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SCIENTIFIC OVERVIEW OF GARCINIA CAMBOGIA

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ABSTRACT

Garcinia cambogia (Family: *guttiferae*), commonly referred to as Malabar tamarind, is a tropical species widely distributed across South and Southeast Asia and traditionally valued for its culinary and therapeutic properties. The fruit rind of this plant is a rich source of diverse bioactive metabolites, predominantly hydroxycitric acid (HCA), along with garcinol, xanthones, benzophenones, flavonoids, and phenolic compounds. HCA, the principal phytoconstituent, acts as a competitive inhibitor of adenosine triphosphate-citrate lyase, thereby regulating lipid biosynthesis, suppressing appetite, and enhancing energy metabolism. Comprehensive phytochemical analyses have revealed the presence of alkaloids, saponins, tannins, flavonoids, terpenoids, and glycosides, conferring potent antioxidant, anti-inflammatory, antidiabetic, and antimicrobial activities. Pharmacological investigations have established the plant's potential in weight management, metabolic regulation, hepatoprotection, and mood modulation through serotonergic pathways. Toxicological assessments affirm its safety at therapeutic concentrations, although excessive or prolonged consumption may result in hepatic alterations. Advanced analytical approaches such as High-Performance Liquid Chromatography (HPLC), Gas Chromatography–Mass Spectrometry (GC–MS), and Thin Layer Chromatography (TLC) are employed for qualitative and quantitative standardization of its active constituents. Collectively, *Garcinia cambogia* stands as a phytopharmaceutical of significant scientific interest, embodying a broad spectrum of pharmacological benefits and offering valuable prospects for further exploration in modern evidence-based medicine.

INTRODUCTION

Garcinia cambogia, commonly known as Malabar tamarind, is a tropical plant belonging to the family *Guttiferae*. It is native to South and Southeast Asia and is widely used in traditional medicine and culinary practices. The fruit rind is rich in hydroxy citric acid (HCA), a key bioactive compound known for its role in weight management, lipid metabolism regulation, and appetite suppression. In addition to HCA, the plant contains diverse phytochemicals such as flavonoids, xanthones, benzophenones, and phenolic compounds, contributing to its antioxidant, anti-inflammatory, antidiabetic, and antimicrobial activities. Owing to its broad pharmacological properties and safety at therapeutic doses, *Garcinia cambogia* continues to attract scientific attention as a potential natural therapeutic and nutraceutical agent.

GARCINIA CAMBOGIA PHARMACOGNOSTICAL REVIEW OF *GARCINIA CAMBOGIA*

Macroscopic evaluation

Morphological characters of Garcinia cambogia

Prakash Chandra Gupta et al (2018) for morphological study, the fresh leaf of *Garcinia xanthochymus* is green, simple, petiolate, linear-oblong in shape with acute apex and cuneate base. Leaf is 20 to 28 cm long, 5 to 7 cm width and petiole 1.5 to 2.5 cm long. Fruit is subglobose, yellow in colour when ripe and 1-4 seeded. Various organoleptic and morphological characters of *Garcinia xanthochymus* leaves like colour, shape, size, apex, margin etc. were studied. For the anatomical studies, free hand transverse sections (T.S.) of the leaf, petiole and stem were prepared using razor blade. The thin sections were stained with phloroglucinol followed by hydrochloric acid in the ratio of 1:1. The stained sections were observed under microscope.[1]

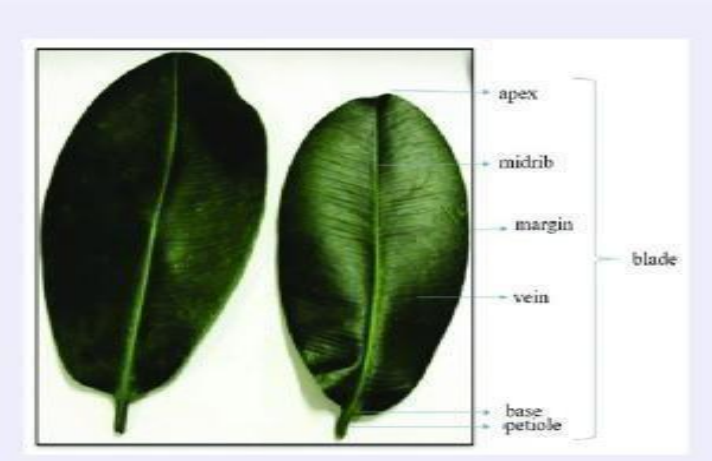

Diagram 1: Dorsal and Ventral view of *Garcinia cambogia*

Dr C K Kokate et al (2018) the morphological characters are studied. It is dark brown to blackish brown in colour. It has a acidic taste and a characteristic odour. The shape of garcinia is avoid and longitudinally grooved in nature. The size is 3 to 4 x 1 to 2 cm. The extra features involved are mesocarp of fruit is very wide.[2]

Diagram 2: *Garcinia cambogia* fruit.

PHYTOCHEMICAL REVIEW OF *GARCINIA CAMBOGIA*

Madappa M B et al (2012) Preliminary phytochemical analysis of the secondary metabolites in the fruit of *Garcinia gummi-gutta* belonging to the family *guttiferae* ,collected from various regions was carried out. The preliminary qualitative chemical tests showed that fruit collected from Western Ghats regions of Kerala have high content of alkaloids, tannins, phenolic flavonoids, flavonoids, carbohydrates and proteins. This justifies that environmental features do have variation in phytochemical content accumulation in plants. Steroids, terpenoids, phlobatannin and Cardiac glycosides were found. These natural chemicals such as steroids, terpenoids, phlobatannins, and cardiac glycosides are not just random byproducts, but serve key functions in plant defense, growth and interaction with their ecosystem.[3]

Table No.1: Phytochemical Analysis.

