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### ETHNOBOTANICAL USES, PHYTOCHEMICAL AND PHARMACOLOGICAL PROFILES, AND TOXICITY OF *COSTUS AFER* KER GAWL. : AN OVERVIEW

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#### ABSTRACT

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Indiscriminate use of plants and herbs by indigenous people for the treatment of various diseases has attracted the interest of many researchers in science and medicine to undertake researches that will significantly unfold the medical importance, appropriate dose, mechanism of action as well as the toxic effect (if any) of these medicinal plants and herbs. *Costus afer* is part of these plants commonly used by traditional healers with a demonstrated effectiveness. In traditional medicine, it is mostly request for the treatment of inflammation, rheumatic and arthritic pains, sleepiness, cough and pneumonia, hepatic disorders, mental disorders, helminths, miscarriages, measles and other skin diseases, malaria and jaundice, urinary diseases, eye defects, hunchback, epileptic attack, hemorrhoids; as a cardiogenic remedy, laxative, diuretic, an antidote for poison and evil repellants. It is also used in some African countries for socio-cultural purposes such as preparation of ritual ornaments. Scientific investigations carried out on this plant also proved its high pharmacological profile. These include Anti-oxidant and radical scavenging, hypolipidemic, corrosion inhibition, hepatoprotective and hepatocurative, anti-inflammatory and analgesic, nephroprotective, anti-tumor and anticancer, antimicrobial and antibacterial, Hypoglycemic and anti-diabetic activities. Some bioactive components such as tannins, polyphenolics, cardiac glycosides, anthraquinones, flavonoids, terpenoids, saponins, alkaloids and steroids present in an appreciable amount in this plant's extract justify its numerous properties and uses by traditional practitioners, while its rich content in carbohydrate, crude fat and minerals validate its high nutritional value. Moreover, this plant's extract can be taken until a dose as high as 375mg/Kg of body weight without any risk of toxicity. This review study is an endeavor to give a detailed survey of the literature on the ethnobotanical uses, phytochemical and pharmacological profiles, as well as the toxicity of *Costus afer*.

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## Introduction

During the last decades, plants and herbs have played a crucial role as the primary source of remedies for human treatment, mostly in the developing countries. For instance, about 80% of the world population depends on the plants and their derived products for the management of their health problems. Moreover, an impressive number of modern drugs have been isolated from natural sources. *Costus afer* is one of those popularly used plants, due to its multiple medicinal virtues. Commonly known as gingerlily or bush cane, this plant initially classifies in the Zingiberaceae family, definitely belongs to the family of costaceae. It is one of the 150 species of tall, perennial, and rhizomatous herbs [1]. *Costus afer* is commonly found in moist or shady and river banks forest of West and Tropical African countries including Senegal, South Africa, Guinea, Nigeria, Ghana and Cameroon [2]. It is often planted in home gardens for medicinal

purposes. The plant is a monocot and a relatively tall, herbaceous, unbranched tropical plant with creeping rhizome. It is a perennial, rhizomatous herb that can attain a height of up to 4 m. Leaves are simple and arranged spirally. Sheath is tubular, closed, and green with purple blotches; ligule is 4–8 mm long, leathery, and glabrous; petioles are 4–12 mm long; blade is elliptical to obovate, 15–35 cm × 3.5–9.5 cm, base is rounded to subcordate, apex is acuminate, and margin is sparsely hairy, usually glabrous above, sometimes shortly hairy beneath. Flowers are bisexual and zygomorphic [3]. In the western part of Nigeria, it is called different names such as; “like omode”, “ireke ogun” while it is called “okpete” or “okpoto” in Igboland, “Kakizawa” in Hausa and “Mbriem” in Efik and anglophone Cameroon calls it “Monkey sugar cane”[4], while francophone Cameroon calls it “canne des jumeaux”, that means twins cane.

