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Ethnopharmacological and Therapeutic Potential of Fig (*Ficus carica* L.)

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ABSTRACT

Ficus carica L. (fig) has been valued since antiquity for its nutritional and medicinal properties. This comprehensive review synthesizes current knowledge on the ethnopharmacological uses, bioactive compounds, and therapeutic potential of different fig plant parts. The fruit, leaves, and latex exhibit remarkable antioxidant activity, with dark-colored cultivars showing 3-4 times higher antioxidant capacity than light-colored ones due to greater phenolic content. Fig extracts demonstrate significant anticancer effects against breast, liver, cervical, and colon cancers by modulating cell cycle regulators (CDKs) and apoptotic genes (BAX, TP53). The plant shows promising antidiabetic activity, with leaf extracts enhancing glucose uptake and insulin secretion. Additionally, fig exhibits anti-angiogenic, hepatoprotective, hypocholesterolemic, and immunomodulatory properties. Its antimicrobial activity against Gram-positive and Gram-negative bacteria, as well as antiviral potential against COVID-19 and HSV-1, highlights its broad pharmacological spectrum. The laxative effects of figs are well-documented in both animal models and clinical studies, improving constipation symptoms. Economically, figs are globally significant, with Turkey, Egypt, and Algeria being top producers, though post-harvest losses remain a challenge. Despite these benefits, key limitations persist, including variability in bioactive compounds, undefined safety profiles and dosages, understudied latex components, and climate vulnerability in cultivation. Addressing these challenges through standardization, clinical trials, processing innovations, and sustainable cultivation could unlock the full potential of fig. This review underscores F. carica as a multifunctional therapeutic agent with applications in modern medicine, functional foods, and nutraceuticals, while emphasizing the need for sustainable utilization and value-added processing to enhance its economic potential.

Keywords: *Ficus carica, bioactive compound, antioxidant activity, ethnopharmacology, therapeutic, anticancer, antidiabetic, immunomodulatory.*

Introduction

Since ancient times, plants have played a fundamental role in human societies, providing essential nourishment, therapeutic remedies, and deep-rooted cultural symbolism. Among these, *Ficus carica* Linn., widely known as the fig, has been an invaluable resource throughout human history, prized for its nutritional content and extensive ethnomedicinal applications [1]. With a history of domestication spanning over 11,000 years, the fig has traditionally been used to treat a diverse range of ailments, including digestive and respiratory disorders, metabolic diseases, and even cancer [2,3]. Modern phytochemical studies have validated its therapeutic potential, revealing a rich array of bioactive compounds that underscore its value as both a functional food and a source for novel drug development [4,5].

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Phytochemical investigations have revealed a rich array of bioactive compounds across all parts of the fig plant, including enzymes, pigments, and secondary metabolites like flavonoids, coumarins, sterols, and triterpenoids [6,7]. Notably, fruits and leaves are rich in anthocyanins and flavonoids, with prominent compounds like cyanidin, epicatechin, and quercetin derivatives identified [8,9]. These secondary metabolites are believed to underpin the fig's diverse pharmacological potential [7,10]. Nutritionally, figs offer significant value, with compositions varying between fresh and dried forms, and influenced by environmental factors [5]. Dried figs are particularly rich in carbohydrates, primarily glucose and fructose, making them a dense energy source [2]. The edible peel and pulp contribute significantly to its nutritional profile [11,12]. Figs are also an excellent source of essential minerals, including calcium, iron, phosphorus, potassium, and sodium, crucial for normal bodily functions [2,12]. They notably contain more calcium than many common fruits and are a good source of strontium, beneficial for bone health [13]. This rich nutritional and phytochemical profile underscores *F. carica's* promise as a source for novel drug development and a valuable natural dietary supplement [14].

