IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

A REVIEW ON *Chamaecostus cuspidatus* (Nees & Mart.) C. Specht & D. W. Stev. AND ITS MEDICINAL USES

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Abstract: *Chamaecostus cuspidatus* (Nees & Mart.) C. Specht & D. W. Stev. is a perennial herb, a beautiful and well-known medicinal plant due to its anti-diabetic property, hence commonly called as Insulin plant. The biochemical and phytochemical constituents comprise of steroids, triterpenoids, alkaloids, tannins, flavonoids, glycosides, saponins, carbohydrates, and proteins. This plant has been reported for its anti-diabetic, anti-oxidant, antiinflammatory, anti-proliferative, anti-urolithiasis, hypolipidemic, neuroprotective and anti-microbial activity. This is a review article that attempts to explore various medicinal properties of *Chamaecostus cuspidatus* mostly as anti-diabetic plants that can be used for the welfare of mankind.

IndexTerms- Insulin plant, perennial, anti-diabetic, phytochemical, welfare

INTRODUCTION

Medicinal plants, referred as the medicinal herbs are used as traditional medicines since prehistoric times. Those plants synthesize many chemical compounds that are major requisites for defense of plants against abiotic and biotic stresses. Numerous phytochemicals are discovered with potential biological and pharmacological activities. Medicinal plants play a crucial role, as traditional herbal medicines for health care for the treatment of certain disorders and health related conditions, irrespective of education and income levels [7]. The analyses are being carried out to prepare a comprehensive inventory of medicinal plants and information on phytochemistry, pharmacology and pharmacognosy is being enriched. Most of the medicinal plants are being extracted for drug and pharmaceuticals industries from wild populations. This has adversely affected very survival of a number of plants of high commercial value. The traditional medicines use the drugs that are derived either from whole plant or from different plant parts like leaves, stem, bark, root, flower, seed, etc., even some drugs are also prepared from the excretory plant products such as gums, resins and latex. The Allopathic system of medicine has also adopted a number of plant-derived drugs which form an important part of the modern pharmacopoeia. The plant-derived drugs not only offer a stable and mounting market worldwide, but the plants continue to be a chief source for new drugs and nutraceuticals. The plant kingdom synthesizes diverse range of novel molecules, called phytochemicals, which are secondary metabolites synthesized by plants. These secondary metabolites are, in principle, non-essential to life but they unquestionably contribute to the overall species fitness and survival. The plants produce secondary metabolites and are accumulated in various organs like leaf, root, stem, bark, flowers, fruits, etc. for immediate and future use. These secondary metabolites are classified as steroids, terpenoids, flavonoids, glycosides, alkaloids etc. based on their chemical structure. The above mentioned various natural compounds present in plants can act almost on all systems of the body and have high therapeutic activity. *Chamaecostuscuspidatus* (Nees & Mart.) C. Specht & D. W. Stev. is a perennial herb, a beautiful and well-known medicinal plant due to its anti-diabetic property, hence commonly called as Insulin plant. It is native of south and Central America and is recently introduced in India during 2002-03. It is being widely cultivated in south India as an ornamental plant, especially in Kerala [7]. It is commonly called as fiery costus or spiral flag.

DISTRIBUTION OF *Chamaecostus cuspidatus*

Chamaecostus cuspidatus, commonly known as “fiery costus” or “spiral flag” belonging to costaceae family. The different synonyms of this plant are *Costuscuspidatus*, *Costusigneus*, *Globbacuspidatus*, *Costus pictus* [38].It is native to primary Atlantic rainforests, deep shade in south-eastern Brazil (state of Bahia and spiritosanto) [57]. It is tropical in distribution [1;13]. The geographical distribution is varied seasonally dry forest of south west Amazonia. It has a distribution that is completely outside Amazonia domain [38].

It is an introduced plant in India from South and Central America [19]. In the southern India, it usually grows as an ornamental plant and also run as wild [1]. It is cultivated in Kashmir and the Himalayan regions for its roots. It has a close relation to gingers

and was originally a part of the Zingiberaceae family. It is used for treating diabetes by the tribal people of Kohli hills of Namakhel district, Tamil Nadu [14]. Due to its anti-diabetic properties, the plant is commonly called as insulin plant in India [38].

