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Medicinal Applications Of *Carica Papaya* Linn.: A Comprehensive Review Of Its Different Parts

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Abstract: *Carica papaya Linn., commonly known as papaya, is a tropical fruit tree of immense nutritional, economic, and medicinal significance. Every part of the plant including the leaves, fruits, seeds, roots, bark, and latex is used traditionally across the tropics for managing a wide range of ailments. From ancient ethnomedicine to modern pharmacology, papaya has been recognized for its therapeutic potential, driven by a diverse repertoire of phytochemicals such as alkaloids, flavonoids, terpenoids, isothiocyanates, carotenoids, and proteolytic enzymes. This review provides a detailed and critical examination of papaya, integrating ethnomedicinal uses, phytochemistry, pharmacological activities, and emerging therapeutic applications. Ethnobotanical surveys reveal papaya's relevance in treating malaria, dengue fever, gastrointestinal disorders, diabetes, inflammation, microbial infections, and reproductive challenges. Phytochemical analyses highlight key bioactive molecules including papain, chymopapain, carpaine, quercetin, benzyl isothiocyanate, and lycopene. Pharmacological studies support its roles in antidiabetic, anticancer, antioxidant, antimicrobial, hepatoprotective, cardioprotective, antiviral, and neuroprotective activities. Comparative discussion emphasizes the uniqueness of papaya as both a functional food and a medicinal plant, underscoring its potential in polyherbal formulations and integrative medicine. Current challenges include variability in phytochemical content, poor bioavailability of certain compounds, and limited large-scale clinical validation. Future directions include nanotechnology-based formulations, standardized extract development, and clinical trial designs to establish evidence based applications. This review consolidates current knowledge and identifies opportunities for translating papaya's traditional significance into modern therapeutic innovations.*

Keywords: *Carica papaya*, Ethnomedicine, Phytochemistry, Pharmacology, Herbal medicine, Integrative therapy

1. Introduction

Plants have always occupied a central role in healthcare systems worldwide, serving as both primary remedies and sources of inspiration for modern pharmaceuticals. Despite the rise of synthetic drugs, natural products remain indispensable, particularly in developing countries where traditional medicine is the backbone of healthcare for much of the population. Among tropical medicinal plants, *Carica papaya* Linn. stands out for its versatility and extensive use in both traditional medicine and modern scientific research.

Carica papaya is a fast growing herbaceous plant native to Central America but widely cultivated across tropical and subtropical regions of Africa, Asia, and Latin America (Ediriweera et al., 2017). The plant belongs to the family Caricaceae and is commonly referred to as papaya or pawpaw. Beyond its nutritional significance as a fruit crop, papaya is valued for its medicinal applications. Virtually every part of the plant has therapeutic uses. The leaves are employed in managing malaria, dengue fever, and diabetes. The seeds are used as natural vermifuges and contraceptives. The latex, rich in proteolytic enzymes such as papain and chymopapain, has applications in wound healing and digestive disorders. The ripe fruit is prized for its antioxidant properties, while the roots and bark are used for treating infections and inflammation (Ismail et al., 2021).

The broad spectrum of pharmacological effects observed in papaya can be attributed to its rich phytochemical diversity. Compounds such as alkaloids (carpaine), flavonoids (quercetin, kaempferol), phenolic acids (gallic acid), isothiocyanates (benzyl isothiocyanate), carotenoids (lycopene and beta carotene), and proteolytic enzymes (papain, chymopapain) have been isolated and characterized from different parts of the plant (Okeniyi et al., 2022). Each compound contributes uniquely to the medicinal potential of papaya, ranging from antimicrobial and anticancer effects to hepatoprotective and immunomodulatory activities.

The scientific validation of papaya's ethnomedicinal uses has grown significantly in the past two decades, with preclinical and clinical studies supporting its therapeutic value. For example, papaya leaf extracts have gained attention for their ability to increase platelet counts in dengue patients, while papaya seed extracts have been investigated for contraceptive and anticancer applications (Ahmad et al., 2022).

This review aims to present a comprehensive analysis of *Carica papaya*, synthesizing information on its ethnomedicinal relevance, phytochemistry, pharmacological activities, and future therapeutic potential. By bridging traditional knowledge with modern pharmacological evidence, this work highlights papaya's role as an integrative medicinal resource and identifies areas for further exploration.

2. Literature Review

2.1 Scope of prior reviews

Prior reviews on papaya have tended to focus on single aspects, such as the proteolytic enzymes of latex, the nutritional composition of the fruit, or clinical reports of leaf extract use in dengue fever (Ekezie et al., 2020; Torres-León et al., 2021; Ahmad, Yusuf, & Ali, 2022). Comprehensive syntheses that compare phytochemistry and pharmacology across all plant parts are fewer, and they leave gaps in standardization and clinical evidence. Systematic reviews of papaya leaf use in dengue report promising but limited evidence due to small trials and heterogeneous preparations (Nagarajan & Manoharan, 2024).

