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A COMPREHENSIVE REVIEW: "MORPHOLOGICAL INSIGHTS AND PHARMACOLOGICAL POTENTIALS OF *CARICA PAPAYA* LINN."

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ABSTRACT

Papaya or Carica papaya Linn. is a tropical plant that is widely grown and prized for its economic, medical, and nutritional worth. This article highlights the plant's importance in both traditional and modern medicine by summarizing its morphological traits and pharmacological qualities. Carica papaya is a herbaceous plant that grows quickly. It is characterized by a hollow trunk, big lobed leaves, milky latex, and fleshy fruit that resembles berries and is full of nutrients and bioactive substances. Alkaloids, flavonoids, carotenoids, tannins, and proteolytic enzymes like papain and chymopapain are among the phytochemicals found in the plant's leaves, fruits, seeds, roots, and latex. A wide range of medicinal activity, such as anti-inflammatory, antioxidant, antibacterial, anthelmintic, hepatoprotective, anti-diabetic, antifertility, and wound-healing qualities, are demonstrated by Carica papaya pharmacologically. Its leaf extract has demonstrated significant promise in promoting platelet count rise, especially in thrombocytopenia associated with dengue. While the fruit and latex have a wide range of applications in the digestive and dermatological fields because of their enzymatic action, seeds and their extracts exhibit antihelminthic and contraceptive properties. Carica papaya's varied pharmacological potential highlights its value as a natural remedy and promotes more investigation into its bioactive ingredients, modes of action, and therapeutic uses. Overall, this study emphasizes the significance of Carica papaya Linn. in herbal medicine as well as

its potential for future drug development by highlighting its extensive morphological profile and diverse pharmacological effects.

KEYWORDS: Carica papaya, pharmacological activity, papain, traditional medicine.

INTRODUCTION

The carica papaya popularly known as papaya, a tree comes under the family Caricaceae. Every part of the plant i.e. fruit, leaf, flowers, seeds, latex, and roots having unique therapeutic and medicinal property .The papaya tree comes under the category of proteolytic enzymes. Under this, leaves of carica papaya plays an important role, also the greatest components of carica papaya possess more medicinal property. The leaves contain some phytochemicals i.e. saponins, tannins, steroids, alkaloids, flavonoids, and vitamins .Minerals such as calcium, magnesium, James et al; Hasseri Halim 2023. • It is one of the most popular and cultivated plant in tropical countries. Papaya is also called as garden plant in tropical. The height of papaya plant is about 5 to 10m. Leaves are spirally arranged with big oval shape 20 to 28 in. diameter.

These are used in many diseases like stomach disorder, diarrhea, skin diseases, male contraceptives and home remedies for cold. Also papaya possess anti-cancer property for prostate, cervical and .breast and colorectal. Ashish B. Wadekar et al; Wrushali A. Panchale 2021.

Due to its buttery taste and appearance, it is known as exotic fruit. It consider as a nutraceutical fruit because it contain more medicinal property .Although it possess anti-fertility, uterotonic, diuretics, anti-hypertensive, wound-healing, anti-fungal, anti-helmintic, nephroprotective agent, anti-oxidant effect. After performing HPLC (High performance liquid chromatography) quantitative analysis of carica papaya leaves it has significant amount of flavonoids i.e. kaempferol 3-(2G- rhamnosylrutinoside) exibit more anti-oxidant property compared to other compound. Mohd Mursyidul Amin Nasir et al; Hasseri Halim et al; 2023 • It is one of the most nutritionally abundant source of vitamins A,B and C. It contain most important enzyme i.e. papain which help in digestion also used in ulcer treatment. Also it is effective against gram- negative bacteria at higher dose. • Seed extract consist of benzyl isothiocynate they are bactericidal, bacterioststic and fungicidal at single beneficial dose 4 to 5 gm seeds. Papaya plays an important role to prevent pathogenesis and also in neutralization of free radicle generation. Papaya tree contain most important constituent like latex which