TAXONOMIC POSITION [38]

Insulin plant belongs to the family of costaceae. It consists of eight major species of genus *Chamaecostus* i.e. *C.cuspidatus, C.subsessilis, C.lanceolatus, C.congestiflorus, C.fragilis, C.curcumoides, C.fusiformis, C.acaulis.*

Domain: Eukaryota
Kingdom: Plantae
Subkingdom: Viridaeplantae
Phylum: Tracheophyta
Subphylum: Euphyllophytina
Infraphylum: Radiotopses
Class: Liliopsida
Subclass: Commelinidae
Superorder: Zingiberanae
Order: Zingiberales
Family: Costaceae
Subfamily: Asteroideae
Tribe: Coreopsideae
Genus: *Chamaecostus*
Specific epithet: *C. cuspidatus*

IDENTIFICATION

Chamaecostus cuspidatus (Nees& Mart.) C.Specht&D.W.Stev. (Maas, Flora Neotropica No.18, 1972) [9].

HABIT AND HABITAT

Chamaecostus cuspidatus is small, non- aromatic herbaceous plant. It is caulescent in habitat. It grows well in large rocky outcrops and in rocky soil with ample moisture. It is rare in wild but widely cultivated. Growth and propagation by division of the clumps, cutting or by separating the offsets or plantlets from below the flower heads [41].

BOTANICAL DESCRIPTION OF *Chamaecostus cuspidatus*:

The insulin plant has rhizome running underground horizontally, striking out new fibrous roots out of their nodes, down into the soil [37].

Figure 1. *Chamaecostuscuspidatus* plant, showing its leaves, stem, rhizome, flower.

These are plants of low or very small height less than 1 meter in height at maturity. Stems erect from rhizome, branched, spirally contorted, and formed at the base by bladeless sheaths [10]. Leaves are simple, smooth, large, alternate, entire, oblong, evergreen, 4-8 inches in length with parallel venation [41]. Leaves are spirally arranged on stem, phyllotaxis monostichous. These tropical evergreen plants have leaves with light purple underside and are spirally arranged around stems, forming attractive clumps arising from underground root stocks. The inflorescence is open, globose, terminal on leafy stems. Flowers are beautiful, around 1.5 inch in diameter. They are epigynous, perfect and zygomorphic. It has a bright orange colour occurring on cone like heads at the tips of branches with broad flat irregular chopped labellum [10]. The petals are sweet and nutritious [16]. Calyx tubular, more or less deeply 2-3 lobed. Corolla 3- lobed, lobes basally fused, imbricate in bud, overlapping at maturity. Labellum large, obovate, thin, margin often crisped. Androecium- stamen with broad petaloid filament that curves forward and closes the entrance to the tube of the flower, tip turned, 2 bisporangiate theca attached below apex, introrsely dehiscing by longitudinal slits. Basal part of stamen and labellum get united into papillate tube. Stigma bilobed with two rounded dorsal appendages. Ovary bilocular, inferior, anatropous, placentation axile, ovules many arranged in two rows. Fruit is a capsule, inconspicuous, not showy (less than 0.5 inches) and green coloured [41]. Seeds are numerous, fleshy, cushion like aril, embryo straight, endosperm poorly developed, perisperm abundant with copious starch.

CULTIVATION AND PROPAGATION

Insulin plant needs full sunlight or half-shade for its growth due to its perennial nature. It thrives well in fertile soil with sufficient moisture; hence, it is mostly grown in areas close to water. It prefers sandy loam soil and a temperature of 35-40°C. The plants can be propagated by stem cuttings, fragmentation of clumps or detachment of the offsets or plantlets, found at the base of the flower heads [9].

