



PHYTOCHEMICAL AND PHARMACOLOGICAL INSIGHTS OF *CARICA PAPAYA*: AN UPDATE REVIEW

Smrutiranjana Dash, Jaya Rani Sonkar*

Department of Pharmacology, Faculty of Pharmacy, Kalinga University, Naya Raipur,
Chhattisgarh, India.

Article Received on 31 Jan. 2026,
Article Revised on 21 Feb. 2026,
Article Published on 01 March 2026,

<https://doi.org/10.5281/zenodo.18810751>

*Corresponding Author

Jaya Rani Sonkar

Department of Pharmacology, Faculty
of Pharmacy, Kalinga University,
Naya Raipur, Chhattisgarh, India.



How To Cite This Article: Smrutiranjana Dash, Jaya Rani Sonkar* (2026). Phytochemical and Pharmacological Insights of *Carica Papaya*: An Update Review. World Journal of Pharmacy and Pharmaceutical Sciences, 15(3), 444-463.
This work is licensed under Creative Commons Attribution 4.0 International license.

ABSTRACT

Carica papaya L. (CP) (family *Caricaceae*), commonly known as papaya, is a widely cultivated tropical fruit plant valued for its nutritional, medicinal, and economic importance. Native to southern Mexico and Central America, papaya is now grown extensively in tropical and subtropical regions, with India being the largest global producer. Traditionally, *C. papaya* has been used in various medicinal systems for the management of digestive disorders, wounds, infectious diseases, and inflammatory conditions. Different parts of the plant, including leaves, fruits, seeds, and latex, contain diverse bioactive constituents such as papain, chymopapain, flavonoids, alkaloids, carotenoids, lycopene, vitamins, and antioxidants, which contribute to its broad pharmacological activities. These compounds exhibit antioxidant, anti-inflammatory,

antimicrobial, antidiabetic, anticancer, and immune-modulatory properties. In addition to its therapeutic potential, papaya is nutritionally rich, providing essential vitamins, dietary fiber, and phytonutrients, making it an affordable and valuable dietary component. This review comprehensively summarizes the taxonomy, origin, nutritional composition, phytochemistry, traditional and ethnopharmacological uses, post-harvest practices, genomics, genetic improvement, and commercially available value-added products of *Carica papaya*. By integrating findings from diverse scientific sources, this article highlights key research developments and emphasizes the potential of *C. papaya* as a functional food and medicinal

plant, while identifying future research opportunities for its effective utilization in healthcare and agriculture.

KEYWORDS: *Carica papaya*, Pharmacological activity, Phytoconstituents, Phytochemistry.

INTRODUCTION

Even with major progress in modern medicine, quality healthcare is still not available to everyone. Traditional medicine, especially herbal medicine, continues to play an important role in healthcare, particularly in rural and developing regions. Many people depend on systems such as Ayurveda, Siddha, and Unani, which have a long history of effective use. Today, scientific research also supports the value of these systems, and medicinal plants are seen as important sources for new drugs. Integrating traditional medicine into modern healthcare can help improve access to treatment for all.^[1] The appeal of herbal medicines lies in their favourable safety profile and broad pharmacological activities. Medicinal plants contain diverse bioactive compounds exhibiting antioxidant, anti-inflammatory, antimicrobial, antidiabetic, and anticancer properties, enabling multi-target therapeutic actions that support both preventive and curative healthcare.^[2,3] Herbal medicines remain important in global healthcare because they are affordable, culturally accepted, and widely perceived as safe. They offer therapeutic potential and support holistic health approaches. However, issues related to standardization, scientific validation, and regulation limit their broader acceptance. Addressing these challenges through a balanced, evidence-based approach is essential to ensure their safe and effective integration into modern healthcare.^[4]

Carica papaya belongs to the family *Caricaceae* and is commonly known as papaya. It is known by various vernacular names such as tree melon, papaia, papita, tapaya, lapaya, kapaya, paw-paw, papaw, lechosa, fruta bomba, mammon, mamona, mamao and papaia in different regions of the world.^[5] CP is widely recognized worldwide for its rich nutritional value, and almost all parts of the plant are well known for their traditional medicinal uses.^[6] CP is widely grown in tropical and subtropical regions. India is the leading producer, contributing about 43% of global production, while the United States is a major consumer. CP was historically assigned to several families, including *Passifloraceae*, *Cucurbitaceae*, *Bixaceae*, and *Papayaceae*, but is now placed in the family *Caricaceae*, which comprises approximately 35 latex-producing species distributed among four genera: *Carica*, *Jarilla*, *Jacaratia*, and *Cyclicomorpha*.^[7] CP is native to southern Mexico and Central America and

has also been introduced to regions such as the Philippines.^[8,9] *Carica papaya* L. is believed to have arisen through hybridization with related wild species.^[10]

Carica papaya, regarded as a “quasi-drug” for its therapeutic properties, has been traditionally used to manage various health conditions.^[11,12] In Africa, papaya pulp is used in hospitals to treat burns and promote wound healing.^[13] *Carica papaya* leaf extract has shown potential as a supportive therapy in cancer treatment.^[14] Studies have reported that it can reduce the growth and proliferation of cancer cells in vitro.^[15–17] Papain combined with urea is effective for enzyme wound debridement. Papaya latex aids in treating dyspepsia, burns, diarrhea, and whooping cough, while unripe fruit is used for impotence, ulcers, and menstrual regulation.^[18,19]

Carica Papaya is a fast-growing, tropical, semi-woody herb with a usually hollow, straight stem showing apical dominance. Branching occurs only if the apical meristem is removed, and the crown bears large, palmately lobed, spirally arranged leaves. Variations in leaf structure and arrangement have been reported in Malaysian cultivars.^[20,21] Unripe papaya is green with hard skin and abundant white latex, while ripe fruit is yellow-orange with thick, juicy, aromatic flesh. Seeds are gray to black, partly attached by fibrous tissue. Two main cultivars are grown: ‘red papaya’ with orange-red flesh and ‘yellow papaya’.^[22] Papaya, often called the “common man’s fruit” for its affordability and high nutritional value, contains phytonutrients in leaves and fruits. It is rich in thiamine, folate, riboflavin, niacin, vitamins A, B1, B2, C, and dietary fiber, ranking among the top five fruits for nutritional quality alongside kiwi, watermelon, grapefruit, and guava.^[23–25]

CP is widely recognized for its high nutritional value. Almost all parts of the plant are used in traditional medicine, and extensive research over recent decades has confirmed its pharmacological and therapeutic potential, supporting its use as a beneficial nutritional supplement.^[26] CP has long been used in traditional medicine for managing digestive disorders, wounds, jaundice, Malaria, Dengue, Zika virus infection, and Chikungunya.^[27] Its bioactive constituents including papain, chymopapain, alkaloids, flavonoids, lycopene, carotenoids, anthraquinone glycosides, antioxidants, and vitamins contribute to its pharmacological potential. This chapter summarizes the ethnopharmacological and traditional applications of various parts of the plant.^[28]

This review aims to provide a comprehensive overview of *Carica papaya*, covering its nutritional profile, phytochemistry, medicinal uses, disease management, post-harvest practices, genomics, genetic improvement, and commercially available value-added products. By integrating data from multiple reliable sources, this work highlights the major milestones in papaya research, tracing its evolution from origin to biotechnological applications, and aims to guide future research directions in this versatile crop.

