. igneus*, findings indicated toxicity at 250 mg/kg body weight. ⁽²³⁾ Further, in another investigation, palmitic acid was found to be the major component in the stem, leaf, and rhizome oils of *C. pictus*. Palmitic acid is found to induce degeneration of myofibrils in healthy adult rat cardiomyocytes, enhance LDL to HDL cholesterol ratio, and it was found to be the important precursor for the development of coronary heart diseases. So, the constant use of *C. pictus* leaves for diabetic treatment may cause serious cardiac diseases, and it is not recommended for the treatment. ⁽²⁴⁾

Hypolipidemic activity: A study was carried out to comparatively evaluate the methanolic and aqueous extracts of *C. igneus* in diabetes-induced hyperlipidemia in rats. The study revealed that methanolic and

aqueous extracts at a dose of 200 mg/kg body weight reversed the diabetes-induced hyperlipidemia. (25,26) Alcoholic extract of *C. igneus* at the dose of 400 mg/kg (p.o) had significantly decreased the levels of serum cholesterol, triglycerides, LDL in Triton-induced hyperlipidemic rats. (27)

Table no. 2. Pharmacological activities of different parts of costus igneus

Plant part	Reported Biological activity	Result
Leaf	Hypoglycemic	75.70% reduction of blood glucose level
	Hypolipidemic	Significant reduction in total cholesterol, LDL, VLDL, phospholipids and triglyceride levels and rise in HDL level
	Antioxidant	The marked rise in enzyme levels such as SOD, CAT, and GSH. Complete recovery of enzyme level shown at the highest dose, 600mg/kg. And a significant reduction in MDA level also has been indicated.
	Antiuro lithiatic	1.00% of aqueous extract of leaves could reduce the nucleation rate and growth of CHPD crystals at maximum. But the activity was more for root and stem extracts.
	Antiproliferative	The methanolic extract could reduce the tumor size and showed 97.46% cytotoxicity.
	Anti- inflammatory	Isolated compound β -amyrin has shown 97% inhibition of paw edema at a given dose of 100 μ g.
	Prevent learning and memory deficit	<i>Costus igneus</i> treated diabetic rats maintained their innate behavior and indicated an improvement in their learning tendency. Also shown a marked improvement in the entrance latency and decrease in the time spent in the dark room.
Stem		98.25% decrease in the weight of CHPD crystals has been observed
	Antioxidant	Showed significant antioxidant activity
		Antimicrobial Methanolic extract showed significant antimicrobial activity
Root	Antibacterial	Methanolic extract indicated significant activity against for both gram positive and gram negative bacteria
	Antioxidant	Maximum activity due to the presence of highest phenol content
		Hepatoprotective Hepatoprotective potential is indicated by bringing AST, ALT to near normal levels
Rhizome	Hypoglycemic	68.26% reduction of blood glucose level
	Antioxidant	Showed elevated levels of SOD, CAT, and GSH

	Significant reduction of TC, TG, LDL, VLDL, and attenuation of serum HDL levels	
	Hypolipidemic	
	97.125% weight reduction of CHPD crystals has been Antirolithiatic obtained	
Whole plant	Hypoglycemic	50.46% reduction of blood glucose level

Diuretic effect: A study was carried out to measure the diuretic effect of an aqueous extract of *C. pictus* D. Don at doses of 100 and 200 mg/kg body weight and to compare it with the one induced by furosemide at 4 mg/kg. The results revealed that *C. pictus* induced a natriuretic effect similar to furosemide. The aqueous extract induced an increment in sodium and potassium clearance similar to the one obtained with furosemide, suggesting that it represents significant diuresis. ⁽²⁸⁾