Botanical profile

The common fig is a deciduous tree growing 3–9 m tall, characterized by a spreading canopy, a trunk rarely exceeding 2.0 m (7 ft) in diameter, and a shallow, wide root system. The tree is distinguished by its large leaves (15-30 cm), which range from unlobed to deeply lobed with 1–5 sinuses, resembling those of papaya (*Carica* spp.), a trait reflected in its species name carica, denoting its hypothesized origin in Caria, Asia Minor [11,14]. These leaves have a rough, hairy upper surface and a softer, pubescent underside. The smooth, silvery-gray bark peels to reveal reddish-brown inner layers, while all tissues contain a milky latex rich in ficin, a proteolytic enzyme that aids in defense and wound healing [4,12]. The edible fig is botanically a syconium, a hollow, fleshy, pear-shaped hypanthium that encloses inward-facing flowers (female above male) [2,7]. At maturity, this pseudo-fruit develops a peel that transitions from green to purple-brown, often cracking to expose the pulp and 30–1,600 tiny, nutty-flavored achenes, which may remain hollow if unpollinated. Like all Ficus species, *F. carica* produces latex in specialized laticifers; this cytoplasmatic fluid contains terpenoids, alkaloids, and proteins that deter herbivory and promote tissue repair [12]. Cultivated globally for its fruit, the species also holds value in traditional medicine due to its antioxidative properties.

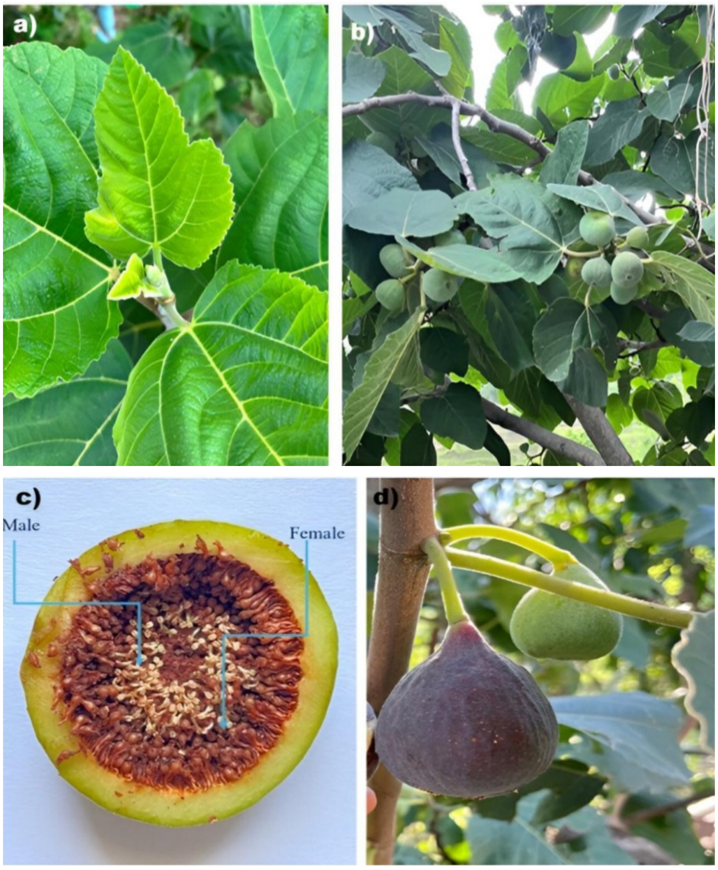

Fig. 1 a) Leaf; b) Immature fruits; c) Male and female flowers; d) Ripened fruit

Ethnopharmacological activities

Antioxidant activity

From a biochemical standpoint, antioxidants mitigate age-related degeneration by scavenging metabolic byproducts, particularly free radicals. These reactive species induce cellular and macromolecular damage, driving the pathogenesis of chronic degenerative diseases [15]. Under typical biological functioning, reactive oxygen species (ROS) production remains balanced by endogenous antioxidant defenses. However, pathological states arise when ROS overproduction disrupts this equilibrium, leading to oxidative stress and loss of ionic/osmotic homeostasis. Such oxidative damage manifests as lipid peroxidation (elevated MDA levels), DNA mutations (potentially carcinogenic), and structural deterioration of membrane phospholipids and proteins [15]. Flavonoids counteract oxidative stress through dual mechanisms: upregulating antioxidant enzymes while inhibiting prooxidant enzymes, thereby reducing ROS accumulation [16]. Notably, studies reveal a direct relationship between anthocyanin-rich pigmentation, phenolic content, and enhanced antioxidant capacity. Dark-pigmented fig cultivars demonstrate 3-4 times higher antioxidant activity than light-pigmented varieties due to their greater phytochemical content [7]. Comparative analysis of *Ficus carica* plant parts demonstrated that leaf extracts exhibit superior antioxidant capacity, while pulp extracts show the weakest activity [17]. The antioxidant properties of fig phenolic compounds have been validated through standardized assays, including hydrogen peroxide scavenging and DPPH radical inhibition tests [18], as systematically presented in Table 1. A comprehensive evaluation of fig leaf waste extracts employed three established methods: DPPH, ABTS, and FRAP assays. Solvent-dependent studies revealed that ethyl acetate extracts displayed the strongest DPPH radical scavenging activity, followed by aqueous and petroleum ether phases, with dose-dependent efficacy observed across all solvents [19]. Notably, fig peels contribute significantly more to antioxidant activity than pulps [10], with anthocyanin-rich dark peels outperforming light-colored variants due to their higher phenolic content. The IC50 values serve as critical indicators of antioxidant potency, quantitatively representing the extract concentration required for 50% radical neutralization in these assays.