MATERIALS AND METHODS

The present study was carried using information obtained from a comprehensive review of published literature sources. Data were collected from various online scientific databases, including Google Scholar, ResearchGate, ScienceDirect, PubMed, Springer Nature, as well as from Indian Flora, World Flora, and relevant botanical and pharmacological reference books.

Morphological characteristic

Carica papaya is a softwood, single-stem tree (about 10 m tall) that produces milky latex and is commonly grown in topical low-land areas, where it often spreads on its own. All the morphological characteristics are represented in table no.1.^[29,30]

Table 1: Morphological characteristic of *Carica Papaya*.

Sl.No-	Parts	Description	Size	Shape
1	Leaves	Leaves dropping proximally, erect spreading distally..	leaf blade has 20-35cm wide, contains 5-9 lobes, petiole length is 35-70cm .	lobe has long and narrow egg shape, leaf blade has round shape
2	Inflorescence	Inflorescences; bracts $\pm$ rhombic	It has 15-60 cm	Bracts $\pm$ rhombic
3	Stamina (male) flowers	Sessile; calyx green, short-tubular, teeth triangular to linear; corolla white; stamens yellow.	Calyx about 1.5mm; corolla 2-3.5cm; lobes about 1.3 cm.	Lobes narrowly oblong.
4	Pistillate (female) flowers	Subsessile; calyx yellow, short-tubular, teeth triangular to linear; petals white to pale yellow.	Calyx 5-10mm; petals 3-5cm; ovary 2-3 cm.	Petals lanceolate; and ovary 2-3 cm.
5	Fruit (berries)	Hanging from truck near summit; green to orange; roundes distally	About 8-45 cm	Ellipsoidal to oblong
6	Stem	Bark green to gray or brown, leaf	About 20 cm	cylindrical

		scars prominent, smooth	diameter	
7	Plant	It is big with single trunk. It has many large leaves at the top that look like an umbrella. It is a polygamous species.	Height about 20-30 feet	Umbrella-like canopy

RESULTS AND DISCUSSION

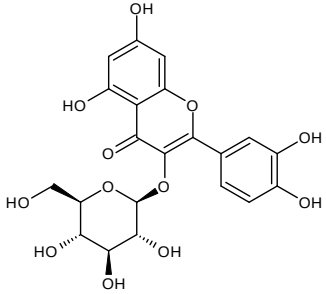
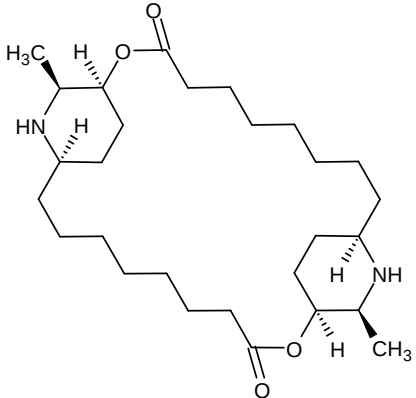
Phytoconstituents

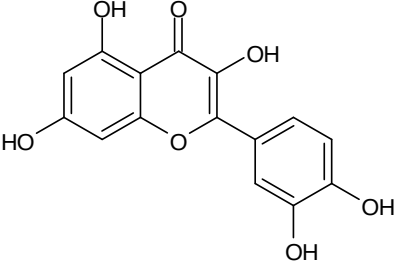
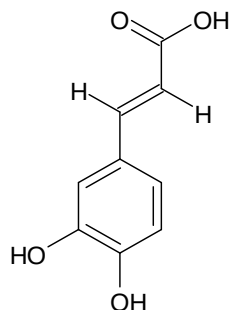
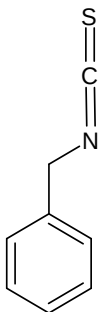
Carica papaya exhibited a diverse phytochemical composition across its various plant parts, reflecting its wide-ranging pharmacological potential. The leaves were predominantly rich in flavonoids and phenolic acids, including quercetin-3-O-glycopyranoside, carpaine, caffeic acid, kaempferol-3-O-rutinoside, quercetin-3-O-rutinoside, ferulic acid, kaempferol, protocatechuic acid, vanillic acid, and 5,7-dimethoxycoumarin. The seeds were characterized by the presence of bioactive compounds such as benzyl isothiocyanate, oleic acid, p-coumaric acid, 1,2,3,4-tetrahydropyridin-3-yl-octanoate, p-hydroxybenzoic acid, salicylic acid, hyperoxide, gentisyl alcohol, trigalloyl glucose, chlorogenic acid, cinnamic acid, apigenin, and coumaric acid. Latex was primarily composed of the proteolytic enzyme papain, which is responsible for its digestive and medicinal properties. The fruit contained high levels of carotenoids, including lycopene, β -carotene, β -cryptoxanthin, along with quercetin, contributing to its antioxidant activity. Additionally *Carica papaya* was reported to contain several phenolic and bioactive constituents, including isochlorogenic acid, sinapic acid, malic acid, dehydrocarpaine I & II, and chrysin, highlighting the plant's therapeutic potential. All the Phytoconstituents of *Carica papaya* are represented in (Table 2).^[32,33]

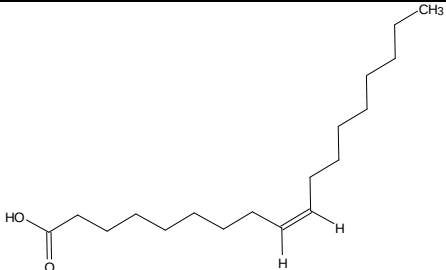
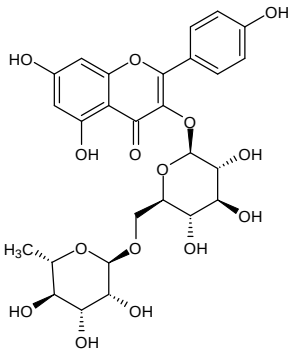
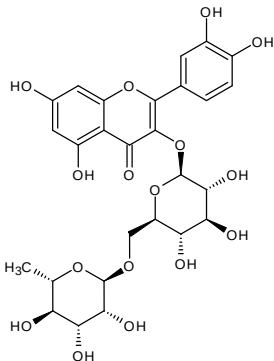
Carica papaya is widely recognized for its rich phytochemical profile, with a majority of its bioactive compounds demonstrating potent antioxidant activity. Antioxidants from *C. papaya* play a crucial role in neutralizing free radicals, thereby potentially preventing oxidative stress-related diseases, including cancer, cardiovascular disorders, and neurodegenerative conditions.^[34] In addition to antioxidant effects, numerous studies report that *C. papaya* phytochemicals exhibit diverse pharmacological activities such as anti-inflammatory, antimicrobial, anticancer, and hepatoprotective effects. The anti-inflammatory properties are particularly notable for their potential in managing chronic inflammatory conditions, while antimicrobial activities suggest the plant's utility against a broad spectrum of pathogens. Evidence of anticancer activity highlights the ability of specific compounds to modulate cell proliferation and apoptosis, and hepatoprotective effects support traditional applications in liver health. The multifunctional bioactivity of *C. papaya* compounds underscores its

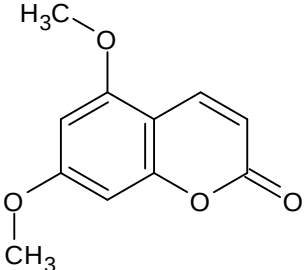
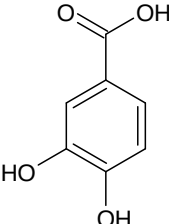
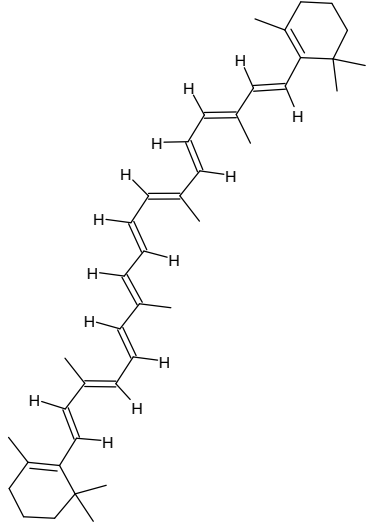
significance as a promising source of natural therapeutic agents. Despite the extensive *in vitro*, there remains a need for more mechanistic studies and clinical evaluations to fully elucidate the therapeutic potential and safety profile of these compounds. Future research focusing on isolation, characterization, and pharmacokinetics of these bioactive molecules will enhance the development of CP based nutraceuticals and pharmaceuticals.