contain papain, glycyl, endopeptidase, chymopapain, and caricain. It also used against various diseases i.e. fever, asthma, colica, beriberi, and jaundice. Surya singh et al; sanjay Kumar et al; Rana P. singh et al; Amit Kumar et al; Arbind Acharya 2020. • Purified papain is white or grayish white slightly hygroscopic powder. It is widely available in common areas completely soluble in water and glycerol and practically insoluble in most of the organic solvents. The required pH for its activity is 5.0 but it function in neutral and alkaline media. Papain molecule contain 1 folded polypeptide chain of 212 amino acid with molecular weight 23400 dalton.

Fig. No. 1: Papaya Tree.

BOTANICAL CLASSIFICATION

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Brassicales

Family: Caricaceae

Genus: *Carica*

Species: *Carica papaya* Linn.

GEOGRAPHICAL DESCRIPTION

The papayas are cultivated in all parts of the world. Mostly in tropical America and on large scale in India, South Africa, Australia, Shrilanka, Tanzania, florida. In India papaya is cultivated in Bihar, Maharashtra, Bengal, Punjab, Haryana, Uttar Pradesh, Andhra Pradesh.

MORPHOLOGICAL DESCRIPTION

The papaya belonging to species polygamous. The papaya plant majorly categorized primarily three sex types:-

- Male (staminate)
- Female (pistillate)
- Hermaphroditic (bisexual)

At same time, some plants can produce more than one kind of flower. From bisexual plant fruits are preferred in markets, but male trees are unfruitful. The studies have shown that from pollination fruits are come.

1. Staminate flower pollinated to pistillate flower giving equal number of female and male progeny.
2. By pollen pistillated flowers are pollinated from bisexual flowers gives an equal number of female and bisexual progeny.
3. Bisexual flowers are either self-pollinated or cross pollinated with bisexual gives ratio of one female to two bisexual.

a) Habit and Habitat

Carica papaya is a fast-growing, short-lived, evergreen herbaceous plant. It thrives in tropical and subtropical climates with well-drained soil and abundant sunshine.

b) Leaves: The leaves of plant are simple and spirally arranged in a terminal cluster petioles are 30 – 70 cm long. The lobes have margin are very variable, and undulated to deeply lobed. The diameter of leaves are 60-90cm, alternately arranged between stem and branches bundled present at apex. The bundle of leaves is dark green to yellow-green, bright, visibly by off-white nerve embedded and reticulated veins; the surface is pale green-yellow and opaque with visibly prominent vascular structure; petioles are yellow – green and round shape with sporadic purple or violet stains fragile, fistulous form 25-100cm length and 0.5-1.5 cm thick. The lifespan for each leaf is 4 to 6 months.

c) Flowers: The female flowers have calyx formed by crown or having five-pointed star are easy to differentiate. On top of the calyx, the ovaries are located at yellowish sepals. Fruits are lobed and have balloon shaped. Second types of flowers are referred as elongate, bears 10 anther. The papaya plant are hermaphroditic or dioeciously, producing female, male, or bisexual flower. Papaya are referred as “trioecious” means that separate

the plant either female, male, bisexual flower. Bisexual and female flowers are ivory, waxy, white, or borne on short peduncles in leaf axial along the main stem. The position of ovary is superior. The flowers are small or solitary cymes of 3 individuals. At opening, bisexual flowers are tubular, the shape of female flowers are pear shaped. Bisexual plants are self-pollinating, and produce most desirable fruit.

The female flowers have calyx formed by crown or having five-pointed star are easy to differentiate. On top of the calyx, the ovary is located at yellowish sepals. Fruits are lobed and have balloon shaped. Second types of flowers are referred as elongate, bears 10 anther.