BIOCHEMICAL AND PHYTOCHEMICAL CONSTITUENTS

The biochemical and phytochemical constituents comprise of steroids, triterpenoids, alkaloids, tannins, flavonoids, glycosides, saponins, carbohydrates, and protein [63]. Qualitative analysis of both wild plant and callus in various solvents showed the presence of phenols, alkaloids, flavonoids, and terpenoids in methanolic extracts in high amount. Insulin leaves after consecutive phytochemical screening were reported to be rich in protein, iron, and antioxidant components such as ascorbic acid, α-tocopherol, β-carotene, terpenoids, steroids, and flavonoids(Table) [10].The different parts of the insulin plant contain several essential oils (Table) [40].The leaves of insulin plant show the presence of distinct active principals like carbohydrates, triterpenoids, proteins, alkaloids, tannins, saponins, and flavonoids, etc.[42]. The leaves also contain other vital compounds like steroids and carbohydrate like roseoside, fatty acids like hexadecanoic acid, 9, 12- octadecanoic acid, tetradecanoic acid, ethyl oleate, oleic acid, and squalene [31]. In contrast, the stem is rich in terpenoid compound like lupeol and steroid compound such as stigmasterol [31].While the rhizome contains few important compounds like quercetin, diosgenin, a steroidal sapogenin etc. [46] the root is also rich in certain constituents like terpenoid, alkaloids, tannins, etc(Figure) [13]. The leaf, stem and rhizome of the insulin has multiple ethnobotanical uses in the tables mentioned below[44]

