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Review Article

A Review on the Antidiabetic, Antioxidant, Antidyslipidemic, and Hepatoprotective Effects of *Coccinia grandis*

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Abstract: Since ancient times, *Coccinia grandis* has been utilized for its numerous health benefits. Furthermore, it provides nutritional and therapeutic benefits without being harmful. *Coccinia grandis*, a member of the Cucurbitaceae family, has been used traditionally to treat metabolic syndrome and skin conditions. Because this plant contains a variety of chemical constituents, such as phenolic acid, flavonoids, terpenoids, alkaloids, glycosides, carotenoids, sterols, and coumarins, among others, researchers have determined through various animal studies that different parts of this plant exhibit desirable pharmacological effects, including antidiabetic, anti-hyperlipidemic, antioxidant, and hematopoietic effects.

Keywords: Antidiabetic, Antihyperlipidemic, Antioxidant, Telakucha, Cucurbitaceae*; Coccinia grandis*; oxidative stress, Hepatoprotective

1. Introduction

A member of the Cucurbitaceae family, *Coccinia grandis* (L.) is a perennial climbing vine that grows quickly (2). Additionally, *Coccinia grandis* is an East African native plant that has spread by seed to various parts of tropical Asia and the Pacific region (3). Not only is this plant used in traditional medicine extensively but also as a nutritious vegetable. Almost any part of the plant has been used as a traditional medicine in Asian countries to treat skin diseases such as leprosy, acne, scabies, and wounds. It has also been used to treat poisoning, malaria, jaundice, and hepatitis, and it is now traditionally used to treat diabetes and obesity (4). Moreover, In Southeast Asia, the squashed fresh leaves of this plant are used as a traditional herbal treatment for bruises and itching from bug bites. This process is done by applying the crushed leaves directly to the lesion. So, it was also added as one of the traditional home remedies used to treat common illnesses (5). The whole plant of *Coccinia grandis* having pharmacological activities like analgesic, antipyretic, anti-inflammatory, antimicrobial, antiulcer, antidiabetic, antioxidant, hypoglycemic, hepatoprotective, antimalarial, antidyslipidemic, anticancer, antitussive, mutagenic and the present review gives botany, chemical constituents, and pharmacological activities of *Coccinia grandis* (6, 7). For individuals recently diagnosed with type 2 diabetes mellitus, an herbal medication made from *Coccinia grandis* extract showed promise as a helpful treatment. The medication was safe, well tolerated, and greatly improved glycemic and lipid profile parameters in randomized and controlled clinical trials (8). Evidences also suggest that the plant's ethanolic extract may be safely incorporated into herbal remedies for the clinical development of antibacterial

activity against strains of bacteria that are resistant to many drugs (3). This review focuses on the pharmacological responses of the sections of the *Coccinia grandis* plant in this study, which include hepatoprotective, antioxidant, antihyperlipidemic, and antidiabetic activities.

2. Morphological Characteristics

2.1 Synonyms of Coccinia grandis

Many names are associated with *Coccinia grandis*, including Staphylosyce, Physedra, Cephalandra indica, Coccinia indica, and Coccinia cordifolia. It is known by various names, including kundru (Urdu), tindoli (Oriya), ivy gourd (English), and scarlet gourd. (9-11) In Bangladesh, it is known as Telakucha (12).

2.2 Taxonomy and visual inspection

Kingdom: Plantae; Order: Cucurbitales; Family: Cucurbitaceae; Genus: *Coccinia;* Species: *Coccinia grandis* (L.) (13, 14)