Free Radical Scavenging Activity

A study by [16] developed an ultrasound-assisted extraction protocol to isolate total flavonoids from *Ficus carica* Linn. leaves and evaluated their free radical scavenging capacity against hydroxyl and superoxide anions [61]. Through optimization studies, the ideal extraction parameters were determined as: 40% ethanol solvent, 1:60 (g/mL) solid-to-liquid ratio, 60°C extraction temperature, and 50 minutes of ultrasonication. These conditions yielded a maximum flavonoid extraction efficiency of 25.04 mg/g. The obtained flavonoid extract demonstrated significant, dose-dependent antioxidant activity, effectively scavenging both hydroxyl and superoxide anion radicals.

Anticancer activity

Cancer remains a leading cause of morbidity and mortality worldwide, with incidence rates rising rapidly across Central and South America, Africa, and Asia [27]. Research has identified numerous bioactive compounds in *Ficus* species with demonstrated anticancer properties. Historically, fig leaves have been employed in traditional medicine systems for treating various malignancies [26]. Contemporary studies confirm that leaf extracts and their phytoconstituents exhibit significant anticancer effects against liver, cervical, breast, prostate, and colon cancers [28]. *In vitro* investigations reveal that *Ficus* leaf extracts demonstrate superior anticancer potency compared to fruit extracts, particularly in suppressing liver and cervical cancer cell proliferation. [16] demonstrated that aqueous leaf extracts effectively reduce viability and inhibit migration in breast cancer cells.

Further mechanistic studies show that *Ficus carica* leaves modulate critical gene expression patterns: downregulating cell cycle regulators (CDK1, CDK5, CDK9, CDK10) and migration-promoting genes (MPP2), while upregulating pro-apoptotic factors (BAX, TP53, TP21) and migration suppressors (TIMP1, TIMP2) [29]. The aqueous leaf extract demonstrated reduced viability and suppressed migration in breast cancer cells [26]. Similarly, β-caryophyllene exhibited selective antiproliferative activity against colorectal cancer cells [30], while δ-element was found to inhibit colon cancer cell proliferation [31]. The Fiber in fruit is said to lower the risk of colon cancer by speeding up the removal of waste from the body. The methanol extract of *F. carica* leaves significantly inhibited the proliferation of the MDA-MB-231 cell line in a dose-dependent manner, with an IC50 value of 0.081 mg/mL [32]. Figs contain compounds like 6-O-acyl-β-D-glucosyl-β-sitosterols, which are associated with chemopreventive properties. The acyl groups, such as palmitoyl, linoleyl, stearyl, and oleyl, exhibit significant anticancer effects by inhibiting cell growth and triggering cell death in cancers like breast cancer and glioblastoma [33]. The details of the anticancer activity of FC extract are presented in Table 2.

Hypoglycemic effect

In traditional and folk medicine, the leaves of *Ficus carica* (FC) were utilized for the management of diabetes [36]. The elevation of blood glucose levels in diabetic rats was normalized following treatment with ethanol extract derived from the leaves [37]. Additionally, a reduction in plasma glucose levels was observed in diabetic rats administered the aqueous leaf extract, attributed to enhanced glucose uptake by skeletal muscle tissue [38]. The high potassium content in figs further supports glycemic control by promoting pancreatic β-cell function and insulin secretion. A recent study reinforced these findings, showing that methanolic extracts of leaves and buds (200 mg/kg) administered for 30 days effectively restored normal glycemia (≈1 g/L) in Type-1 diabetic rats [39]. Additionally, the biochemical analysis also confirmed the extracts' antidiabetic properties by lowering serum liver enzyme levels.