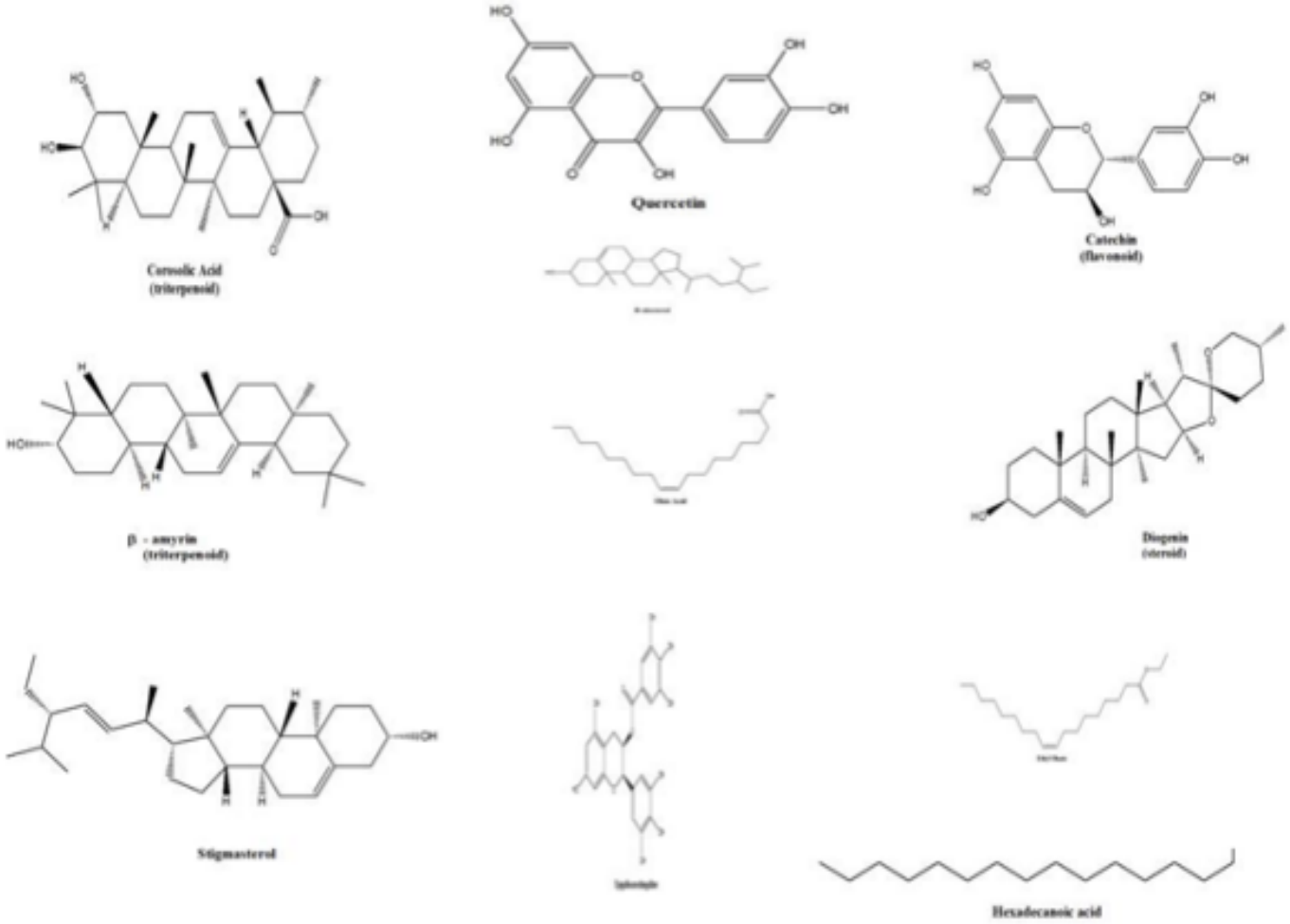

Figure2. Chemical Structure of the important bioactive compounds in *Chamaecostus cuspidatus* [13].

Table 2. Nutrient composition of the dehydrated sample [11].

Nutrient	Content
Moisture	4.0%
Total ash	6.3%
Protein	18%
Iron	40mg
Phosphorus	6.6mg
Calcium	5.1mg
Total phenols	4.4mg
Total flavonoids	0.848mg/g
β-carotene	667µg
α-tocopherol	149mg
Ascorbic acid	81mg
Fat	2.8%
Glutathione (GSH)	75mmol

Table.3 Parts of insulin plant, their individual constituents and essential oils in percentage.

Parts of the plant	Constituents identified	Content (in %)
Rhizome	Hexadecenoic acid	25.26
	12-octadecadienoic acid	7.74
	Dodecanoic acid	16.56
	Tetradecanoic acid	10.20
	Linalool	8.48
	α-Terpinol	4.44
Stem	Hexadecanoic acid	28.3
	12-octadecadienoic acid	18.33
	Dodecanoic acid	5.62
	Linalyl propanoate	6.03
	Tetradecanoic acid	4.82
	A-eudesmol	3.55
	Y-eudesmost	3.21
	4-ethoxy phenol	3.06
Leaf	Hexadecenoic acid	24.51
	2. pentanol	22.41
	Didecanoic acid	3.96
	β-ionone	8.69
	Farnesyl acetone	7.04
	α-ionone	8.01

Table 4. Ethnobotanical uses of different parts of Chamaecostuscuspidatus [44]

Plant Part Used	Traditional Uses	References
Rhizome	Treatment of fever, rash, asthama, bronchitis, intestinal worms, ailments to eyes, stomach, neck, jaws, tongue, mouth, edema, wheezing (dyspnoea) Haemorrhoids, spermaturia	[50]
Leaf	Diabetes is treated by leaves juice	[60]; [14]
Stem	In Siddha medicine system, it is used as powder (Choornam), decoction (Kudineer) and oil (Thylam)	[38]

MEDICINAL USES OF *Chamaecostus cuspidatus*:

C. cuspidatus has therapeutically potential and possesses number of pharmacological activities like antidiabetic, hypolipidermic, anticancer, diuretic, antioxidant, ameliorative, antimicrobial (Table 5) [45].

Table 5. Pharmacological activities of *Chamaecostuscuspidatus* [63].

Plant part	Reported Biological activity	Result	Reference
Leaf	Hypoglycemic	Decrease in blood glucose level by 75.70%.	
	Hypolipidemic	Noticeable decrease in total cholesterol, LDL, VLDL, phospholipids and triglyceride levels and increase in HDL levels.	[35]
	Antioxidant	A significant rise in enzyme levels such as SOD, CAT, and GSH. Full recovery of enzyme level shown at the	[54]