2.2 Key bioactive classes and trends

Across studies, certain chemical classes recur. Proteolytic enzymes in latex including papain and chymopapain are among the best characterized, with clear mechanisms in wound debridement and protein digestion (Ekezie et al., 2020). Seeds yield benzyl isothiocyanate and related glucosinolates, compounds with antimicrobial and anticancer activity in vitro (Okeniyi, Adeyemi, & Uchenna, 2022). Leaves concentrate flavonoids such as quercetin and kaempferol, which underpin antioxidant, anti-inflammatory, and platelet supporting effects observed in several models (Ismail, Ahmed, & Ibrahim, 2021). Ripe fruit offers carotenoids and vitamin C with classical antioxidant and cardioprotective effects (Torres-León et al., 2021).

2.3 Gaps identified

Three major gaps emerge from the literature. First, variability in preparations and phytochemical content complicates comparison across studies, limiting reproducibility. Second, pharmacokinetic data on key molecules such as benzyl isothiocyanate and quercetin are sparse, creating uncertainty about effective human doses. Third, clinical trials are few and often small or methodologically limited. Addressing these gaps requires standardized extraction and quality control, mechanistic pharmacokinetic studies, and well-designed clinical trials.

3. Methodology

3.1 Search strategy

A targeted literature review was performed to capture ethnomedicinal reports, phytochemical analyses, in vitro and in vivo pharmacology, and clinical studies on *Carica papaya*. Databases searched included PubMed, Scopus, Web of Science, and Google Scholar. Search terms combined botanical and topical keywords, for example, "Carica papaya", "papaya leaf", "benzyl isothiocyanate", "papain", "papaya dengue", "papaya antidiabetic", and "papaya clinical trial".

3.2 Inclusion and exclusion criteria

Included publications were peer reviewed articles, systematic reviews, meta analyses, and ethnobotanical reports published in English between 2000 and 2025, with priority given to studies from 2016 onward for recent evidence. Preclinical in vitro and animal studies were included to elucidate mechanisms. Case reports and small observational studies were considered for clinical context, but methodological limitations were noted. Studies were excluded if they lacked original data or if they were not specific to *Carica papaya*.

3.3 Data extraction and synthesis

From each included article, data were extracted on plant part studied, preparation or extract type, main phytochemicals identified, experimental model, observed effects, proposed mechanisms, and safety findings. Findings were synthesized in narrative form and organized by theme. Tables were generated to summarize phytochemicals by plant part and pharmacological activities mapped to mechanisms.

3.4 Limitations of method

This review is not a systematic review with formal meta-analysis. The literature is heterogeneous in extraction methods, doses, and endpoints. Consequently, conclusions emphasize patterns and gaps, rather than pooled effect sizes.

4. Ethnomedicinal Uses of *Carica papaya*

The ethnomedicinal significance of papaya spans multiple cultures and geographies. Indigenous communities in Africa, Asia, and Latin America have relied on the plant for centuries to manage infectious diseases, metabolic disorders, and reproductive health concerns.

4.1 Leaves

The leaves are the most widely used part in ethnomedicine. In African traditional medicine, papaya leaves are boiled into teas or decoctions to treat malaria, gastrointestinal disturbances, and hypertension (Oyeyemi et al., 2023). In India and Southeast Asia, leaf juice is consumed as a remedy for dengue fever, based on its ability to improve platelet counts. Papaya leaves are also applied topically for skin conditions such as eczema, warts, and burns.

4.2 Seeds

Papaya seeds are traditionally used as anthelminthic agents. In Nigerian folklore medicine, ground seeds mixed with honey are given to children and adults to expel intestinal worms. Seeds are also used in African communities as contraceptives, with documented evidence of antifertility effects in animal studies (Okeniyi et al., 2022).

4.3 Latex

The white latex exuded from unripe fruits is employed for wound healing, digestive disorders, and as a topical remedy for skin lesions. In rural communities of South America, papaya latex is used as a meat tenderizer and as a digestive aid for those suffering from dyspepsia.

4.4 Fruits

Ripe papaya fruits are valued not only as nutritious foods but also for their medicinal properties. They are used to relieve constipation, improve digestion, and strengthen immunity. Unripe fruits are sometimes consumed as vegetable dishes with perceived benefits in regulating menstruation and fertility.

4.5 Roots and Bark

The roots and bark are less commonly used but have notable applications in ethnomedicine. Decoctions are prepared for treating malaria, syphilis, and respiratory infections. In parts of West Africa, papaya root extracts are used as a purgative and for the management of jaundice.