Angiogenesis-suppressing activity

The inhibitory effects of F. carica latex extract on blood vessel formation (angiogenesis) and cell multiplication were examined in human umbilical vein endothelial cells (HUVECs) [40]. The latex extracts of *F. carica* significantly inhibited cell proliferation and capillary tube formation in a dose-dependent manner within the range of 100–400 μg/ml without showing cytotoxicity up to 450 μg/ml. These findings suggest that *F. carica* latex extract possesses potent anti-angiogenic and anti-proliferative activities, making it a promising candidate for suppressing blood vessel formation in oncological and chronic disorders.

Erythropoietic effect

The erythropoietic potential of several Indian medicinal plants, including *Aegle marmelos*, *Eugenia jambolana*, *Boerhavia diffusa*, *Carissa congesta*, *Ficus carica*, *Phoenix sylvestris*, *Phyllanthus emblica*, *Spinacia oleracea*, and *Vitis vinifera* was was demonstrated in Wistar albino rats [41]. The extract of fruit, leaf, and root of these plants was administered to the experimental rats for seven consecutive days to assess their impact on key hematological parameters, specifically red blood cell (RBC) count and hemoglobin (Hb%) levels. Enhanced hematological indices were observed in the treated animals compared to the control group. Notably, fruit extracts from *Aegle marmelos*, *Carissa congesta*, *Eugenia jambolana*, *Ficus carica*, *Phoenix sylvestris*, *Phyllanthus emblica*, and *Vitis vinifera* individually demonstrated a significant rise in these parameters. The findings suggest that most of the plant extracts stimulated hemoglobin synthesis and RBC production, with efficacy ranked in descending order as follows: *Phyllanthus emblica*, *Spinacia oleracea*, *Ficus carica*, *Phoenix sylvestris*, *Boerhavia diffusa*, *Aegle marmelos*, *Vitis vinifera*, *Eugenia jambolana*, *Asparagus racemosus*, and *Carissa congesta* [41].

Cholesterol lowering activity

In vitro investigations using HepG2 cells demonstrated the cholesterol-lowering effects of fig extracts [38]. Researchers evaluated extract efficacy under both basal and hyperglycemic conditions (48-hour incubation), with glucose stimulation significantly elevating cholesterol secretion (17 ± 0.76 mg/dL versus basal 6.91 ± 0.66 mg/dL). Fig extracts co-treatment effectively attenuated this glucose-induced cholesterol hypersecretion across multiple concentrations. Intracellular cholesterol analysis revealed significantly higher accumulation in glucose-treated cells (2.73 ± 0.39 mg/dL) compared to basal controls (1.96 ± 0.14 mg/dL; $p < 0.001$), with extract treatment mitigating this metabolic dysregulation [38]. This could be beneficial for managing conditions like postprandial hyperlipidemia (high cholesterol after eating) [42]. A study on rats supplemented with dried figs (*F. carica* L.) observed lower levels of total cholesterol, triglycerides, LDL-C, and VLDL-C, along with higher HDL-C levels and a better atherogenic index (LDL-C/HDL-C ratio) [43].

Hepatoprotective Effects

Multiple studies have underscored the liver-protective properties of Ficus extracts, demonstrating their capacity to shield the liver from conditions like hepatitis, cirrhosis, and fatty liver disease caused by oxidative stress. Extracts and components derived from *F. carica leaves* have shown potential in reversing liver damage. Chloroform extracts reduced cholesterol secretion in HepG2 cells and lowered blood cholesterol in streptozocin-induced diabetic rats [38]. Furthermore, Leaf and bud extracts decreased ALT/AST levels in diabetic and normal rats over 4 weeks. [44] demonstrated the hepatoprotective effects of dried fig leaves, highlighting significant liver cell regeneration post-intoxication. Supporting these findings, experiments on albino rats, *F. carica demonstrated* hepatoprotective effects against CCl_4-induced liver damage, evidenced by lowered serum levels of SGOT, SGPT, alkaline phosphatase levels (177.76, 112.38, 73.74 units/ml), and total serum bilirubin (2.29 mg/dl) [13]. The hepatoprotective effect was dose-dependent (50 mg/kg, 100 mg/kg, and 200 mg/kg) and comparable to silymarin (10 mg/kg), a standard hepatoprotective drug. Consistent with these outcomes, β-caryophyllene restored normal serum levels of alanine transaminase, aspartate transaminase, and total malondialdehyde in rats suffering from ketoprofen-induced hepatic injury [24]. Similarly, umbelliferone was shown to replenish total glutathione and alanine transaminase concentrations while decreasing liver lipid peroxidation in rodents with N-nitrosodiethylamine-induced hepatic damage [45].

