An emergence on potentialities and uniqueness of *Carica papaya* Plant

Harikesh Maurya*

Associate Professor, Department of Pharmacology, Hygia Institute of Pharmaceutical Education and Research, Prabandh Nagar, Lucknow (UP), India
E-Mail: mauryaharikesh2@gmail.com

ABSTRACT

Papaya plant known as *Carica papaya* belonging to the family Caricaceae, is an important climacteric fruit grown in lowland and conventionally bred through pedigree and backcross methods. In view of the pharmaceutical industries papaya fruit is the 5th important valued plant for the nutrition qualities as rich of provitamin A, calcium and proteolytic enzyme papain. It is only one of the plant with presence of huge phyto-constituents like; Alkaloids, Glycosides, specific glycosides like Saponin Glycosides, Anthraquinone Glycosides, Cardiac Glycosides, Cyanogenetic Glycosides, Tannins and Phenolic Compounds, Flavonoids, Proteins and Amino Acids, Sterols & Triterpenoids, Carbohydrates, Fats & Fixed Oils. Due to the presence of these phyto-constituents, it has several medicinal values including antiseptic, antimicrobial, antiparasitic, anti-inflammatory, antihypertensive, diuretic, antihyperlipidemic, antidiabetic, and contraceptive activity. Papaya is also well known for its exceptional nutritional and medicinal properties throughout the world. Traditionally, papaya is an herbal medicament in developing countries for burns, soft tissue wounds and skin infection. The whole papaya plant including its leaves, seeds, ripe and unripe fruits and their juice is used as a traditional medicine. Nowadays, papaya is considered as a nutraceutical fruit due to its multifarious medicinal properties. Hence extensive investigation on its pharmacodynamics, kinetics and proper standardization and clinical trials is needed to exploit their therapeutic activity to combat various diseases.

Keywords: *Carica papaya*, nutraceutical, provitamin A, papain, skin infection.

Introduction

One of the most tropics and sub-tropics worldwide cultivated species of the *Caricaceae* family is Papaya (*Carica papaya* L.) an important climacteric fruit crop grown in lowland and [1] conventionally bred through pedigree and backcross methods [2], as well as inbreeding of ambivalent males to produce homozygous females [3]. It is indigenous to tropical America and cultivated in large scale and also in Sri Lanka, Tanzania, India, Hawii, Florida, Philippines, South Africa and Australia. In India papaya is cultivated in Maharastra, Bengal, Bihar, Haryana, Punjab, Delhi, Andhrapradesh and Uttarpradesh [4]. For the pharmaceutical industries papaya fruit is the fifth important valued plant for the nutrition qualities as rich of provitamin A, calcium and papain. Papaya fruits give economically high yield per acre in comparison to banana, because of starts fruiting within a couple of years [5].

A phytochemical analysis was performed by Yadu Nandan Dey and Ajoy Kumar Ghosh, 2010 for the presence of following chemical constituents such as; Alkaloids, Glycosides, specific glycosides like Saponin Glycosides, Anthraquinone Glycosides, Cardiac Glycosides, Cyanogenetic Glycosides, Tannins and Phenolic Compounds, Flavonoids, Proteins and Amino Acids, Sterols & Triterpenoids, Carbohydrates, Fats & Fixed Oils [6,7].

In presence of these constituents it possess some medicinal properties including antiseptic, antimicrobial, antiparasitic, anti-inflammatory, antihypertensive, antihyperlipidemic, antidiabetic, diuretic, and contraceptive activity. Further it has some evidence for healing decubitus ulcers, wounds and treating intestinal worms in humans [8].

Botanical description

The papaya tree has a straight trunk that grows up to 8 m high. It does not branch. At the base, the trunk is about 30-40 cm thick. Latex flows from all parts of the tree when it is cut or injured. The leaves grow from the top part of the stem in a spiral. They have long, horizontal stalks measuring 35-105 cm long. The leaves are large, and divided into 5-9 irregular segments. They have prominent yellow ribs and veins. The papaya plant may produce female, male or hermaphrodite (perfect) flowers. The fragrant flowers are fleshy and waxy with five petals. The tree may produce flowers of different sexes depending on environmental conditions or stress [9].

Kingdom: Plantae
Subkingdom: Tracheobionta
Super division: Spermatophyta
Division: Magnoliophyta
Class: Magnoliopsida
Subclass: Dilleniidae
Order: Violales
Family: Caricaceae
Genus: Carica L.
Species: *Carica papaya* L.

The papaya fruit range from oval to round, measuring 15-50 cm long and 10-20 cm wide. The largest may weigh up to 9 kg. Unripe fruit are green and hard with white latex. Ripe fruit have light to deep yellow skins with yellow, orange, salmon or red succulent flesh. The flesh is juicy, sweet with an aromatic to musky flavour. The seeds, found in the centre of the fruit, are usually black and surrounded by a transparent, fleshy coating [10].