		highest dose, 600mg/kg. And a substantial reduction in MDA level also has been shown.	
	Antiurolithiatic	Reduction in the nucleation rate and growth of CHPD crystals at maximum induced by 1.00% of aqueous extract of leaves. But the activity was more for root and stem extracts.	[54]
	Antiproliferative	Reduction of the tumor size and 97.46% cytotoxicity rate was shown by the methanolic extract.	[63]
	Anti-inflammatory	At a given dose of 100 µg, isolated compound β-amyrin has shown 97% inhibition of paw edema.	[27]
	Prevent learning and memory deficit	Maintenance of their innate behavior andan improvement in their learning tendency was exhibited by *C.cuspidatus* treated diabetic rats. Also shown a marked improvement in the entrance latency and decrease in the time spent in the dark room.	
Stem	Antiurolithiatic	98.25% decline in the weight of CHPD crystals has been observed.	[54]
	Antioxidant	Exhibited substantial antioxidant activity.	[43]
	Antimicrobial	Methanolic extract showed significant antimicrobial activity.	[20]
Root	Antibacterial	Remarkable activity against for both gram positive and gram-negative bacteria was shown by Methanolic extract.	[20]
	Antioxidant	Maximum activity due to the presence of highest phenol content.	Ramya et al., 2015
Rhizome	Hypoglycemic	Reduction in blood glucose level by 68.26%.	[23]
	Antioxidant	Showed higher levels of SOD, CAT, and GSH.	[23]
	Hepatoprotective	Hepatoprotective potential is indicated by bringing AST, ALT to near normal levels.	[22]
	Hypolipidemic	Noteworthy reduction of TC, TG, LDL, VLDL, and attenuation of serum HDL levels.	[21]
	Antiurolithiatic	Weight reduction of CHPD crystals by 97.125% has been observed.	[57]
Whole plant	Hypoglycemic	Reduction of blood glucose level by 50.46%.	[39]

Antidiabetic Action:

Insulin plant is a nature's gift for the people who are suffering from diabetes [6]. It is widely used for treating diabetes (Table) [6]. The major compounds isolated from the insulin plant that show a high range of anti-diabetic activity are corosolic acid, quercetin, catechin, etc. (Table 6) [31].

Table 6. Summary of anti-diabetic effect of *Chamaecostus cuspidatus* [63].

Plant part	Extraction method	Animal/ Induction	Dose	% Reduction in glucose	Reference
Leaves	Alcohol extract	STZ induced Wistar rats	250mg	70.97%	[35]
			500mg	75.70%	
			DC	419.16±5.403	
Leaves 100g	Ethanolic extract	STZ induced Wistar rats	200mg	61.40%	[35]
			300mg	67.86%	
Glibenclamide			DC	280.11±19.33	
			5mg/kg	69.93%	
Leaves		Dexamethasone-induced (10 mg/kg/day) male Wistar rats	FBG		[52]
			250mg	24.35%	
Glibenclamide 500µg/kg			500mg	26.01%	
			DC	120.3±1.8	
			Drug	27.59%	
			PPBG		
			250mg	30.47%	
			500mg	33.91%	
			DC	182.8±1.7	
			Drug	31.56%	
Leaves	Ethanolic extract 500mg	Alloxan induced (150 mg/kg body wti.p.) adult albino rats of Wistar strain (150-200 gms) of either sex	500mg	21.78%	[2]
Glibenclamide 600µg/kg			DC	345.21±5.427	
			Drug	61.90%	
Leaves	Methanol extract	Alloxan induced (150 mg/kg body wti.e.,Male Wistar albino rats (150-200 gms)	50 mg/kg	52.44%	[30]
			100mg/kg	64.81%	
	aqueous extract		200mg/kg	69.08%	
			50mg/kg	48.47%	
Glibenclamide (0.5 mg/kg)			100mg/kg	59.76%	
			200mg/kg	67.52%	
			DC	295.0± 3.3	
			Drug	71.79%	
Leaves	crude extract	Alloxan induced (150 mg/kg body wt, i.p.)male albino rats (150-250 gms)	250 mg/kg	62.81%	[63]
Glibenclamide (5 mg/kg body wt)			500 mg/kg	55.84%	
			DC	349.17±1.01	
			Drug	58.03%	
Rhizome	Ethanol extract	STZ induced (40mg/kg bw,i.p.) Albino Wistar rats(150-200g)	100mg	63.30%	[21]
			200mg	68.26%	
			DC	285.13±1.315	
			Drug	62.64%	
Glibenclamide (0.5mg/kg bw per day)					
Whole plant	ethanol extract	dexamethasone induced	250mg	50.46%	[39]
			DC	283.00 ± 1.52	
Glibenclamide			10mg/kg	55.33%	

DC – Diabetic control STZ – Streptozotocin

Table 7. Major compounds isolated from *Chamaecostuscuspidatus* and their anti-diabetic mode of action [31].