Hypocholesterolemic activity

Ficus carica leaves demonstrate significant hypocholesterolemic effects. The chloroform extract derived from aqueous leaf decoction effectively reduces total cholesterol levels and improves the total cholesterol/HDL ratio while simultaneously lowering blood glucose concentrations. Furthermore, this extract significantly decreases intracellular cholesterol accumulation in HepG2 cells, correlating with observed reductions in serum cholesterol levels in streptozotocin-induced diabetic rat models [38].

Anti-bacterial activity

Fig leaf extract contains flavonoids, tannins, and terpenoids, known for their antibacterial properties. Flavonoids possess antioxidant and antimicrobial abilities, while tannins inhibit microbial growth by protein binding. Terpenoids also exhibit antimicrobial effects. Research supports fig leaf extract's potential as a natural remedy for bacterial infections, but further investigation is necessary. Numerous studies have demonstrated the antibacterial properties of *F. carica* leaf extracts and their bioactive components [46]. Research has revealed particularly strong activity against Gram-negative pathogens including *C. violaceum, P. aeruginosa, A. niger, and E. coli* [46]. The constituent vanillic acid exhibited antimicrobial effects against *E. cloacae* (MIC = 600 µg/mL) through membrane disruption [46]. Against Gram-positive bacteria, ethanol extracts completely inhibited *Enterococcus faecalis* growth at 50% concentration [27], while methanol extracts showed efficacy against *S. aureus* (MIC 125-250 µg/mL), *S. epidermidis* (MIC 31.25-62.5 µg/mL), and *S. pyogenes* (MIC 62.5-125 µg/mL) [40]. Notably, the volatile compound β-caryophyllene demonstrated potent activity against S. aureus (MIC 3 ± 1.0 µM) [30]. Three principal bioactive compounds was characterized in fig extracts with both antibacterial and antioxidant properties: eugenol, psoralen, and notably acetyleugenol, the latter representing a novel phenolic identification in *F. carica* [18]. Furthermore, phytosynthesized calcium oxide nanoparticles using fig extract displayed differential antimicrobial effects, with inhibition zones ordered as: *P. aeruginosa* (28 ± 1.0 mm) >*S. aureus* (23 ± 0.3+9 mm) >*K. pneumoniae* (18 ± 0.9 mm) >*P. vulgaris* (13 ± 1.6 mm) >*E. coli* (11 ± 0.5 mm) [47].

Anti-viral activity

Phytochemical screening of the common fig has identified over 50 components with therapeutic potential [3]. Among these, 38 compounds were specifically examined for their antiviral effects targeting COVID-19. To gauge the efficacy of these compounds in inhibiting ACE 2 and COVID-19 MPro, Remdesivir, a known antiviral agent, was included in the docking analysis as a reference for comparison [48]. Molecular docking analysis, a computational approach used in this investigation [49], predicted binding interactions between fig-derived compounds and target proteins. Among the 38 compounds analyzed, cyanidin-3-rhamnoglucoside, quercetin-3-O-rutinoside, α-amyrin, quercetin-3-glucoside, and lanosterol demonstrated the strongest binding affinity for ACE2 based on docking scores. For COVID-19 MPro, the top binders were cyanidin-3-rhamnoglucoside, quercetin-3-glucoside, quercetin-3-O-rutinoside, lupeol and α-amyrin. Notably, cyanidin-3-rhamnoglucoside and quercetin-3-O-rutinoside emerged as particularly promising bioactive candidates, with cyanidin-3-rhamnoglucoside showing exceptional potential for COVID-19 management based on molecular docking results [50].

Anti-spasmodic potential

The spasmolytic properties of aqueous ethanol extract from mature dried figs have been documented [2]. The study demonstrated potent antispasmodic effects, likely mediated through K+ ATP channel activation, comparable to cromakalim's mechanism of action. This was confirmed by the extract's capacity to inhibit both spontaneous and low K+ induced contractions in isolated rabbit jejunum preparations. Glibenclamide pretreatment caused a shift in low K+ induced contractions, further confirming K+ ATP channel involvement. Additionally, *F. carica* exhibited inhibitory effects on human platelet aggregation triggered by adenosine 5'-diphosphate and adrenaline, indicating combined spasmolytic and antiplatelet activities.