Antioxidant activity: An *in vitro* study of alcoholic extract of leaves of *C. mexicanus* showed moderate antioxidant activity. ⁽²⁹⁾ The antioxidant activities of leaves and rhizomes in methanol, aqueous, ethanol, and ethyl acetate extracts were assessed using different models like DPPH, β -carotene, Deoxyribose, superoxide anion, reducing power, and metal chelating assay at different concentrations. Leaves and rhizomes of *C. pictus* showed good antioxidant activity of about 89.5% and 90.0% when compared with standard BHT (Butylated Hydroxy Toulene) (85%) at a concentration of 400 μ g/ml. Results obtained revealed that methanolic extracts of both leaves and rhizomes of *C. pictus* possess higher antioxidant activity when compared with other extracts. ⁽³⁰⁾ In another study, methanolic leaf extract of *C. pictus* D. Don caused significant increase in superoxide dismutase, catalase, glutathione peroxidase, glutathione reductase, vitamin A, vitamin C, vitamin E and reduced glutathione, and thus, could be effective in reducing oxidative stress and free radical-mediated diseases. The antioxidant property of this plant may be due to the presence of phenolic substances. ⁽³¹⁾ Methanolic extracts of flower and stem of *C. pictus* possess *in vitro* antioxidant activity against oxidative protein damage. ⁽³²⁾ Among the extracts tested for, chloroform extract of *C. pictus* D. Don bark possessed high antioxidant activity. ⁽³³⁾ Oral administration of ethanolic extract of *C. igneus* rhizome at 200 mg/kg body weight to diabetic rats for 30 days induced a significant antioxidant effect. The bioactive compound quercetin and diosgenin present in the plant exhibited antioxidant activity, which was sufficient to reverse oxidative stress in liver, pancreas, and kidney of diabetic rats as well as to stimulate glycolytic enzymes and control gluconeogenesis in diabetic animals. ⁽³⁴⁾

Ameliorative effect: A study was conducted to evaluate the ameliorative effect of ethanolic extract (50 mg/kg b.wt, orally) of rhizome on mitochondrial enzymes in alcohol-induced free radical toxicity in male albino rats. After 21 days of treatment, mitochondrial enzymes were restored to normal levels, which showed that *C. pictus* improved mitochondrial activities during alcohol-induced free radical stress. ⁽³⁵⁾

Anti-microbial activity: Methanolic extract of *C. igneus* showed maximum anti-bacterial activity against gram-positive *Bacillus cerus*, *Bacillus megaterium*, *Micrococcus leuteus*, *Staphylococcus aureus*, *Streptococcus lactis*, and gram-negative strains *Pseudomonas aeruginosa*, *Escherichia coli*, *Enterobacter aerogenes*, *Klebsiella pneumoniae*, and *Salmonella typhimurium*. ⁽³⁶⁾ The isolated compound from the ethanolic extract of *Costus igneus* showed moderate anti-bacterial and anti-fungal activity against *Staphylococcus aureus*, *Escherichia coli*, and *Candida albicans*. Among the extracts of various parts of *C. pictus*, methanolic extracts of stem and flower exhibited maximum inhibitory activity on the growth of tested microbes, viz., *Shigella flexneri*, *Klebsiella pneumonia*, *Bacillus subtilis*, *Escherichia coli* at the concentration of 150 μ g/ml. ⁽³⁷⁾

Anti-cancer effect: The ethanolic extract of leaves of *C. pictus* was found to have anti-proliferative and anti-cancer potential in *in-vitro* mammalian fibrosarcoma (HT-1080) cells. All the extracts of bark had potent

Putative activity: Aqueous extract of *Costus* stem and isolated compounds lupeol, and stigmasterol had an inhibitory effect on calcium oxalate urolithiasis, and its putative activity was confirmed by the promotion of formation of calcium oxalate dehydrate (COD) crystals and may possibly treat urinary stones by inhibiting the formation of calcium oxalate monohydrate (COM) crystals. (40,41)

CONCLUSION:

This review supports the therapeutic potential of the leaves in diabetes. However, these results have to be further evaluated and revalidated by clinical trials. The anti-diabetic effect of its leaves is currently been tested in diabetic patients. Studies reveal its role in various diseases, which opens up new clinical research areas. Furthermore, it paves new avenues to explore the compounds responsible for these therapeutic effects, and study the mechanism of its action.

MARKETED PRODUCTS:

Table 3 : Various Marketed products of *Costus igneus*

PLANT NAME	PRODUCT NAME	CATEGORY MANUFACTURER	MANUFACTURER
Costus igneus	Insulin Plant Leaf powder 180g	Dietary supplement	The Insulin Plant.com, USA
	Kostam Keerai (Costus igneus) 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

REFERENCES:

1. Jose B, Reddy LJ. Analysis of the essential oils of the stems, leaves and rhizomes of the medicinal plant *Costus pictus* from southern India. *Int J Pharmacy Pharm Sci.* 2010;2:100–1.
2. Benny M. Insulin plant in gardens. *Natural Product Radiance.* 2004;3:349–50.
3. Devi VD, Urooj A. Hypoglycemic potential of *Morus indica*. L and *Costus igneus*. Nak: A preliminary study. *Indian J Exp Biol.* 2008;46:614–6.
4. Elavarasi S, Saravanan K. Ethnobotanical study of plants used to treat diabetes by tribal people of Kolli Hills, Namakkal District, Tamilnadu, Southern India. *Int J Pharm Tech Res.* 2012;4:404–11.
5. Meléndez-Camargo ME, Castillo-Nájera R, Silva-Torres R, Campos-Aldrete ME. Evaluation of the diuretic effect of the aqueous extract of *Costus pictus* D. Don in rat. *Proc West Pharmacol Soc.*

2006;49:72–4.