Sl NO	Name of test			Water extract		Methanol extract		Ethanol extract		Acetone extract		Chloroform extract		Diethyl ether extract		Petroleum ether extract		hexane extract	
				F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C
1	Alkaloids			0	++	++	++	+	+	++	++	0	0	0	0	0	0	0	0
2	Phenolics /Tanins			+	++	++	++	+	+	+	+	+	+	+	+	+	+	+	+
3	Saponins			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Anthraquinones			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Anthocyanoids			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Phenolic flavonoids			++	++	+	+	+	+	+	+	0	0	0	0	0	0	0	0
7	Flavonoids			++	++	++	+	+	+	+	+	0	0	0	0	0	0	0	0
8	Carbohydrates	Benedicts		+	++	++	++	++	++	++	++	0	0	0	0	0	0	0	0
		Molischs		++	++	++	++	++	++	0	0	0	0	0	0	0	0	0	0
		Fehlings	A	+	++	0	+	++	++	+	+	0	0	0	0	0	0	0	0
			B	0	0	+	+	++	++	++	++	0	0	0	0	0	0	0	0
9	Proteins			+	++	+	++	+	+	++	++	+	+	+	+	0	0	0	0
10	Steroids			0	0	+	+	+	+	++	++	+	+	0	0	0	0	0	0
11	Terpenoids			+	+	0	++	0	+	0	0	+	+	0	0	0	0	0	0
12	Cardiac glycosides			0	+	0	0	0	0	++	++	0	0	0	0	+	+	0	0
13	Phylobatannins			0	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0

Absent-0;Moderately present-+; Present -++; Filtered- F; Crude- C

Vijayalakshmi Krishnamoorthy et al (2014) the qualitative analysis of phytochemicals profile of fruit rind of Garcinia cambogia belonging to the family *guttiferae*. Qualitative tests for alkaloids, flavanoids, carbohydrates, glycosides, saponins tannins, terpenoids, proteins and anthraquinone were performed.[4]

Table No. 2: Phytochemical Analysis.

S.No	Compounds	Ethyl acetate Extract	Ethanolic Extract	Hydroalcoholic Extract	Aqueous Extract
1.	Flavonoids	+++	+++	++	-
2.	Terpenoids	+++	+++	+	-
3.	Phenols	+++	+++	++	+
4.	Tannins	+++	++	-	-
5.	Cardiac glycosides	++	++	+	-
6.	Carbohydrates	++	++	+	-
7.	Saponin	+++	++	+	+
8.	Amino acids	+	+	+	-
9.	Phlobatannin	+	++	-	-
10.	Sterols	++	++	+	-
11.	Coumarin	++	+	-	+

+++ = Present in higher amounts + = Present
++ = Moderately present - = Absent

Rehna A et al (2021) Preliminary phytochemical analysis of the rind extract of the plant showed the presence of phytochemical constituents such as alkaloids, phenolic compounds, steroids, tannins, flavonoids, glycosides, diterpenes and triterpenes.[5]

Table No. 3: List of phytochemical compounds.

Active principle	Result
Steroids	Present
Alkaloids	Present
Phenolic compounds	Present
Tannins	Present
Flavonoids	Present
Glycosides	Present
Diterpenes	Present
Triterpenes	Present
Saponins	Absent

Indhumathi Thangavel (2023) Qualitative phytochemical screening of the hydroalcoholic fruit extract showed the presence of resins, carboxylic acids, flavonoids, carbohydrates, proteins, saponification products, phenols, saponins, and alkaloids, while tannins, steroids, glycosides, biuret, gum, and flavanoglycosides were absent. Quantitative analyses demonstrated notable concentrations of several bioactive compounds: phenols ranged from 0.24 to 0.42 mg/mL (as gallic acid equivalents), flavonoids between 0.403 and 0.593 mg/mL (as quercetin equivalents), saponins at 39% w/w, alkaloids at 69.6% w/w, and terpenoids were present in appreciable amounts. These secondary metabolites are known to contribute to the antioxidant, antimicrobial, and anti-inflammatory properties of the plant.[6]

Table No. 4: Phytochemical compunds present.

Sl. No.	Phytochemical compound	Results
1	Resins	+
2	Carboxylic acid	+
3	Tannins –	–
4	Steroids	–
5	Flavanoids	+
6	Carbohydrates	+
7	Glycosides	–
8	Saponification	+
9	Proteins	+
10	Phenol	+
11	Biuret	–
12	Saponin	+
13	Gum	–
14	Flavanoglycoside	–
15	Alkaloids	+

+ Positive; – Negative

Ramdas Bhat et al (2024) Phytochemical analysis of *Garcinia cambogia* belonging to the family *guttifera* was performed. Initial analyses of phytochemical composition indicated the existence of alkaloids, flavonoids, phenolic compounds, saponins, tannins, carbohydrates, and proteins. The observed phytochemical analysis shows the presence of Xanthones: One plant's root was used to isolate

garbogiol, while the bark was used to isolate rheediaxanthone A. The fruits produced oxy guttiferone I, oxy-guttiferone K (4), oxy guttiferone K2 , and oxy-guttiferone M, which are tetracyclic polyisoprenylated xanthone. Benzophenones: While guttiferone I, guttiferone N, guttiferone J, guttiferone K and guttiferone M , the polyisoprenylated benzophenones, were recovered from the fruits, garcinol (also known as *camboginol* or *guttiferone E*) and isogarcinol (also known as cambogin) were reported from the bark..Amino acids :The total quantity of free amino acids was ascertained to be below 60 mg per 100 g of *Garcinia Cambogia* fruit belonging to the family *guttiferae*. Identified amino acids encompass arginine, asparagine, glutamine, threonine, glycine, proline, γ-aminobutyric acid, leucine, isoleucine, ornithine, and lysine.[7]

Sogand Tavakoli et al (2024) The study investigated the ethanolic extract of *Garcinia cambogia* leaves belonging to the family *guttiferae* for its phytochemical content. The extract was obtained by defatting dried leaves with petroleum ether and then extracting with 90% ethanol. Phytochemical screening revealed the presence of flavonoids, phenolic acids, tannins, glycosides, and carbohydrates. Quantitative analysis showed a total phenolic content of 0.48±0.014 mg gallic acid equivalent/g and total flavonoid content of 0.35±0.016 mg quercetin equivalent/g of extract. The extract exhibited moderate cytotoxic activity against human liver (HEPG-2) and breast (MCF-7) cancer cell lines with IC_{50} values of 59.3 ±10.07 and 48.23 ± 9.31 µg/mL, respectively, and weak activity against colon cancer (HCT-116) cells (IC_{50} = 84.6 ± 12.2 µg/mL), compared to the reference drug doxorubicin. The anticancer effect is attributed to the high content of phenolics and flavonoids, which act via mechanisms such as free radical scavenging, reactive oxygen species inhibition, and metal ion chelation, potentially reducing oxidative DNA damage and inducing apoptosis. These findings support the potential of *Garcinia cambogia* belonging to the family *guttiferae* as a source of natural anticancer agents.[8]