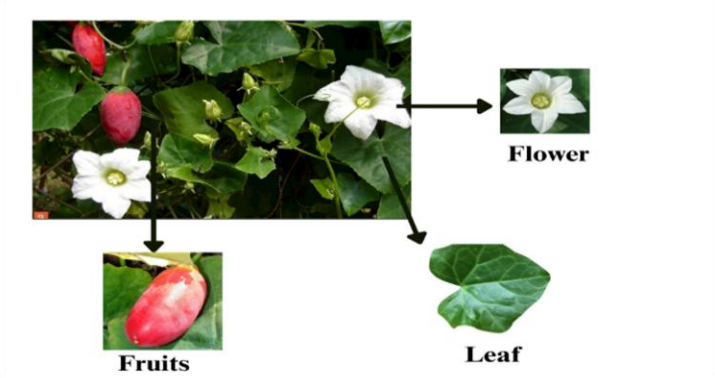


Figure 1: Different parts of *Coccinia grandis* (L.) Voigt

2.3 Distribution of Coccinia grandis

In different subtropical and tropical places of the world, as garden vegetables, sometimes *Coccinia grandis* (Ivy gourd) is cultivated. In the case of Asia, India, and central Africa, it is native. In the case of its base, which humans have obscured, there are also some important aspects of the process that are available, such as transportation, cultivation, usage, and history. In the case of Southeast Asia, it is considered a common weed. In various countries, such as the Solomon Islands, Marshall Islands, Guam, Fiji, Vanuatu, Hawaii, Florida, and Texas, it is neutralized. While in India and Southeast Asia by the local people, it is known as a valuable wild vegetable (32).

2.4 Botanical description of Coccinia grandis

This plant is recognized for its significant morphological variation among wild accessions and cultivated varieties (33).

Parts of the plant	Description	Ref.
Leaves	10 cm wide, and the size and shape are similar to a heart or a pentagon shape. The lower part of the leaf is hairy.	(34)
Fruits	Oblong, color transformation green to bright red (during ripening)	(35)
Stem	Containing high-strength xylem fibers with an average diameter of 25 to 50 µm	(36)
Tendrils	It is used for climbing. Its biomimetic applications such as developing spring devices for holding objects.	(37)
Root fiber	It exhibits a porous xylem, a thin primary cell wall, and thick secondary cell walls with wide lumens, possessing a low density of 1.29 ± 0.005 g/cm³	(38)
Flowers	Exhibiting morphological variation based on the sexual phenotype. Both male and female flowers possess five petals and five sepals.	(34, 39)

Table 2: Different parts of *Coccinia grandis* plants, and their medicinal use

Parts of the plant	Pharmacological Activity and Traditional Use	Ref.
Leaves	Antidiabetic, Antihyperlipidemic, Anti-tyrosinase, Antioxidant (rich in beta carotene) Traditional Use: Skin eruptions, Burns, Tongue sores, psychosis, rheumatism, eczema, Syphilis.	(40, 41)
Fruits	Antidiabetic, Antioxidant, Anti-inflammatory, and antidyslipidemic activities. Traditional Use: Asthma, Bronchitis, Jaundice	(42, 43)
Roots	Antimicrobial Activity Traditional Use: Ulcers, Stomachache, Skin diseases, Jaundice.	(44, 45)

3. Phytochemical and Chemical Constituents

3.1 Phytochemical Composition of Coccinia grandis

The pharmacological properties of *Coccinia grandis* are attributed to its abundance of bioactive substances, such as triterpenes, amino acids, flavonoids, and phenolics(15, 16).

Table 3: Different parts of the plant *Coccinia grandis* and their compounds, with their properties

Plant's Part	Image	Compounds	Properties	Ref.
Leaves		Flavonoids, Phenolic acids, Terpenoids, Alkaloids, Sterols, Glycosides, Carotenoids	Antioxidant, antidiabetic, anti-inflammatory, and antidyslipidemic. Reported as phytochemicals, beta-carotene	(15, 17-20)
Fruits		Flavonoids, Phenolic acids, Terpenoids, Alkaloids, Sterols, Glycosides	Antioxidant, antidiabetic, anti-inflammatory, and antidyslipidemic	(16, 20)
Roots		Flavonoids, Phenolic acids, Terpenoids, Alkaloids, Sterols, Glycosides	Antioxidant, antidiabetic, anti-inflammatory, and antidyslipidemic	(20)
Stem		Flavonoids, Phenolic acids, Terpenoids, Alkaloids, Sterols, Glycosides	Antioxidant, antidiabetic, anti-inflammatory, antidyslipidemic	(20)
Other phytochemical constituents				
Various parts		Flavonoid glycosides, Carotenoids	Reported as phytochemicals, beta-carotene	(20)
Not Specified		Coumarins, Phenolics, Cardiac glycosides,	Reported as phytochemicals	(20)

