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Review Article

Carica Papaya as a Functional Therapeutic Agent: An Integrative Review

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ABSTRACT

More than just a tropical fruit, Carica papaya Linn. is a plant that has been grown for centuries on several continents and has significant agricultural, nutritional, and medicinal uses. Papaya has long been valued in Ayurvedic medicinal system. It has been used to treat everything from inflammatory diseases and skin infections to digestive issues. Beyond its nutritional advantages, scientific research has thoroughly examined its phytochemical profile and pharmacological potential in recent decades, uncovering a diverse range of bioactive chemicals with potential for medicinal use. Enzymes like papain and chymopapain, as well as alkaloids, flavonoids, phenolics, and other secondary metabolites, have been found through phytochemical studies, supporting the plant's therapeutic potential. Papaya has anti-inflammatory, antioxidant, antibacterial, immunomodulatory, and wound-healing qualities, according to experimental and clinical research. Papaya's diverse range of therapeutic uses is further demonstrated by its hepatoprotective, antidiabetic, anticancer, and gastroprotective properties.

INTRODUCTION

The tropical fruit-bearing plant known as papaya is well known for its high nutritional content and several medicinal applications. Fruit, leaves, seeds, and latex are among the parts of the plant that have historically been used to heal wounds, infections, and digestive issues [1].

By showing that papaya extracts greatly improve tissue regeneration and encourage quicker wound healing, scientific research has confirmed many of these traditional claims [2]. Furthermore, the capacity of papaya leaf extract to raise platelet counts has drawn special attention, especially in patients with dengue-induced thrombocytopenia [3]. Significant improvements in platelet recovery have been confirmed by clinical findings, which have further validated these effects [4].

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In addition to these therapeutic uses, papaya is a rich source of bioactive substances with potent antibacterial, anti-inflammatory, and antioxidant properties, particularly the proteolytic enzyme papain [5].

Botanical Description:

Table 1: Botanical description of *Carica papaya* [6].

Domain	Flowering Plant
Kingdom	<i>Plantae</i>
Sub Kingdom	<i>Tracheobionta</i>
Class	<i>Magnoliopsida</i>
Subclass	<i>Dilleniidae</i>
Super division	<i>Spermatophyta</i>
Phylum	<i>Streptophyta</i>
Order	<i>Brassicales</i>
Family	<i>Caricaceae</i>
Genus	<i>Carica</i>

Chemical constituents:

1. Proteolytic Enzymes

Proteolytic enzymes such papain, chymopapain, caricain, and glycy endopeptidase are found in papaya latex and unripe fruit. These enzymes aid in wound healing, protein digestion, and a number of industrial uses [7].

2. Alkaloids

Mostly found in leaves and seeds, alkaloids like carpaine, pseudocarpaine, and dehydrocarpaine I & II have been connected to antimicrobial and cardiovascular properties [7].

3. Phenolic Compounds & Flavonoids

The plant contains phenols and flavonoids that have anti-inflammatory and antioxidant properties, such as quercetin, kaempferol, myricetin, caffeic acid, and protocatechuic acid [6].

4. Carotenoids & Vitamins

In addition to vitamins C and E, the fruit pulp is abundant in carotenoids that support antioxidant defense and overall health, including β -carotene, lycopene, lutein, and zeaxanthin (provitamin A activity) [6,7].

5. Isothiocyanates & Glucosinolates

Seeds contain benzyl isothiocyanate and related glucosinolates, which have been shown to have antimicrobial, antiparasitic, and antifertility properties [7].

6. Other constituents:

Fatty acids like oleic, palmitic, and stearic acid are abundant in seeds. Additionally, the fruit pulp offers natural sugars, dietary fiber, and minerals (Ca, Mg, K, Fe, and Zn) that support nutritive and functional advantages [6,8].