ANALYTICAL REVIEW OF *GARCINIA CAMBOGIA*

Mostafa H.Baky et al(2020) In another study, HCA and other organic acid levels in *Garcinia cambogia* belonging to the family *guttiferae* were estimated compared to other species in that genus to include *Garcinia indica, Garcinia xanthochymus,* and *Garcinia morella* using HPLC-UV. Results revealed that *Garcinia cambogia* encompassed (−)-HCA, HCA lactone, and citric acid at 7.9, 3.2, and 0.13% w/w, respectively. Additionally, *Garcinia cambogia* belonging to the family *guttiferae* and *Garcinia indica* were found to contain the highest (−)- HCA and its lactone levels, and suggestive that *Garcinia indica* can be used instead of *Garcinia cambogia* belonging to the family *guttiferae* especially if targeting its HCA. Likewise, (−) hydroxycitric acid was analyzed in *Garcinia cambogia* belonging to the family *guttiferae* commercial samples using HPLC/UV. The mean recovery of HCA from *Garcinia cambogia* belonging to the family *guttiferae* extracts ranged 98.4−100.5% with coefficients of variation of 0.25−0.63% and accuracy range of 2−10 µg, reflecting that the method is validated for the routine analysis of HCA in commercial *Garcinia cambogia* extracts belonging to the family *guttiferae*. The method also offered selectivity compared to traditional acid base titration methods which quantify for total acids, not only targeting HCA. HCA quantification in two *Garcinia cambogia* belonging to the family *guttiferae* marketed extracts containing 50% of HCA was performed using HPLC-DAD. HCA quantification in samples ranged 36.1−41.5%, and in agreement with results specified by the distributors. Another LC-based method employing capillary electrophoresis coupled to UV detection at 200 nm was reported for the qualitative determination of HCA in the presence of other organic acids, viz., citric, malic, and tartaric in *Garcinia cambogia* fruits belonging to the family *guttiferae.* Lactone and nonlactone from HCA can also be identified and quantified in the fruit rind of *Garcinia cambogia* belonging to the family *guttiferae* using gas chromatography coupled with mass spectrometry (GC/MS) post derivatization. The derivatization step in GC/MS though complicates the procedure and can affect HCA recovery from its matrix and should be accounted for during absolute quantification.[9]

Hanan Y Aati (2022) The analytical studies were performed. Eight compounds from different classes were isolated and purified using various chromatographic techniques. On the positive ion mode except compound 7, which was identified from the negative mode. These compounds (1–8) were identified as quercetin, amentoflavone, vitexin, naringin, catechin, p-coumaric acid, and gallic acid.[10]

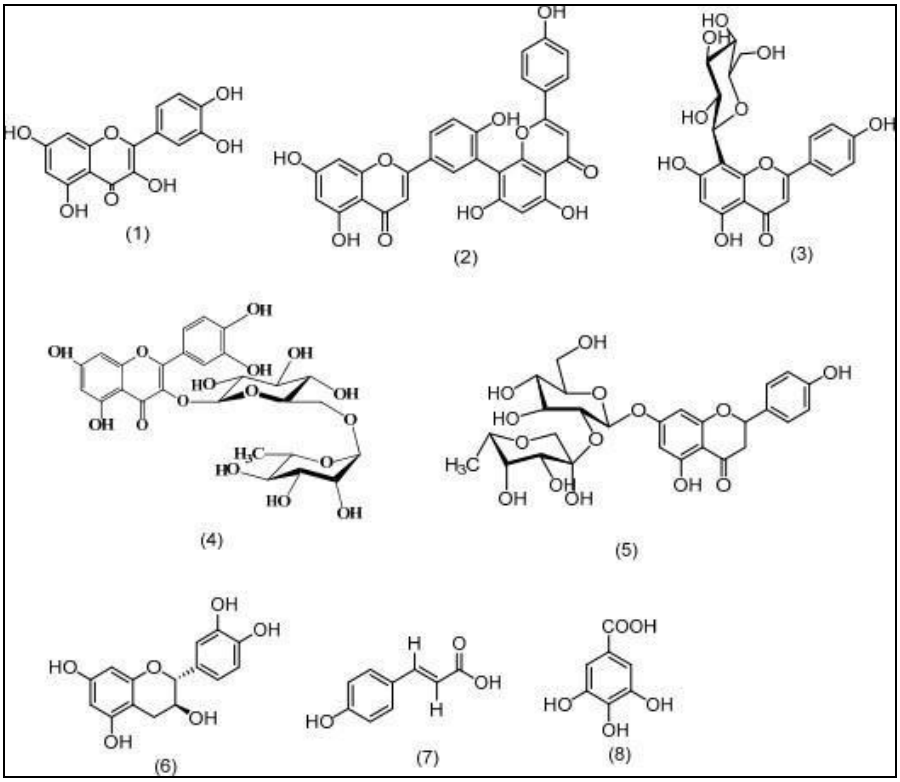

Diagram 3: Structures of compounds obtained.

Indhumathi Thangavel (2023) Analytical studies employed gas chromatography-mass spectrometry (GC-MS) and high-performance thin-layer chromatography (HPTLC) to identify and characterize the chemical constituents of the extract. GC-MS analysis, performed using an Agilent 7890B GC and 5977A MSD with helium as the carrier gas, revealed 25 volatile and semi-volatile bioactive compounds, including derivatives of benzoic acid, cyclohexasiloxane, phosphonous dibromide, naphthofuran, diisooctyl phthalate, dimethyl-flubendazole, and 2'- deoxy-guanosine, among others. HPTLC was conducted using a mobile phase of water, methanol, and ethyl acetate (10:14:76 v/v), with detection under UV light at 254 nm and 366 nm. Specific reagents confirmed the presence of flavonoids, while no bands were observed for alkaloids despite their confirmed chemical presence through Dragendorff's test. Two consistent Rf values (0.015 and 0.036) indicated the presence of certain compounds across plant tissues. The total ash value was 0.39 g, representing the inorganic content of the plant material. Together, these analytical techniques confirmed the rich phytochemical profile of *Garcinia cambogia* and support its pharmacological relevance in natural product-based drug development.[6]