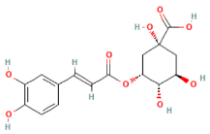
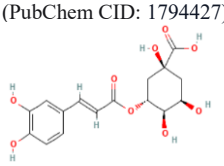
3.2 Nutrient composition of Coccinia grandis

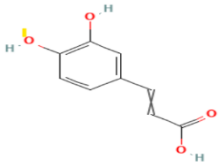
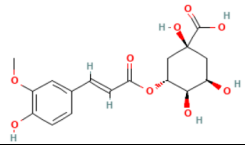
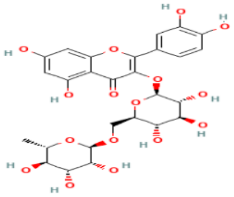
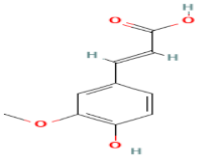
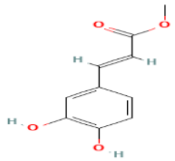
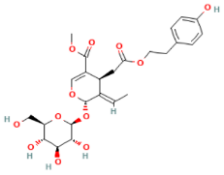
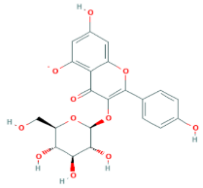
Table 4: Parts of *Coccinia grandis* with their nutrient compositions

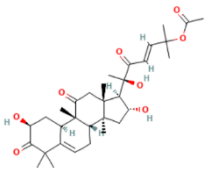
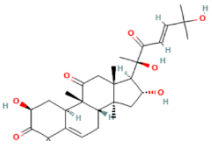
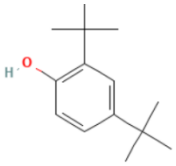
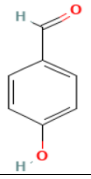
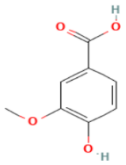
Plant's Part	Nutrient	Percentage/amount (Per 100g edible portion)	Ref.
Leaves	Minerals (Ca, Fe, Mg, Zn)	High	(21, 22)
	Hydroxycinnamic acids	1148.23mg/100g (dry)	(22)
	Flavonoids	82.8mg QE/g (Extract)	
Fruits	Protein	1.4g	(23)
	Carbohydrate	3.4g	
	Fat	0.2g	
	Calcium	25mg	
	Iron	0.9mg	
	Potassium	3.3mg	
	Phosphorous	1.15 mg	
	Sodium	0.95mg	
	Vitamin C	25.55mg	
	β-carotene	70.05 mg	
	Total Phenol	61.92 mg	
	Total Flavonoids	82.8 mg QE/g (Extract)	(24)
	Total Phenolics	11.7 mg GAE/g (Extract)	

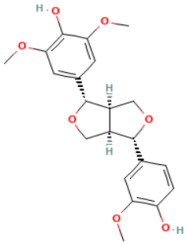
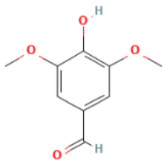
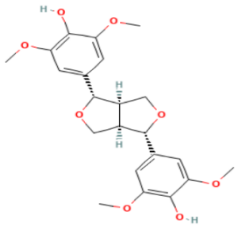
3.3 Chemical constituents of Coccinia grandis

Table 5: Parts of *Coccinia grandis* with their phytochemical constituents

Plant's Part	Compound Name	Percentage/ amount (if available)	Chemical Structure and Formula	Ref.
Leaf	5-O-caffeoylquinic acid	1220.79 ± 40.02 mg/kg dry matter	$C_{16}H_{18}O_9$ (PubChem CID: 5280633) 	(23, 25)
	3-O-caffeoylquinic acid	8999.13 ± 153.86 mg/kg dry matter	$C_{16}H_{18}O_9$ (PubChem CID: 1794427) 	
	3,4-dihydroxycinnamic acid	8.50 ± 0.23 mg/kg dry matter	$C_9H_8O_4$ (PubChem CID: 2518)	