Anti-Herpes Simplex Virus-1 Effects

Ficus leaf extracts demonstrated potent virucidal activity against HSV-1 while maintaining minimal cytotoxicity. When evaluated on Hep-2, BHK21, and PRK cell lines, the aqueous leaf extract showed therapeutic index values of 30.0 [51]. Given the established association between HSV-1 infection and Alzheimer's disease pathogenesis [52], the dual anti-HSV-1 and anticholinesterase properties of fig leaves present significant therapeutic potential for Alzheimer's disease management.

Anti-constipation effect

The laxative properties of figs (*F. carica* L.) have been extensively studied, as constipation is a prevalent gastrointestinal issue worldwide. The study investigated the efficacy of fig paste in alleviating constipation in rodents, where constipation was experimentally induced using loperamide [53]. The experimental design comprised one normal control group and four treatment groups receiving different doses of fig paste (0, 1, 6, and 30 g/kg). Constipation was induced in the four experimental groups with intraperitoneal injections of loperamide (2 mg/kg, twice daily). Fig paste was administered for four weeks to evaluate its anti-constipation effects. Experimental findings revealed that rats administered fig extract exhibited significant improvements in gastrointestinal function, demonstrating increased fecal output (both in quantity and weight) along with higher stool moisture content relative to control animals. The treatment groups also displayed enhanced intestinal motility and ileal contractility. These results indicate fig fruit's efficacy in mitigating constipation symptoms in rodent models [54]. Supporting evidence from human clinical research further substantiates these effects, where fig consumption improved bowel regularity in patients with functional constipation [18]. In a controlled study of 20 female participants, regular fig intake led to more frequent defecation, shorter evacuation time, and reduced abdominal discomfort, highlighting its potential as both a therapeutic intervention and preventive strategy for chronic constipation management. [55] Also found that fig paste effectively relieved constipation in beagles on a high-protein diet with limited movement by increasing fecal output, water content, and defecation frequency while reducing fecal hardness and transit time and promoting beneficial gut bacteria. Significant improvements in irritable bowel syndrome with predominant constipation (IBS-C) symptoms like frequency of pain, distention, defecation frequency, and hard stool) and quality of life were observed following a 4-month intervention with *Descurainia sophia* or *Ficus carica* compared to a control group, suggesting their potential as first-line treatments [41].

Anti-inflammatory activity

Inflammation is a key factor in the development of various diseases, and Ficus extracts have demonstrated promising anti-inflammatory properties in numerous preclinical studies. The potential anti-inflammatory effects of petroleum ether (PEE), chloroform (CE), and ethanol (EE) extracts were investigated from the leaves of *F. carica* Linn [56]. They evaluated anti-inflammatory activity using carrageenan-induced rat paw edema and cotton pellet granuloma models. All three extracts significantly reduced inflammation in both acute and chronic inflammation models in rats. The ethanolic extract at a dose of 600 mg/kg showed the most potent effect, decreasing acute inflammation by 75.90% and chronic inflammation (granuloma weight) by 71.66%. This treatment reduced inflammation by approximately 64.07%, in contrast to the 45.13% reduction achieved with standard diclofenac sodium, in a carrageenan-induced inflammation model using albino rats [57].

Immunostimulant

The ethanol extract derived from *Ficus carica* leaves was evaluated for its immunomodulatory potential in murine models. Through comprehensive hematological and serological analyses, the study demonstrated that treatment with the extract significantly enhanced both cellular and humoral immune responses. These findings indicate that fig leaf ethanol extract exhibits notable immunostimulatory activity [56].

Economics Importance

Global fig production is dominated by Turkey, Egypt, and Algeria, with Spain being the sole European country ranked among the top 10 producers [2]. FAOSTAT (2022) reports that *Ficus carica* cultivation spans 281,522 hectares worldwide, yielding approximately 1,264,943 tonnes annually [2]. However, post-harvest losses occur due to rapid spoilage from overripening or improper maturation, driven by the fruit's high bioactive compound content. Valorizing these discarded figs by extracting their bioactive components for use in food and industrial applications could mitigate economic losses, particularly in Mediterranean economies [58]. Dried figs are the preferred form for consumption, with Iran, the U.S., Germany, India, France, and Italy representing the largest markets [59]. The fruit's perishability and nutrient degradation during storage necessitate preservation methods such as salting, dehydration, and fermentation to extend shelf life [2,5]. However, limited processing infrastructure in some regions exacerbates post-harvest losses [2]. Historically, figs have been consumed fresh or dried as a dietary staple, with fig syrup (10–20 mL) serving as a traditional remedy for constipation [60]. Beyond the fruit, fig leaves are used as animal fodder, while the latex acts as a milk coagulant in artisanal cheese production.