Morphology

Plant: Papaya is a short-lived fast growing soft wooded perennial tree, can grow up to a height of 8–10 meters having an extensive root system with short branches. The trunk is hollow green or deep-purple 30-40 cm or more thick at the base and roughens by leaf scars with latex vessels that occur in all parts (Fig. 1). Stem simple, with stipulate scars helically arranged and hollow petiole 60–100 cm [11].

Leaves: The leaves emerge directly from the upper part of the stem in a spiral on nearly horizontal petioles 30-105 cm long having short life i.e., 4 to 6 months. They are hollow, succulent, green or more or less dark purple. The blade, deeply divided into 5 to 9 main segments, each irregularly subdivided, varies from 30-60 cm in width and has prominent yellowish ribs and veins. Both the stem and leaves contain copious white milky latex [12].

Fruit: Fruit orange-yellow or yellow at maturity, cylindrical, ovoid-cylindrical or subglobose, 10–30 cm lengthy. The peak climacteric respiration is observed within 6 days during harvesting of papaya fruit on ripening stage with physiological changes likes wounding during slicing, earlier skin yellowing, flesh softening and deseeding led to an increase in ethylene production and respiration [13].

Moreover, during ripening stage about 50% yellow fruit skin (sliced and deseeded) shows higher wound-induced ethylene production and respiration. These fruit were suitable for minimal processing when combined with low storage temperature (4°C) to inhibit ethylene production and respiration. About 80% fruit skin yellowing and less than 50 N flesh firmness had more than 50% edible flesh and easily removed seeds [14].

Flowers: Male flowers: pedicel absent; corolla tube creamy yellow, 1.6–2.5 cm, lobes lanceolate, ca. 1.8×0.45 cm; stamens 5 longer and 5 shorter, shorter ones almost without filaments; filaments white, white tomentose. Female flowers usually solitary or aggregated in corymbose cymes; pedicel short or nearly absent; calyx lobes ca. 1 cm; corolla lobes creamy yellow, oblong or lanceolate, 5–6.2×1.2–2 cm; ovary ovoid; stigmas partite, nearly fimbriate. Bisexual flowers: corolla tube 1.9–2.5 cm, lobes oblong, ca. 2.8×0.9 cm; stamens 5 or 10 in 1 or 2 whorls; ovary smaller than in female flowers [15].

Root: Roots rely on warm soil to encourage growth and spreading for a well-established papaya plant. The roots are very sensitive to water logging because of several small branches. Root competition with close plants, such as grasses, reduces the water the papaya takes in at the soil level [16].