			
3-O-feruloylquinic acid	58.39 ± 1.79 mg/kg dry matter	$C_{17}H_{20}O_9$ (PubChem CID: 9799386) 	
Rutin (quercetin-3-O-rutinoside)	0.139 mg/kg dry matter	$C_{27}H_{30}O_{16}$ (PubChem CID: 5280805) 	(25, 26)
Ferulic acid	Not quantified	$C_{10}H_{10}O_4$ (PubChem CID: 445858) 	
Methyl caffeate	Not quantified	$C_{10}H_{10}O_4$ (PubChem CID: 689075) 	(25, 27)
Ligstroside	Not quantified	$C_{25}H_{32}O_{13}$ (PubChem CID: 14136859) 	
Kaempferol-3-O-β-D-glucoside	Not quantified	$C_{21}H_{20}O_{11}$ (PubChem CID: 25203515) 	(25, 27, 28)

	n-Tetracosane (essential oil)	39.18% of essential oil	$C_{24}H_{50}$ (PubChem CID: 12592) 	(25, 29)
	n-Eicosane (essential oil)	30.04% of essential oil	$C_{20}H_{42}$ (PubChem CID: 8222) 	
Fruit	Cucurbitacin B	0.28 mg/g dry matter	$C_{32}H_{46}O_8$ (PubChem CID: 5281316) 	(25, 26)
	Cucurbitacin D	1.282 mg/g dry matter	$C_{30}H_{44}O_7$ (PubChem CID: 5281318) 	
Stem	2,4-Di-tert-butylphenol		$C_{14}H_{22}O$ (PubChem CID: 7311) 	(25, 30)
	4-hydroxybenzaldehyde		$C_7H_6O_2$ (PubChem CID: 8468) 	(25, 31)
	Vanillic acid		$C_8H_8O_4$ (PubChem CID: 8468) 	
	(+)-Medioresinol		$C_{20}H_{22}O_6$ (PubChem CID: 181681)	

	
	$C_9H_{10}O_4$ (PubChem CID: 8655)
Syringaldehyde	
	$C_{22}H_{26}O_8$ (PubChem CID: 443023)
(+)-Syringaresinol	

4. Therapeutic response of *Coccinia grandis*

4.1 Antidiabetic effect

To comprehend the antidiabetic action of *Coccinia grandis*, it is essential to understand the fundamental pharmacological mechanism of an animal model of diabetes. All of the data pertaining to beta cell malfunction, insulin resistance, and two major risk factors for diabetes mellitus have been compiled. The liver, muscle, and fat cells are less responsive to insulin, particularly in individuals with Type 2 diabetes mellitus (T2DM). This reduces the body's ability to absorb glucose, causing the liver to continually produce glucose even when the body doesn't need it. Insulin resistance is caused by a variety of factors, including genetics, obesity, chronic inflammation, excess fatty acids, and dysregulated adipokines (46, 47). The inability of the pancreatic beta cells to perform their intended tasks may result in the release of sufficient insulin to overcome resistance. Beta cells are further harmed by lipo-toxicity and glucose toxicity, which facilitate their degradation (47, 48). The normal insulin pathway is depicted in **Figure 2.**

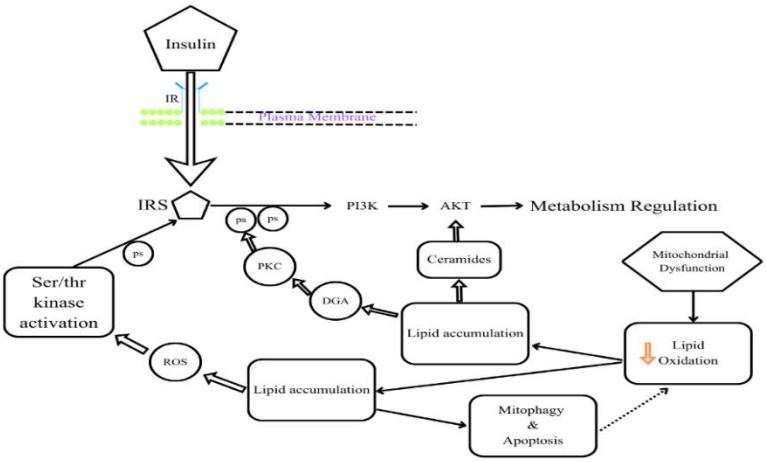


Figure 2: Normal Insulin Signaling Pathway in this figure In this diagram, IR- Insulin Receptor, IRS- Insulin Receptor Substrate, PKc- Protein Kinase C, ROS- Reactive Oxygen Species, Ps- Phosphorylation, DAG Diacylglycerols, PI3K-Phosphoinositide-3-kinase (1)