Pharmacological Activities of *Carica papaya*

Leaves:

Large, deeply lobed papaya leaves are utilized extensively in traditional medicine. Fresh or dried leaves are used as a tonic and are thought to enhance blood cleansing. Drinking leaf tea can lower blood pressure, arteriosclerosis, obesity, and indigestion. In terms of medicine, the leaves have demonstrated anti-inflammatory, anti-malarial, anticancer, antibacterial, antiviral, and immunomodulatory properties. Because papaya leaf extract can raise neutrophil and white blood cell counts, it is used to treat dengue fever in traditional systems like Siddha medicine. Chemically, the leaves include phenolic acids, vitamins C and E, alkaloids (carpaine, pseudocarpaine, and dehydrocarpaine I & II), and flavonoids (kaempferol, myricetin). These substances support their anti-carcinogenic, anti-hypertensive, anti-fertility, antidiabetic, and antioxidant qualities [9].



Fruits:

Typically greenish-yellow or yellow-orange when ripe, papaya fruits are fleshy, cylindrical, or oblong, and range in size from 5 to 30 cm. Papain, an enzyme found in it, helps break down proteins in both acidic and alkaline conditions. The fruit has few calories (around 32 kcal per 100 g) but is high in nutrients. Antihelmintic, antiprotozoal, antibacterial, antifungal, antiviral, anti-inflammatory, antioxidant, antidiabetic, diuretic, and hypolipidemic actions are only a few of the many pharmacological properties of papaya fruit. It is also known to have antihypertensive, anticancer, wound-healing, and cardioprotective properties. Green papaya is used to treat intestinal worms, jaundice, diabetes, hypertension, and malaria. Additionally, the fruit is used to make a variety of food preparations, including candies, ice cream, juices, jams, and jellies. It is a great source of dietary fibre, calcium, iron, potassium, magnesium, and the vitamins A, C, E, and B-complex. Papaya fruit contains the alkaloid carpain, which has a mildly depressive effect and aids in heart function regulation [9].

Flowers:

Prior to the development of sexual organs, the *Carica papaya*'s largely dioecious blossoms resemble one another. The three sex forms of the species—male (staminate), hermaphrodite (bisexual), and female (pistillate)—are categorized as polygamous. Male flowers have slender corolla tubes that are about 2 cm long, are straw-colored, fragrant, and occur in dense clusters. Female flowers have petals up to 7 cm long and are produced individually or in short axillary racemes. Papaya flowers have emmenagogue, febrifuge, and pectoral qualities and are used medicinally to cure jaundice [9].

Peels:

Papaya fruit peels contain bioactive chemicals and are frequently used as animal feed. It has been demonstrated to cause cancer cells to undergo apoptosis and possesses antibacterial, antioxidant, and anticancer qualities. Because of their larvicidal effect on *Aedes aegypti*, peel extracts are widely used in biocides and insecticidal formulations. They can also convert silver ions to generate metallic nanoparticles. Additionally, papaya peel flour has demonstrated good nutritional and sensory quality in food formulation tests. Papaya peel extracts have shown strong antibacterial and wound-healing properties in traditional advantages[9].

Seed:

The black seeds of papayas taste like pepper and are imbedded in the fruit pulp. Seeds, both dried and powdered, can be used in place of spices. The seeds have anthelmintic, antidiarrheal, contraceptive, analgesic, anti-inflammatory, and antibacterial properties in terms of pharmacology. Seed extracts have hepatoprotective and antioxidant qualities and are also utilized as febrifuge and vermifuge agents. In the past, it was used to treat liver and spleen problems, bleeding piles, and as an abortifacient and antifertility drug. Papaya seeds are also used to treat diabetes, high blood pressure, and high cholesterol. Papaya seeds' high protein and oil content (about 25.6%) makes them useful for industrial, biofuel, and medical applications. The seeds have demonstrated promise in the treatment of illnesses linked to poisoning and sickle cell anemia [9].