Amani M D El-Mesallamy et al (2024) *Garcinia cambogia* belonging to the family *guttiferae* leaves ethanolic extract Phytochemical screening revealed the presence of several phytoconstituents such as flavonoids, phenolic acids, tannins, glycosides and carbohydrates compounds. One of the most numerous and common types of plant metabolites is phenolic chemicals. In addition to their free radical terminator activity or antioxidant, flavonoids and other plant phenolics have been shown in the literature to have a number of other biological effects. The major compounds in *Garcinia cambogia* leaves belonging to the family guttiferae extract; guanosine, prephenic acid, tetrahydroxy-cholanic acid, limocitrin, 6,7- dihydroxycoumarin-6-glucoside and hydroxy citric acid The ethanolic extract of *Garcinia cambogia* leaves belonging to the family *guttiferae* revealed the presence of various phytochemicals including phenolic acids, flavonoids, tannins, glycosides, and carbohydrates. Quantitative evaluation showed a total phenolic content of 0.48 ± 0.014 mg gallic acid equivalent (GAE)/g of extract and a total flavonoid content of 0.35 ± 0.016 mg quercetin equivalent (QE)/g of extract. Major identified constituents include guanosine, prephenic acid, tetrahydroxy-cholanic acid, limocitrin, 6,7-dihydroxycoumarin-6-glucoside, and hydroxycitric acid. These phytochemicals are associated with strong antioxidant properties due to their ability to scavenge free radicals and chelate transition metal ions. The richness in phenolics and flavonoids highlights the potential of *Garcinia cambogia* as a source of bioactive compounds with therapeutic relevance.[11]

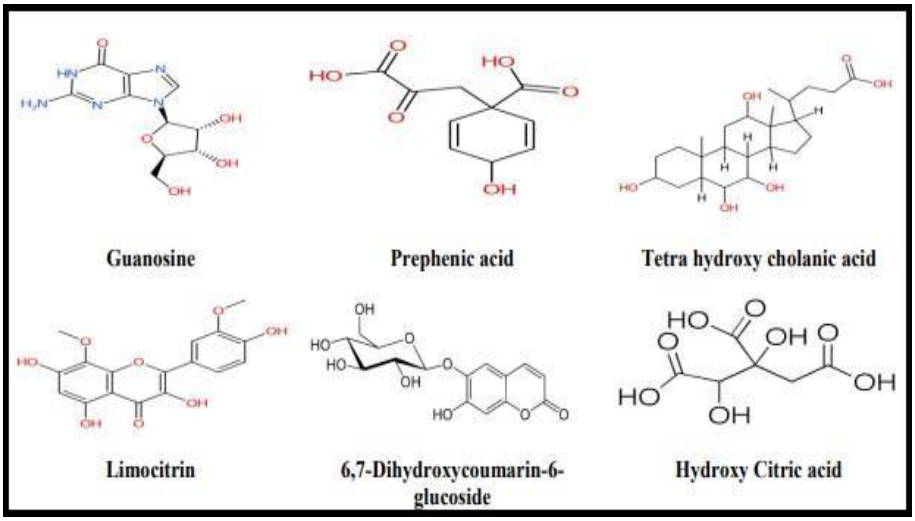

Diagram 4: Structure of componds present.

PHARMACOLOGICAL REVIEW OF *GARCINIA CAMBOGIA*

Peter Y Wielinga et al (2004) studied on the topic 'Hydroxycitric acid delays intestinal glucose absorption in rats'. This study explored the metabolic effects of hydroxycitric acid (HCA), a key bioactive compound derived from Garcinia species, with a particular focus on its influence on postprandial glucose metabolism in rats. The primary finding was that HCA significantly attenuates the rise in blood glucose levels following a glucose load. Through a series of well-controlled experiments using labeled glucose tracers and Steele's one- compartment model, it was demonstrated that this effect is due to a delay in the intestinal absorption of glucose rather than a reduction in total glucose uptake, slowed gastric emptying, or increased hepatic clearance. In rats pre-treated with HCA, both intragastric and intraduodenal glucose administrations resulted in a markedly lower and delayed rise in blood glucose compared to control animals. The rate of appearance of exogenous glucose in systemic circulation (RaE) was significantly reduced in the early postprandial period but normalized later, indicating a shift in the timing of glucose absorption rather than a reduction in total absorption. Further, radioactivity tracing revealed lower concentrations of labeled glucose in the portal vein, liver, and systemic blood, suggesting that HCA primarily delays the translocation of glucose from enterocytes into the bloodstream. Importantly, there was no evidence of enhanced glucose clearance by the liver or peripheral tissues. The underlying mechanism for this delayed absorption remains unclear, though the authors suggest that HCA may interfere with glucose transport across the apical membrane of intestinal cells—possibly through inhibition or modulation of sodium-glucose co-transporters like SGLT-1. This is consistent with the observed accumulation of glucose in intestinal tissues, particularly in the proximal gut, where active absorption primarily occurs. Overall, these findings support the hypothesis that HCA can beneficially modulate postprandial glycemic responses by slowing intestinal glucose uptake. This mechanism may contribute to HCA's reported effects on appetite suppression and body weight regulation. More importantly, the ability of HCA to flatten postprandial glucose peaks could hold clinical relevance in reducing the risk of metabolic disorders such as type 2 diabetes mellitus and cardiovascular diseases. The study thus underscores a potential therapeutic role for HCA as a functional dietary supplement in glucose metabolism management.[12]

Samia Ali Al Askany (2018) conducted the evaluation of *Garcinia Cambogia* belonging to the family *guttiferae* plant as antifungal, antioxidant and anti-bacterial. *Garcinia cambogia* belonging to the family *guttiferae* extract was prepared by milling dried fruits into powder, followed by extraction using both cold and hot water methods at concentrations of 5%, 7.5%, and 10% (w/v). For antifungal testing, a 20% (w/v) crude extract was prepared by boiling 200 g of powdered fruit in 1000 ml of water for one hour, then sterilized by autoclaving. The extract was tested at various dilutions (5%,7.5%,10%) against Aspergillus flavus and Fusarium moniliforme using potato dextrose broth. Fungal inhibition was assessed by measuring mycelial dry weight after 5 days of incubation at 25°C. *Garcinia cambogia* belonging to the family *guttiferae* extracts at 5%, 7.5%, and 10% concentrations significantly inhibited Aspergillus flavus and Fusarium moniliforme, with greater reduction in fungal dry weight at higher concentrations. Aspergillus flavus showed more sensitivity, with an average growth reduction of 42.39%, compared to 31.34% in Fusarium moniliforme. These results confirm the extract's strong antifungal activity, aligning with previous findings on the broad bioactivity of the Garcinia genus. *Garcinia cambogia* extracts belonging to the family guttiferae at 7.5% and 10% concentrations showed antibacterial activity against Bacillus cereus and Escherichia coli, with inhibition zones decreasing as concentration increased. Cold extracts were more effective, especially against Bacillus cereus. At 10%, inhibition zones measured 15.73 mm (cold) and 13.67 mm (hot) for B. cereus, and 12.67 mm (cold) and 13 mm (hot) for E. coli. These findings support earlier studies showing *Garcinia*