Table 1. Ethnomedicinal Uses of Different Parts of *Carica Papaya*

Plant Part	Ethnomedicinal Use	Region
Leaves	Malaria, dengue, hypertension, diabetes	Africa, Asia, Latin America
Seeds	Anthelminthic, contraceptive, anticancer	Africa, India
Latex	Wound healing, digestive aid, skin diseases	South America, Asia
Fruits	Constipation, immunity, fertility regulation	Global tropics
Roots/Bark	Malaria, syphilis, respiratory infections	Africa, South America

5. Phytochemistry of *Carica Papaya*

Papaya produces a broad spectrum of secondary metabolites distributed across its different parts.

- **Leaves** contain alkaloids such as carpaine, flavonoids like quercetin and kaempferol, and phenolic acids.
- **Seeds** are rich in benzyl isothiocyanate, glucosinolates, and phenolic compounds.
- **Latex** is dominated by proteolytic enzymes including papain, chymopapain, and caricain.
- **Fruits** provide carotenoids (lycopene, beta carotene), polyphenols (gallic acid, catechins), and vitamin C.
- **Roots and bark** harbor alkaloids, terpenoids, and tannins.

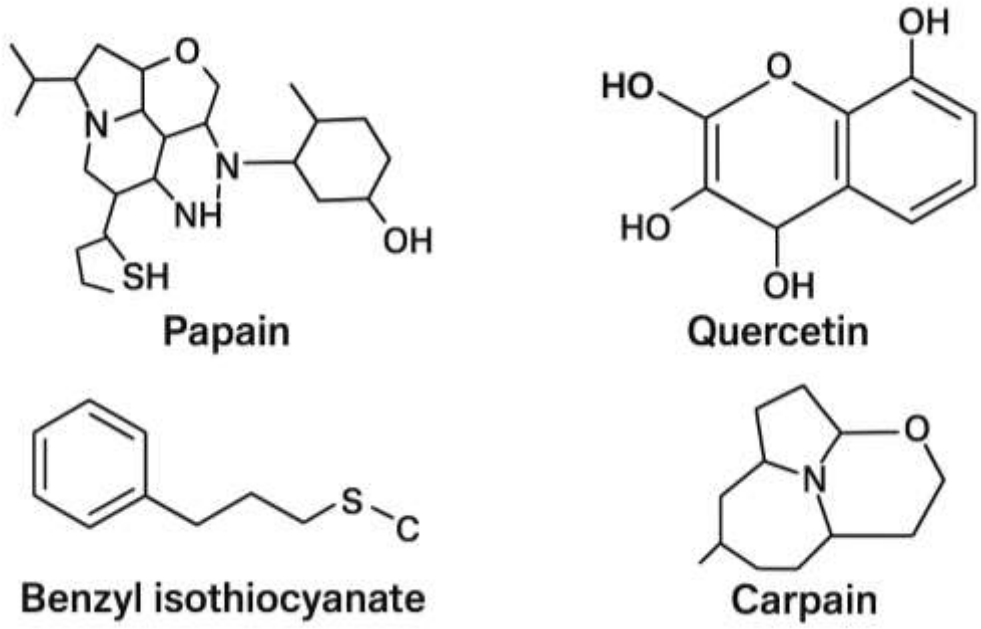

Figure 1. *Representative structures of major papaya compounds (papain, quercetin, benzyl isothiocyanate, carpaine).*

Table 2. Major Phytochemicals of *Carica Papaya*

Part	Compounds	Chemical Class	Activity	Reference
Leaves	Carpaine, Quercetin	Alkaloid, flavonoid	Antimalarial, antioxidant	Ismail et al., 2021
Seeds	Benzyl isothiocyanate	Isothiocyanate	Antimicrobial, anticancer	Okeniyi et al., 2022
Latex	Papain, Chymopapain	Enzyme	Wound healing, digestive aid	Ekezie et al., 2020
Fruits	Lycopene, Vitamin C	Carotenoid, vitamin	Antioxidant, cardioprotective	Torres-León et al., 2021
Roots/Bark	Terpenoids, Tannins	Secondary metabolites	Antimalarial, antimicrobial	Oyeyemi et al., 2023

6. Pharmacological Activities

Papaya exhibits a wide range of pharmacological effects, many of which have been validated in preclinical and clinical studies.

6.1 Antidiabetic effects

Papaya leaves improve glucose homeostasis by enhancing insulin sensitivity and reducing lipid peroxidation. Seeds and fruit extracts also show hypoglycemic effects, attributed to quercetin, carpaine, and triterpenes (Karigidi et al., 2025).

6.2 Anticancer properties

Papaya seed benzyl isothiocyanate and leaf flavonoids induce apoptosis and inhibit angiogenesis. Clinical evidence supports anticancer effects against prostate and breast cancer models (Rajendran, 2024).