Stems:

The high fibre and carbohydrate content of the *Carica papaya* stem adds to its possible nutritional worth. It promotes bowel regularity and can be eaten as food. Because of its low perishability, it can be kept for long periods of time even though it



has very little fat or protein. The stem's twig and bark tissues have pesticidal and anticancer properties. Additionally, the stem may contain bioactive substances that could be utilised to create natural remedies and insecticides [9].

Medicinal benefits of papaya :

1. Anti-inflammatry activity :

Because of its strong anti-inflammatory and antioxidant qualities, caricapapilin, a bioactive substance extracted from *Carica papaya* leaves, exhibits notable wound-healing and skin-protective qualities. By boosting fibroblast proliferation, collagen synthesis, and epithelialization in the wound area, it accelerates tissue regeneration. Additionally, the compound supports cleaner and faster healing by lowering the microbial load and oxidative stress at the wound site. Furthermore, by shielding dermal cells from free radical damage, preserving skin elasticity, and enhancing overall texture, caricapapilin promotes skin renewal and is advantageous in dermatological and cosmetic formulations [10].

2. Antioxidant activity:

Because *carica papaya* contains a variety of bioactive substances, including flavonoids, phenolics, vitamins A, C, and E, and carotenoids, it has strong antioxidant activity. By reducing oxidative stress and neutralizing free radicals, these ingredients help shield cells and tissues from harm. By enhancing the enzymatic activities of catalase, superoxide dismutase, and glutathione peroxidase, papaya extracts' antioxidant potential strengthens the body's defenses. Papaya helps lower the risk of oxidative stress-related chronic diseases like cancer, diabetes, and cardiovascular conditions through this mechanism [11].

3. Cardioprotective Effect

Because *carica papaya* contains natural antioxidants, vitamins, and phytochemicals like flavonoids and carotenoids, which together shield cardiac tissues from oxidative stress and lipid peroxidation, it has been demonstrated to have potent cardioprotective qualities. These bioactive substances lower the risk of oxidative damage and neutralize free radicals, preserving the integrity of the heart. Furthermore, papaya extract improves overall cardiovascular function by reducing levels of triglycerides, total cholesterol, and low-density lipoprotein (LDL) and raising levels of high-density lipoprotein (HDL), which helps regulate lipid metabolism. Additionally, it promotes blood pressure control and cardiac enzyme balance, which helps prevent myocardial damage [12].

4. Anticancer:

In addition, traditional users claim that papaya leaf juice (or its extracts) has anticancer (antitumor) properties. The growth of solid tumor and hematopoietic tumor cell lines was shown to be suppressed in a dose-dependent manner in experimental investigations using aqueous papaya leaf extracts. Papaya extracts specifically inhibited the growth of cancer cell lines derived from mesothelioma, hepatocellular carcinoma, pancreatic epithelioid carcinoma, breast carcinoma, and cervical carcinoma [13].

5. Antimalarial activity :

Plasmodium species are the cause of malaria, which continues to be one of the most important parasitic diseases in the world. At different concentrations, the ethanolic leaf extract of *Carica papaya* (CPL extract) has been tested for its direct anti-malarial effect against *Plasmodium falciparum* as well as its larvicidal and pupicidal effects on malaria vectors [13].

6. Antifungal activity:



It has been demonstrated that papaya latex and fluconazole work in concert to inhibit *Candida albicans*. Papaya tissue extracts (leaves, seeds) have shown bioactivity: both organic and aqueous seed extracts have shown anti-helminthic effects against Pathogens such as *Colletotrichum gloeosporioides*, and some seed extracts have antifungal effects against the same pathogen [6].

7. Antibacterial activity:

A variety of enteropathogenic bacteria, such as *Salmonella typhi*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Salmonella typhi*, *Bacillus subtilis*, *Enterobacter cloacae*, and *Klebsiella pneumoniae*, have been demonstrated to be susceptible to bacteriostatic action by papaya seed extracts. A wide range of antibacterial activity was indicated by the extracts' interesting tendency to be more effective against gram-negative bacteria than gram-positive [6].