Name of the compound	Mechanism of action	Reference
Triterpenoid (Corosolic acid)	Glucose uptake activity	[31]
Steroid (Diosgenin)	Hypoglycemic property	[31]
Steroid (β- sitosterol)	Increases plasma insulin level and also increases glucose uptake activity	[31]
Flavonoid (Quercetin)	Increases insulin mediated glucose uptaking and activity of antioxidant enymes	[43]
Phenol (catechin)	Inhibit α- glucosidase activity and antioxidant activity	[22]
Insulin like protein	Hypoglycemic activity	
Fatty acid (Oleic acid)	Hypoglycemic activity	[22]

Other medicinal uses:

Medicinal plants have provided the modern medicine with a variety of plant derived therapeutic agents [15]. Plants synthesize hundreds of chemical compounds for functions including primary metabolic processes, defense, growth, development etc [30]. Major classes of plant derived agents with disease preventing functions are dietary fibres, antioxidants, antimicrobials, detoxifying agents, immunity penetrating agents and neuromorphological agents [3]. Many are secondary metabolites, of which at least 12,000 have been isolated a number estimated to be less than 10% of the total [32]. It is estimated that more than 25% of modern medicines are derived from plants, either their direct part is useful or their secondary metabolites are of prime importance. The insulin plant has been reported to show several other biological activities (Table 7) ([8];[33];[55];[8]). The insulin plant is also rich in numerous biochemicals and bioactive compounds that show different pharmacological activity (Table 8 and 9) [12].

Table 8. Other mode of action of *Chamaecostus cuspidatus*

Sl.No	Mode of Action	Inference	Reference
1.	Hypolipidemic	Decrease in the level of cholesterol, triglycerides, LDL & increase in HDL.	[5]
2.	Antimicrobial	Enhanced invitro antifungal activity. Antimicrobial activity by Ag nanoparticle leaf extract	[58]
3.	Anti-inflammatory	β – amyrin found shows anti-inflammatory activity.Prevents COX -2, IL – 6, PGE2 via inhibition of NFκβ	[27]
4.	Antioxidant	Significant effect in reducing glutathione & SOD	[54]
5.	Antiproliferative	Potent cytotoxicity against MCF 7 cancer cell (apoptotic effect).	[12]
6.	Hepatoprotective	Prevent damage induced by paracetamol in liver.	[5]
7.	Ameliorative	Effect on mitochondrial enzymes in alcohol induced free radical toxicity.	
8.	Cognitive dysfunction	Effective on cognitive dysfunction	[12]
9.	Urinary Stones	Promote formation of COD crystals & reduce nucleation of COM crystals	[24]
10.	Hepatoproductive	Reverse oxidative stress in liver, pancreas (enzymes involved catalase, SOD, Glutathione)	[21]

Table 9. Important compounds in *Chamaecostuscuspidatus* and their biological role [44].

Phytochemicals	Biological activity	Extract	Plant part	References
Insulin like protein	Hypoglycemic activity	Acidified ethanolic extract		[17]
Lupenol	Anticancer, antiprotozoal, chemopreventive and anti-inflammatory properties		Leaves	[36]
Stigmasterol	Anti-peroxidative and hypoglycemic effects		Leaves	[36]
Quercetin	antioxidant, antiviral, anticancer, antimicrobial, anti-inflammatory	Methanol		[44]
kampeferol	antioxidant, antiviral, anticancer, antimicrobial, anti-inflammatory	Methanol		
Protein	Enzyme activity			[51]