Challenges and future thrust

Despite the significant therapeutic potential of *Ficus carica*, several challenges hinder its widespread utilization, including the lack of standardized extracts due to variability in bioactive compounds influenced by genetic differences, growing conditions, and extraction methods, as well as limited clinical evidence, with most studies restricted to preclinical models. Additionally, high post-harvest losses from the fruit's perishability and insufficient processing infrastructure, particularly in developing regions, pose economic constraints. The key components, like latex remain understudied despite their bioactive promise. Further challenges include undefined toxicity profiles, potential allergenic reactions (e.g., from ficin), and unclear optimal dosages for therapeutic use, alongside agricultural vulnerabilities such as climate sensitivity. To address these challenges, future research should focus on the standardization of bioactive extracts through advanced analytical and processing technologies. Clinical validation via rigorous human trials is needed to establish efficacy, safety and dosing guidelines. Mechanistic and toxicological profiling should be conducted to elucidate molecular pathways and long-term safety. Technological advancements in processing must be developed to minimize post-harvest losses and enhance economic viability. Climate-resilient breeding programs should be implemented to ensure sustainable production. Interdisciplinary collaboration among pharmacologists, agronomists, food scientists, and biotechnologists will be crucial to unlocking the full potential of *F. carica* as a multifunctional therapeutic agent and economically viable crop.

Conclusion

This review establishes *Ficus carica* L. as a multifunctional therapeutic agent with demonstrated antioxidant, anticancer, antidiabetic, antimicrobial, hepatoprotective, and laxative properties. Its bioactive compounds, particularly phenolics and flavonoids, exert therapeutic effects through modulation of critical cellular pathways. While substantial evidence supports its pharmacological potential, significant research gaps remain regarding latex bioactivity and clinical validation of preclinical findings. Fig emerges as a promising candidate for development into functional foods, nutraceuticals, and pharmaceutical applications. Future research priorities should include: (1) comprehensive phytochemical profiling, particularly of latex components; (2) standardization of extraction methods; (3) mechanistic and toxicological studies; and (4) clinical translation of therapeutic applications. This evidence-based approach will enable full realization of the plant's potential in addressing contemporary health challenges while contributing to sustainable economic development.

Author contributions

T.L conceptualization of the study, data curation, writing original draft and funding acquisition; A.S, P.B, S.K. A.D and R.T: Funding acquisition, review & editing.

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Compliance with ethical standards

Conflict of interest: The authors have no financial or commercial conflicts of interest to disclose regarding this study.

Table 1. Antioxidant potential of Ficus carica extracts and their active components