6. Eevera T, Pazhanichamy K, Pavithra S, Rubini S, Lavanya B, Ramya I. Morphological, anatomical and proximate analysis of leaf, root, rhizome of *Costus igneus*. *Journal Int Pharm Res*. 2010;3:747–52.

7. Adiga S, Chetty S, Reddy S. Evaluation of The Effect of *Costus igneus* on Learning and Memory In Normal and Diabetic Rats Using Passive Avoidance Task. *International Journal of Pharmacy and Pharmaceutical Sciences*. Volume 6, 20 Feb 2014, 835-838

8. Gilman EF. Florida: University of Florida, Inc; c2012. *Costus igneus*. Fact sheet. FPS-151. EDIS-Electronic Data Information Source-UF/IFAS Extension.

9. Devi VD, Urooj A. Nutrient profile and antioxidant components of *Costus speciosus* Sm. and *Costus igneus* Nak. *Indian J Nat Prod Resour*. 2010;1:116–8.

10. Shankarappa L, Gopalakrishna B, Jagadish NR, Siddalingappa GS. Pharmacognostic and phytochemical analysis of *Costus ignitius*. *Internationale Pharmaceutica Scientia*. 2011;1:36–41.

11. Jothivel N, Ponnusamy SP, Appachi M, Singaravel S, Rasingam D, Deivasigamani K, et al. Anti-diabetic activity of methanol leaf extract of *Costus pictus* D. Don in alloxan- induced diabetic rats. *Journal of Health Science*. 2007;53:655–63.

12. George A, Thankamma A, Rema Devi VK, Fernandez A. Phytochemical investigation of Insulin plant (*Costus pictus*) *Asian J Chem*. 2007;19:3427–30.

13. Manjula K, Pazhanichamy K, Kumaran S, Eevera T, Dale Keefe C, Rajendran K. Growth characterization of calcium oxalate monohydrate crystals influenced by *Costus igneus* aqueous stem extract. *Int J Pharm Pharm Sci*. 2012;4(Suppl 1):261–70.

14. Kalailingam P, Sekar AD, Samuel JS, Gandhirajan P, Govindaraju Y, Kesavan M, et al. The efficacy of *Costus igneus* rhizome on carbohydrate metabolic, hepatoprotective and antioxidative enzymes in streptozotocin-induced diabetic rats. *Journal of Health Science*. 2011;57:37–46.

15. Jayasri MA, Gunasekaran S, Radha A, Mathew TL. Anti-diabetic effect of *Costus pictus* leaves in normal and streptozotocin-induced diabetic rats. *Int J Diabetes and Metabolism*. 2008;16:117–22.

16. Dhanabal SP, Kumar A, Chandrasekar R, John S, Joseph S, James M, et al. Hypoglycemic and antioxidant activities of *Costus mexicans* (Costaceae) *Aryavaidyan*. 2007;21:53–8.

17. Gireesh G, Dr, Paulose CS. *PhD Thesis*. Kerala, India: Faculty of Science, Cochin University of Science and Technology; 2007. Muscarinic M1 Receptor gene expression in streptozotocin induced diabetic rats: Regulation of insulin secretion by *Aegle marmelose* and *Costus pictus* leaf extracts.

18. Gireesh G, Thomas SK, Joseph B, Paulose CS. Antihyperglycemic and insulin secretory activity of *Costus pictus* leaf extract in streptozotocin induced diabetic rats and in *in vitro* pancreatic islet culture. *J Ethnopharmacol*. 2009; 123:470–475.

19. Sethumathi PP, Nandhakumar J, Sengottuvelu S, Duraisam R, Karthikeyan D, Ravikumar VR, et al. Antidiabetic and antioxidant activity of methanolic leaf extracts of *Costus pictus* D. Don in alloxan induced diabetic rats. *Pharmacologyonline*. 2009;1:1200-13.