cambogia's belonging to the family *guttiferae* effectiveness against both Gram-positive and Gram-negative bacteria and its potential as an antibacterial agent. *Garcinia cambogia* powder belonging to the family *guttiferae* and its 10% cold and hot extracts contain various antioxidant compounds, including phenols, flavonoids, and isoflavonoids. Pyrogallol was the most abundant phenol across all forms, especially in powder and cold extract. Cold extracts had higher levels of epicatechein, protocatchuic, and E-vanillic acid, while hot extracts showed high amounts of catechol and similar phenols. Hesperidin was the dominant flavonoid, with cold extract rich in quercetin and naringin, and hot extract containing more rutin and naringin. Among isoflavonoids, cold extract had the highest daidzein, while biochanin was most abundant in powder. These findings confirm *Garcinia cambogia's* belonging to the family *guttiferae* strong natural antioxidant.[13]

Manu Tomar et al (2019) Performed a clinical and computational study on anti-obesity effects of hydroxycitric acid. This study evaluated the anti-obesity effects of hydroxycitric acid (HCA), the principal active compound derived from *Garcinia cambogia* belonging to the family *guttiferae*, through a combined clinical and computational approach. The clinical trial involved 100 obese individuals (BMI ≥28) who received a 600 mg caplet twice daily for three months. Each caplet contained 250 mg of an aqueous extract standardized to 60–66% HCA and 350 mg of additional plant powder. The extract was prepared by water extraction to remove hydrophobic compounds and included calcium, citric acid, lactones, and moisture, yielding a total HCA dose of approximately 500 mg per day. Results showed significant reductions in body weight, skin fold thickness, and serum lipid levels (triglycerides, cholesterol, HDL, LDL). Even among subjects who gained weight, fat mass decreased while fat-free mass increased, suggesting improved body composition. A hepatic metabolic model further demonstrated that HCA inhibits ATP citrate lyase, leading to reduced fatty acid, triglyceride, and cholesterol synthesis, and enhanced protein and glycogen synthesis. HCA also modulated metabolic fluxes, promoting fatty acid oxidation and bile cholesterol excretion. However, it may increase ketogenesis under lipogenic conditions, indicating that HCA should be used alongside dietary management and physical activity to avoid potential adverse effects such as ketoacidosis or nitrogen imbalance.[14]

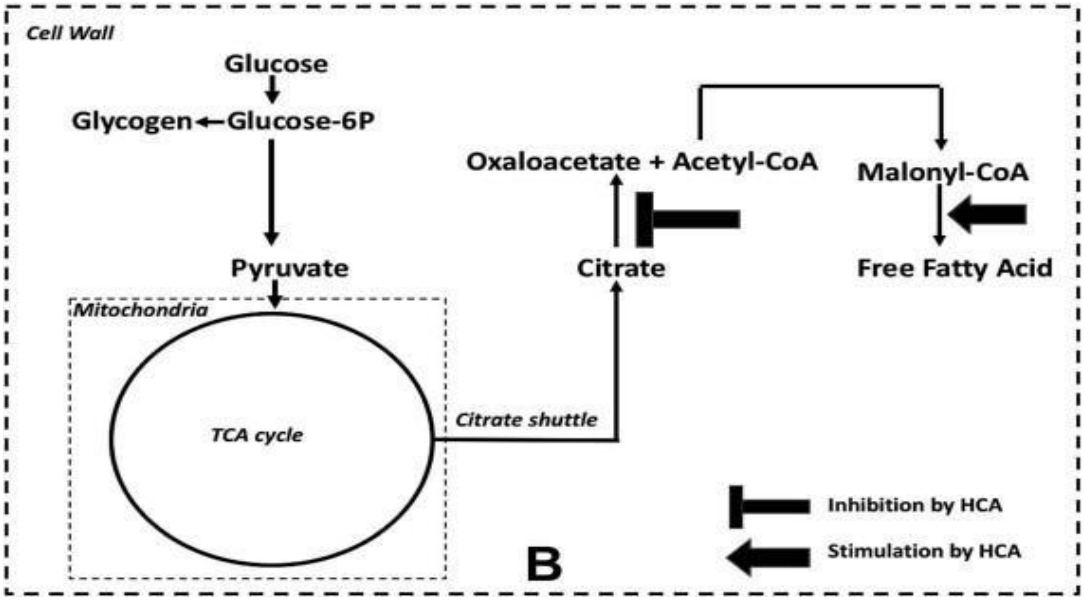

Diagram 5: Anti-obesity effects of Garcinia cambogia/HCA. Possible mechanisms that contribute to anti-obesity effects of HCA. Highlights two reactions which have been perturbed in the metabolic pathway model25 to simulate the anti-obesity effect of HCA.