6.3 Antioxidant and anti-inflammatory activity

The fruit is exceptionally rich in carotenoids and vitamin C, while the leaves provide flavonoids that scavenge free radicals. This dual antioxidant and anti-inflammatory action protects against cardiovascular and neurodegenerative diseases (Yarasvam, 2023).

6.4 Antimicrobial activity

Papaya latex enzymes disrupt microbial membranes. Seeds are particularly effective against bacterial and fungal pathogens, making them promising antimicrobial agents (Okeniyi et al., 2022).

6.5 Hepatoprotective and cardioprotective effects

Leaf and fruit extracts reduce hepatic oxidative stress and improve lipid metabolism, while carotenoids provide cardioprotective benefits (Ediriweera et al., 2017).

6.6 Antiviral potential

Leaf extracts are widely used in dengue therapy, increasing platelet counts and supporting immune modulation (Ahmad et al., 2022).

6.7 Neuroprotection

Quercetin and papaya polyphenols protect neurons from oxidative damage, highlighting potential benefits in Alzheimer's and Parkinson's disease (Yarasvam, 2023).

Table 3. Pharmacological Activities of *Carica Papaya*

Activity	Key Compounds	Mechanism	References
Antidiabetic	Quercetin, Carpaine	Insulin sensitization	Karigidi et al., 2025
Anticancer	Benzyl isothiocyanate	Apoptosis, angiogenesis inhibition	Rajendran, 2024
Antioxidant	Lycopene, Vitamin C	ROS scavenging	Torres-León et al., 2021
Antimicrobial	Papain, BITC	Membrane disruption	Okeniyi et al., 2022
Hepatoprotective	Quercetin, Lycopene	Lipid regulation	Ediriweera et al., 2017
Antiviral	Flavonoids, Papain	Immunomodulation	Ahmad et al., 2022

7. Comparative Discussion

Papaya demonstrates a unique balance between nutritional and pharmacological benefits. Compared with other medicinal plants, papaya stands out because its fruits are widely consumed as food, providing a direct dietary source of antioxidants. The seeds are particularly potent in antimicrobial and anticancer applications, while the leaves dominate in metabolic and antiviral research. A major limitation is phytochemical variability, which depends on soil, climate, and harvesting methods. Another concern is poor bioavailability of compounds like benzyl isothiocyanate and quercetin, which may limit clinical efficacy. Advanced formulations including nanoparticles and liposomal delivery are being developed to overcome these challenges (Islas et al., 2020).

8. Polyherbal Formulations and Synergism

Papaya is frequently combined with other medicinal plants to enhance efficacy. Polyherbal formulations containing papaya and neem have shown improved glycemic control in diabetic models. Combinations with mango or ginger enhance antioxidant and digestive functions (Saleem et al., 2019)

Table 4. Examples of Papaya Based Polyherbal Formulations

Formulation	Other Plants	Indication	Reported Effect
Papaya + Neem + Bitter Melon	Neem (Azadirachta indica), Bitter Melon (Momordica charantia)	Antidiabetic	Enhanced glucose control, improved insulin sensitivity
Papaya + Mango	Mango (Mangifera indica)	Antioxidant	Synergistic ROS reduction, reduced lipid peroxidation
Papaya + Ginger	Ginger (Zingiber officinale)	Gastrointestinal	Improved digestion, reduced bloating and inflammation
Papaya + Turmeric	Turmeric (Curcuma longa)	Anti-inflammatory	Enhanced anti-inflammatory effects due to synergistic action of papain and curcumin
Papaya + Aloe Vera	Aloe vera (Aloe barbadensis)	Immunomodulatory	Increased IL-2 and IFN-γ production, enhanced immune response
Papaya + Garlic	Garlic (Allium sativum)	Cardioprotective	Improved lipid profile, reduced oxidative stress
Papaya + Moringa	Moringa (Moringa oleifera)	Nutritional Supplement	Enhanced micronutrient content, antioxidant synergy
Papaya + Turmeric	Turmeric (Curcuma longa)	Anti-inflammatory	Reduced pro-inflammatory cytokines, pain alleviation
Papaya + Aloe Vera	Aloe vera (Aloe barbadensis)	Immunomodulatory	Increased IL-2 and IFN-γ production, enhanced immune response
Papaya + Garlic	Garlic (Allium sativum)	Cardioprotective	Improved lipid profile, reduced oxidative stress
Papaya + Moringa	Moringa (Moringa oleifera)	Nutritional Supplement	Enhanced micronutrient content, antioxidant synergy

7. Conclusion and Future Perspectives

Papaya is a versatile medicinal plant with validated applications in multiple therapeutic areas. Its dual role as a food and medicine positions it uniquely within functional foods and nutraceuticals. However, standardization of extracts, improved bioavailability strategies, and rigorous clinical validation are essential steps for advancing papaya based therapies. Future directions should focus on exploring papaya in integrative medicine, advancing polyherbal formulations, and developing sustainable cultivation and extraction practices.

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