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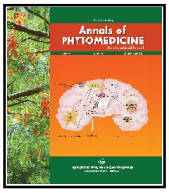

Review Article : Open Access

# A review on comprehensive nutritional assessment and health importance of Papaya (*Carica papaya* L.)

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**Abstract**

A balanced diet must include both fruits and vegetables. In tropical and subtropical areas, papaya tree is a well-known and prominent fruit tree (*Carica papaya* L.). People consume the fruit in processed dishes, as a raw fruit, and as a vegetable all across the world. Everything in the papaya plant, including the peel, flower, leaves, latex, roots, fruit and seeds, has a purpose in terms of nutrition and medicine. Papaya may be consumed as food, as a culinary ingredient, or as medication. The antifungal, antisickling, antibacterial, anti-inflammatory, anticancer, and wound healing properties of papaya are just a few of its many health benefits. Vitamins A, B and C as well as proteolytic enzymes like papain, which are abundant in papaya, are responsible for many of its health advantages. Papain is a photolytic enzyme with cysteine protease activity derived from papaya, which has a green colour and is obtained from latex.

## 1. Introduction

Papaya (*Carica papaya* L.) is a common tropical fruit that ranks third in terms of value after mango and pineapple (which each contribute for around 53% and 26%, respectively). Only ten countries produce around 86% of the annual papaya production of approximately 11 million tonnes (Evans and Ballen, 2012). There are multiple more common names of *C. papaya*, including tree melon papaya, chichpu, mamao, pawpaw, papaw (AbdElgadir *et al*., 2014). It is an 8-foot-tall, mid plant with a hollow, cylindrical stem that resembles a tree. The papaya has several different names around the globe and in many multiple dialects. Carotenoids, phenolic compounds, fibre, folate, minerals (K and Mg and others), and vitamins A, C, and E are all plentiful in papaya. Because of the nutritional value and healing properties of *C. papaya*, it has long been used in many nations. According to sources, *C. papaya* is used in cooperation with certain other herbs to heal illnesses (Anwar *et al*., 2008). At room temperature, the fruit ripens quickly. When the fruit feels soft and becomes an amber or orange tone, it is ripe. The fruit is only good for two to three days after it ripens (Archbold *et al*., 2003). It may also be known to as a berry-like fruit or the "fruit of the common man," depending on the context (Basalingappa *et al*., 2018). Papayas, or *C. papaya* are indigenous to northern South America and Mexico and are members of the Caricaceae family. In many tropical and subtropical parts of the globe, it has become a naturalised species. The digestive enzyme papain, which is often utilised in the pharmaceuticals, cosmetics, and brewery sectors as well as for meat tenderization, has also been shown to be plentiful in papaya, according to the FAO (2020). The papaya leaves are also helpful for treating pyrexia, diabetes, syphilis, and wound healing in addition to the fruit, which has laxative properties (Sudhakar *et al.,* 2014). Over the years, papaya's classification has undergone numerous changes. Previously, the plant families Passifloraceae, Cucurbitaceae, Bixaceae, and Papayaceae were among those that included the genus Carica. However, as of present moment, it is categorised as a part of the Caricaceae plant family, including includes 35 various species of plants that yield latex and are classified into the four genera Carica, Cylicomorpha, Jacaratia and Jarilla (Kumar and Srinivasan,1944). It is largely agreed that the papaya fruit originates on the Caribbean coast of Latin America, which extends from southern Mexico to Argentina and Chile (Manshardt,1992). Because to its therapeutic and nutritional benefits, the *C. papaya* became the initial fruit to be acknowledged as having been biologically engineered for human consumption. Also, it has a long and storied history of being prized for its remarkable medicinal and nutritional benefits (Yadav *et al*., 2017). The digesting enzyme papain, which is used in pharmaceuticals, the brewing industry, cosmetics, and other fields, is also said to be abundant in papaya. Along with the fruit, papaya leaves can help with syphilis, healing wounds, pyrexia, and diabetes. The papaya's uncooked fruit also has laxative properties (Sudhakar and Theivanai, 2014). The effects of an aqueous extract of *C. papaya* on several cancer cell lines and human lymphocyte proliferation were also examined, and the findings were encouraging (Otsuki *et al*., 2010). Only the pulp of papayas is often consumed, but the ripe fruit is also a diuretic, sedative, expectorant, and carminative, and possesses antidysentery, antipsoriasis, and antiringworm properties. The unripe fruit is used to treat ulcers, impotency,and menstrual abnormalities, and to improve women's natural menstrual flow (Maisarah *et al*., 2014). Fruits rich in nutrients including apples, papayas, citrus, berries, and pineapples are being considered as a way to strengthen resistance and prevent diseases. Along with nutritional