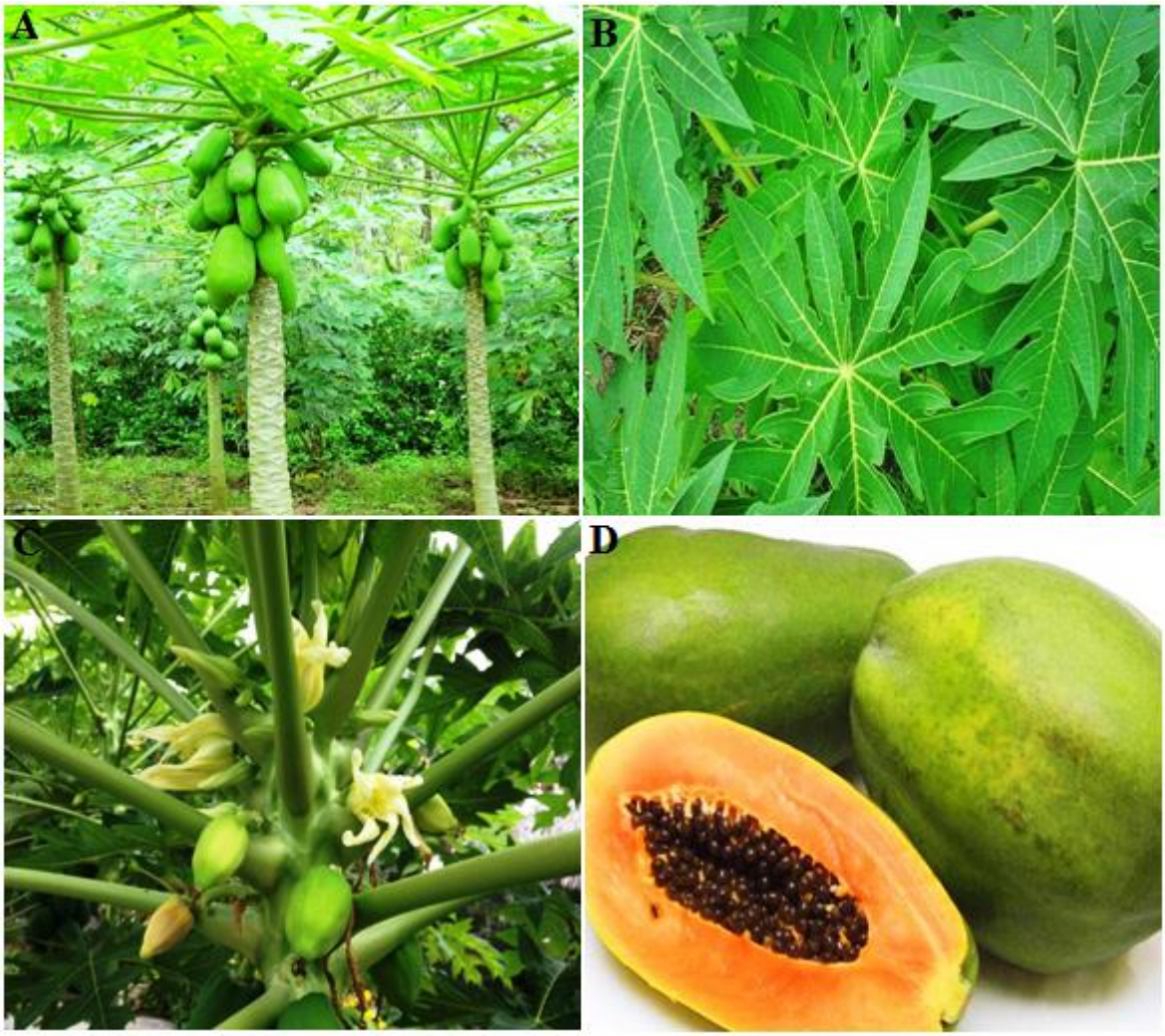

Figure 1: Morphology of Papaya (a) Plant, (b) Leaf, (c) Flower, (d) Fruit & seed

Pollination: Some papaya cultivars are self-pollinating, but many varieties depend on nearby shrubs for cross-pollination; both insects and wind patterns move pollen between flowers of different papaya plants. After a papaya plant is inadequately pollinated, it will bear a light crop of fruits lacking uniformity in size and shape. Therefore, hand-pollination is advisable in commercial plantations that are not entirely bisexual [17].

Growth and Development

Papayas are fast growing plants that require an abundant supply of nutrients if they are to be highly productive. The plants are usually grown from seed, which take 2 to 3 weeks to germinate [18]. Papaya trees may live up to 25 years or more but productivity declines with age. For fresh fruit production as well as papain production it is best to renew the plantation every 3 years. A high initial growth rate leads to early flowering (within 6 months from sowing) and fruiting (fruit maturing 4-5 months after flowering). The fruit moderates the growth rate, but a steady and relatively fast pace should be maintained to produce fruit throughout the year and in large quantities [19]. It takes about eight to ten weeks after sowing before seedlings reach a height of 20 cm or 10-12-leaf stage when they are ready for transplanting. After transplanting, shoot growth is initially slow, though considerable root growth is taking place extending out well beyond the canopy line. Stem growth is then rapid up to flowering, increasing in circumference up to 2 mm per day. Growth rate peaks at flowering then declines as the tree starts bearing. The rate of stem growth is influenced by nitrogen and phosphorus

supply, irrigation, and temperature. Root growth declines dramatically as flower initiation occurs, continuing at a very low rate during flowering and fruiting [20].

The cluster of leaves at the apex and along the upper part of the stem makes up the foliage of the tree. New leaves are constantly formed at the apex and old leaves senesce and fall. Usually there are 15 mature leaves per plant. In the tropics, new leaves appear at a rate of two to three a week. The leaf petioles develop at a rapid rate until flowering then increases slowly, and peaking after fruit bearing starts [21].

ECOLOGY

The environmental factors such as light, wind, soil chemical and physical characteristics, temperature, soil water, relative humidity, and biotic factors such as mycorrhizal fungi and genotype profoundly affect the productivity and physiology of papaya. An understanding of the environmental factors and their interaction with physiological processes is extremely important for economically sustainable production in the nursery or in the field. With improved, science-based management, growers will optimize photosynthetic carbon assimilation and increase papaya fruit productivity and quality [22].

The papaya is a tropical and near-tropical species, limited to the region between 32º north and 32º south of the Equator, with a temperature range of 21-33°C. It needs plenty of rainfall or irrigation but must have good drainage. Plantations should be in sheltered locations or surrounded by windbreaks, as strong winds are detrimental, particularly on soils that cannot make up for large transpiration losses [23].

Papaya grows best in light, well-drained soils rich in organic matter with soil pH of 6.0-6.5. It can tolerate any kind of soil provided it is well-drained and not too dry. Overly acid soils are corrected by working in lime at the rate of 2.4-4.8 tons/ha. On rich organic soils the papaya grows well and bears heavily but produces fruits of low quality. The roots are very sensitive to water logging. Even short periods of flooding can kill the plants [24].