Barathne Datchanamurty et al (2019) Therapeutic potential of *Garcinia cambogia* belonging to the family *guttiferae* and *Emblica officinalis* in the management of obesity and lipid profiles in a rat model of dietinduced obesity was evaluated This study evaluated the anti-obesity and hypolipidemic effects of *Garcinia cambogia* belonging to the family guttiferae and Emblica officinalis (Indian gooseberry) in high-energy diet (HED)-induced obese albino rats. Thirty-six rats were randomized into six groups: a control group, two *Garcinia cambogia* belonging to the family *guttiferae* groups (200 mg/kg/day and 400 mg/kg/day), two Emblica officinalis groups (20 mg/kg/day and 40 mg/kg/day), and a standard drug group receiving Orlistat (20 mg/kg/day). Commercially prepared aqueous extracts of both plants were obtained from the Himalaya Drug Company. After obesity induction via a HED (carbohydrates 51.4%, fat 31.8%, protein 16.8%) over 3 months, rats were treated daily for another 3 months. Both plant extracts significantly reduced body weight gain and improved lipid profiles, including reductions in total cholesterol (TC), triglycerides (TG), and low-density lipoprotein

cholesterol (LDL-C), along with mild increases in high-density lipoprotein cholesterol (HDL-C). The effects were more pronounced in the high-dose *Garcinia cambogia* group belonging to the family *guttiferae*, which closely matched Orlistat in efficacy. Mechanistically, the anti-obesity effect of *Garcinia cambogia* is attributed to hydroxy citric acid (HCA), which inhibits ATP- citrate lyase, a key enzyme in de novo lipogenesis, thereby reducing fat synthesis and enhancing glycogen storage. *Emblica officinalis* exerts its effects through its rich antioxidant content, including vitamin C, flavonoids, and tannins, which enhance lipid metabolism, reduce oxidative stress, and upregulate PPARs, promoting lipid catabolism. Overall, both herbal extracts demonstrated potential as natural therapeutic agents for managing obesity and dyslipidemia, with *Garcinia cambogia* belonging to the family *guttiferae* exhibiting a greater degree of efficacy. Further studies in human populations are recommended to confirm these findings and determine optimal dosing strategies.[15]

Zheling Feng et al (2022) This study identified guttiferone J (GOJ) from *Garcinia cambogia* belonging to the family *guttiferae* as a promising natural anti-obesity compound using bioactivity-based molecular networking. GOJ, isolated alongside garcinol and 14-deoxygarcinol, significantly reduced lipid accumulation in 3T3-L1 and C3H10T1/2 adipocytes. Mechanistically, GOJ increased the expression and activity of SIRT3, a mitochondrial deacetylase, which deacetylated PGC-1α, enhancing mitochondrial biogenesis and expression of UCP1, thus promoting white adipose tissue (WAT) browning and thermogenesis. In high-fat diet-induced obese mice, oral administration of GOJ reduced adiposity, insulin resistance, hyperlipidaemia, and liver lipotoxicity by activating SIRT3-mediated pathways. GOJ demonstrated strong interaction with SIRT3 in molecular docking and was shown to directly bind and stabilize the protein. This study provides mechanistic evidence that GOJ is the key anti-obesity agent in *Garcinia cambogia* and supports its development as a potential thermogenic therapeutic for obesity and metabolic disorders.[16]

Park M Y et al (2022) This study investigated the anti-obesity and lipid-modulating effects of *Garcinia cambogia* extract (GCE) in Sprague Dawley rats subjected to high-fat diet (HFD)- induced obesity. The extract was prepared from the dried rind of the fruit, which is rich in (-)- hydroxycitric acid (HCA)—a known inhibitor of ATP citrate lyase (ACLY), an enzyme critical for de novo fatty acid biosynthesis. The experimental protocol involved feeding rats an HFD for 5 weeks to induce obesity, followed by oral administration of GCE (200 mg/kg body weight/day) for an additional 5 weeks, with continued HFD exposure. GCE treatment significantly reduced body weight gain, epididymal and perirenal fat mass, and body fat percentage compared to HFD- only controls. It also improved serum lipid profiles, including a reduction in total cholesterol (TC), triglycerides (TG), and low-density lipoprotein cholesterol (LDL-C), while elevating high-density lipoprotein cholesterol (HDL-C) levels. Histological analysis of adipose tissues showed a marked decrease in adipocyte size and number, indicating an anti-adipogenic effect of the extract. Liver histology further revealed decreased lipid accumulation and improved hepatic architecture. At the molecular level, GCE exerted its anti-obesity effects via multiple mechanisms. The major component, HCA, acts by inhibiting ACLY, thereby lowering acetyl-CoA availability, which is essential for lipogenesis. This blockage limits fatty acid and cholesterol synthesis. Additionally, GCE upregulated AMP-activated protein kinase (AMPK)—a key energy sensor that promotes lipolysis, enhances fatty acid oxidation, and inhibits lipid storage. It also down regulated PPARγ expression, a nuclear receptor that regulates adipogenesis and lipid uptake, further suppressing fat cell differentiation. Moreover, GCE helped restore gut microbiota balance, suggesting a systemic regulatory role in metabolic homeostasis.Overall, this study provides strong evidence that Garcinia cambogia extract has multi-targeted anti-obesity potential, acting through metabolic enzyme inhibition, gene expression modulation, lipid profile improvement, and histological changes. It positions GCE as a promising natural therapeutic agent for managing diet-induced obesity and associated metabolic disorders.[17]

Ramdas Bhat et al (2024) The pharmacological studies of *Garcinia cambogia* belonging to the family *guttiferae* was performed.

Hypolipidemic activity: Several extracts, like flavonoids and *garcinia cambogia*, have exhibited potential in research concerning lipid metabolism and associated health markers. Over a period of 45 days, rats administered an oral dosage of 10 mg/kg body weight of a fruit rind extract rich in flavonoids displayed a notable decrease in cholesterol. Interestingly, higher doses of the flavonoid extract diminished its efficacy in reducing cholesterol level. This indicates that the hypolipidemic impact of the extract may be attributed to a reduction in lipogenesis, which is the synthesis of fat, and an elevation in breakdown rates. The ingestion of *Garcinia cambogia* fruit extract substantially lessened the cholesterol levels in rats treated with dexamethasone when provided orally for eight days at a dosage of 1000 mg/kg body weight. It effectively thwarted the production of free acids in the liver and plasma triggered by dexamethasone and restored elevated levels of triglycerides and cholesterol to normal levels. The extract's modest preventive efficacy and moderate decline in the activity of γ-glutamyl transferase, aspartate aminotransferase, and alanine aminotransferase implied potential advantages for liver wellbeing. In a clinical analysis, obese women who consumed 800 mg of *Garcinia cambogia* extract (50% HCA) orally three times daily for 60 days observed a reduction in their

triglyceride levels. Nevertheless, there were no alterations in insulin and leptin levels or other components of the lipid profile. The hypotriglyceridemic effect of *Garcinia cambogia* was not found to be associated with changes in leptin levels Hydroxycitric acid, the primary constituent of *Garcinia cambogia* belonging to the family *guttiferae*, has been proven to enhance glucose utilization during physical activity and stimulate lipid oxidation in mice. It raised blood free fatty acid levels following an oral intake of 100 minutes; sixteen hours later, it notably increased the glycogen concentration in the gastrocnemius muscle. Lastly, a polyherbal blend named Antichol, comprising various herbal extracts including *Garcinia cambogia*, exhibited preventative impacts against cholesterol-induced alterations in glucose, lipid profile, and alkaline phosphatase levels in rats.