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supplements, having enough slumber and exercising frequently may strengthen the immune system and lessen the impact of viruses (Indhuleka *et al*., 2021).

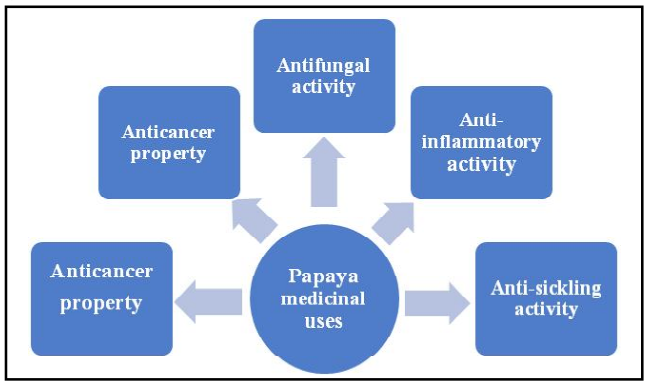


**Figure 1: Papaya medicinal uses.**

**Source:** Iwu (1993); Bhattacharjee (2001)

## 2. Medicinal uses

Instead of having a single "active" component, the interconnections between both the minerals and phytochemicals in the entire papaya fruit are what provide the fruit its total health and nutritional value (Iwu, 1993; Bhattacharjee, 2001). Due to its high antioxidant content, papaya may prevent atherosclerosis, strokes, cardiac arrest, and diabetic heart disease by lowering lipid oxidation. Several civilizations across the globe regularly recommend fresh fruit as a diuretic, antibacterial, carminative, and stomachic (Iwu, 1993; Bhattacharjee, 2001). According to clinical research, taking 6 g of a fermented papaya product for 14 weeks improved hemolytic anemia and protein buildup in the plasma of prediabetics (Chellammal, 2022). Several studies have shown how effective papaya leaf extracts are at increasing platelets (Tan *et al*., 2022).

### 2.1 Anticancer property

According to estimates, one in three individuals may get cancer at some stage in their lives, making it a public health concern that might possibly have an impact on almost everyone in the world (Nguyen, 2016). According to *in vitro* research, papayas contain anticancer qualities that can be used to treat different cancer cell lines. The papaya enzyme papain has anticancer properties. Fibrin, a protein found in cancer cells, is converted into amino acids by papain. It also includes lycopene, which is highly reactive to oxygen and free radicals in addition to papain. Leukemia, breast, lung, colon, pancreatic, and prostate are all cancers that are successfully treated with an isothiocyanate. These enzymes have the power to stop the development and spread of cancerous cells (Fauziya and Krishnamurthy, 2013).

### 2.2 Antibacterial activity

It has been demonstrated that the antibacterial activity of the ripe and unripe fruits is comparable against the bacteria *Bacillus cereus, Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Proteus, Pseudomonas aeruginosa vulgaris, Trichomonas vaginalis, Salmonella typhi, Shigella flexneri, Shigella sonnei and Salmonella typhi* (Emeruwa, 1982; Osato *et al*., 1993; Dawkins *et al*., 2003). *Staphylococcus, Pseudomonas aeruginosa, Protease vulgaris, Klebsiella pneumonia and Salmonella typhi* were just a few of the enteropathogens that bacteriostatic properties of the seeds of *C. papaya* have been identified. Testing revealed that gram-negative bacteria are more susceptible to the extract than gram-positive bacteria (Doughari *et al*., 2007; Emeruwa, 1982; Leite *et al*., 2005).

### 2.3 Antifungal activity

Combined, fluconazole and the latex of the *C. papaya* can stop the growth of *Candida albicans*. Part of the cell wall is degraded as a result of this synergistic impact. According to reports, the minimal protein concentration needed to provide a full inhibition is around 138 mg/ml of latex proteins, which are thought to be responsible for the antifungal impact (Giordani *et al*., 1991).