Table 5: The key factors in insulin resistance and beta-cell dysfunction

Factor/Mechanism	Insulin Resistance	*β*-Cell dysfunction	Ref.
Obesity/Free Fatty Acid	✓	✓	(49-52)
Inflammation	✓	✓	(51, 52)
Oxidative/ER Stress	✓	✓	(52-54)
Genetic /Epigenetic	✓	✓	(53)
Amyloid Deposition	×	✓	(52)

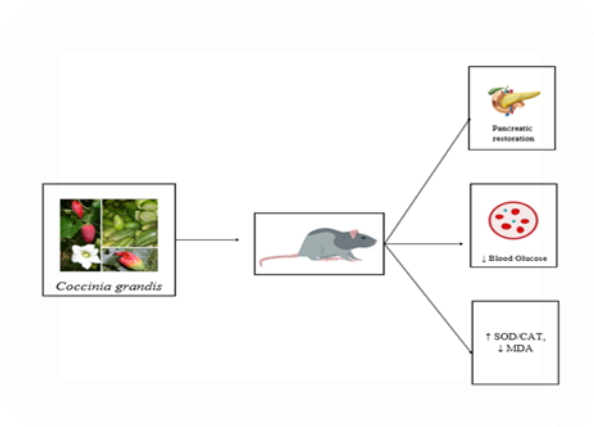


Figure 3: Antidiabetic effect of *Coccinia grandis*

4.2 Antihyperlipidemic effect

The term 'hyperlipidemia' refers to the condition characterized by abnormally high levels of lipids in the human systemic circulation, primarily triglycerides (TG) and cholesterol. The body produces, absorbs, transports, and eliminates lipoproteins, which include chylomicrons, VLDL, LDL, and HDL, in an imbalanced way. High dietary fat intake, heredity, and insulin resistance are among the variables that influence cholesterol homeostasis. This imbalance may promote cardiovascular disease and result in the development of atherosclerosis(62-65). After eating a high-fat meal that has a lot of TGs, chylomicrons, and VLDL, the amount of lipoprotein goes up. In hyperlipidemic situations, these lipoproteins take longer to clear, which leads to a persistent rise in the number of particles in the blood(62, 65). VLDL and chylomicron residual balance depend on lipoprotein lipase activity. The primary role of lipoprotein lipase activity is compromised in cases of metabolic syndrome development, such as obesity and type 2 diabetes. Therefore, hyperlipidemia is a possibility(62, 63). Chronic inflammation and oxidative stress lead to the disruption of lipid metabolism and the development of endothelial dysfunction(64, 66-68).

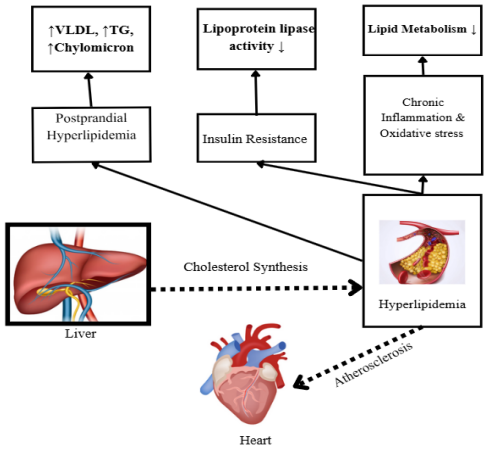


Figure 4: Mechanisms that are driving heart disease through the development of dyslipidemia.

Table 6: Cellular and organ effects of regular and impaired function in hyperlipidemia

Organ	Regular function	Impaired function	Ref.
Liver	Center of lipid synthesis, packaging, and clearance.	↑ VLDL, LDL Clearance impaired	(69, 70)
Heart and Vessels	Smooth blood flow to the cardiac cells	The development of Atherosclerosis may cause cardiac dysfunction	(63, 66)
Gut Microbiota	Keep balancing in bile acid metabolism and lipid absorption	Hyperlipidemia due to alter the bile acid metabolism and lipid absorption	(64, 71, 72)

According to research based on animal trials, *Coccinia grandis* extract exhibits antihyperlipidemic properties that can lower body weight and cholesterol levels (including triglycerides, VLDL, and LDL), while reducing the risk of vascular atherosclerosis.