Extracts	Active compound		Results	References
Bark extract	Eugenol, psoralen, and acetyleugenol, eugenol	H_2O_2 and DPPH free radical scavenging activity assay	49.35 ± 0.29%, 90.07 ± 0.15%.	[18]
Waste leaf (ethyl acetate extract)	quercetin, isoschaftoside, and rutin	DPPH radical scavengingABTS, and FRAP	DPPH- IC50 0.54 mg/mL, ABTS- 80.28%, and FRAP- 3.46 mmol/g.	[19]
Pulp and peel extract	quercetin-3-O-rutinoside, quercetin-3-O-glucoside, cyanidine-3,5-diglucoside and cyanidine-3-O-rutinoside.	DPPH, ABTS and LPIC assays	IC 50 = 3.97, 56.49 and 76.19 μg/mL, respectively,	[10]
Latex extracts	gallic acid equivalent and catechin equivalent	To scavenge free DPPH and ABTS radicals,	IC_{50} = 13.6, 7.0, 6.0 μg/ml and 4.5, 6.4, 2.0 μg/ml, respectively	[20]
Leaves (methanol extract)	Polyphemol (Gallic acid) and flavanoid (quercetin)	DPPH radical scavenging activity and FRAP	DPPH assay IC50 of 275.23 ± 0.045 μg/mL, while FRAP values ranged from 0.113 ± 0.004 to 0.494 ± 0.008 μg TE/mL	[21]
Leaves	Psoralic acid glucoside (PAG)	ORAC	ORAC value of 0.79 ± 0.17 μmol TE/μmol	[15]
Leaves and bark	Hydroalcohol	DPPH radical scavenging activity	Radical scavenging activity against DPPH radicals showed IC50 values of 64.00 ± 0.59 μg/mL	[21]
Leaves, bark and woody parts (ethanol extract)	coumarins, psoralen, bergapten, fatty acid	Linoleic acid peroxidation and DPPH test	DPPH scavenging and lipid peroxidation IC(50)= 100 and 1.48 μg/ml respectively	[23]
Leaves and fruit (methanol exatract)	-	GSH content, SOD, CAT activities	Increased cellular glutathione (GSH) levels (47.91%), superoxide dismutase (SOD) (27.5%) and catalase (CAT) activities (26.2%)	[24]
Pulp, peel and leaves (lyophilized extract)	-	DPPH, •NO, O2•– Scavenging activity	DPPH, superoxide ($O_2^{\bullet -}$), and nitric oxide (•NO) with IC_{25} values below 75.2 μg/mL, 118.5 μg/mL, and 33.0 μg/mL, respectively	[17]
Bark, fruits and leaves extracts (*F. microcarpa*) (ethyl acetate fraction)	Phenolic compounds	DPPH and ABTS+ free radicals, superoxide radicals scavenging	effective in radicals scavenging activity, EC_{50} = 4.83, 1.62 and 63.2 lg/ml, respectively.	[25]

DPPH- 1-diphenyl-2-picrylhydrazyl, FRAP- Ferric reducing power; GSH- blood glutathione; SOD- superoxide dismutase, CAT- catalase; ABTS- 2,20-azino-bis(3-ethylbenzothiazoline-6-sulfonic) acid; Note: The antioxidant capacity is inversely related to the (Inhibitory Concentration) IC50 value.

Table 2. Anticancer activity of Ficus carica extracts and bioactive compounds

EXTRACTS	COMPOUND TYPE	CANCER TYPE	CELL TYPE	RESULTS	REFERENCES
Leaf and fruit extract (methanolic)		Liver	Huh7it cells	High apaoptosis and necrosis of Huh7it cells Reduced IC_{50} value (>653 653 μg/mL and 2000 μg/mL in leaf and fruit extracts respectively)	[12]
Leaf and fruit extract, latex (ethanolic)	ethanolic, ethyl acetate and dichloromethane	Cervical	HeLa cell line	Reduce the viability of the He La cells, IC_{50}= 12, 12, 11.5 μg/mL respectively	[28]
Leaf extract (ethanolic)		Breast and Colon cancer	CaCo-2, Hep2, MCF7 and HepG2 cells	Inhibited the viability of cancer cells with inhibition percentage of 80.7-66.9%	[8]
Leaf extract (ethanolic)	psoralen, and bergapten	Breast	RD cell	Promote cancer cell death	[16]
Essential oil	β-Caryophyllene	Colorectal	HCT-116 cells	IC_{50} = 19 μM	[30]
Leaf extract *F. crocata*	hexane (Hex-EFc), dichloromethane (Dic-EFc), and acetone (Ace-EFc)	Breast	MCF-7 and MDA-MB-231	IC_{50} = 40.92 and 54.89 μg/mL)	[34]
Leaf and stem extract *F. carica*		Liver	HepG2 cells	Antiproliferative effects against HepG2 cells, IC_{50} = 0.179 mg/mL	[35]
Latex extracts: *F. carica* (FCE) and *F. sycomorus* (FSE)	gallic acid equivalent and catechin equivalent	Acute myeloid leukemia, breast and liver	HL-60, MCF-7 and HepG2 cancer cell lines	Showed potent cytotoxic with an IC50 value of 25.30 ± 2.11 μg/ml, comparable to doxorubicin (IC50: 24.50 ± 1.72 μg/ml).	[20]
Leaves, bark and wood parts (*F. carica*)	Coumarins, bergapten and psoralen, polyphenols, flavonoid and fatty acids	Skin	C32 human melanoma cells,	Anti-proliferative activity showing IC(50) = 3.92 μg/ml.	[23]

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