### 2.4 Anti-inflammatory activity

The literature has revealed that plant cysteine proteolytic enzymes have anti-inflammatory capabilities. The histological intensity of inflammatory bowel illness was evaluated in a clinical study for the therapy for chronic inflammation and related diseases. The benefits and safety of papain have been established (Salas *et al*., 2008). The leaf extract's inflammatory-reducing properties, as well as those of the reference drug, were relatively poor when utilising the carrageenan technique; the 100 mg/kg extract peaked 3 h (2.7%) after the carrageenan injection, while the 200 mg/kg extract peaked 3 h (6.7%). As the effect of the reference medicine, indomethacin, increased after 3 h (11.4%) of carrageenan administration, there was a time-dependent decline. According to the study's findings, indomethacin was somewhat more effective compared to the leaves' aqueous extract (Adeolu and Vivian, 2013).

**Table 1: Vitamins and minerals composition of fresh papaya fruit**

| Parameters | Range |
|---|---|
| Vitamin A | 23-55 (µg/100 g) |
| Vitamin E | 3.13-5.3 (mg/100 g) |
| Vitamin K | 2.3-2.9 (µg/100 g) |
| Vitamin C | 57-108 (mg/100 g) |
| Thiamine (vitamin $B_1$) | 0.04-0.05 (mg/100 g) |
| Riboflavin (vitamin $B_2$) | 0.05-0.07 (mg/100 g) |
| Niacin | 0.34-44 (mg/100 g) |
| Pyridoxine | 0.1-0.15 (mg/100 g) |
| Folate | 39-55 (µg/100 g) |
| Calcium | 17-24 (mg/100 g) |
| Phosphorous | 5-9 (mg/100 g) |
| Magnesium | 10-33 (mg/100 g) |
| Sodium | 3-24 (mg/100 g) |
| Potassium | 90-257 (mg/100 g) |
| Iron | 0.23-0.66 (mg/100 g) |
| Manganese | 0.01-0.03 (mg/100 g) |
| Zinc | 0.06-0.09 (mg/100 g) |
| Copper | 0.06-0.14 (mg/100 g) |
| Boron | 0.01-0.21 (mg/100 g) |
| Selenium | 1.2-1.5 (µg/100 g) |

**Source**: Adetuyi *et al.* (2008); Gouado *et al.* (2007); Nakamura *et al.* (2007); Nguyen and Schwartz (1999); Sirichakwal *et al.* (2005); Wall (2006); Wall *et al.* (2010); Veda *et al.* (2007).

### 2.5 Antisickling activity

A glutamic acid at position 6 of the protein haemoglobin, which is located inside red blood cells, is converted to a valine in the development of sickle cell disease (SCD). Recent investigations shown that papaya fruit extract has antisickling properties (Oduola *et al*., 2006). α-Thalassemia and thalassemia are two categories for sickle cell anaemia. Although, it is still present among the races in the Mediterranean regions, the black race is the one where this sickness is most prevalent (Buchanan *et al*., 2004).

## 3. Ripe and unripe papaya

### 3.1 Ripe

Natural fruit for breakfast, dessert, and fresh fruit all over the tropics. In terms of nutrition, papaya is a fantastic provider of calcium, vitamin A, and vitamin C (Nakasone and Paull, 1998). Humans regularly consume ripe *C. papaya* as a source of its necessary minerals (Ikram *et al*., 2015). However, eating typical, ripe *C. papaya* is unlikely to pose any significant risks to a pregnant woman. However, because it induces visible uterine contractions, consuming pregnant women should avoid eating semi-ripe or green papaya since it has a higher latex content (Krishna *et al*., 2008; Nayak *et al*., 2007). As papayas mature, the fruit's thick wall of flavorful flesh becomes fragrant, yellow-orange, salmon-colored, or other hues of red, and the fruit's skin turns light or dark yellow-orange (Morton,1987). On the other hand, ripe papaya has little to no latex, likely because the latex-producing cells have quit functioning or have broken down (Aravind *et al*., 2013).