There are six types of flowers are known in papaya plant classified in following manner:-

- Typical female flower
- similar to the above when closed
- Hermaphrodite intermediate flower
- Hermaphrodite elongated flower
- Hermaphrodite sterile flower
- Typical male flower

Sr. No	Constituents	Ripe fruit	Green fruit
1.	Water	89.1 gm	92.6 gm
2.	Protein	8.26 gm	10.8 gm
3.	Total lipid	0.93 gm	1.35 gm
4.	Ash	4.59 gm	6.76 gm
5.	Carbohydrate	86.2 gm	81.1 gm
6.	Total DF	11.9 gm	27.0 gm
7.	Sodium	128.4 mg	283.8 mg
8.	potassium	1238 mg	2743 mg
9.	Magnesium	229.4 mg	635.1 mg
10.	Calcium	146.8 mg	635.1 mg
11.	Iron	12.84 mg	8.11 mg
12.	Copper	0.18 mg	0.14 mg
13.	Zinc	0.92 mg	0
14.	Vitamin	568.8 mg	391.9 mg
15.	Thiamine	0.28 mg	0.54 mg
16.	Riboflavin	0.28 mg	26 mg
17.	Niacin	2.80 mg	4.05 mg

d) Fruits: Fruits are sometime referred as pepo-like barrier because this are big and oval oblong berry preform or almost cylindrical, large fleshy, juicy fruit, single cell of orange or reddish internal color, it contain many parietal seeds and having length 10-25 cm or 7-

15 cm diameter. The skin of fruit is waxy and thin but tough. If fruit is hard or green it contain more amount of white latex. When fruit is ripens, externally it becomes deep-yellow with thick wall of flesh becomes yellow, aromatic orange, or salmon or red. Individually fruits required duration for maturation becomes 5-9 month. Average weight of fruit 0.5 up to 20lbs.

Nutritional

e) Seeds: The papaya seed extract contain more medicinal and nutritional property. Each seed of papaya fruit made up of endosperm and sarcotesta. All parts of plant such as seeds, roots, fruits, give positive effect against diseases.

f) Latex: The milky latex from unripe fruits contains papain, chymopapain, and other proteolytic enzymes widely used in pharmaceutical and food industries.

Fig No. 2: Leaves.

Fig No. 3: Hermaphrodite elongated.

Fig No. 4: Flower.

Fig No. 5: Fruit.

PHYTOCHEMICAL CONSTITUENTS

Different parts of *Carica papaya* contain diverse phytochemicals:

Leaves: Alkaloids (carpaine), flavonoids (quercetin), phenolics, tannins, saponins

Fruits: Vitamins (A, C, E), carotenoids, lycopene, enzymes

Seeds: Glucosinolates, benzyl isothiocyanate, fatty acids

Latex: Papain, chymopapain, cysteine proteases

Roots: Tannins, saponins, alkaloids

These compounds contribute to the plant's medicinal activities.

MEDICINAL USES OF DIFFERENT PARTS OF PAPAYA PLANT

Plant part	Medicinal uses
Ripe fruit	Sinuses, digestive, diuretics, expectorant, sedative.
Green fruit	*Malaria, hypertension, diabetes mellitus*
Latex	Dermatitis, psoriasis in Africa asia, Europe
Leaves	Heart tonic, colic dengu fever, beriberi, asthma
Flowers	Jaundice, cough, bronchitis, laryngitis, hoarseness
Seeds	Anti-fertility, anti-microbial, fungicidal, carminative
Roots/Bark	Digestive, tonic, abortifacient in Australia, syphilis