Rainfall: Papayas grow well and produce substantial yields without supplementary irrigation if there is a minimum monthly precipitation of approximately 100 mm. Such an ideal distribution rarely occurs as most tropical areas have monsoon-type climates with well-defined wet and dry seasons. Successful production therefore depends upon the availability of supplemental irrigation during the dry period. Drought frequently leads to the rapid shedding of older leaves, reversion of sex to unproductive male and poor fruit set. At the other extreme, flooding frequently leads to plant death due to root [25].

Temperature: Optimum temperature for growth is between 21°C to 33°C. Dioecious cultivars are better suited to low temperatures (<20°C), as female trees do not exhibit the sex changes shown by the more sensitive bisexual (hermaphroditic) cultivars. Hermaphroditic cultivars (Eksotika or Solo types) grown with minimum temperature less than 17°C may have 100% of the flowers reverting to femaleness. At higher temperatures (>35°C), there is a tendency of hermaphrodite cultivars to form functional male flowers with poorly developed and non-functional female parts. This tendency varies with cultivars and within a cultivar [26].

Radiation: Papaya is a sun-loving plant. When subjected to shade the plant grows tall with increased internode length and etiolated leaves [27].

Wind: Papaya trees are delicate and require protection from strong winds. The root system is well-developed though relatively shallow and the tree can be uprooted by winds of 64 km/hr, especially if the soil is softened by rain. Even though trees withstand uprooting, considerable damage occurs to the large leaves leading to flower and young fruit abscission and low total soluble solids in the more mature fruits. Recovery from wind damage can take from 4 to 8 weeks [28].

Soil: Papayas are grown in a variety of soil types with the most essential requirement being drainage; poor drainage leads to the development of root rots. A porous loam or sandy loam soil is preferred. Papaya grows well at soil pH between 5.0 and 7.0. At pH levels below 5.0, lime application is necessary to increase growth and yield [29].

Papaya can be grown successfully even on marginal soils such as peat, and acid sulphate, if the inherent shortcomings of these soils are taken care of. For peat soils, high rates of lime application (6 – 8 tonnes/ha) are essential for cultivation. Micronutrients like boron, zinc and copper should also be applied regularly to ensure production of quality fruits. Since

the water table is usually high, the area requires drainage before papaya, which is sensitive to flooding, can be grown. Yields of more than 100 mt/ha for some selected hybrids have been obtained from peat soils. However one major constraint is the tendency for trees to lodge (fall over), especially for heavy bearers, because of poor anchorage. To overcome lodging, trees need to be staked or supported. It is also difficult to mechanize farm operations on the soft peat surface [30].

With proper management and liming, papaya can also be grown on acid-sulphate soils, which are compact, acidic, contain toxic concentrations of certain micro-nutrients and are prone to flooding. However, papayas cultivated on these soils have a relatively shorter economic life span due to poorly developed root systems and extreme susceptibility to root and collar diseases resulting from poor drainage conditions. Heavy clay soils should preferably be avoided as the compact nature of these soils cause prolonged flooding, which is detrimental to papaya growth [31].

Cultivation

The water contains major constituent such as mineral ions or carbon dioxide are required for growth and development of higher plants. Stomata play an important role in water loss control in leaves coordinated by light intensity and quality, CO_2 external concentration, leaf water condition, metabolites produced into foliar mesophyll and into roots, and air humidity. The leaf-to-air vapor pressure deficit influences stomatal closure and high values of VPD leaf-to-air cause stomatal closure. Papaya, which presents stomata only in the leaf abaxial surface, had a decrease of 47 and 48% in the stomatal conductance and photosynthesis net rate. In papaya, water limitations reduce stomatal conductance, net rate of photosynthesis and quantum yield, which significantly affect the crop yield [32].

Productivity

In order to assess the performance of farms in the Region, it is necessary to develop appropriate performance parameters. The yield potential of Papaya depends on a number of factors including variety, duration of harvest, irrigation, crop husbandry and management including spacing, nutrition and pest/disease control, field sanitation. New flower buds are formed at leaf axils every two to three days. The time from bud initiation to flower anthesis ranges from 46 to 80 days, the wide discrepancy due to effects of temperature [33].

Fruit growth shows two major phases. The first phase of rapid growth lasts about 80 days after flower opening, while the second phase is apparent just before fruit maturity. Flesh color is white in immature fruit to a pale orange-yellow, salmon pink, or red depending upon cultivar in ripe fruit. Total fruit starch declines during the first 80 days of fruit development. Sugars begin to accumulate only during the last 28 to 42 days of fruit development. Fruit development usually takes 130 to 160 days from anthesis in the tropics and can be extended to 190 to 270 days in the cooler subtropics [34].