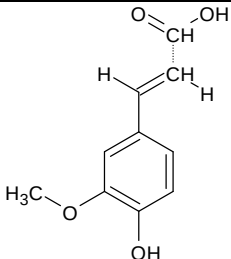
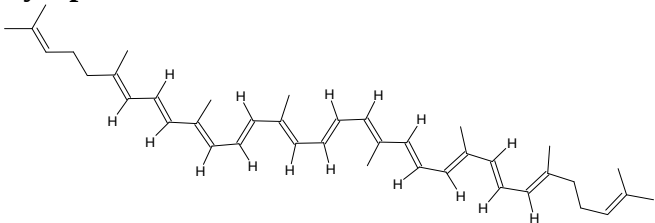
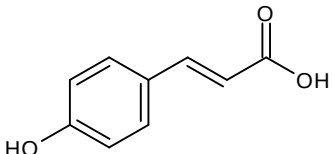
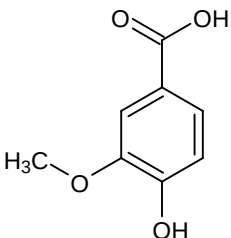
Table 2: Phytoconstituents of *Carica Papaya*.

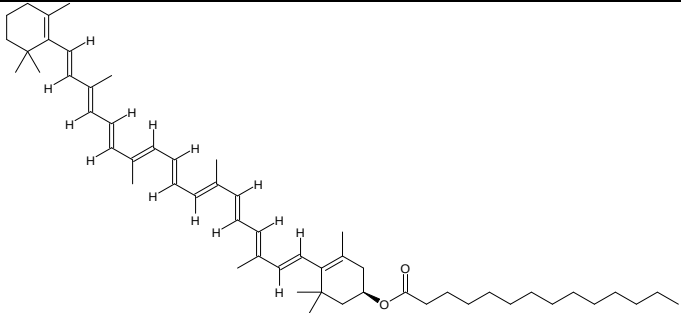
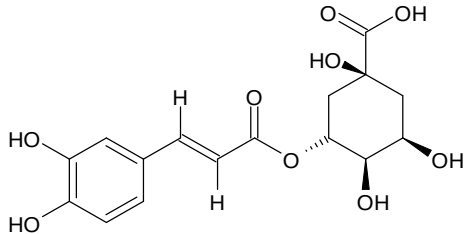
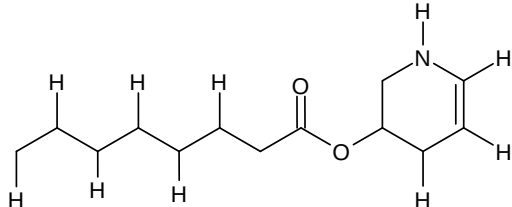
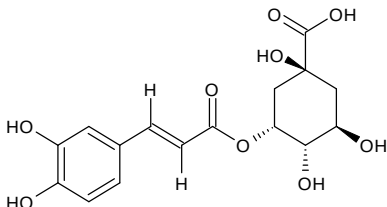
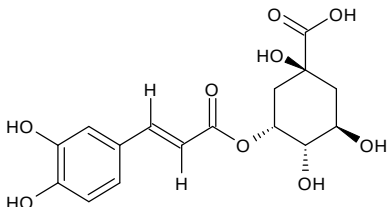
SI no.	Name of the compound	Nature of the compound	M.F	M.W. g/mol	Activity
1	Quercetin-3-O-glycopyranoside 	Flavonoid	C ₂₁ H ₂₀ O ₁₂	464.38	Antioxidant, Anti-inflammatory, Anti-HIV, Antiulcer, Antitumor, Antimicrobial, Anticancer, Anti diabetic, Cardioprotective, Neuroprotective. ^[35,36]
2	Carpaine 	Alkaloid	C ₂₈ H ₅₀ N ₂ O ₄	478.7	Antioxidant, Cardioprotective, Antimicrobial, Anti-plasmodial activity. ^[37]
3	Quercetin	Flavonoid	C ₁₅ H ₁₀ O ₇	302.23	Anti-carcinogenic, Antioxidant, Antiviral, Anticancer, Hepatoprotective, Antifungal, Cytotoxic, Cardiovascular protection, Anti-parasite, Antibacterial, Anti-immunosuppression, Anti-

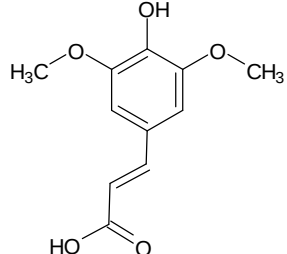
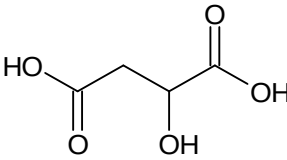
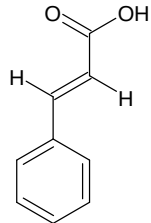
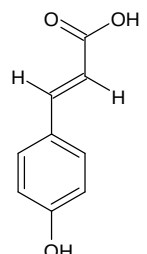
					oncology. ^[38,39]
4	Caffeic acid 	Polyphenol	C ₉ H ₈ O ₄	180.16	Anti-hepatocellular carcinoma, Anticancer, Anti-proliferative, hepatoprotective, Anti-diabetic, Cardioprotective, Immunostimulatory, Anti-atherosclerotic, Antioxidant, Anti-inflammatory, Anti-viral, Anti-bacterial. ^[40]
5	Benzyl isothiocyanate 	Isothiocyanate	C ₈ H ₇ NS	149.21	Antimicrobial, Anti-inflammatory, Antioxidant, Anti-cancer, Anti-proliferative, Anti-obesogenic ^[41,42] , ^[43]
6	Oleic acid	Monounsaturated	C ₁₈ H ₃₄ O ₂	282.5	Antibacterial, Antifungal, Anticancer, Antimalarial, Cardioprotective ^[44]

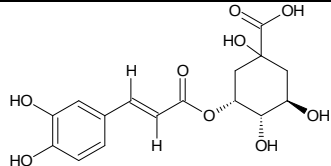
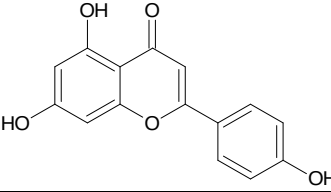
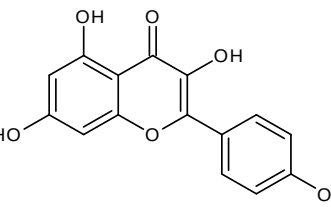
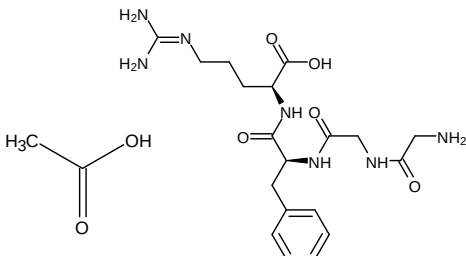
					