Iron	Iron deficiency			[59]
Ascorbic acid	Vitamin- C deficiency			
α-Tocopherol	Vitamin E activity			
β-Carotene	Precursor of retinol			
Steroids	Precursor for sex hormones, adrenal cortical hormones, bile acids and sterols	Ethanol	Stem	[48]
Phytol	Antinociceptive And Antioxidant activities	Aqueous	Leaves	[62]
cis-9,10-Epoxyoctadecan-1-ol	Anti-microbial activity, antipest activity, etc	Aqueous	Leaves	
Oleyl alcohol	Anti-microbial activity	Aqueous	Leaves	
(Z)-14-tricosenyl formate	Antibacterial and antifungal activity	Aqueous	Leaves	
Dodecanal	Antimicrobial activity	Aqueous	Leaves	
Tridecanal	Antimicrobial activity	Aqueous	Leaves	
Undecanal	Antimicrobial activity	Aqueous	Leaves	[62]
Hexadecanedi-1,16-ol	Antimicrobial activity	Aqueous	Leaves	
Undecanoic acid, 2-methyl	Antimicrobial activity	Aqueous	Leaves	
Decanoic acid, 2-methyl	Antimicrobial activity	Aqueous	Leaves	
Octanoic acid, 4-methyl, methyl ester	Antimicrobial activity	Aqueous	Leaves	
Acetamide, 2-amino	Antimicrobial activity	Aqueous	Leaves	
Urea, butyl	Antimicrobial activity	Aqueous	Leaves	
Octanoic acid, 2-methyl-	Antimicrobial activity	Aqueous	Leaves	
Butanoic acid, 2-methyl-	Antimicrobial activity	Aqueous	Leaves	
Pentanoic acid, 2-methyl-, butyl ester	Antimicrobial activity	Aqueous	Leaves	
Decanoic acid, 10-fluoro-, trimethylsilyl ester	Antimicrobial activity	Aqueous	Leaves	

9.3. Folkloric Uses of *Chamaecostus cuspidatus*

Insulin plant has also been mentioned in the Allopathic and Siddha system of medicine. In Siddha medicine, it is used to control diabetes, known that diabetic people eat one leaf daily to keep blood glucose level low [9]. It has a great therapeutic potential, it promotes longevity, treat fever, asthma, bronchitis, skin rashes and helps to eliminate intestinal worms [39]. Root of *Chamaecostus*has used as powder, decoction and oil [39]. In Mexico,infusion of aerial parts used in treatment of renal disorder [4]. In Philippines, it has become popular as an antidiabetic herbal medicine. The leaves are used as fresh, dried and powder forms.Various products of insulin plant are available in the market in different forms (Table 10) [63].

Table 10. Various Marketed products of *Chamaecostus cuspidatus* [63].

Product name	Category	Manufacturer
Insulin plant leaf powder (180g)	Dietary supplement	TheInsulinPlant.com, USA
KostamKeerai (*Costusigneus*) Capsule 500mg	Dietary supplement	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

TOXICOLOGY STUDIES

According to the US Food and Drug Administration (FDA), it must be important for researchers to search and isolate the novel bioactive compounds from plants in order to use them for different pharmacological activity and to also test their toxicity issues in animals as per the 21 Code of Federal Regulation Part 314. Ethanolic extracts of *Chamaecostus cuspidatus* leaves at doses of 50 mg/kg b.w up to the dose of 5000 mg/kg b.w, when administered, showed no toxic effects. Such observation was reached during the first four hours. Similarly, no deaths were reported after 14 days of observations; hence, the extracts were confirmed to be safe for use [10]. Another study exhibited toxicity at 250 mg/kg b.w. On administration of methanolic extracts of *Chamaecostus cuspidatus* leaves [10]. A case study of acute toxicity in animals showed that they were resistant to the aqueous and ethanolic extract of *Chamaecostus cuspidatus* stem at an extreme dose of 1000mg/kg b.w [10].

CONCLUSION

The treatment of diabetes using the *Chamaecostus cuspidatus* plant has no side effect still date. The anti-diabetic effect of its leaves is currently been tested in diabetic patients and the results are being analyzed. Further, studies reveal its role in various diseases, which opens up new clinical research areas. Investigations are needed to evaluate the mechanism of action of the compounds and standardization of herbal drugs using models and this in turn would be useful to provide many links to develop various kinds of anti-diabetic drugs in low costs. It can be further concluded that the *chamaecostus cuspidatus* is rich in the bioactive compounds such as tannins, flavonoids, alkaloids, saponins and glycosides. If those compounds are taken through diet can be an effective method for controlling diseases.

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