20. Bhat V, Asuti N, Kamat A, Sikarwar MS, Patil MB. Antidiabetic activity of insulin plant (*Costus igneus*) leaf extract in diabetic rats. *J Pharm Res*. 2010;3:608–11.

21. Mani P, Kumar AR, Bastin TM, Jenifer S, Arumugam M. Comparative evaluation of extracts of *C. igneus* (or *C. pictus*) for hypoglycemic and hypolipidemic activity in alloxan diabetic rats. *Int J Pharm Tech*. 2010;2:183–95.

22. Al-Romaiyan A, Jayasri MA, Mathew TL, Huang GC, Amiel S, Jones PM, et al. *Costus pictus* extracts stimulate insulin secretion from mouse and human islets of Langerhans *in vitro*. *Cell Physiol Biochem*. 2010;26:1051–8.

23. Shetty AJ, Choudhury D, Rejeesh VN, Nair V, Kuruvilla M, Kotian S, editors. Effect of the insulin plant (*Costus igneus*) leaves on dexamethasone-induced hyperglycemia. *Int J Ayurveda Res*. 2010;1:100–2.

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“<http://www.ncbi.nlm.nih.gov/pubmed/?term=Choudhury%20D%5Bauth%5D>”. 675-685.

24. Devi VD, Urooj A. Evaluation of anti hyperglycemic and anti lipid peroxidative effect of *Costus*

- igneus* Nak in streptozotocin induced diabetic rats. *International Journal of Current Research*. 2011;33:4–8.
25. Krishnan K, Vijayalakshmi NR, Helen A. Beneficial effects of *Costus igneus* and dose response studies in streptozotocin induced diabetic rats. *International Journal of Current Pharmaceutical Research*. 2011;3:42–6.
26. Isaac ST, Alphonse JK. Comparative study of hypoglycemic activity of *Costus pictus* and *Costus igneus* in streptozotocin induced diabetic rat. *J Pharm Res*. 2011;4:3628–9.
27. Kalailingam P, Kaliaperumal R, Shanmugam K. Vol. 5. International Conference on Bioscience, Biochemistry and Bioinformatics; 2011. Efficacy of methanolic extract of *Costus igneus* rhizome on hypoglycemic, hypolipidemic activity in streptozotocin diabetic rats and HPTLC analysis of its active constituents; pp. 318–21.
28. Suganya S, Narmadha R, Gopalakrishnan VK, Devaki K. Hypoglycemic effect of *Costus pictus* D. Don on alloxan induced type 2 diabetes mellitus in albino rats. *Asian Pacific Journal of Tropical Disease*. 2012;2:117–23.
29. Kumudhavalli MV, Jaykar B. Evaluation of antidiabetic activity of *Costus igneus* (L) leaves on STZ induced diabetic rats. *Der Pharmacia Sinica*. 2012;3:1–4.
30. Remya R, Daniel M. Phytochemical and pharmacognostic investigation of antidiabetic *Costus pictus*. D. Don. *Int J Pharm Biomed Res*. 2012;3:30–9.
31. Shetty AJ, Parampalli SM, Bhandarkar R, Kotian S. Effect of the insulin plant (*Costus igneus*) leaves on blood glucose levels in diabetic patients: A cross sectional study. *J Clin Diagn Res*. 2010;4:2617–21.
32. Pareek A, Suthar M, Godavarthi A, Goyal M, Bansal V. Negative regulation of glucose uptake by *Costus pictus* in L6 myotube cell line. *J Pharm Negative*. 2010;1:24–6.
33. Keller AC, Vandebroek I, Liu Y, Balick MJ, Kronenberg F, Kennelly EJ, et al. *Costus spicatus* tea failed to improve diabetic progression in C57BLKS/J db/db mice, a model of type 2 diabetes mellitus. *J Ethnopharmacol*. 2009;121:248–54.
34. Chacko N, Shastry CS, Shetty P, Shyamma P, D'souza U, Maulika P. Anti hyperlipidemic activity of *Costus igneus* in Triton X-100 induced hyperlipidemic rats. *International Journal of Pharmaceutical and Chemical Sciences*. 2012;1:813–8.
35. Jayasri MA, Mathew L, Radha A. A report on the antioxidant activity of leaves and rhizomes of *Costus pictus* D. Don. *Int J Integr Biol*. 2009;5:20–6.
36. Majumdar M, Parihar PS. Antibacterial, antioxidant and antiglycation potential of *Costus pictus* from southern region, India. *Asian J Plant Sci Res*. 2012;2:95–101.
37. Sathuvan M, Vignesh A, Thangam R, Palani P, Rengasamy R, Murugesan K. *In vitro* antioxidant and anticancer potential of bark of *Costus pictus* D. Don. *Asian Pac J Trop Biomed*. 2012;2:S741–9.
38. Maruthappan V, Sakthisree K. Ameliorative effect of *Costus pictus* D. Don rhizome on mitochondrial enzymes in male albino rats. *Int J Integ Biol*. 2010;9:62–6.
39. Gothandam KM, Aishwarya R, Karthikeyan S. Preliminary screening of antimicrobial properties of few medicinal plants. *J Phytol*. 2010;2:1–6.
40. Saraswathi R, Upadhyay L, Venkatakrishnan R, Meera R, Devi P. Isolation and biological evaluation of steroid from stem of *Costus igneus*. *J Chem Pharm Res*. 2010;2:444–8.
41. Nadumane VK, Rajashekar S, Narayana P, Adinarayana S, Vijayan S, Prakash S, et al. Evaluation of the anticancer potential of *Costus pictus* on fibrosarcoma (HT-1080) cell line. *J Nat Pharm*. 2011;2:72–6.
42. Mani P, Kanivalan N, Rajakumar R. Anti-Diabetic and Hypolipidemic Effects of *Costus igneus* Leaves Extracts Against Streptozotocin Induced Diabetic Albino Rats. *Acta Biomedica Scientia*. 1, 2014, 74- 79
43. Shivaprakash G, Elizabeth D, Rai S, Nischal, Nandini, Reshma K, Fahim, Natesh and Pallavi. Evaluation of Antioxidant potential of *Costus igneus* in ethanol induced peroxidative damage in albino rats. *Journal of Applied Pharmaceutical Science*. Vol. 4, August 2014, 052-055.
44. Yuvarani T, Manjula K, Perumal A G. Growth Characterization of Calcium Hydrogen Phosphate Dihydrate Crystals Influenced By *Costus igneus* Aqueous Extract. *International Journal of Pharmacy and*