Differences in Productivity by Country: For the representative farms in the study, exportable yields are shown in Figure 4.1. In interpreting yield information it is important to take note of the following three factors that could account for differences with respect to production:

- The duration of the harvest period
- Use of supplemental irrigation
- The variety

Based on irrigated production systems, generally the commercial growers in Jamaica, Belize and Trinidad & Tobago achieved yields that were close to the benchmark levels of productivity. When one considers that the duration of harvest in Trinidad & Tobago is generally about 10 months and in the case of Belize and Jamaica, approximately 16 months, this performance may be considered very good. Guyana's productivity however is quite low, explained partly by climatic conditions. It should be noted that local growing conditions, including the probability of early onset of diseases, is one of the reasons for a shorter harvest period in Trinidad & Tobago and Guyana than elsewhere [35].

Phytoconstituents

Carica papaya is one of the valuable plants used for various purposes in medicinal field. Leaves, fruit and seeds of the *Carica papaya* are used as ethno medicine. Phytoconstituents of various part of *Carica papaya* plant are described (Table 1) [36].

Table 1: Phytochemical constituents present in different part of plant

Plant part	Constituents
Unripe fruits	*Enzymes:* Papain, chymopapain, glutamine peptidase A & B and lysozymes.
Rip fruits	*Carotenoids:* β carotene, crytoxanthin, violaxanthin, zeaxanthin. *Monoterpenoids:* 4-terpineol, linalool, linalool oxide.
Leaves	*Alkaloids:* Carpinine, vitamin C & E, pseudocarpine, choline, carposide. *Minerals:* Calcium, potassium, magnesium, iron, copper, zinc.
Shoots	*Vitamins:* Thiamine, riboflavin, niacin, ascorbic acid, α-tocopherol. *Flavonoids:* Quercetin, myricetin, kaempferol.
Seeds	*Glucosinolates:* Caricin, benzylthiourea, β-sitosterol, myrosin, Benzyl isothiocynate.
Roots	Carposide, and an enzyme myrosin.

NUTRITINAL VALUES OF PAPAYA

The chemical evaluation of papaya revealed the presence of potassium (223 mg/100 g of fresh fruit) along with sodium, calcium, phosphorus, zinc, iron, copper, manganese, and magnesium in appreciable amounts. Papaya occupies a key position among the fruits for vitamin A, C, B_1, and B_2, thiamine, folate, riboflavin, niacin, calcium, potassium, iron, and fiber contents. It is low in calories, but rich in vitamins and minerals. About 60% of the ripe fruit is edible per 100 g of fruit. The energy value of papaya is 200 kJ/100 g. The chemical evaluation of papaya revealed the presence of potassium (223 mg/100 g of fresh fruit) along with sodium, calcium, phosphorus, zinc, iron, copper, manganese, and magnesium in appreciable amounts. Papaya occupies a key position among the fruits for vitamin A, C, B_1, and B_2, thiamine, folate, riboflavin, niacin, calcium, potassium, iron, and fiber contents. It is low in calories, but rich in vitamins and minerals. About 60% of the ripe fruit is edible per 100 g of fruit. The energy value of papaya is 200 kJ/100 g. (Table 2) [37].

Table 2: Nutritional facts of papaya per 100g

Nutrients	Amount	Percentage
Folates	38µg	9.5%
Vitamin A	55micg	06%
Vitamin B1	0.04mg	03%
Vitamin B2	0.05mg	03%
Vitamin B3	0.338mg	02%
Vitamin B6	0.1mg	08%
Vitamin C	61.8mg	103%
Pantothenic acid	0.218mg	04%
Sodium	3mg	00%
Potassium	257mg	05%

Calcium	24mg	02%
Iron	0.01mg	01%
Magnesium	10mg	03%
Phosphorus	5mg	01%
Zinc	0.07mg	0.5%
B-carotene	276µg	03%
Carbohydrates	9.81g	
Sugar	5.90g	
Dietary fiber	1.80g	
Fat	0.14g	
Protein	0.61g	
Energy	39.0 kcal	

Pharmacological Activities

The *Carica papaya* plant possesses several pharmacological activities used for the management of human ailments. It includes antifertility, dengue fever, anticancer, antihelmintic, antibacterial, hepatotoxicity, antifungal, antimalarial, antiamoebic, uterotonic activity etc. (Table 3) [38].