### 3.2 Unripe

Unripe fruits are eaten in salads, used to make pickles, and served as vegetables in recipes (Hainida *et al*., 2015). In contrast to the three weeks required by ripe papaya, lesions treated with unripe fruit extract were seen to heal significantly more quickly. Studies on the benefits of fermented papaya extract on healing wounds were done orally (Collard and Roy, 2010). Not only in Asia, but also in Africa, Europe, and Jamaica, unripe fruit's latex is recommended for topical treatments for psoriasis, dermatitis, and chronic skin ulcers in addition to its culinary use (Hewitt *et al*., 2000; Nguyen *et al*., 2013). Additionally, unripe fruits have a lot of white latex, which is why they are green in colour, as opposed to ripe fruits, which have red skin and become delicious, aromatic, and juicy as they transform from yellow-orange to red during the ripening process (Silva *et al*., 2007).

**Table 2: Chemical composition of various parts of papaya plant**

| | |
|---|---|
| **Fruits** | Fibre, fat, carbohydrates, protein, minerals: iron, calcium, phosphorous, vitamin C, carotene, thiamine, niacin and riboflavin, citric and malic acids (green fruits), aminoacids, volatile compounds:benzylisothiocyanate, linalool,6-dimethyl-3,cis and trans 2, epoxy-7 octen-2-olAlkaloid, α;benzyl-β-D glucoside, carpaine, 2-phenylethyl-β-D-glucoside, 4-hydroxy-phenyl-2 ethyl-β-D-glucoside and four isomeric malonate benzyl-β-D-glucosides |
| **Juice** | N-butyric, n-octanoic and n-hexanoic acids, lipids |
| **Seed** | Crude protein, papaya oil, Fatty acids, crude fibre, benzylthiourea, hentraconatane, carpain, benzylisothiocyanate, glucotropacolin, benzylglucosinolate, β-siosterol, caricin and an enzyme myrosin |
| **Root** | Carposide and an enzyme myrosin |
| **Leaves** | Choline, alkaloids carpain, alkaloids carpain, vitamin C and E, pseudocarpain, dehydrocarpaine 1 and 2 |
| **Bark** | β-Sitosterol, fructose, galactose, glucose, sucrose and xylitol |
| **Latex** | Papain and chemopapain, chymopapains A, B and C, glutamine-cyclotransferase, proteolytic enzyme, peptidase A and B and lysozymes |

**Sources:** Bruneton (1999); Nadkarni (1954); Yogiraj *et al*. (2014).

## 4. Papain

The papaya fruit is used to obtain the plant enzyme papain since it is concentrated there. With 212 amino acids and a mass of 23 kDa, it is a globular protein. Cysteine protease papain has remarkable stability in a variety of conditions, including at high temperatures (Mamboya, 2012). Papain and hymopapain, are two significant physiologically active chemicals found in papaya that are frequently commonly used to treat digestive issues (Huet *et al*., 2006). When young papaya is peeled, a fluid called latex is released, which is then assembled and dried to produce papain. To get rid of undesirable products, purification is required, which includes solubilizing and extracting active papain. On how green the fruit is, papain activity depends. Superfamily is the grouping for this enzyme. All living things need papain for several crucial processes (Tsuge *et al*.,1999). Well-managed papaya production has been shown to produce 8.17 g of papain per fruit, according to published research (Amri and Mamboya, 2012).

### 4.1 Medicinal uses of papain

In addition to proteins, amide linkages, amino acid esters, short-chain peptides are all significantly proteolyzed by papain. Both food and medicine often use it (Uhlig, 1998). Papain functions as a debriding agent without causing any harm to healthy tissues because of the enzyme's specificity, which only affects tissues devoid of the 1antitripsine plasmatic antiprotease that inhibits proteolysis in healthy tissues (Flindt, 1979). As papain regulates and transforms leukocytes in response to an immunological response, it aids the immune system in the treatment of tumours. Reduced joint and prostate redness and swelling (Krishna *et al*., 2008). When combined with iron chelating and hydroxyl scavenging characteristics, papain is effective at preventing and removing infection and necrotic tissue, as well as in antioxidant and antibacterial activities. Increased hydroxyproline content in latex may also lessen the risk of oxidative tissue degeneration and potentially hasten the healing process after burns in (Gomes *et al*., 2005). The use of papain-based gel in dentin biochemical excavation techniques has also been suggested to be