7	Kaempferol 3-O- rutinoside 	Flavonoid glycoside	$C_{27}H_{30}O_{15}$	740.7	Antiviral, Antibacterial, Hypoglycemic, Immunomodulatory, Antineoplastic, Anti-inflammatory ^[45]
8	Quercetin-3-O-rutinoside 	Flavonoid glycoside	$C_{27}H_{30}O_{16}$	610.5	Anti-carcinogenic, anti-oxidant, anti-inflammatory. ^[46]
9	5, 7 Dimethoxycoumarin	Coumarin	$C_{11}H_{10}O_4$	206.19	Anti-allodynic, Antidepressant, Anti-diabetic, Anti-inflammatory, Neuroprotective, Antioxidant

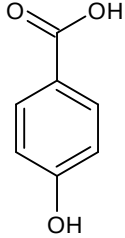
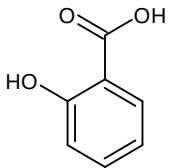
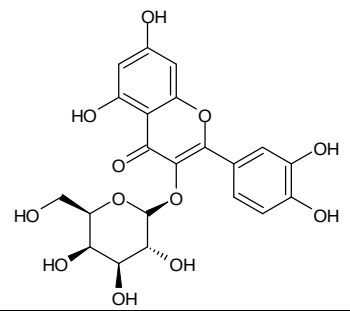
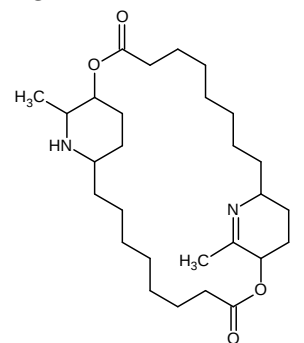
					Anticonvulsant, Anti-Alzheimer. ^[47]
10	Protocatechuic acid 	Phenolic	C ₇ H ₆ O ₄	154.12	Antibacterial, Neuroprotective, Antiviral, Anti-oxidant, Anticancer, Anti-osteoporotic, Analgesia, Anti-aging. ^[48]
11	β-carotene 	Carotenoid	C ₄₀ H ₅₆	536.9	Antioxidant, Anti-inflammatory, Anticancer, Covid 19, Anti-diabetic ^[49]
12	Ferulic acid	Phenolic	C ₁₀ H ₁₀ O ₄	194.18	Anti-carcinogenic, Anti-inflammatory, Antioxidant,

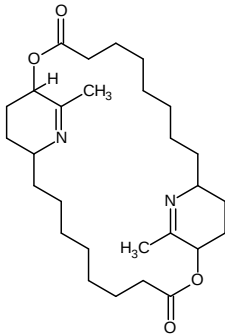
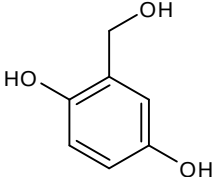
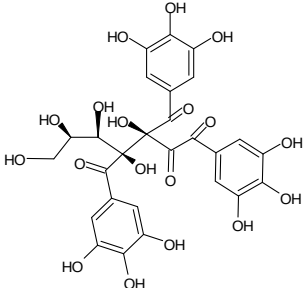
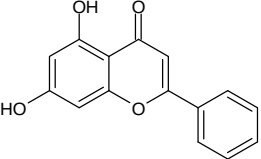
					Antimicrobial, Hepatoprotective, antiviral. ^[50]
13	Lycopene 	Carotenoid	C ₄₀ H ₅₆	536.9	Cardioprotective, Antioxidant, Anti-inflammatory, dyslipidaemia ^{[51] [52]} .
14	p – Coumaric acid 	Phenolic	C ₉ H ₈ O ₃	164.16	Anticancer, Anti-inflammatory, Antioxidant, Antimicrobial ^[53]
15	Vanillic acid 	Phenolic	C ₈ H ₈ O ₄	168.15	Neuroprotective, Antioxidant, Anti-inflammatory ^[54]
16	β- cryptoxanthin	Carotenoid	C ₅₄ H ₈₂ O ₂	763.2	Anticancer, Anti-inflammatory, Antioxidant, Anti-obesity ^[55]

					
17	Chlorogenic acid 	Phenolic	$C_{16}H_{18}O_9$	354.31	Antitumor, Anti-inflammatory, Antibacterial, Antioxidant ^[56]
18	1,2,3,4-tetrahydropyridin-3-yl-octanoate 	Alkaloid	$C_{13}H_{23}NO_2$	225.3	Antifertility. ^[57]
19	Isochlorogenic acid 	Phenolic	$C_{16}H_{18}O_9$	354.31	Anti-inflammatory, Antioxidant, Antimicrobial, Hypoglycemic, Neuroprotective, and Cardiovascular protective and Hepatoprotective ^[58] ^[59]
20	Sinapic acid 	Phenolic	$C_{11}H_{12}O_5$	224.21	Anti-mutagenic, Antimicrobial, Antioxidant, Anticancer,

					Antianxiety, Anti-inflammatory ^[60]
21	Malic acid 	Organic	C ₄ H ₆ O ₅	134.09	Antifungal, Antimicrobial, Anti-parasitic, Anti-inflammatory, Antibacterial, Antioxidant ^[61]
22	Cinnamic acid 	Phenolic	C ₉ H ₈ O ₂	148.16	Anti-diabetic, Antimicrobial, Antioxidant, Anticancer, Anti-inflammatory, Anticancer, Neuroprotective ^[62]
23	Coumaric acid 	Phenolic	C ₉ H ₈ O ₃	164.16	Anti-inflammatory, Anti-diabetes, Antioxidant, Anti-bacterial, Anti-aging ^[63]
24	Neochlorogenic acid	Phenolic	C ₁₆ H ₁₈ O ₉	354.31	Anticancer, Antibacterial, Antioxidant, Hypoglycemic, Hypolipidemic ^[64]

					
25	Apigenin 	Flavonoid	$C_{15}H_{10}O_5$	270.24	Antitumor, Antimicrobial, Antioxidant, Anti-inflammatory ^[65]
26	Kaempferol 	Flavonoid	$C_{15}H_{10}O_6$	286.24	Anti-inflammatory, Anti-carcinogenic, Antiprotozoal, Antibacterial, Antifungal ^[66]
27	Papain 	Enzyme	$C_{21}H_{33}N_7O_8$	511.5	Antioxidant, Anti-inflammatory, Analgesic, Immunomodulatory ^[67]
28	p-Hydroxybenzoic acid	Phenolic	$C_7H_6O_3$	138.12	Antioxidant, Antiviral, Anti-platelet aggregating, Anti-inflammatory, Antimicrobial, Antialgal, Anti-mutagenic, Anti-estrogenic ^[68]

					
29	Salicylic acid 	Phenolic	$C_7H_6O_3$	138.12	Anti- cancer, Anti-tumor, Anti-bacterial, Anti-oxidant, Anti-carcinogenic, Antiviral, Anti-proliferative. ^[69]
30	Hyperoxide 	Flavonoid glycoside	$C_{21}H_{20}O_{12}$	464.4	Antidepressant, Antiviral, Antibacterial, Anti-inflammatory, Anticancer. ^[70]
31	Dehydrocarpaine I 	Alkaloid	$C_{28}H_{48}N_2O_4$	476.7	Anti-dengue, Anticancer, Anti-diabetic, Neuroprotective, Anti-inflammatory. ^[71]