**Table 1:** Scientific Classification

<b>Kingdom:</b> Plantae	<b>Genus:</b> <i>Costus</i>	
<b>Class:</b> Liliopsida	<b>Species:</b> <i>Costus afer</i>	
<b>Order:</b> Zingiberales	<b>Scientific name:</b> <i>Costus afer</i> Ker Gawl.	
<b>Family:</b> Costaceae		
		<b>Plant images</b>

## Traditional Uses:

All the parts of this plant are involved in the traditional medicine, but the stem is the most used. Clinical conditions for which *costus afer* extracts are currently being used in folkloric medicine include inflammation, rheumatic pains, sleepiness, cardiogenic remedy, arthritis, cough, hepatic disorders, helminthic, miscarriages, measles,

malaria, eye defects, hunch back, epileptic attack, hemorrhoids and evil repellants. Also, it is used as laxative, diuretics, and had served as an antidote for poison [4-8]. In Nigeria, the plant extract is used as a medicament to treat goats with retained placenta [9]. In Ohafia, Abia State, Nigeria and in some parts of Anglophone Cameroon, the decoction of the plant is administered to

diabetic patients to alleviate the clinical signs [10]. *Costus afer* is a useful medicinal plant that is highly valued for its anti-diabetic, anti-inflammatory and anti-arthritis properties in South-East and South-West Nigeria [11]. In Ogba community of Rivers State, the leaf and stem of the when cutting and crushed into smaller bits, boiled together with the leaf and bark of *Alchornea cordiflora* is used for the treatment of hunch bark and malaria. Among the Ikwerre ethnic group in Rivers State, it is applied in various ways. The leaves are reputed to be an effective remedy for fever and malaria when boiled with leaves of *Carica papaya* (pawpaw), citrus species (orange) and bark of *Mangifera indica* (mango). The stem juice has traditional use for treatment of cough, measles and malaria in Aluu community of Rivers State. The juice of *Costus afer* is extracted and used as an instillation for eye inflammation and defects in Ogoni land, Rivers State. The young and tender leaves when chewed are believed to give strength to the weak and dehydrating patient. An infusion of the inflorescence is taken to treat stomach complaints. A stem decoction mixed with sugarcane juices are taken to treat cough, respiratory problem and sore throat. The smoke of dried stem is also inhaled to treat cough in Akenfa community of Bayelsa state. In Ogoniland of Rivers State, the leaf sap is used as eye drops to treat eye troubles and as nose drops to treat headache and malaria. In Akenfa community of Bayelsa State, stem sap is applied to treat urethral discharges, venereal diseases, jaundice and to prevent miscarriage. A stem decoction is widely used to treat rheumatoid arthritis in parts of the Niger Delta. An infusion of the dried aerial parts is used to treat hypertension in Ogbolom a community in Bayelsa state [7]. The stem is used as an enema to worms and hemorrhoids. The pulped stems taken in water are strongly diuretic. It is also chewed to treat nausea and to quench thirst. A cold water extract of the

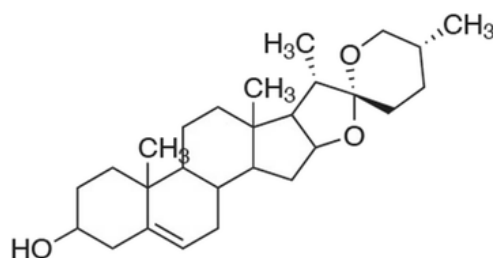
stem is used to treat small epileptic attacks. Rhizome pulp is applied to teeth to cure toothache. The rhizome decoction is taken to treat leprosy and venereal diseases in Ogboloma, Bayelsa State. In Aluu community of Rivers State the leaf and stem of *Costus afer* is used to treat gonorrhoea, for reduction of fat and as a source of water for grasscutter during the dry season [7]. The leaves are used as poultry feed additives to increase both the size and number of eggs of treated birds [12]. Rhizomes are used to treat pneumonia, rheumatism, dropsy, urinary diseases, jaundice, skin diseases and leaves are used to treat mental disorders [13]. In Nigeria, the debarked stem is chewed to treat nausea and to quench thirst. In Gabon, the stem sap is rubbed on the body to treat colic [1]. Furthermore, *Costus afer* is used for other socio-cultural purposes such as preparation of ritual ornaments, wrapping of indigenous foods, mat making, and as feed for ruminant animals [9, 14]. Moreover the rhizome is an alternative source of diosgenin and generally used to control diabetes. In Ayurveda, the rhizomes are ascribed to be astringent, acrid, cooling, aphrodisiac, purgative, anthelmintic, depurative and expectorant. In Cameroon the decoction of this plant and *Zingiber officinale* rhizome in water is said to be a potent remedy against arthritic and rheumatic pains. The decoction of the whole plant is used to cure measles and other skin diseases. The same decoction is supposed to significantly lower blood sugar level and to contribute in the management of diabetes.