useful (Piva *et al*., 2008). Studies show that the enzyme papain may be used to make skin-cleansing products because of its strong effect on proteins being broken down into smaller peptides and amino acids, which makes the process of removing dead skin cells from the skin easier (Anindia, 2018). Papain has also been utilized effectively to treat intestinal symbiotic conditions such gluten intolerance, hypochlorhydria (insufficient stomach acid), and allergies related to the leaky gut syndrome. Previous research have shown that papain significantly reduces pain and inflammation in response to acute allergic sinusitis symptoms like headache and toothache without causing any negative side effects (Mansfield *et al*., 1985). According to studies, papain can help dyspeptic individuals who are incapable of to digest gliadin since it prevents cell damage from free radicals, that is why gliadin is necessary for digestion. It decreases bacterial assaults and oxidative food spoiling, that is why it is employed in food preservation. As a result of the oxidation-causing feature of yogurt, it is also demonstrated that probiotic bacteria thrive there (Farahat and El-Batawy, 2013).

**Table 3: Medical usages of different parts of *C. papaya***

| Parts | Usage | References |
|---|---|---|
| **Leaves** | Treatment of dengue fever | Joseph *et al*. (2015); Kala (2012), Mulgund (2017); Palbag *et al*. (2016); Pangtey *et al*. (2016) |
| | Healing wounds and injuries | Umar *et al*. (2018) |
| | Fighting yellow fever and prolonged jaundice | |
| | Eliminating liver-related, respiratory, oedematous, and appetite-related disorders as well as spleen problems | Priyadarshi and Ram (2018) |
| | Addressing malaria | Kovendan *et al*. (2012); Okpe *et al*. (2016) |
| | Stop cancer cell proliferation. | Aravind *et al*. (2013); Yogiraj *et al*. (2014) |
| | Decreasing blood sugar | Juárez-Rojopa *et al*. (2014) |
| | Higher platelet count | Hainida *et al*. (2015); Subenthiran *et al*. (2013) |
| | Therapy for gonorrhoea, beriberi, utis, asthma, pathogens, intestinal worms, injuries, and jaundice | Aravind *et al*. (2013); Hainida *et al*. (2015); Krishna *et al*. (2008) |
| | Therapies for liver disorders | Mohammed *et al*. (2011) |
| | Ulcer medication | Odo and Odo (2017) |
| | Treating hypertension | Ahmad *et al*. (2011) |
| **Seeds** | Avoid poisonous and bacteriostatic effects inhibition of prostate cancer cells | Gunde and Amnerkar (2016); Peter *et al*. (2014); Yogiraj *et al*. (2014); Alotaibi *et al*. (2017) |
| | Dealing with a stomach ulcer Preventing jejunal contractions Employ as a contraceptive | Okewumi and Oyeyemi (2012) Adebiyi and Adaikan (2005); Krishna *et al*. (2008) Chinoy (1984); Hamman *et al*. (2011); Joshi and Chinoy (1996); Abdulazeez *et al*. (2009); Mustapha (2013); Nurcahyani *et al*. (2018); Praveena *et al*. (2017); Wiryawan *et al*. (2018) |
| **Roots** | Fight against malaria | Kfuri *et al*. (2016) |
| | Healing injuries | Tiwari *et al*. (2011) |
| **Stems** | Restoring injuries | Ajani and Ogunbiyi (2015); Ancheta and Acero (2016); Gurung and Skalko-Basnet (2009); Anyakudo and Erinfolami (2015); Nayak *et al*. (2007); Yusof (2005). |
| **Fruits** | Sickle cell anemia therapy Medication for sinus conditions, tongue, mouth, including throat ulcers, epidermolysis bullosa, and other skin disorders | Buchanan *et al*. (2004); Dawson (1998) |
| | Reduce rheumatic issues and the formation of elephantoids | Hainida *et al*. (2015), Lim (2012) |

## 5. Cultivation of papaya

Papaya ranked third among all tropical fruit crops produced nationally in 2020. Among them are important producing countries like Mexico, Indonesia, Brazil, the Dominican Republic, India, and Brazil. The fruit papaya, which is sold extensively on worldwide markets in both fresh and processed forms, is mostly imported into the USA, Germany, and Portugal (FAO, 2022).