32	Dehydrocarpaine II 	Alkaloid	$C_{28}H_{46}N_2O_4$	474.7	Antiviral, Antimicrobial, Antimalarial, anti-helminthic, Hepatoprotective. ^[72]
33	Gentisyl alcohol 	Phenolic	$C_7H_8O_3$	140.14	Antioxidant, Antiviral, Anti-bacterial, Anticancer. ^[73]
34	Trigalloyl glucose 	Tannin	$C_{27}H_{24}O_{18}$	636.5	Anti-diabetes, Anti-angiogenesis, Anti-cancer. ^[74]
35	Chrysin 	Flavonoid	$C_{15}H_{10}O_4$	254.24	Antioxidant, Anticancer, Antiviral, Anti-inflammatory. ^[75]

Pharmacological activity of *Carica papaya*

Anti-ulcer activity

The methanolic seed extract of *Carica papaya* showed anti-ulcer activity in indomethacin-induced ulcers at 100–200 mg/kg body weight, indicated by increased gastric pH, reduced gastric acidity and acid output, and increased ulcer inhibition percentage (Table 3).^[76]

Anti-oxidant activity

The methanolic leaf extract of *Carica papaya* showed significant in vitro antioxidant activity in the DPPH assay, with an IC₅₀ value of 213.68 µg/mL, exhibiting concentration-dependent free-radical scavenging.^[77] The ethanolic bark extract of *Carica papaya* exhibited strong in vitro antioxidant activity in the DPPH free radical scavenging assay, with an IC₅₀ value of approximately 23.9 µg/mL, indicating effective free radical neutralization.^[78] Ethanolic peel extract of *Carica papaya* exhibited antioxidant activity with an IC₅₀ of ~55.50 µg/mL in the DPPH free-radical assay, effectively neutralizing free radicals.^[79] Methanolic flower extract of *Carica papaya* showed moderate antioxidant activity, scavenging DPPH free radicals with an IC₅₀ of ≈ 425.28 µg/mL (Table 3).^[80]

Anti-inflammaory activity

The methanolic leaf extract of *Carica papaya* exhibited significant anti-inflammatory activity in vitro, as demonstrated by RBC membrane stabilization, with 74.29% inhibition of hemolysis observed at 800 ppm across a concentration range of 50–800 ppm (Table 3).^[81]

Anti-diabetic and Anti-hyperlipidemic activity

Ethanolic fruit peel extract of *Carica papaya* showed concentration-dependent inhibition of α-amylase, α-glucosidase, and pancreatic lipase, indicating anti-diabetic and anti-hyperlipidemic potential (IC₅₀: 0.089, 0.140 mg/mL, and 279.6 µg/mL, respectively (Table 3).^[82]

Anticancer activity

The methanolic seed extract of *Carica papaya* exhibited significant in vitro anticancer activity, with an IC₅₀ value of approximately 183 µg/mL, indicating cytotoxic effects through reduced viability of MCF-7 breast cancer cells (Table 3).^[83]

Wound healing

Aqueous latex extract of *Carica papaya* promoted in vitro wound healing by increasing the proliferation of skin-repairing cells across 10–100 µg/mL (Table 3).^[84]

Anti-microbial activity

Ethanollic root extract of *Carica papaya* exhibited broad-spectrum antimicrobial activity in vitro using the cup-plate diffusion method, showing inhibitory effects against *E. coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Candida albicans* at concentrations of 62.5–1000 mg/mL (Table 3).^[85] Ethanollic peel extract of *Carica papaya* exhibited antimicrobial activity in the agar-well diffusion assay, inhibiting bacterial growth, including *E. coli* and *Klebsiella pneumoniae*, at 100 µg/mL (Table 3).^[79]

Anti-bacterial activity

Aqueous and organic root extracts of *Carica papaya* exhibited antibacterial activity in vitro, inhibiting bacterial growth across a concentration range of 62.5–1000 mg/mL (Table 3).^[86]

Table 3: Pharmacological activity of *Carica papaya*.

Sl no.	Plant Parts	Solvent used	Activity	Method used	Dose	Key outcomes	Ref.
1	Seeds	Methanol	Anti-ulcer	Indomethacin-induced ulcer (in vitro)	100, 150, 200 mg/kg	Increase gastric pH, decreased gastric acidity and acid output, increase ulcer inhibition %.	[76]
2	Leaves	Methanol	Antioxidant	DPPH assay (in vitro)	IC=213.68 µg/ml	Demonstrated strong, concentration-dependent free-radical scavenging and supports antioxidant potential of papaya leaves	[77]
3	Leaves	Methanol	Anti-inflammatory	RBC membrane stabilisation (in vitro)	50-800ppm	74.29% inhibition of hemolysis at 800 ppm	[81]
4	Fruit peel	Ethanol	Anti-diabetic, Anti-hyperlipidemic	In vitro (anti-diabetic)	α-amylase IC ₅₀ = 0.089 mg/mL α-glucosidase IC ₅₀ = 0.140 mg/mL Pancreatic lipase IC ₅₀ =	Concentration-dependent inhibition of carbohydrate-digesting enzymes and lipase	[82]

					279.6 µg/mL		
5	Seeds	Methanol	Anticancer	In vitro	IC ₅₀ ~183 µg/mL	Significantly cytotoxicity; reduced viability of MCF-7 cells.	[83]
6	Latex	Aqueous	Wound-healing	In vitro	10–100 µg/mL	The cells that repair skin increase in number, so the wound heals faster.	[84]
7	Root	Ethanol	Antimicrobial	Cup plate diffusion (in vitro).	62.5–1000 mg/mL	Root extract showed inhibition against <i>E.coli</i> , <i>S. aureus</i> , <i>P. aeruginosa</i> , <i>K. pneumoniae</i> , <i>Candida albicans</i>	[85]
8	Root	Water/organic	Antibacterial	In vitro	62.5–1000 mg/mL	Inhibited bacterial growth.	[86]
9	Bark	Ethanol	Antioxidant	DPPH free radical assay (in vitro)	IC ₅₀ ≈ 23.9 µg/mL	Helps neutralize harmful molecules that damage cells.	[78]
10	Peel	Ethanol	Antimicrobial	Agar-well diffusion	100 µg/mL	inhibited bacteria (e.g., <i>E. coli</i> , <i>K. pneumoniae</i>)	[79]
11	Peel	Ethanol	Antioxidant	DPPH free-radical assay	IC ₅₀ ~55.50 µg/mL	Peel extract neutralized free radicals	[79]
12	Flower	Methanol	Antioxidant	DPPH assay	IC ₅₀ ≈ 425.28 µg/mL	Neutralised free radicals.	[80]

Conclusion and future prospective

Carica papaya L. is a nutritionally rich and medicinally important plant with wide traditional and modern relevance. Its diverse bioactive constituents including papain, chymopapain, flavonoids, alkaloids, carotenoids, lycopene, vitamins, and antioxidants contribute to a broad spectrum of pharmacological activities such as antioxidant, anti-inflammatory, antimicrobial,

antidiabetic, and anticancer effects. The traditional use of various parts of the plant for managing digestive disorders, infectious diseases, and inflammatory conditions is well supported by emerging scientific evidence.