#### **Reported phytoconstituents**

Phytochemical screening in the extract revealed the presence of tannins, polyphenolics, cardiac glycosides, anthraquinones, flavonoids, terpenoids, alkaloids and steroids [12, 15, 16]. The rhizomes of *Costus afer* contain several steroidal sapogenins (diosgenin), aferosides, dioscin and paryphyllin C and flavonoid glycoside kaempferol 3-O- $\alpha$ -L-

rhamnopyranoside [1], oxalic acid, lanosterol, trigogenin, stigmasterol, sitosterol, costugenin and a new steroidal saponin aferoside A [17, 18]. Sesquiterpenoids are the most abundant group of volatile compounds in the essential oil of the leaf [19]. In another study conducted by Nduka Anyasor *et al.*, qualitative analysis detected the presence of alkaloids, saponins, diterpenes, triterpenes, phytosterol, phlobatannins, and tannins in both *n*-butanol fractions of *Costus afer* leaf and stem. Phenols were detected in leaves alone while flavonoids were present in stem alone. Some bioactive compounds were isolated in the *n*-butanol fraction of *Costus afer* leaf, it is: indolizine, 2-methoxy-4 vinyl phenol, phytol, hexadecanoic acid-methyl ester, *n*-hexadecanoic acid, 9,12-octadecanoic acid-methyl ester, eicosane, *cis*-vaccenic acid and oleic acid while *n*-butanol fraction of *C. afer* stem contain benzofuran, 2,3-dihydro, 2-methoxy-4 vinyl phenol, 9-octadecenoic acid (*Z*)-2-hydroxy-1-(hydroxymethyl) ethyl ester, campesterol, stigmasterol, hexadecanoic acid-methyl ester, *n*-hexadecanoic acid, and *cis*-vaccenic acid. Rosemary *et al.* also found ten compounds in the ethanol extract of *Costus*

afer, including: *n*-Hexadecanoic acid forming the bulk of the oil (27.35%), followed by 4-methyl-4-hapten-3-one (24.27%), Oleic acid (18.79%), Stearic acid (10.27%), 3,5-Dihydroxy-6-methyl-2,3-dihydro-4H-pyran-4-one (8.46%). Other compounds present were Furfural (2.46%), 6-Methyl-3(2H)-Pyridazinone (1.75%), etc. The proximate analysis [20] revealed that the carbohydrate content was highest in the leaf ( $55.83 \pm 3.71\%$ ) and stem ( $50.38 \pm 1.27\%$ ) while the crude fat content was lowest in the leaf ( $1.83 \pm 0.43\%$ ) and stem ( $1.75 \pm 0.48\%$ ). The minerals detected in appreciable quantity in both the leaf and stem samples were calcium, magnesium, potassium, sodium, chromium, lead, manganese, nickel, and copper. The findings from these studies indicate that *Costus afer* could serve as a source of nutrient and minerals for animal nutrition and human metabolism. Moreover, the bioactive compounds identified in the various solvent's fractions of *Costus afer* support the traditional use of its leaves, stem and rhizomes extracts in the treatment of oxidative stress associated diseases, including rheumatoid arthritis and hepatic disorder.