PHARMACOLOGICAL EFFECTS

- **Anti-inflammatory and immunomodulatory responses:** Papaya contains an extensive range of secondary metabolites such as alkaloids, tannins, flavonoids, saponins, which have been shown to a marked effect to reduce chronic inflammatory reaction. Proteolytic enzymes that are present in papaya such as papain and chymopapain also showed an anti-inflammatory effect as well as an effect on immunomodulation. Papain in combination with other proteolytic enzyme such as trypsin and chymotrypsin reduce TGF- β1 level in osteo-myelo-fibrosis, rheumatoid arthritis and herpes zoster. Alkaloids of papaya such as choline and nicotine showed anti-inflammatory potential. In vivo research was performed to investigates the immunomodulatory activities of fruit. It is also reported that transgenic and native papaya fruit (both ripe and unripe) have significant immunomodulatory properties. These immunomodulatory effects were observed in the ovalbumin sensitized mouse model. A remarkable decrease in OVA-specific IgE titre was noticed with native green papaya fruit, whereas an increase in OVA-specific IgG2a titre was observed with green and ripened papaya fruit. The ripened transgenic papaya fruit has a significant increase in IgM level which leads to enhanced humoral immunity. Another study also showed that the seed extract of this plant has both anti-inflammatory activity and immunomodulatory effects. For instance, the bioactive reactions and immunomodulatory effect of crude seeds extract of this plant were investigated in vitro using comp Papaya contains an extensive range of secondary metabolites such as alkaloids, tannins, flavonoids, saponins, which have been shown to a marked effect to reduce chronic inflammatory reaction. Proteolytic enzymes that are present in papaya such as papain and chymopapain also showed an anti-inflammatory effect as well as an effect on immunomodulation.

- **Anti-dengue activity:** Larvicidal efficiency of chloroform, methanol and aqueous extracts of C. papaya latex against larvae of C. quinquefasciatus and A. aegypti which were effective in a dose-dependent manner. Order of toxicity effect is as chloroform extract > methanol extract > aqueous extract. One report on the clinical trial of C. papaya suggested that improve in platelet count of dengue patients and faster improvement. C. papaya leaf juice prepared by the traditional method; and two tablespoons of juice were given to 5 dengue patients three times/day after 6 h. It was found that leaf juice causes a significant intensification in the platelet counts within 24 h of treatment (An increase in platelet count was observed when a patient was given C. papaya leaf extract tablet three times daily for five days and it was suggested that this effect may be due to the expression of the gene responsible for platelet construction named as platelet- activating factor receptor gene. Another investigation has also shown that the leaves of C. papaya have a promising effect on to increase in the platelet counts of a dengue patient.
- **Anti-malarial activity:** There were several reports available that support the anti-malarial activity of C. papaya. Papaya along with other plants used by peoples in the treatment of malaria and related symptoms. Another study also revealed about antimalarial effect of methanolic extract of C. papaya in mice on Plasmodium bergheiNK65 strain. Also, leaf extract was tested against Plasmodium falciparum 3D7 and Dd2 strains. Carpaine was the most active alkaloid extract in dichloromethane leaf extract and displayed good activity against both strain of Plasmodium falciparumIC50 of 2.01 ± 0.18 µg/mL (4.21 µM) and 2.19 ± 0.60 µg/mL(4.57 µM). This alkaloid is highly selective against the parasite and non-toxic to healthy uninfected R.B.C. Further, methanol, chloroform, petroleum ether extract of fruit rind, and roots of papaya were tested against Plasmodium berghei in mice for their antiplasmodial activity. The result showed that petroleum ether and chloroform extract of C. papaya fruit rind has considerable antiplasmodial activity in a dose-dependent manner but petroleum ether extract had the highest antimalarial activity.
- **Anticancer activity:** In vitro investigation of C. papaya suggested that it has anti-cancer properties. The plant contains an enzyme, namely papain which is a constituent of papaya and very helpful in cancer treatment. Fibrin breaks down by papain which coats the tumor cells into amino acid. The pigment lycopene is found inside the papain which is highly reactive towards free radical and oxygen. Papaya also contains isothiocyanate which protects the breast, prostate, pancreas, lung, leukemia, and colon cancer. In a research