In addition to its therapeutic potential, CP holds significant agricultural and economic value, particularly in tropical and subtropical regions. Advances in genomics, genetic improvement, and post-harvest technologies have further enhanced papaya productivity, quality, and disease resistance. Despite its extensive traditional use and promising bioactivities, challenges related to standardization, quality control, safety evaluation, and clinical validation remain. Addressing these limitations through well-designed experimental and clinical studies is essential for the effective integration of CP into modern healthcare systems. Overall, *Carica papaya* represents a valuable functional food and medicinal plant with considerable potential for future research and pharmaceutical, nutraceutical, and biotechnological applications.

ACKNOWLEDGEMENT

The authors are very much thankful to Kalinga University for providing valuable support, facilities, and encouragement throughout this study.

Funding

No funding was received from any public, commercial, or non-profit funding agencies for this study.

Conflict of interest

No conflict of interest.

REFERENCE

1. Sen S, Chakraborty R. Revival, modernization and integration of Indian traditional herbal medicine in clinical practice: Importance, challenges and future. *J Tradit Complement Med.*, 2017 Apr 1; 7(2): 234–44.
2. Salm S, Rutz J, van den Akker M, Blaheta RA, Bachmeier BE. Current state of research on the clinical benefits of herbal medicines for non-life-threatening ailments. *Front Pharmacol.*, 2023 Sept 28; 14.
3. Moreira D de L, Teixeira SS, Monteiro MHD, De-Oliveira ACAX, Paumgarten FJR. Traditional use and safety of herbal medicines1. *Rev., Bras., Farmacogn.* 2014 Mar. 1; 24(2): 248–57.

4. Sharma S, Chatterjee A. Impact of Herbal Medicine on Human Health.
5. Ayodipupo Babalola B, Ifeolu Akinwande A, Otunba AA, Ebenezer Adebami G, Babalola O, Nwifo C. Therapeutic benefits of *Carica papaya*: A review on its pharmacological activities and characterization of papain. Arab J Chem., 2024 Jan 1; 17(1): 105369.
6. K A, M RK, Pa SB, Gowda SK, Ajay A, Baby B. Ethanobotanical and biological activities of *Carica papaya* Linn: A review. Int J Pharm Drug Anal. 2020 Aug. 15; 1–5.
7. Koul B, Pudhuvai B, Sharma C, Kumar A, Sharma V, Yadav D, Jin JO. *Carica papaya* L.: A Tropical Fruit with Benefits beyond the Tropics. Diversity. 2022 Aug; 14(8): 683.
8. Fuentes G, Santamaría JM. Papaya (*Carica papaya* L.): Origin, Domestication, and Production. In: Ming R, Moore PH, editors. Genetics and Genomics of Papaya [Internet]. New York, NY: Springer; 2014 [cited 2026 Jan 24]: 3–15.
9. Gonsalves C, Lee DR, Gonsalves D. The Adoption of Genetically Modified Papaya in Hawaii and Its Implications for Developing Countries 1. In: Transgenics and the Poor. Routledge; 2007.
10. Saeed F, Arshad MU, Pasha I. Full article: Nutritional and Phyto-Therapeutic Potential of Papaya (*Carica Papaya* Linn.): An Overview.
11. Starley IF, Mohammed P, Schneider G, Bickler SW. The treatment of paediatric burns using topical papaya. Burns. 1999 Nov. 1; 25(7): 636–9.
12. De Oliveira JG, Vitória AP. Papaya: Nutritional and pharmacological characterization, and quality loss due to physiological disorders. An overview. Food Res. Int., 2011 June 1; 44(5): 1306–13.
13. Starley IF, Mohammed P, Schneider G, Bickler SW. The treatment of paediatric burns using topical papaya. Burns. 1999 Nov. 1; 25(7): 636–9.
14. Singh SP, Kumar S, Mathan SV, Tomar MS, Singh RK, Verma PK, Kumar A, Kumar S, Singh RP, Acharya A. Therapeutic application of *Carica papaya* leaf extract in the management of human diseases. DARU J Pharm. Sci., 2020 Dec 1; 28(2): 735–44.
15. Pandey S, Walpole C, Cabot PJ, Shaw PN, Batra J, Hewavitharana AK. Selective anti-proliferative activities of *Carica papaya* leaf juice extracts against prostate cancer. Biomed., Pharmacother., 2017 May 1; 89: 515–23.
16. Otsuki N, Dang NH, Kumagai E, Kondo A, Iwata S, Morimoto C. Aqueous extract of *Carica papaya* leaves exhibits anti-tumor activity and immunomodulatory effects. J Ethnopharmacol. 2010 Feb. 17; 127(3): 760–7.

17. Nguyen TT, Parat MO, Hodson MP, Pan J, Shaw PN, Hewavitharana AK. Chemical Characterization and in Vitro Cytotoxicity on Squamous Cell Carcinoma Cells of Carica Papaya Leaf Extracts. *Toxins*. 2016 Jan; 8(1): 7.
18. Essiett1 UA, Ukpong1 UJ. Reed: Information summaries on 1000 economic plants - Google Scholar.
19. Kafaru E. Elizabeth: Immense help from nature's workshop - Google Scholar.
20. Chen., LFC, Bau HJ, Yeh SD. Chen: Identification of viruses capable of breaking... - Google Scholar.
21. Silva JAT da, Rasid Z, Nhut DT. Da Silva: Papaya (*Carica papaya* L.) biology and biotechno... - Google Scholar.
22. Koul B, Pudhuvai B, Sharma C, Kumar A, Sharma V, Yadav D, Jin JO. *Carica papaya* L.: A Tropical Fruit with Benefits beyond the Tropics. *Diversity*. 2022 Aug; 14(8): 683.
23. Alara OR, Abdurahman NH, Alara JA. *Carica papaya*: comprehensive overview of the nutritional values, phytochemicals and pharmacological activities. 2020; 22(1): 17–47.
24. Kaliyaperumal, K., Kaliyaperumal, J., X J, Jayaraman, V. *Papaya: A gifted nutraceutical plant - a critical review of recent human health research*.
25. Saeed F, Arshad MU, Pasha I. Saeed: Nutritional and phyto-therapeutic potential... - Google Scholar.
26. K A, M RK, Pa SB, Gowda SK, Ajay A, Baby B. Ethanobotanical and biological activities of *Carica papaya* Linn: A review. *Int J Pharm Drug Anal*. 2020 Aug. 15; 1–5.
27. Malviya N, Saxena R, Gupta R, Malviya S. Scientific and ethnopharmacological evidence of *Carica papaya* for the effective management of vector-borne disease. In: *Natural Products in Vector-Borne Disease Management*. Academic Press; 2023: 467–97.
28. Singh G, Chawla P, Faruk A, Chawla V. *Ethnopharmacology and Therapeutic Potential of Carica papaya*. In: *Herbs, Spices, and Medicinal Plants for Human Gastrointestinal Disorders*. Apple Academic Press; 2022.
29. Flora of North America @ efloras.org [Internet]. Available from: <https://www.worldfloraonline.org/organisation/Flora%20of%20North%20America%20@%20efloras.org>.
30. Kumar M, Kumar G, Kumar Gautam G, Ali Rona Z, Kumar R. A review of *Carica papaya*'s geographical origins and pharmacological activities. *IP Int J Compr. Adv., Pharmacol.*, 2025; 7(2): 81–6.