Chemical structure of diosgenin, the main bioactive compound of *Costus afer* plant [21]

### Pharmacological profiles

Scientific investigations on *Costus afer* proved the tremendous pharmacological and nutritional values of this plant which validate its various traditional uses for the treatment of various diseases. The most important are:

### Anti-oxidant and Radical Scavenging Activities:

Many scientific studies have demonstrated the antioxidant activities of *Costus afer* extracts *in vitro* [15, 16, 19, 20, 22]. Akaninwor *et al.* [16] in their work proved the *in vitro* radical scavenging activities of *costus afer*. In fact, the extracts

scavenged the 2, 2-diphenyl-1-picrylhydrazyl radical, and also hydroxyl radicals and hydrogen peroxide in a concentration-dependent manner. Another antioxidant study conducted by Okugbo et al revealed that *Costus afer* extract had high DPPH radical scavenging (IC<sub>50</sub> of 156.48 µg/ml), FRAP (12.25 µmol Fe (II)/g), and TBARS (42.5%) [22]. These findings support local claims of its therapeutic virtues and suggest that *Costus afer* extracts could serve as free radical scavengers, acting possibly as primary antioxidants which could be used in the treatment or management of disease caused as a result of oxidative damaged like malaria.

**Hypolipidemic activity:** Emeh et al carried out a study to evaluate the hypolipidemic activity of aqueous extract of *Costus afer* stems in diet-induced hyperlipidemic rats [23]. Wistar albino male rats (100-135g) were then randomly distributed into 5 groups of 12 rats each. Group, I received water and normal diet; groups II, III, IV, and V were fed with high-fat diet (10g egg yolk/day) for 2 weeks. In addition to the hyperlipidemic diets 400, 800 and 1600 mg/kg, groups III, IV, and V rats received aqueous *Costus afer* extract for another 4 weeks. The body weights and plasma lipid profiles were measured at specific intervals (2 weeks). Results proved that the rats in all the groups gained weight: 19.44% for group I (Normal control), 104% for group II (Hyperlipidemic control), 45.45%, 40% and 57.43% for groups III, IV and V respectively. Treatment with *Costus afer* extract showed a significant ( $p < 0.05$ ) reduction in body weight, total cholesterol, triglycerides, LDL-cholesterol and atherogenic index and a significant ( $p < 0.05$ ) increase in the serum HDL-Cholesterol of treated groups when compared to untreated hyperlipidemic control rats (Group II). In addition, the extract reduced the liver microvesicular steatosis in hyperlipidemic rats. These findings demonstrate that *Costus*

*afer* extract possesses significant lipid-lowering activity in diet-induced hyperlipidemia, thus suggesting its beneficial role in the treatment of cardiovascular diseases.

**Corrosion inhibition activity:** Uwah et al investigated the corrosion inhibition performance of the ethanol extracts of *Costus afer* leaves on the corrosion of mild steel in 5M H<sub>2</sub>SO<sub>4</sub> solutions at 303K and elevated temperatures of 313, 323 and 333K using weight loss method (gravimetric) and hydrogen evolution (gasometric) techniques respectively [24]. The results indicate that the leave extract inhibits the corrosion of mild steel with maximum inhibition efficiency (93.1%) at 3.0g/L. Generally the inhibition efficiency was found to increase with increase in concentration of the leave extract but decreased with rise in temperature.

**Hepatoprotective and Hepatocurative activity:** Ayakeme et al in their research examined the immunomodulatory effect of the hepatoprotective activity of *Costus afer* methanolic extract on alcohol-induced liver cirrhosis in rats [25]. The hepatoprotective effect of this plant was measured in a rat model of alcohol-induced liver cirrhosis over 6 weeks. Hepatic cytochrome P450 2E1 and serum levels of transforming growth factor-beta (TGF-β) and tumor necrosis factor-alpha (TNF-α) were evaluated. Immunologic response mechanism of liver damage was significantly lower in the *Costus afer*-treated groups compared with controls, and effects of co-treatment were observed to be in a dose-response order. *Costus afer* stem extract modulates the expression of pro-inflammatory cytokines but had no effect on hepatic cytochrome P450 2E1 (CYP2E1) levels. The suggested that the progression of liver cirrhosis is inhibited by the antioxidant and anti-inflammatory activities of the plant and the normal status of the liver could be preserved. Other scientific studies also



proved the hepatoprotective activity of *Costus afer* leaf and stem crude extracts [15, 26]. These findings sufficiently support the present scientific world focus on developing traditional therapies as pharmacological medicines to treat liver cirrhosis.