Pharmaceutical Sciences. Vol 9, 2017, 173-178.

45. Dhanasekaran S, Akshaya M, Preethi S. In Vitro Anti-Proliferative Potential of Leaves of *Costus igneus*. International Journal of Innovations in Engineering and Technology. Volume 4, December 2014, 277-283.

46. Krishnan K, Mathew LE, Vijayalakshmi NR, Helen A. Anti-inflammatory potential of β - amyrin, a triterpenoid isolated from *Costus igneus*. Inflammopharmacology. 22, 2014 Dec 1, 373-385.

47. Ramya Urs S.K and Jyoti Bala Chauhan. Phytochemical Screening, Antimicrobial Activity and Antioxidant Activity of *Costus igneus*. European Journal of Molecular Biology and Biochemistry. 2, 2015, 93-96.

48. Kala S. Antimicrobial Activity of *Coleus For skohlilii* (Wild) Briq and *Costus igneus* N.E.Br. Journal of Pharmacy and Biological Sciences. Volume 9, 2014, 01-06.

49. Kalailingam P, Sekar AD, Samuel JS, Gandhirajan P, Govindaraju Y, Kesavan M, Kaliaperumal R, Tamilmani E. The efficacy of *Costus igneus* rhizome on carbohydrate metabolic, hepatoprotective and antioxidative enzymes in streptozotocin-induced diabetic rats. Journal of Health Science Vol.57, 2011, 37-46.

50. Kalailingam P, Kaliaperumal R, Shanmugam K, Tamilmani E. Efficacy of Methanolic Extract of *Costus igneus* rhizome on hypoglycemic, hypolipidemic activity in streptozotocin (STZ) diabetic rats and HPTLC analysis of its active constituents. In International Conference on Bioscience, Biochemistry, and Bioinformatics 26 (Vol. 5), 2011 Feb, pp. 318-321.

51. V.Palanivel, Mohamed Jihad EV, K.L. Senthil Kumar. Evaluation of hypoglycemic activity of *Costus igneus* extract (whole plant) on alloxan induced diabetic rats. International Journal of Advanced Pharmaceutical Genuine Research. Vol.1, 2013, 9-19.