Antidiabetic activity: Mice administered with 3.3% Garcinia extract and 10% sucrose daily for a duration of 28 days did not manifest any alterations in body weight, fat pad weight, or serum glucose concentrations. Conversely, it amplified glucose metabolism while diminishing serum insulin, leptin, and the leptin/WAT ratio. Rats afflicted with type-2 diabetes-related inflammation and oxidative stress displayed diminished quantities of malondialdehyde, protein carbonyl, and protein tyrosine nitration in their liver and kidney subsequent to the intake of Super Citrimax (HCA SX) at a concentration of 500 mg/kg for the initial fourteen days followed by 1500 mg/kg BW per day for a maximum of seven weeks. The levels of Interleukin-6 and C-reactive protein in plasma were observed to decline subsequent to supplementation without concurrent elevation in insulin resistance. In rats, the assimilation of enterally administered glucose in the small intestine mucosa was delayed post oral administration of HCA at a dosage of 310 mg/kg BW. Furthermore, it led to a reduction in postprandial plasma glucose levels subsequent to intragastric and intraduodenal glucose delivery. The administration of a polyherbal blend of Gymnema sylvestre, Garcinia cambogia belonging to the family guttiferae, and Lagerstroemia speciosa to human skeletal muscle for seven days, with 500 mg/day of HCA, upregulated the expression of fatty acid translocase/CD36 mrna, enhanced glycogen synthesis, and augmented muscle sensitivity to insulin post meals. The beneficial effects were demonstrated in rats with obesity-induced diabetes when provided with dosages of 412, 825, and 1625 mg/kg BW/day for a duration of 21 days. The formulation resulted in reductions in blood sugar, triglycerides, total cholesterol, as well as increments in very-low density and low-density lipoprotein levels. The formulation exhibited comparable efficacy to the positive controls, which encompassed sibutramine (5 mg/kg) for obesity and glibenclamide (4 mg/kg) for diabetes.

Anti-inflammatory activity: An excerpt derived from the pericarp of the Garcinia cambogia fruit belonging to the family guttiferae, containing 51.2% (-)-HCA, exhibited notable anti- inflammatory properties in rats with TNBS-induced colitis. Administration of the extract at doses of 500 and 1000 mg/kg body weight led to a significant decrease in the expression of three inflammatory biomarkers: MPO, COX-2, and inos, alongside an exacerbation of macroscopic damage. Additionally, the extract lowered colonic levels of PGE2 and IL-1β without eliciting any adverse reactions. These results indicate a potential therapeutic efficacy of the extract in managing inflammatory bowel disease, characterized by an abnormal immune response of the mucosa. Numerous compounds derived from *Garcinia cambogia* belonging to the family *guttiferae*, such as garcinol, guttiferone K, and guttiferone M, have displayed anti- inflammatory effects. Garcinol hindered the activation of JAK/STAT-1 and/or NF-κB in LPS-stimulated macrophages at a concentration of 5 μm. Furthermore, it suppressed the synthesis of inos and COX-2 while reducing intracellular ROS levels. Guttiferone M, K, and G were shown to impede STAT-1 nuclear translocation and DNA binding, thereby modulating cytokine signaling. Particularly noteworthy was the efficacy of garcinol in halting cytokine-induced STAT-1 activation. Additionally, garcinol inhibited NF-κB activation induced by TNF-α. Rats treated with 28 and 84 mg/day of oral potassium-magnesium hydroxycitrate (kmghca) exhibited marginal enhancements in systolic blood pressure and reductions in paw edema. Moreover, it decreased inflammatory markers like TNF-α and CRP.

Hepatoprotective activity: For a period of 45 days, rats were administered an oral fruit extract at a dosage of 1000 mg/kg BW, resulting in a reduction of peroxidative damage induced by ethanol. The extract's ability to mitigate lipid levels and ethanol-induced peroxidative damage is attributed to its antioxidant properties. Treatment led to normal serum levels of alkaline phosphatase (ALP), alanine transaminase (ALT), and aspartate aminotransferase (AST). Studies conducted on hepg2 cells in vitro demonstrated that a 1% concentration of Garcinia extract (60% HCA) decreased palmitate-induced lipotoxicity by minimizing cellular damage and reactive aldehydes, despite concerns regarding hepatotoxicity in humans associated with *Garcinia Cambogia*/HCA. Furthermore, the *Garcinia Cambogia* belonging to the family *guttiferae* (8% w/w) product, Antichol, altered the liver antioxidant enzymes glutathione, catalase, and superoxide dismutases, and shielded the rats' livers from fatty degeneration induced by cholesterol.

Anti-ulcer activity: Indomethacin protected the stomach mucosa from harm when rats received an oral dose of 1000 mg/kg BW/day of a *Garcinia cambogia* fruit extract belonging to the family *guttiferae* for 5, 10, or 15 days. Moreover, the extract enhanced mucosal protection and decreased stomach acidity. The same group's follow-up investigation found that by lowering the amount and

acidity of stomach fluid, the extract at 1000 mg/kg BW/day at intervals of 7 and 15 days had protective effects against hcl-ethanol-induced damage in rats' gastric mucosa. Furthermore, the extract increased lipid peroxidation and antioxidant enzyme activity, and also altered the quantities of proteins and glycoproteins in the ulcerated mucosa. A polyherbal formulation including 150 mg of Glycyrrhiza glabra , 500 mg of Garcinia, 200 mg of deglycyrrhizinated licorice extract, and 150 mg of Azadirachta indica was administered to rats suffering from ulcers brought on by naproxen, histamine, cysteamine, and ethanol. These ulcers were treated with the mixture's anti-ulcer properties. The oral formulation dramatically reduced the ulcer index and ulcer area and showed stomach healing efficacy at doses of 300 and 600 mg/kg, with an 80% protection value.