8. Hepatoprotective activity :

Because of its potent antioxidant and membrane-stabilizing qualities, caricapapilin, a phenolic compound that was extracted from *Carica papaya* leaves, demonstrates significant hepatoprotective activity. Caricapapilin has been demonstrated in experimental studies to improve histopathological features in models of toxin-induced liver injury and to help restore liver enzyme levels (ALT, AST, and ALP). The substance reduces oxidative stress and lipid peroxidation in hepatocytes while strengthening endogenous antioxidant defenses like catalase and superoxide dismutase. According to these results, caricapapilin can shield liver tissues from harm caused by chemicals and could be used as a natural hepatoprotective agent in future medication for gram-positive [14].

9. Antidiabetic (hypoglycemic) activity:

Diabetes is a long-term illness marked by insulin resistance or insufficiency, which raises blood sugar levels (hyperglycemia). Uncontrolled hyperglycemia may harm pancreatic islet cells by causing oxidative stress, protein glycation, lipid peroxidation of LDL, and secondary production of reactive oxygen species (ROS). The body's antioxidant defenses are overtaxed, which accelerates the development of complications from diabetes. Given their bioactive and antioxidant qualities, papaya extracts are suggested to support glycemic control and pancreatic protection by reducing oxidative stress [6]. Herbal remedies are generally safer, according to evidence. One of the most serious diseases, diabetes, may be effectively managed with the help of bioactive compounds derived from medicinal plants [15].

10. Wound healing activity :

Because of its strong anti-inflammatory and antioxidant qualities, caricapapilin, a bioactive substance extracted from *Carica papaya* leaves, exhibits notable wound-healing and skin-protective qualities. By boosting fibroblast proliferation, collagen synthesis, and epithelialization in the wound area, it accelerates tissue regeneration. Additionally, the compound supports cleaner and faster healing by lowering the microbial load and oxidative stress at the wound site. Caricapapilin is also useful in dermatological and cosmetic formulations because it protects dermal cells from free radical damage, preserves skin elasticity, and improves overall texture, all of which aid in skin rejuvenation [10].

11. Hair health:

Because papayas contain vitamin A, which is necessary for sebum production and hair moisture retention, they may help maintain healthy hair. Additionally, papaya contains vitamin C, which



helps to the production and upkeep of collagen, the structural protein essential to the integrity of skin (which indirectly supports the environments of the scalp and hair follicles) [13].

12. Antifertility activity:

Research has investigated the antifertility effects of *Carica papaya* by giving adult and pregnant rats different parts of the fruit. In one study, Lungor monkeys developed prolonged azoospermia after being exposed to a chloroform extract of *Carica papaya*. Sperm concentration and motility gradually decreased as a result of the treatment. After 90 days of treatment, azoospermia was noticed, and it continued during the investigation [13].

Toxicity:

Papaya's milky sap can irritate the skin on the outside, but eating it can cause severe stomach lining inflammation. Furthermore, the papain enzyme itself may have negative effects, and some people exhibit allergic reactions to specific fruit parts [7]. To ensure that herbal formulations continuously maintain their high quality and therapeutic efficacy, the manufacturing process must be validated [16]. Due to inappropriate methods for their collection, storage, and transportation, as well as advantageous weather conditions, the raw materials used in herbal formulations in India are vulnerable to fungal contamination [17].

CONCLUSION:

With a lifespan of roughly 20 years, *Carica papaya* is a tropical and subtropical perennial herb belonging to the Caricaceae family. Every part of the plant has nutritional and therapeutic value, including the fruit, peel, flower, seed, leaf, stem, and root. *Papaya's* pharmacological activities, such

as its anti-inflammatory, anti-cancer, antifungal, anthelmintic, wound-healing, and antioxidant qualities, are well known due to its rich phytochemical and nutrient composition. Originating in Central America and currently grown all over the world, *papaya* is still a vital component of both conventional and alternative medicine.

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