31. Singh SP, Kumar S, Mathan SV, Tomar MS, Singh RK, Verma PK, Kumar A, Kumar S, Singh RP, Acharya A. Therapeutic application of *Carica papaya* leaf extract in the management of human diseases. *DARU J Pharm Sci.* 2020 Dec. 1; 28(2): 735–44.
32. Gogna N, Hamid N, Dorai K. Metabolomic profiling of the phytochemical constituents of *Carica papaya* L. leaves and seeds by H NMR spectroscopy and multivariate statistical analysis. *J Pharm. Biomed Anal.*, 2015 July 2; 115: 74–85.
33. Sharma A, Bachheti A, Sharma P, Bachheti RK, Husen A. Phytochemistry, pharmacological activities, nanoparticle fabrication, commercial products and waste utilization of *Carica papaya* L.: A comprehensive review. *Curr., Res., Biotechnol.*, 2020 Nov., 1; 2: 145–60.
34. Dash S, Sidhan R, Mishra SK, Prajapati SK. Hepatoprotective potential of *Urochloa distachya* (L.) ethanol extract against paracetamol and CCl₄-induced liver injury in rats. *Inflammopharmacology.* 2025 Nov 19.
35. Zheng YZ, Deng G, Liang Q, Chen DF, Guo R, Lai RC. Antioxidant Activity of Quercetin and Its Glucosides from Propolis: A Theoretical Study. *Sci., Rep.*, 2017 Aug 8; 7(1): 7543.
36. Debnath A, Lo YH, Wen ZH, Bhattacharya M, Abdelhameed AS, Chakraborty C, Das A. Quercetin, Isoquercitrin, and Quercetin-3-Rutinoside: Understanding the Pharmacological, Organoleptic, ADME Properties, Human Health Toxicity, Ecological Risk, and Cosmetic Risk of Using Integrative Bioinformatics. *J Food Qual.*, 2025; 2025(1): 4025459.
37. Sudi S, Chin YZ, Wasli NS, Fong SY, Shimmi SC, How SE, Sunggip C. Caripaine Promotes Proliferation and Repair of H9c2 Cardiomyocytes after Oxidative Insults. *Pharmaceuticals.* 2022 Feb., 15; 15(2): 230.
38. Yang D, Wang T, Long M, Li P. Quercetin: Its Main Pharmacological Activity and Potential Application in Clinical Medicine. *Oxid., Med., Cell Longev.* 2020; 2020: 8825387.
39. Gaber El-Saber Batiha, Beshbishy AM. The Pharmacological Activity, Biochemical Properties, and Pharmacokinetics of the Major Natural Polyphenolic Flavonoid: Quercetin.
40. Espíndola KMM, Ferreira RG, Narvaez LEM, Silva Rosario ACR, da Silva AHM, Silva AGB, Vieira APO, Monteiro MC. Chemical and Pharmacological Aspects of Caffeic Acid and Its Activity in Hepatocarcinoma. *Front Oncol.*, 2019; 9.

41. Nakamura T, Tsutsui C, Okuda Y, Abe-Kanoh N, Okazawa S, Munemasa S, Murata Y, Kato Y, Nakamura Y. Benzyl isothiocyanate and its metabolites inhibit cell proliferation through protein modification in mouse preosteoclast RAW264.7 cells. *J Biochem Mol Toxicol.*, 2022 Nov; 36(11): e23184.
42. Lo CW, Yen CC, Chen CY, Chen HW, Lii CK. Benzyl isothiocyanate attenuates activation of the NLRP3 inflammasome in Kupffer cells and improves diet-induced steatohepatitis. *Toxicol Appl Pharmacol.* 2023 Mar., 1; 462: 116424.
43. Park WS, Lee J, Na G, Park S, Seo SK, Choi JS, Jung WK, Choi IW. Benzyl Isothiocyanate Attenuates Inflammasome Activation in *Pseudomonas aeruginosa* LPS-Stimulated THP-1 Cells and Exerts Regulation through the MAPKs/NF- κ B Pathway. *Int J Mol. Sci.*, 2022 Jan; 23(3): 1228.
44. Ramadan AMAA, Zidan SAH, Shehata RM, EL-Sheikh HH, Ameen F, Stephenson SL, Al-Bedak OAHM. Antioxidant, antibacterial, and molecular docking of methyl ferulate and oleic acid produced by *Aspergillus pseudodeflectus* AUMC 15761 utilizing wheat bran. *Sci., Rep.*, 2024 Feb. 7; 14(1): 3183.
45. Zheng W, Wang H, Wang X, Li X, Hu J, Zi X, Zhou Y, Pan D, Fu Y. Kaempferol 3-O-Rutinoside, a Flavone Derived from *Tetrastigma hemsleyanum* Diels et Gilg, Reduces Body Temperature through Accelerating the Elimination of IL-6 and TNF- α in a Mouse Fever Model. *Molecules.* 2024 Apr., 5; 29(7): 1641.
46. Verma S, Dutta A, Dahiya A, Kalra N. Quercetin-3-Rutinoside alleviates radiation-induced lung inflammation and fibrosis via regulation of NF- κ B/TGF- β 1 signaling. *Phytomedicine.* 2022 May 1; 99: 154004.
47. Usman M, Malik H, Tokhi A, Arif M, Huma Z, Rauf K, Sewell RDE. 5,7-Dimethoxycoumarin ameliorates vincristine induced neuropathic pain: potential role of 5HT3 receptors and monoamines. *Front Pharmacol.* 2023 Oct., 17; 14: 1213763.
48. Song J, He Y, Luo C, Feng B, Ran F, Xu H, Ci Z, Xu R, Han L, Zhang D. New progress in the pharmacology of protocatechuic acid: A compound ingested in daily foods and herbs frequently and heavily. *Pharmacol Res.*, 2020 Nov. 1; 161: 105109.
49. Anand R, Mohan L, Bharadvaja N. Disease Prevention and Treatment Using β -Carotene: the Ultimate Provitamin A | *Revista Brasileira de Farmacognosia* | Springer Nature Link.
50. Pyrzynska K. Ferulic Acid—A Brief Review of Its Extraction, Bioavailability and Biological Activity. *Separations.* 2024 July; 11(7): 204.