**Anti-inflammatory and analgesic activity:**

A scientific study was carried out to estimate the anti-inflammatory activity of *Costus afer* in vitro and identify the chemical constituents in its most active fraction [27]. Hexane, ethyl acetate, n-butanol and aqueous fractions obtained through successive solvent partitioning of 70% methanolic leaf or stem extracts of *Costus afer* were subjected to in vitro anti-inflammatory screening assays viz. antidenaturation of protein, stabilization of human red blood cell (HRBC) membrane against hypotonicity-induced hemolysis and anti-proteinase activities. Diclofenac sodium was used as a standard drug. Results showed that hexane fraction of this plant's leaf with an IC<sub>50</sub> of 33.36µg/mL, 33µg/mL, and 212.77µg/mL exhibited the highest anti-denaturation of protein, stabilization of HRBC membrane and anti-proteinase activities respectively when compared with other test fractions. In another study, the chloroform and methanol extracts from the aerial parts of this plant showed anti-inflammatory activity as they reduce carrageenan-induced rat paw edema [2]. Chloroform-soluble fraction of the rhizome methanol extract also demonstrated an anti-inflammatory activity (64% oedema inhibition 50 mg/200µl, P<0.0001) [28]. This plant's extracts could, therefore, be considered as a potential source of anti-inflammatory agents for herbal formulation or pharmaceutical drug production against all forms of Arthritis, Rheumatism and other conditions associated with pain.

**Nephroprotective activity:** In a study, Uboh et al. demonstrated that *Costus afer* leaves' juice protected renal tissues against the nitrocellulose thinner-induced

nephrotoxicity as indicated by restoration of serum area, blood urea nitrogen, uric acid, and creatinine levels, as well as renal tissues malondialdehyde, glutathione peroxidase and superoxide dismutase activities to the control range [29]. Also, the tubular epithelial necrosis and atrophy of the glomeruli, observed to be associated with the exposure to the nitrocellulose thinner (one of the industrial commonly used solvent) were restored to the normal after treatment with *Costus afer* leaves' juice. It is obvious from this study that this plant's constituents are effective against nitrocellulose thinner-induced renal tissues damages and support the beneficial use of *Costus afer* in the treatment of various clinical disorders. Ezejiofor et al in their own work evaluated the nephroprotective and antioxidant properties of the aqueous leaf extract of *Costus afer* against cyclosporine A-induced nephrotoxicity in Wistar albino rats [30]. Treatment with *Costus afer* extract at doses of 375, 750 and 1125 mg/kg prevented the cyclosporine-A induced nephrotoxicity and oxidative impairments of the kidney, as evidenced by a significantly ( $p < 0.05$ ) reduced plasma creatinine, blood urea nitrogen (BUN), K<sup>+</sup> and renal malondialdehyde (MDA). Moreover, all the doses were able to induce a significant increment ( $P < 0.05$ ) of renal levels of glutathione (GSH) and plasma superoxide dismutase (SOD) activity, catalase (CAT), glutathione-S-transferase (GST), serum electrolytes (Na<sup>+</sup> and HCO<sub>3</sub><sup>-</sup>), body and kidney weight. The nephroprotective effects of *Costus afer* extract were confirmed by a reduced severity of renal cellular damage. Aqueous extract of *Costus afer* leaves was shown in another work to also attenuate gentamicin-induced nephrotoxicity in rats [31]. Hence aqueous leaf extract of this plant has a protective role against many sources of induced nephrotoxicity, probably mediated through its antioxidant properties.

**Anti-tumour and anticancer activities:**

Selim and Jaouni conducted a work to estimate the *in vitro* anticancer and apoptotic effects on cell proliferation of diosgenin isolated from *Costus species* [21]. The results indicated that the treatment of HepG2 cells with the sample resulted in a cytotoxic effect as concluded from the IC<sub>50</sub> value 32.62 µg/ml, while the treatment of HepG2 cells with paclitaxel, a known anti-cancer drug, resulted in an IC<sub>50</sub> value of 0.48 µg/ml. The treatment of MCF-7 cells with the tested sample resulted in high inhibition in the cell viability, and resulted in an IC<sub>50</sub> value of 11.03 µg/ml, while the treatment of MCF-7 cells with paclitaxel resulted in an IC<sub>50</sub> value of 0.61 µg/ml. The levels of DR4 and caspase-3 were significantly increased ( $P < 0.01$ ) in MCF-7 cells treated with the tested sample compared to untreated cells and possessed a similar activity of paclitaxel in DR4 induction but lower induction in caspase-3. On the other hand, the treatment of macrophages or lymphocytes with diosgenin (250 µg/ml) resulted in an induction in the cell proliferation up to 3.2-fold and 2.1-fold of control, respectively. The present study, therefore, shows the efficacy of diosgenin for the cytotoxicity towards MCF-7 cells thus suggesting protection against breast cancer.