Table 7: Evidence from animal studies is gathered to understand the effect of *Coccinia grandis* as an antidiabetic and antihyperlipidemic agent.

Animal Model	Disease Group, Treatment & Standard Drug	Toxicity	Pharmacological Activity	Ref.
HFD-induced Wistar Rat	*Coccinia grandis* leaf extract (ethanolic) (2 mg/g (~2000 mg/kg)) for 5 weeks	N/A	↓TC,↓LDL, ↓ VLDL, ↓ TG; ↓ Body weight with ↑ HDL;	(73)
HFD -induced Wistar Rat	*Coccinia grandis* leaf extract (ethanolic) (900 mg/kg) for 28 Days	N/A	↓ TC, ↓ TG, ↓LDL with ↑ HDL	(74)
HFD-induced Wistar Rat	*Coccinia grandis* leaf extract (ethanolic) (Medium/high dose) for 28 days	No toxicity up to 2000 mg/kg	↓ TG, TC; No significant effect on HDL/LDL; Improved SGPT, SGOT	(75)
HFD-induced Hamsters	Chloroform fraction (polyprenol) (50mg/kg)	N/A	↓ TG (42%), TC (25%), Gly (12%); ↑ HDL/TC ratio; Effect comparable to Fenofibrate	(76)
STZ-induced Sprague Dawley rats	Methanolic extract (leaves) (125,250,500 mg/kg) for 28 days	No toxicity up to 2000 mg/kg	↓ TC, TG, LDL with ↑ HDL	(77)
Alloxan-induced Mice	Methanolic Extract (100mg/kg (2x/day)) for 21 days	No toxicity up to 1000 mg/kg	↓ TC, TG, LDL; ↑ HDL;	(77)
Dexamethasone-induced hyperlipidemia in Rats	Ethanolic extract (fruits)(400mg/kg)	N/A	↓ TC, TG, LDL, VLDL with ↑ HDL; Effect better than Atorvastatin	(78)

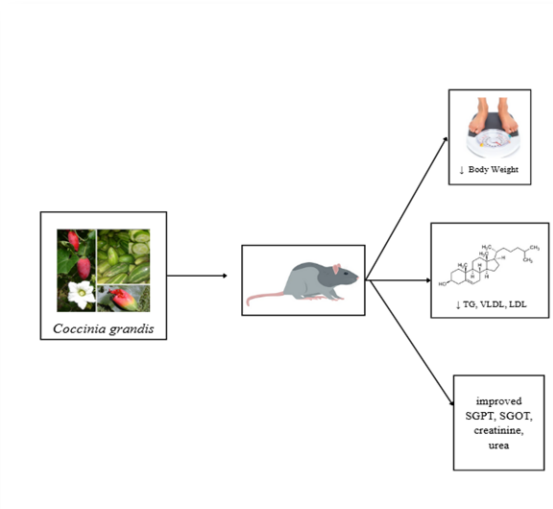


Figure 5: Antihyperlipidemic effect of *Coccinia grandis*.

4.3 Antioxidant effect

When the body produces more free radicals than it can counteract, primarily reactive oxygen species (ROS) and reactive nitrogen species (RNS), the state is known as oxidative stress. Both endogenous (normal physiological processes) and exogenous (external exposures) pathways may produce these free radicals. The mitochondrial electron transport chain generates highly reactive hydroxyl radicals (•OH) during the process of ATP synthesis. During the synthesis of ATP, superoxide (O2•) is first produced and then radicals (into hydrogen peroxide (H2O2). Extremely reactive hydroxyl free radicals are produced by the Fenton reaction.(79-81). Numerous studies indicate that several enzymes, including nitric oxide synthase, cytochrome P450, xanthine oxidase, and NADPH oxidase, may be involved in the production of ROS and RNS during immunological and metabolic processes (79-81). The generation of lipid radicals and peroxyl radicals can be produced due to the initiation of the chain reaction by abstracting hydrogen from polyunsaturated fatty acids in membranes(79, 80). During a respiratory burst can be produced a large number of ROS/RNS during the activation of immune cells, including macrophages and neutrophils, to destroy pathogens (79, 81-83). Several external environmental factors are responsible for stimulating the production of free radicals in the body, including Ultraviolet and ionizing radiation, pollution, cigarette smoke, certain drugs, and heavy metals. These factors can generate free radicals or stimulate their production in tissues. (79, 81, 82).