Table 3: Reported pharmacological activity on papaya plant

S.N.	Name of activity	Plant's part used	Animal species	Out comes
1	Female anti-fertility activity	Unripe fruit	Female Rats	Interrupted the oestrus cycle and induced abortion, anti-implantation effect
2	Sperm concentration and motility	Chloroform extract of seeds	Monkey	Induced long term azoospermia
3	Uterotonic	Latex extract	Rats	Increased uterine contractile activity in proestrus & estrus stages
4	Nephro-protective activity	Aqueous extract of the unripe seeds	Wistar rats	Potent Nephro-protective effect was observed in rats
5	Anti-inflammatory	Ethanolic extract of leaves	Rats	Shows good anti-inflammatory effect
6	Anti-hypertensive	Papaya leaves decoction	Cats	Hypertensive activity was reported in large animals
7	Hypoglycemic, hypolipidemic	Aqueous seed extract	Wistar Rats	Positive effect was observed

8	Anthelmintic	Aqueous seed extract	Ascaris lumbriocide & ascaridia galli	Showed anthelmintic property
9	Wound healing	Aqueous extract of leaves	Rats	Diabetic wound-healing potential observed
10	Anti-bacterial	Seeds extracts	Against enteropathogen and bacteria	Possess bacteriostatic activity
11	Anti-tumor	Aqueous extract of leaves	Solid and haematopoietic tumor cell lines	Inhibits the proliferative responses of solid tumor cell lines derived from several carcinomas, at dose dependent
12	Anti-oxidant	Aqueous extract of leaves	Wistar rats	Shows Free-radical scavenging activity
13	Anti-sickling	Unripe papaya fruit extract	Mice	Anti- sickling property
14	Antimicrobial	Seeds	Trichomonas vaginalis(mice)	In urogenital disorder like tricomoniasis observed
15	Anti-malarial	Petroleum ether extract of fruit	Hamsters	Exhibits significant antimalarial activity
16	Male antifertility	Seed extract	Male rats	Degeneration of germs, sertoli cells & germinal epithelium

Traditional uses

- Traditionally, papaya is an herbal treatment in developing countries for burns, soft tissue wounds and skin infection.
- Unripe Papaya is commonly used as a contraceptive in Pakistan, India and Sri Lanka.
- Papaya contains a natural pain reliever. Papaya paste was used for the relief of burns, cuts, rashes and stings.
- The papain's presence in Papaya makes it helpful against heartburn and indigestion. It can prevent heartburn, when mixed with a little honey and taken before meals.
- The fruit's proteolytic enzymes and other compounds, including a substance called carpaine, are effective against intestinal worms and other parasites.
- Papaya latex is a very effective meat tenderizer.
- Papain has been employed to dissolve membranes in diphtheria.
- It reduces swelling, fever and adhesions after surgery.
- Chemopapain is sometimes injected in cases of slipped spinal discs or pinched nerves.
- The ripe fruit, when eaten fresh, improves digestion and is reported to have a complimentary laxative effect.
- It is used as a disinfectant and as an anti-ulcer medicine.
- It can be used in celiac disease and crohn's disease.
- Latex, the milk like juice from unripe papaya is rich in papain. Studies showed that helps in removing freckles (melanin cluster on face).
- Papain helps in thinning of the blood and inhibits clotting [39].

Surprising benefits of Papaya

Skin Benefits

- Moisturizes Skin
- Clears Pigmentation
- Reduces Wrinkles
- Reduces Under-Eye Dark Circles
- Cures Eczema And Psoriasis
- Treats Melasma
- Removes Tan
- Controls Acne Breakout [40]

Hair Benefits

- Stimulates Hair Growth
- Controls Dandruff
- Conditions Hair

- Make Hair Soft
- Boosting Hair Strength
- Removes Excess Oil from Hair [41]

Health Benefits

- Promotes Cardiovascular Health
- Prevents Macular Degeneration
- Boosts Immunity & Heals Wounds
- Aids Digestion & Prevents Arthritis
- Has Anticancer Effects
- Reduce Inflammation In The Lungs
- Treats Throat Disorders & Vitiligo
- Treatment For Ringworm & Gout
- Helps In Muscle Tissue Renewal
- Activates Human Growth Hormones
- Helps Ease Menstrual Pain
- Helps Reduce Stress & Weight Loss
- Good For Diabetics & Treats Piles
- Prevents Irritable Bowel Syndrome
- Treats Nausea And Motion Sickness
- Helps Increase Platelet Count
- Keeps Blood Pressure Under Control
- Used For Birth Control
- Good For Babies
- Good For Pregnant Women
- Aids Breast Enlargement
- Helps Increase Lactation [42,43]

Conclusion

Carica papaya is well known for its exceptional nutritional and medicinal properties throughout the world. The whole papaya plant including its leaves, seeds, ripe and unripe fruits and their juice is used as a traditional medicine. Nowadays, papaya is considered as a nutraceutical fruit due to its multifarious medicinal properties. Hence extensive investigation on its pharmacodynamics, kinetics and proper standardization and clinical trials is needed to exploit their therapeutic activity to combat various diseases.