**Antimicrobial and antibacterial activity:**

Akpan et al conducted a work designed to evaluate the antibacterial effect of ethanolic leaf extract of *Costus afer* on bacterial strains including Gram-positive organisms: *Streptococcus pneumoniae*, *Streptococcus pyogenes* and *Staphylococcus aureus*, and Gram-negative organisms: *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Escherichia coli* [32]. The concentrations used were 150mg/ml, 100mg/ml and 50mg/ml. All the organisms tested varied in their percentage susceptible to the extract of the plant leaves at different concentrations, except *Klebsiella pneumonia* which was 100% resistant. The Gram-positive

organisms were more sensitive to the plant extract than the Gram-negative organisms. *Costus afer* leaves can hence be used for the treatment of a disease associated with tested organisms. Duraipandiyar et al also conducted a work designed for evaluating the antibacterial and antifungal activities of *Costus afer* extracts, using Disc diffusion method and Minimum Inhibitory Concentration (MIC) [13]. Antibacterial and antifungal activities were observed in hexane, chloroform, ethyl acetate and methanol extracts. Two sesquiterpenoid compounds were isolated (costunolide and eremanthin) from the hexane extract. Both the compounds inhibited the tested fungi, with costunolide showing significant antifungal activity. The MIC values of costunolide were; 62.5 µg/ml against *Trichophyton mentagrophytes*, 62. µg/ml against *T. simii*, 31.25 µg/ml against *T. rubrum* 296, 62.5 µg/ml against *T. rubrum* 57, 125 µg/ml against *Epidermophyton floccosum*, 250 µg/ml against *Scopulariopsis* sp, 250 µg/ml against *Aspergillus niger*, 125 µg/ml against *Curvularia lunata*, 250 µg/ml against *Magnaporthe grisea*. Hence hexane extract showed promising antibacterial and antifungal activity. In another study, the aqueous leaves and stem extracts showed significant antibacterial and amoebicidal activity *in vitro* [17]. Together, these studies support the traditional use of *Costus afer* for the management of infectious diseases.

**Hypoglycemic and anti-diabetic activity:**

Many scientific studies focused on the use of *Costus afer* for the reduction of blood glucose, serum total cholesterol, triglyceride, LDL cholesterol, alterations in the expression of insulin (I&II) and gluconeogenic genes, DNA Fragmentation, and the restoration of the altered plasma enzyme (AST, ALT, LDH, ALP and ACP) levels to near normal [33-35]. Tchamgoue et al evaluated the inhibitory activity of *Costus afer* extracts against carbohydrate hydrolyzing enzymes [34]. Hexane, ethyl

acetate, methanol, and water extracts were prepared from the leaf, stem, and rhizome of the plant and subjected to phytochemical screening, assayed for  $\alpha$ -amylase and  $\alpha$ -glucosidase inhibitory activities and antioxidant capacity (determined by total phenolic and total flavonoids contents, ferric reducing antioxidant power (FRAP), and DPPH radical scavenging activity). All extracts inhibited  $\alpha$ -amylase and  $\alpha$ -glucosidase activities. Ethyl acetate rhizome and methanol leaf extracts exhibited the best inhibitory activity against  $\alpha$ -amylase and  $\alpha$ -glucosidase (IC<sub>50</sub>: 0.10 and 5.99 mg/mL), respectively. All extracts showed antioxidant capacity, with hexane extracts exhibiting the best activity. DPPH assay revealed that methanol leaf, rhizome, and ethyl acetate stem extracts (IC<sub>50</sub> < 5 mg/mL) were the best antioxidants. They suggested that the presence of bioactive compounds such as flavonoids, alkaloids, phenols, and tannins account for the antioxidant capacity and carbohydrate hydrolyzing enzyme inhibitory activity of the plant. Monago *et al* also on their part studied the effects of the aqueous stem extract of the plant on fasting blood glucose of streptozotocin-induced diabetic male rats [35]. Adult male Wistar strain albino rats were given graded doses (500, 1000 and 1500mg/kg) of the aqueous stem extract of *Costus afer*, and a standard hypoglycemic drug, metformin was co-administered with 500mg/kg of the plant extract for a period of 3, 6 and 9 weeks. *Costus afer* showed significant hypoglycemic effect ( $p < 0.05$ ) compared to a glucose level of the normal control rats. Also, a combination of plant extract and metformin caused a significant reduction in fasting blood sugar in the streptozotocin-induced diabetic rats. In the histological evaluation of the pancreas, the islet cells of the Langerhans of the pancreas were repopulated and preserved in all the groups treated with the plant extract and its combination with metformin contrary to the