Antimicrobial activity: Fruit rind extracts containing ethanol, hydroalcoholic extract, and ethyl acetate showed antimicrobial activity against *Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Bacillus subtilis,* and *Staphylococcus aureus* when tested at a concentration of 25 mg/ml, with inhibition zone diameters ranging from 15 to 34 mm. The results showed that the most effective extracts against all test pathogens were ethanol and ethyl acetate, while hexane extracts showed no impact against any of the infections. The two main HIV enzymes, HIV-1 integrase and HIV-1 protease, were repressed by water and ethanolic preparations made from *Garcinia cambogia* leaves belonging to the family *guttiferae.* The water extract had IC50 values of 67 and 70 µg/ml against protease and integrase, respectively, whereas the ethanolic extract demonstrated relatively low activity with an IC50 value of 100 µg/ml against both enzymes.[18]

TOXICOLOGICAL REVIEW OF *GARCINIA CAMBOGIA*

Li Oon Chuah et al (2012) In Vitro and In Vivo Toxicology Studies: in vitro antiproliferative effects of the aqueous extracts of dried fruit rind of *Garcinia indica* (0, 50, 100, 200 µg/mL) on Balb/c 3T3 mouse fibroblasts and human peripheral lymphocytes. The results showed that *Garcinia indica* extracts inhibited lymphocytes and 3T3 fibroblast cell survival. Thus, the authors concluded that *Garcinia indica* extracts exhibited pronounced cytotoxic effects. However, there was a flaw in their methodology, since the authors also reported that *Azadirachta indica* and *Coleus aromaticus* exhibited cytotoxic effects on lymphocytes despite the low cell viability in the control group (only 50–55% of viable lymphocytes). In the case of *Garcinia indica*, percentage of viability in lymphocytes was not even mentioned. Thus, definitive conclusion of *Garcinia indica* induced cytotoxicity could not be drawn due to the poorly described methodology of their study.

Clinical Toxicity: A total of 17 clinical studies with approximately 873 subjects were summarized to assess the effects of HCA and HCASX intake on human body weight and its safety for human consumption. Out of these studies, only 1 subject was reported itching around the mouth and 2 with headache and nausea. Taken all together, these studies provided sufficient qualitative and quantitative scientific evidence to report “no observed adverse effect level (NOAEL)” at levels up to 2800 mg/day, suggesting its safety in-use. In this section, we have analyzed the symptoms of adverse reactions reported in 15 clinical trials carried out in human subjects after the administration of *Garcinia cambogia* extract belonging to the family *guttiferae*. There are 12 parallel, randomized, double-blind, placebo controlled studies, involving 745 subjects, one parallel, randomized, single-blind, placebo-controlled study, three cross-over, randomized, double-blind, placebo controlled trials, one cross-over, randomized, single blind, placebo- controlled study, and one reexamination of the data from two previous parallel, randomized, double-blind, placebo-controlled clinical trials. Out of 16, only nine of the clinical studies were performed with *Garcinia cambogia* extract/HCA alone belonging to the family *guttiferae*.[19]

Amani M D El Mesallamy et al (2024) According to this study, the cytotoxic potential of *Garcinia cambogia* belonging to the family *guttiferae*, ethanolic extract was assessed in vitro against three human cancer cell lines: breast (MCF-7), liver (HEPG-2), and colon (HCT- 116), using doxorubicin as a reference drug. The extract exhibited moderate cytotoxic activity against MCF-7 and HEPG-2 with IC_{50} values of 48.23 ± 9.31 µg/mL and 59.3 ± 10.07 µg/mL, respectively, and weaker activity against HCT-116 with an IC_{50} of 84.6 ± 12.2 µg/mL. These effects are attributed to the high phenolic and flavonoid content, which may induce apoptosis through antioxidant mechanisms and inhibition of reactive oxygen species generation. Compared to doxorubicin (IC_{50} values between 2.7–5.03 µg/mL), the extract shows milder but promising selective cytotoxicity, suggesting potential as a safer complementary anticancer agent pending further mechanistic studies.[20]

Nor Akmalyati Sulong (2025) The cytotoxic evaluation was conducted. The in vitro cytotoxicity of an aqueous extract of *Garcinia cambogia* (Asam Gelugur) belonging to the family *guttiferae* on the Vero cell line to assess its safety for use in nutraceuticals. *Garcinia cambogia* belonging to the family *guttiferae*, known for its traditional and commercial use in weight management, contains hydroxycitric acid (HCA), which inhibits fatty acid synthesis and modulates appetite through serotonin regulation. Despite its popularity, concerns regarding its safety have prompted scientific evaluation. In this study, the extract (TS006) was prepared via aqueous extraction and freeze-drying, and its cytotoxicity was evaluated using the MTT assay, which measures mitochondrial activity as an indicator of cell viability. Taxol, a well-known cytotoxic drug, was used as a positive control. Results showed that the *Garcinia cambogia* extract had an IC50 value ≥500 µg/mL, indicating very low cytotoxicity, and in some cases, even increased cell

viability, suggesting a potential stimulatory effect. In contrast, Taxol exhibited a strong dose-dependent cytotoxic response, with an IC50 of 0.0581 ± 0.0303 µg/mL, confirming its potency. These findings suggest that the aqueous extract of *Garcinia cambogia* is safe for inclusion in herbal and nutraceutical formulations. However, the study's limitations include its reliance on a single cell line, absence of in vivo validation, and lack of isolated analysis of HCA, warranting further research to fully establish its safety profile.[21]

CONCLUSION

Garcinia cambogia demonstrates significant pharmacognostic, phytochemical, analytical, and pharmacological potential supported by multiple experimental and clinical evaluations. The fruit and leaf extracts are rich in bioactive compounds such as hydroxycitric acid (HCA), flavonoids, phenolic acids, tannins, and glycosides, which contribute to its antioxidant, antimicrobial, and cytotoxic effects. HCA, the principal compound, plays a crucial role in modulating glucose absorption, reducing postprandial blood glucose levels, and potentially aiding anti-obesity and metabolic regulation. Analytical techniques including HPLC, GC-MS, and HPTLC have confirmed the presence and accurate quantification of these phytochemicals, validating the plant's chemical and therapeutic consistency. Pharmacological studies highlight anticancer, antifungal, and antibacterial activities, mainly due to the high phenolic and flavonoid content, which help reduce oxidative stress and induce apoptosis in cancer cells. Toxicological assessments reveal a high safety margin, with a no observed adverse effect level (NOAEL) up to 2800 mg/day in human studies, supporting its safe consumption when used appropriately.

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