Papaya is a principal horticultural crop of tropical and subtropical regions. A better understanding of genotypic responses to specific environmental factors such as light, wind, soil chemical and physical characteristics, temperature, soil water, relative humidity, and biotic factors such as mycorrhizal fungi and genotype profoundly affect the productivity and physiology of papaya. For that purpose, the protein composition of three different latexes was analyzed. The first one, commercially available, was provided in the form of a spray-dried powder, the second one was harvested from fully grown but unripe papaya fruits that are regularly tapped for latex production and the last one, was obtained from similar fruits wounded for the first time. Repeated mechanical wounding was found to profoundly affect the protein content of the latex inducing, among others, activation of papain. Regularly tapped latexes also accumulated several low molecular weight proteins not yet identified, as well as three proteins identified as a trypsin inhibitor, a class-II chitinase and a glutaminyl cyclase on the basis of their enzymatic or inhibitory activities.

Acknowledgment

I am very thankful to the Director of HIPER, Prabandh Nagar, Lucknow (UP) for providing such type of facilities to do my research work peacefully.

References

1. Melo de-Araujo MM, Tavares ET, Rodrigues da-Silva F, de-Almeida Marinho VL, Manoel TS. Molecular detection of Papaya meleira virus in the latex of *Carica papaya* by RT-PCR. Journal of Virological Methods 2007;146:305–310.
2. Manshardt RM. Papaya. In: Hammerschlag, FA, Litz, RE (Eds), Biotechnology of Perennial Fruit Crops. CAB International, Oxon, 1992; pp. 489–511.
3. Rimberia FK, Adaniya S, Ishimine Y, Etoh T. Morphology of papaya plants derived via anther culture. Scientia Horticulturae 2007;111:213–219.
4. Milind P, Gurditta. Basketful benefits of papaya. International research journal of pharmacy 2011;2(7):6-12.
5. Agnihotri S, Singh SK, Ain M, Sharma M, Sharma AK. Chaturvedi HC. In vitro cloning of female and male *Carica papaya* through tips of shoots and inflorescence. Indian Journal of Biotechnology 2004;3:235-240.
6. Dey YN, Ghosh AK. Pharmacognostic evaluation and phytochemical analysis of the tuber of Amorphophallus paeoniifolius. International Journal of Pharma Research and Development 2010;2(9):44-49.
7. Josiah SJ, Nwangwu SCO, Akintola AA. Protective role of water extract of unripe pulp of *Carica papaya* (fruit) against a potassium bromate induced tissue damage in wistar rats. British Journal of Pharmacology and Toxicology 2011;2(4):205-208.

8. Reddy CL, Kuppast IJ, Veerashekar T, Valli Kanagarla NSSA. A review on pharmacological activities of Carica papaya. International Journal of Universal Pharmacy and Bio Sciences 2013;2(1):299-307.

9. Medina JDLC, Gutiérrez GV, García HS. Papaya post-harvest operations. Food and agriculture organization of the United Nations 2003;1-37.

10. Medinilla A. El cultivo de la pawpaw maradol. Plantaciones Modernas 2000;5(2):5-34.

11. Jaiswal P, Singh DK. Molluscicidal activity of *Carica papaya* and Areca catechu against the freshwater snail Lymnaea acuminata. Vet Parasitol 2008;152(3-4):264-70.

12. Anishkumar PK, Bhattacharya A, Dutta OP, Chatterjee M. Biology of the Papaya Plant. Springer 2014;10:409-421.

13. Marler TE, Discekici HM. Root development of 'Red Lady' papaya plants grown on a hillside. Plant and Soil 1997;195: 37–42.

14. Paull RE, Chen W. Minimal processing of papaya (*Carica papaya* L.) and the physiology of halved fruit. Postharvest Biology and Technology 1997;12:93–99.

15. Ronse De Craene LP, Smets EF. The floral development and anatomy of *Carica papaya* (Caricaceae). Canadian Journal of Botany 2011;77(4):582-598.

16. Teixeira Da Silva JA, Rashid Z, Nhut DT, Sivakumar D. Papaya (*Carica papaya* L.) Biology and Biotechnology.Tree and Forestry Science and Biotechnology 2007:61-62.

17. Verma S, Varma RK, Singh S. Medicinal and pharmacological parts of *Carica papaya*: A review. Indian Journal of Drugs 2017;5(3):88-93.

18. Terra De Almeida F, Bernardo S, Fernandes De Sousa E, Marin SLD, Grippa S. Growth and yield of papaya under irrigation. Scientia Agricola 2003;60(3):419-424.

19. Paull RE, Duarte O. Crop production science in horticulture series, 2nd edition, 2011; (1):291-320.

20. Aiyelaagbe I, Fawusi MOA, Babalola O. Growth, development and yield of pawpaw (*Carica papaya* L.) 'Homestead selection' in response to soil moisture stress. Plant and Soil 1986;93(3):427-435.