51. Świątkiewicz I, Wróblewski M, Nuszkievicz J, Sutkowy P, Wróblewska J, Woźniak A. The Role of Oxidative Stress Enhanced by Adiposity in Cardiometabolic Diseases. *Int J Mol., Sci.*, 2023 Mar., 28; 24(7): 6382.
52. Khan UM, Sevindik M, Zarrabi A, Nami M, Ozdemir B, Kaplan DN, Selamoglu Z, Hasan M, Kumar M, Alshehri MM, Sharifi-Rad J. Lycopene: Food Sources, Biological Activities, and Human Health Benefits. *Oxid Med Cell Longev.* 2021 Nov., 19; 2021: 2713511.
53. Jadhao RB, Yusuf M. p-Coumaric Acid: A review of its chemistry, biological activities and therapeutic potential. *Int J Chem., Res., Dev.*, 2019; 1(1): 33–5.
54. Ingole A, Kadam MP, Dalu AP, Kute SM, Mange PR, Theng VD, Lahane OR, Nikas AP, Kawal YV, Nagrik SU, Patil PA. A Review of the Pharmacological Characteristics of Vanillic Acid. *J Drug Deliv., Ther.*, 2021 Apr. 15; 11(2-S): 200–4.
55. Kulczyński B, Sidor A, Brzozowska A, Gramza-Michałowska A. The role of carotenoids in bone health—A narrative review. *Nutrition.* 2024 Mar., 1; 119: 112306.
56. Wang L, Pan X, Jiang L, Chu Y, Gao S, Jiang X, Zhang Y, Chen Y, Luo S, Peng C. The Biological Activity Mechanism of Chlorogenic Acid and Its Applications in Food Industry: A Review. *Front Nutr.*, 2022; 9.
57. Julaehe E, Permatasari Y, Mayanti T, Diantini A. Antifertility Compound from the Seeds of *Carica papaya*. *Procedia Chem.*, 2015; 17: 66–9.
58. Wang Q, Xiao L. Isochlorogenic acid A attenuates acute lung injury induced by LPS via Nf- κ B/NLRP3 signaling pathway. *Am J Transl Res.*, 2019 Nov., 15; 11(11): 7018–26.
59. Wang HN, Shen Z, Liu Q, Hou XY, Cao Y, Liu DH, Jiang H, Du HZ. Isochlorogenic acid (ICGA): natural medicine with potentials in pharmaceutical developments. *Chin J Nat Med.*, 2020 Nov., 1; 18(11): 860–71.
60. Prša P, Karademir B, Biçim G, Mahmoud H, Dahan I, Yalçın AS, Mahajna J, Milisav I. The potential use of natural products to negate hepatic, renal and neuronal toxicity induced by cancer therapeutics. *Biochem., Pharmacol.* 2020 Mar 1; 173: 113551.
61. Raybaudi-Massilia RM, Olga Martin-Belloso. Antimicrobial activity of malic acid against *Listeria monocytogenes*, *Salmonella Enteritidis* and *Escherichia coli* O157:H7 in apple, pear and melon juices |. *ResearcGate.* 2025;
62. Ruwizhi N, Aderibigbe BA. Cinnamic Acid Derivatives and Their Biological Efficacy. *Int J Mol., Sci.*, 2020 Aug 9; 21(16): 5712.

63. Chen F, Zhang X, Wang J, Wang F, Mao J. P-coumaric Acid: Advances in Pharmacological Research Based on Oxidative Stress. *Curr Top Med Chem.* 2024; 24(5): 416–36.
64. Mishra G, Singh P, Molla M. Neochlorogenic Acid - an overview | ScienceDirect Topics. 2022.
65. Durgeshwer Singh, Khushboo Kumari, Salim Ahmed. Apigenin - an overview | ScienceDirect Topics.
66. Periferakis A, Periferakis K, Badarau IA, Petran EM, Popa DC, Caruntu A, Costache RS, Scheau C, Caruntu C, Costache DO. Kaempferol: Antimicrobial Properties, Sources, Clinical, and Traditional Applications. *Int J Mol., Sci.*, 2022 Nov., 30; 23(23): 15054.
67. Storer AC, Ménard R. Papain. In: *Handbook of Proteolytic Enzymes.* Academic Press; 2013; 1858–61.
68. Chaudhary J, Jain A. A Comprehensive Review on Biological activities of p-hydroxy benzoic acid and its derivatives. *ResearchGate.* 2025.
69. Rosheen, Sharma S, Utreja D. Salicylic Acid: Synthetic Strategies and Their Biological Activities. *ChemistrySelect.* 2023; 8(13): e202204614.
70. Wang Q, Wei HC, Zhou SJ, Li Y, Zheng TT, Zhou CZ, Wan XH. Hyperoside: A review on its sources, biological activities, and molecular mechanisms. *Phytother Res., PTR.* 2022 July; 36(7): 2779–802.
71. Sharma A, Sharma R, Sharma M, Kumar M, Barbhai MD, Lorenzo JM, Sharma S, Samota MK, Atanassova M, Caruso G, Naushad Mo, Radha, Chandran D, Prakash P, Hasan M, Rais N, Dey A, Mahato DK, Dhumal S, Singh S, Senapathy M, Rajalingam S, Visvanathan M, Saleena LAK, Mekhemar M. Carica papaya L. Leaves: Deciphering Its Antioxidant Bioactives, Biological Activities, Innovative Products, and Safety Aspects. *Oxid., Med., Cell Longev.* 2022 June 9; 2022: 2451733.
72. Shrivastava N, Alagarasu K, Cherian S, Parashar D. Antiviral & platelet-protective properties of Carica papaya in dengue. *Indian J Med., Res.*, 2022 Sept; 156(3): 459–63.
73. Ham J, Lim W, Kim K, Heo YM, Ryu SM, Lee D, Kim JJ, Song G. Gentsyl Alcohol Inhibits Proliferation and Induces Apoptosis via Mitochondrial Dysfunction and Regulation of MAPK and PI3K/AKT Pathways in Epithelial Ovarian Cancer Cells. *Mar Drugs.* 2019 June 3; 17(6): 331.
74. Zhang J, Li L, Kim SH, Hagerman AE, Lü J. Anti-cancer, anti-diabetic and other pharmacologic and biological activities of penta-galloyl-glucose. *Pharm., Res.*, 2009 Sept; 26(9): 2066.

75. Mani R, Natesan V. Chrysin: Sources, beneficial pharmacological activities, and molecular mechanism of action. *Phytochemistry*. 2018 Jan; 145: 187–96.
76. Oloyede HOB, Adaja MC, Ajiboye TO, Salawu MO. Anti-ulcerogenic activity of aqueous extract of *Carica papaya* seed on indomethacin-induced peptic ulcer in male albino rats. *J Integr Med*. 2015 Mar; 13(2): 105–14.
77. Aboobacker HK, Valoth G, Kizhedath S. In vitro study on the antioxidant activity of methanolic leaf extract of *Carica papaya*. *Int J Basic Clin Pharmacol*. 2020 Mar. 24; 9(4): 652–6.
78. Saha L, Das R, Chakma B, Kundu MK. Screening of antioxidant activities of bark of carica papaya l by different methods. *Arts Sci., Fac., Publ.*, 2021.
79. Vasundra, Dutta U. Antimicrobial and antioxidant properties of peel and seed extract of *Carica papaya* L.: Antimicrobial and antioxidant potential of papaya. *Indian J Exp Biol IJEB*. 2024 July 31; 62(08): 660–9.
80. Halder S, Dutta S, Khaled KL. Evaluation of phytochemical content and *in vitro* antioxidant properties of methanol extract of *Allium cepa*, *Carica papaya* and *Cucurbita maxima* blossoms. *Food Chem., Adv.*, 2022 Oct 1; 1: 100104.
81. Kamilla L, Tumpuk S, Salim M. Anti-Inflammatory of Papaya Leaf Extract (*Carica Papaya* L) Towards Membrane Stabilization of Red Blood Cells. *J Kesehat Prima*. 2021 Feb., 27; 15(1): 1–7.
82. Pattilthodika S. *Biomedical and Biotechnology Research Journal (BBRJ)*. 2025.
83. Mohansrinivasan V, Janani SV, Meghaswani P, Jemimah NS, Rajasekaran C, Sridevi MS, Devi CS. Exploring the Bioactive Potential of *Carica papaya*. *Nat Prod. J*. 7(4): 291–7.
84. Nayak SB, Pinto Pereira L, Maharaj D. Wound healing activity of *Carica papaya* L. in experimentally induced diabetic rats. *Indian J Exp Biol*. 2007 Aug; 45(8): 739–43.
85. Isaac AO, Adekoya A. Phytochemical and Antimicrobial Screening of Root Extracts of *Carica papaya*. *Niger J Pharm Appl., Sci., Res.*, 2016; 5(2): 18–24.
86. Isaac AO, Adekoya A. Phytochemical and Antimicrobial Screening of Root Extracts of *Carica papaya*. *Niger J Pharm., Appl Sci., Res.*, 2016; 5(2): 18–24.