According to some research-based data, *Coccinia grandis* extract contains antioxidant properties that can help lower the body's oxidative stress levels by reducing the formation of highly reactive oxygen and nitrogen species.

Table 8: The antioxidant activity of *C. grandis* in multiple animal model studies:

Animal Model	Disease Group, Treatment & Standard Drug	Toxicity	Pharmacological Activity	Ref.
Ethylene glycol-induced Rats	Ethanolic fruit extract	N/A	Significant in vitro antioxidant activity (DPPH, NO scavenging); in vivo anti-urolithiatic	(84)
MSG-induced Wistar rats	*Coccinia grandis* fruit extract	N/A	↓Oxidative Stress, ↓ Lipid peroxidation, ↓Inflammation, Apoptosis via NF-kB/caspase-3 inhibition	(85)
Potassium oxonate-induced Mice	Methanolic leaf extract	No toxicity up to 2000 mg/kg	Significant xanthine oxidase inhibition; ↓Serum urate, antioxidant effect comparable to Allopurinol	(86)

Seizure models (MES, PTZ, INH) in Mice	Hydroethanolic leaf extract (200/400 mg/kg)	N/A	Anticonvulsant and antioxidant activity; Higher dose showed greater effect	(87)

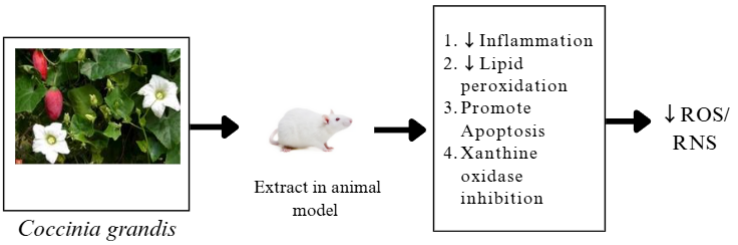


Figure 6: Antioxidant effect of *Coccinia grandis*.

4.4 Hepatoprotective effect

Multiple mechanisms, including direct injury, inflammation, and metabolic stress, may cause damage to hepatocytes. The primary processes that harm hepatocytes and result in fibrosis and inflammation include apoptosis, necrosis, pyroptosis, and organelle dysfunctions. The most widely used biomarker for liver function is the measurement of serum enzyme levels; however, other specialized biomarkers are increasingly available. The damage in hepatocytes may occur due to apoptosis (regulated cell death), necrosis (uncontrolled lysis), and pyroptosis (inflammatory cell death). The release of inflammasome particles is able to activate hepatic stellate cells and further drive them to fibrosis in the case of pyroptosis (88, 89)The production of DAMPs, or damage-associated molecular patterns, may occur in hepatocytes when certain essential organelles, including the mitochondria, lysosomes, and endoplasmic reticulum, sustain damage. These DAMPs have the ability to cause hepatocyte inflammation and further damage(89, 90).Cytokines, chemokines, and extracellular vesicles are released by a damaged hepatocyte, increasing inflammation and attracting immune cells. Additionally, this may stimulate hepatic stellate cells, which could lead to fibrosis (88, 89, 91, 92).Hepatic cell damage is caused by a variety of factors, including autoimmune illnesses, metabolic abnormalities, ischemia/reperfusion, alcohol use, viral hepatitis, and medications like paracetamol (89, 91).

Table 9: Biomarkers to understand liver function are given below

Biomarkers	What it measures	Additional information	Ref.
ALT (SGPT)-Alanine transaminase	Elevation of ALT indicates injury in hepatocytes	Widely Used	(93-95)
AST (SGOT)-Aspartate	Elevation of ALT indicates injury in hepatocytes	Commonly used	(93-95)
Albumin	Low-level albumin suggests chronic liver disease	Strength: Reflects protein synthesis and chronic damage	(96, 97)
Oxidative Stress Markers	BAP and dROMs are used method to understand the systemic oxidative balance.	MDA, SOD, and GPx are also indicative of oxidative stress in liver function	(98, 99)
Total Bilirubin (TB)	An elevated amount indicates a cholestasis condition, which may further lead to jaundice	It's reliable to ensure the liver dysfunction	(95)
Alkaline Phosphate	Elevation level indicates dysfunction in the liver	Further investigation is required to confirm liver involvement as cholestasis can also originate from the bone, intestinal, and placental tissues.	(94)