study, it was revealed that the leaf extract of C. papaya can prevent the progression of cancerous cells. Various markers such as CA15-3 and LDH are the important biochemical parameter for the detection of cancerous cells; and it was found that the leaf extract in a dose of 200 mg/kg body weight has a significant effect to decrease both markers in the treatment of cancer. Petroleum ether, ethyl acetate, chloroform, and methanol (80%) extracts of aerial parts C. papaya were analyzed for their anticancer effect against three types of cancer cells such as UACC62 (melanoma) TK10 (renal) and MCF7 (breast) cancer cells. It was concluded that the petroleum extract of papaya aerial parts had a significant effect on MCF7 (breast) cancer cells. One research report concluded that black seed from yellow ripe papaya has a direct effect to reduce the growth of prostate cancer cells. Methanolic extract of black seed (ripe papaya) and white seed (unripe papaya) was tested against the prostate cancer cell line. It has been reported that the black seed extract is effective against prostate cancer cells whereas the white seed shows a stimulating effect on pre-existing prostate cancer cells. Another research study reported that papaya leaf juice has also an anti-proliferative effect on prostate cancer cells.

- **Anti-diarrheal responses:** Chloroform extract (25 mg/mL) of raw C. papaya and acetone extract (25–0.39 mg/mL) of ripe C. papaya had essential antidiarrheal activity against the gut pathogens. The antidiarrheal activity of ripe C. papaya extract was extensively seen against Plesiomonas shigelloides with ranges from 50 mg/mL 0.39 mg/mL. DAS-77 (herbal mixture prepared dried root of C. papaya with young bark of Mangifera indica) effective in the treatment of diarrhoea. DAS-77 was tested on mice and the result showed that DAS-77 possesses antidiarrhoeal activity. In another study antidiarrheal activity of leaf aqueous extract of C. papaya was tested in rats' model and found that extract has good antidiarrheal activity and the extract was observed to be safe at 200 mg/kg in the case of rats model.
- **Antioxidant Activity:** High concentrations of flavonoids, phenolics, and vitamins provide strong free-radical scavenging properties, offering protection against oxidative stress and chronic diseases.
- **Antimicrobial Activity:** Papaya extracts exhibit antibacterial, antiviral, and antifungal actions against pathogens such as *E. coli*, *S. aureus*, and *Candida* species.
- **Antidiabetic Activity:** The leaf extract enhances insulin sensitivity, reduces blood glucose levels, and protects pancreatic β-cells due to its antioxidant and hypoglycemic effects.

- **Hepatoprotective Activity:** The plant provides protection against toxin-induced liver damage by restoring antioxidant enzymes and reducing lipid peroxidation.
- **Anthelmintic Activity:** Seeds are particularly effective due to benzyl isothiocyanate, which paralyzes and eliminates intestinal worms.
- **Platelet-Enhancing Activity:** Papaya leaf juice is widely studied for its ability to increase platelet counts in dengue fever. Bioactive ingredients stimulate bone marrow to produce platelets and protect them from damage.
- **Wound-healing activity:** Various skin disorders as well as wounds can be cured by papaya. The ethanolic papaya seed extract was tested in Sprague-Dawley rats, for its wound-healing activity. Results showed that the seed extract assists wound healing in rats. C. papaya loaded PVA/Gelatin nano fibrous was prepared from leaves of C. papaya by electrospinning process. The fabricated nano fibers were hydrophilic and showed wound healing activity. It also exhibited strong antibacterial activity against both S. aureus (Gram-positive) and E. coli (Gram-negative). In a research investigation, the effect of aqueous extract of the root of C. papaya on wound healing in albino rats was checked and root extract showed wound healing activity. It was concluded that the extract-treated wound shows remarkable wound healing activity like standard FSC (Framycetinsulpha cream) In comparison with control (80.38%), tested animals reveal 89.40% reduction in wound part after treated by latex of C. papaya. In one research study, C. papaya stem was analyzed for its wound healing property in albino rats. Ten albino rats were used as experimental animals in two groups. The first group of five animals was treated with an antiseptic named Betadine, whereas other groups of five animals were treated with ointment obtained from C. papaya. Initial and mean size of the wound every two days interval showed no major effect. The final wound size in millimeters after fifteen days showed a major effect. This result suggested the wound healing activity of C. papaya in albino rats
- **Antifertility Activity:** Seed extracts exhibit reversible antifertility effects due to their impact on sperm motility and reproductive hormones.
- **Gastroprotective Activity:** The latex enzyme papain aids digestion, reduces constipation, and supports gastrointestinal health.