21. O'Hare TJ, Wong LS, Williams DJ et al. Papaw ***(Carica papaya)*** as a source of glucotropaeolin and its active derivative, benzyl-isothiocyanate. In: Proceedings of the tropical fruits in human nutrition and health Conference, Gold Coast 2008:197–201.

22. Campostrini E, Glenn DM. Ecophysiology of papaya: a review. Brazilian Journal of Plant Physiology 2007;19(4):413-424.

23. Oliveira JG, Vitória AP. Papaya: Nutritional and pharmacological characterization, and quality loss due to physiological disorders. Food Research International 2011;44(5):1306-1313.

24. Runnie I, Salleh MN, Mohamed RJ et al. Vasorelaxation induced by common edible tropical plant extracts in isolated rat aorta and mesenteric vascular bed. Journal of Ethnopharmacology 2004;92:311–316.

25. Yu Q, Tong E, Skelton RL, Bowers JE, Jones MR, Murray JE, et al. A physical map of the papaya genome with integrated genetic map and genome sequence. BMC Genomics 2009;10:371.

26. Krishna KL, Paridhavi M, Patel GA. Review on nutritional, medicinal and pharmacological properties of Papaya. Natural products and radiance 2008;7(4):364- 373.

27. Webster RE, Waterworth WM, et al. Biomechanical, biochemical, and morphological mechanisms of heat shock-mediated germination in *Carica papaya* seed. Journal of experimental Botany 2016; 67(22):6373–6384.

28. Fabi JP, Broetto SG, da Silva SL, Zhong S, Lajolo FM, do Nascimento JR. Analysis of papaya cell wall-related genes during fruit ripening indicates a central role of polygalacturonases during pulp softening. PLoS One. 2014;9(8):e105685.

29. Fabi JP, Mendes LRBC, Lajolo FM, Nascimento JRO. Transcript profiling of papaya fruit reveals differentially expressed genes associated with fruit ripening. Plant Science 2010;179:225–233.

30. Fabi JP, Cordenunsi BR, Seymour GB, Lajolo FM, Nascimento JRO. Molecular cloning and characterization of a ripening-induced polygalacturonase related to papaya fruit softening. Plant Physiol Biochem 2009;47:1075–1081.

31. Devaki CS, Samreen F, Prakash J. A Review on Composition, Processed Products and Medicinal Uses of Papaya (*Carica Papaya* L.).

International Journal of Food, Nutrition and Dietetics 2015;3(3):99-117.

32. Fabrı´cio de Oliveira Reis, Campostrini E, Fernandes de Sousa E, Gabetto e Silva M. Sap flow in papaya plants: Laboratory calibrations and relationships with gas exchanges under field conditions. Scientia Horticulturae 2006;110(3):254–259.

33. Sachdeva S, Sachdev TR, Sachdeva R. Increasing Fruit and Vegetable Consumption: Challenges and Opportunities. Indian J Community Med 2013;38(4):192–197.

34. Da Silva Júnior GB, Cavalcante IHL, Santos EM, Albano FG, Silva AM. Growth, physiology and yield of formosa 'papaya' cultivated under different doses of coated and conventional urea. Revista Caatinga 2016;29(3):559-568.

35. Ming R, Hou S, Feng Y, Yu Q, Dionne-Laporte A, Saw JH, et al. The draft genome of the transgenic tropical fruit tree papaya (*Carica papaya* Linnaeus). Nature 2008;452(7190):991-997.

36. Yogiraj V, Goyal PK, Chauhan CS, Goyal A, Vyas B. *Carica papaya* Linn: An Overview. International Journal of Herbal Medicine 2014;2(5):01-08.

37. Saeed F, Arshad MU, Pasha I, Naz R, Batool R, et al. Nutritional and Phyto-Therapeutic Potential of Papaya (*Carica Papaya* Linn.). International Journal of Food Properties 2014;17(7):1637-1653.

38. Ashok AK, Mol N, Karthikeyan M. Pharmacological potentials of Carica papaya. Innovat international journal of medical & pharmaceutical sciences 2017;2(1):18-20.

39. Aravind, Bhowmik D, Duraivel, Harish G. Traditional and Medicinal Uses of Carica papaya. Journal of Medicinal Plants Studies 2013;1(1):7-15.

40. Singh O, Ali M. Phytochemical and antifungal profiles of the seeds of *Carica papaya* L. Indian Journal of Pharmaceutical science 2011;73(4):447–451.

41. Kumar NS, Devi PSS. The surprising health benefits of papaya seeds. Journal of Pharmacognosy and Phytochemistry 2017; 6(1):424-429.

42. Parle M, Gurditta. Basketful benefits of papaya. International Research Journal of Pharmacy 2011; 2(7):6-12.

43. Boshra V, Tajul AY. Papaya-An Innovative Raw Material for Food and Pharmaceutical Processing Industry. Health and the Environment Journal 2013; 4(1):68-76.

Source of Support: Nil
Conflict of Interest: Nil