Table 10: Hepatoprotective effects of *Coccinia grandis* in animal models

Animal Model	Disease Group, Treatment & Standard Drug	Toxicity	Pharmacological Activity	Ref.
CCl_4 induced Wistar rats	Alcoholic fruit extract (250 mg/kg) for 14 days		↓ (SGOT, SGPT, ALP, Bilirubin) ; Effect comparable to Silymarin	(100)

CCl_4 induced Wistar Rats	Methanolic leaf/stem/calli extract (180 mg/kg) for 14 days	N/A	↓ SGOT, SGPT, ALP, TB; ↑Total protein; Histopathological recovery; Effect like Silymarin	(101)
CCl_4 induced Wistar Rats	Aqueous leaf extract for 10 days	N/A	↓ ALT, AST, ALP; Histopathological Improvement	(102)
DEN-induced Wister rats	Methanolic fruit extract (100,200 mg/kg) for 30 days	N/A	↓ AST, ↓ALT, ↓ALP (liver enzymes), Antioxidant enzymes (↓ADH, ↓MDA), Effect comparable to Silymarin	(103)
High-lipid diet induced Wistar Rats	Ethanol leaf extract for 28 days	N/A	↓(Inflammation, Apoptosis, NF-kB/caspase pathway modulation); Improved hematological/biochemical markers	(104)
Paracetamol & CCl_4 induced Wistar rats	Ethanolic leaf extract (150,300 mg/kg)	No toxicity up to 3.2 g/kg	↓ SGOT, SGPT, ALP, Bilirubin; Effect comparable to silymarin	(105)
Cyclophosphamide-induced Albino rats	Leaf extract (200,400,600 mg/kg) for 59 days	N/A	↓ Liver enzymes, MDA; ↑ GSH, SOD; Improved histopathology	(106)

According to research on animal models, extracts from various parts of *Coccinia grandis* can lower several indicators related to liver function, providing insight into the plant's hepatoprotective effects (**Table 10**). It has the capacity to lower hepatocyte inflammation and apoptosis, as well as oxidative indicators MDA and SOD, which are closely related to liver function.

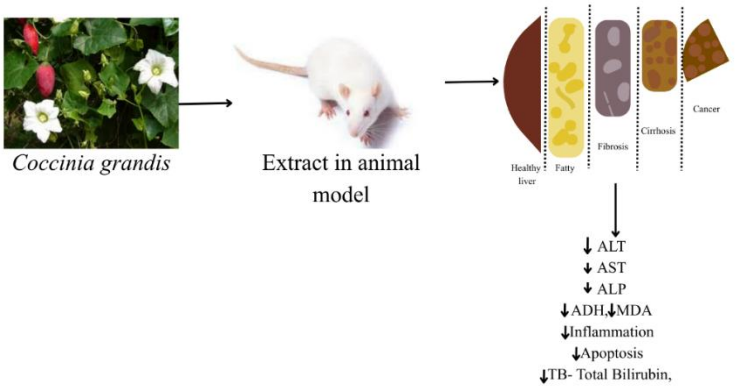


Figure 7: Hepatoprotective effect of *Coccinia grandis*.

Conclusion

From the information above, it can be concluded that *Coccinia grandis* is a natural blessing due to its remarkable properties, numerous pharmacological activities, nutritional benefits, and traditional uses. Numerous investigations have demonstrated that this plan's intended therapeutic value cannot be abandoned because it does not exhibit any significant toxicities. Following these discoveries, further research is required to determine the pharmacokinetics and pharmacodynamics of phytoconstituents, assess the plant's potential for therapeutic use, and understand the lowest level of toxicity. Due to its availability, pharmaceutical companies can now benefit from this plant's parts by conducting in-depth research in their "Research & Development" department. By developing and manufacturing various formulations with their phytochemical health benefits, which may offer human health advantages over synthetic chemicals, they can also secure their profitability.

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