TRADITIONAL USES

- Treatment of digestive problems
- Management of dengue fever

- Antiworm remedy
- Relief from menstrual pain
- Use in skin care for acne, pigmentation, and wounds
- Control of hypertension and inflammation

INDUSTRIAL APPLICATIONS

- **Pharmaceutical:** Papain for digestive formulations, wound-care products
- **Food Industry:** Meat tenderizer, brewing, cheese making
- **Cosmetics:** Skin whitening, exfoliating, anti-aging formulations
- **Agriculture:** Biofertilizers, natural pesticides

TOXICITY AND SAFETY PROFILE

- While generally safe, some parts may cause adverse effects when consumed in excess:
- High doses of latex may cause gastric irritation
- Seeds may show antifertility effects
- Unripe fruit may induce uterine contractions
- Allergies to latex proteins may occur
- Proper dosage and processing are essential.

DISCUSSION

The present review highlights the comprehensive morphological features and diverse pharmacological activities of *Carica papaya* Linn., emphasizing its significance as a multipurpose medicinal plant. The morphological characteristics—such as its soft hollow stem, large palmate leaves, and latex-rich tissues—reflect the plant's adaptive growth pattern and contribute to its unique phytochemical profile. The abundant presence of secondary metabolites, including alkaloids, flavonoids, tannins, saponins, carotenoids, and enzymes like papain, supports its widespread traditional and therapeutic use.

The pharmacological studies reviewed in this paper consistently reveal that *C. papaya* exhibits a broad spectrum of biological activities. Notably, the leaf extract has gained scientific recognition for its platelet-enhancing effect, particularly useful in dengue-associated thrombocytopenia. This aligns with various clinical and preclinical findings that demonstrate its ability to restore platelet count and enhance bone marrow activity. Similarly, the antioxidant and anti-inflammatory properties found in different plant parts confirm its potential for managing chronic inflammatory and oxidative stress-related disorders.

Moreover, the antimicrobial, antidiabetic, hepatoprotective, and anthelmintic activities demonstrate the versatility of the plant in addressing both infectious and metabolic diseases. The seeds, in particular, show promising antifertility and anthelmintic effects, suggesting potential avenues for future contraceptive or antiparasitic drug development. The presence of papain in the fruit and latex further broadens its applications in pharmacology, food processing, and biotechnology.

Despite these promising findings, several gaps remain. Many pharmacological studies have been conducted in vitro or in animal models, and there is a need for well-designed clinical trials to validate efficacy, establish safe dosage ranges, and explore long-term safety. Additionally, variations in extraction methods, plant maturity, environmental conditions, and phytochemical compositions may influence the consistency of results. Standardization of extracts and formulation development is therefore essential for translating the plant's therapeutic potential into clinical practice.

Overall, *Carica papaya* Linn. demonstrates strong potential as a natural therapeutic agent with applications across medical, nutritional, and industrial sectors. Future research should focus on active compound isolation, mechanism elucidation, toxicity profiling, and the development of standardized herbal formulations. This will strengthen its acceptance in modern phytotherapy and support its integration into evidence-based medical practices.

CONCLUSION

Carica papaya Linn. is a highly valuable medicinal plant possessing rich morphological and phytochemical diversity. Its broad spectrum of pharmacological properties—anti-inflammatory, antidiabetic, antimicrobial, hepatoprotective, antioxidant, and platelet-boosting—has been widely validated through scientific studies. The plant continues to play a significant role in traditional and modern medicine, offering promising prospects for future drug development, nutraceutical production, and therapeutic applications. Further clinical research is required to establish standardized dosages, mechanisms of action, and long-term safety profiles.

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