diabetic control group whose islet cells were reduced. These results validate the use of *Costus afer* as a hypoglycaemic plant in native medicine. *Costus afer* could be a promising plant for the development of anti-diabetic drugs.

**Reported toxicity:** Ezejiofor *et al* conducted a work aimed at investigating the sub-chronic toxicity (28-day) of the aqueous extract of *Costus afer* leaves on the liver and kidney of male albino Wistar rats [36]. The results showed that the average body, organ, relative weights, feed and fluid intake were no significant changes ( $P > 0.05$ ) when compared to the control. The liver function tests (ALT, ALP, AST, CB, TB, and ALB) showed significant differences ( $P < 0.05$ ) in the test groups when compared with the control while TG showed no statistical difference ( $P > 0.05$ ). The kidney function tests (urea, creatinine, sodium, potassium, and bicarbonate) showed no significant differences ( $P > 0.05$ ) in the test groups when compared to the control. Dioka *et al* on their side observed no adverse effect level of *Costus afer* in the liver below 375 mg/kg and in the kidney till 1125 mg/kg [37]. Finally, Chukwunke and Chukwunonso investigated the acute and subchronic toxicity profiles of aqueous stem bark and leaf extract of *Costus* [38]. Acute oral toxicity studies in male and female mice did not produce any sign of acute toxicity or death even at the dose of 4,000 mg/kg. Thirty-six albino Wistar mice of varied sexes weighing between 28 and 35 g were divided into four groups. Groups A, B, and C were given different concentrations of the extract at 20, 13.33, and 6.67 mg/ml, respectively in water. Group D served as the control and was given only water. The experiment lasted for a period of 56 days. The packed cell volume, hemoglobin concentration, and the total red blood cell count decreased significantly ( $p < 0.05$ ) in comparison with the control. Serum biochemistry showed no significant changes



in the activities of alanine aminotransferase, aspartate aminotransferase, and alkaline phosphatase when compared with the control. The histopathological studies revealed no significant lesions in the heart, kidney, and liver. There were also no significant changes in weight between the experimental animals and the control. Hence, these studies show that this plant's extract can be safe taken since the toxic doses are difficult to reach.

### Conclusion

*Costus afer* is among the plants currently involved in the treatment of various diseases, and particularly diabetes and diseases associated with inflammation. Pharmacological test carried out on this plant's extracts for its Anti-oxidant and radical scavenging, hypolipidemic, corrosion inhibition, hepatoprotective and hepatocurative, anti-inflammatory and analgesic, nephroprotective, anti-tumour and anticancer, antimicrobial and antibacterial, Hypoglycemic and anti-diabetic activities give positive results without any risk of toxicity, even at dose as high as 375mg/Kg of body weight. bioactive components such as tannins, polyphenolics, cardiac glycosides, anthraquinones, flavonoids, terpenoids, saponins, alkaloids and steroids present in an appreciable amount in this plant's extract justify its numerous properties and use by traditional practitioners, while its rich content in carbohydrate, crude fat and minerals validate its high nutritional value. We sincerely hope that the data provided in this review will stimulate researchers to undertake more studies for a proper evaluation of this plant extracts which could lead to the discovery of new purified compounds and thereby, new and more potent drugs.

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