**Table 4: Plantation and production area of papaya**

| Countries | Plantation area (Ha) | Production (Tones) |
|---|---|---|
| India | 142,000 | 6,011,000 |
| Dominican Republic | 12,395 | 1,271,303 |
| Brazil | 28,450 | 1,235,003 |
| Mexico | 18,983 | 1,117,437 |
| Indonesia | 11,404 | 1,016,388 |
| Nigeria | 92,338 | 877,120 |
| Democratic Republic of the Congo | 12,404 | 210,000 |
| Colombia | 7,309 | 194,332 |
| Peru | 12,359 | 186,580 |
| Thailand | 4234 | 164,360 |

**Source:** FAO (2022).

### 5.1 Papaya production

Cuttings, grafting, and *in vitro* culture are methods that may be used to grow papayas from seeds as well as vegetative tissues. It is also feasible to micro-propagate somatic tissues and embryos (Santana *et al*., 2019). Producers of papayas gather seeds from open-pollinated varieties of both female and hermaphrodite species in numerous countries, including India, Bangladesh, and Malawi, and tend the plants with little to no fertilisation, watering, insect, or disease control (Arya *et al*., 2018). Because of this, the yield, quality, and phenotype characteristics typically vary (Ferdous *et al*., 2016). Fruits are an important source of dietary fibre that may be gathered and eaten at home (Jones *et al*., 2014).

#### 5.1.1 Open field

Traditionally, large open fields have been used to grow papayas for commercial purposes. Selected cultivars, especially inbred and hybrid types, are grown from seedlings and have the colour, weight, size, shape, and texture of the fruit that the market wants. The plants are kept healthy by being fertilised, rouged to get rid of defective and vegetation-invading kinds, and treated with insecticides, fungicides, and other preventive treatments against illnesses and insects that reduce productivity. Rain water may be used to irrigate commercial papaya farms, or mechanical methods such as sprinklers, drip irrigation, furrow irrigation, or drip irrigation may also be used (Janthasri and Chaiayaboon, 2016). It has been demonstrated that integrated farm management, which is used in several countries, increases even when compared to conventional management practises, papaya fruit yields and financial profits for farmers (Kulkarni and Rathod, 2020). The papaya fruit is picked manually by skilled pickers, or in some more industrialized nations, by mechanized harvesters. Fruit can be prepared for the long-distance shipment before being wrapped (Burns *et al*., 2022). Fruit is more readily available on the market because to the use of refrigerated storage, which also enables farmers and exporters to enter untapped markets and seasons with considerably increased margins (Burns *et al*., 2022).

#### 5.1.2 Protected cultivation

The cultivation of papaya under protected conditions has become very popular, and a number of adaptations to the local climate and cultivars are used (Burns *et al*., 2022).When compared to open or protected field production, it requires a significant initial investment and ongoing operating costs, using greenhouses with total temperature control results in year-round, high-quality fruit production with maximum yields. In India, "Red Lady" papaya plants grown in greenhouses, had good results with fewer pests and diseases and better-quality fruit (Reddy and Gowda, 2011; Kaur and Kaur, 2017). Papaya can be grown all year round thanks to short-stem varieties and greenhouse conditions in Argentina and other temperate countries (Ceccoli *et al*., 2013). High yields have been achieved with the use of plastic tunnels that are completely sealed in subtropical areas of Europe, such as the Mediterranean and the Canary Islands. Similar strategies have also been used in Turkey, where a variety of crops are often grown in greenhouses and under protected agriculture (Gunes and Gubbuk, 2012). According to a study of papaya growth and harvesting phases throughout the year, a constant season contributes to more uniform fruit quality when grown in greenhouses (Gunes *et al*., 2022). Southeast Spain was used to cultivate five commercial papaya varieties during set intervals of 456 days low-density polyethylene is used to cover multiple-tunnel greenhouses. They were seen as a commercial success (Honore *et al*., 2019).

## 6. Conclusion

According to this review paper, *C. papaya* most significant tropical and subtropical fruits for health and nutrition is still papaya. The herb is medicinal throughout. The plant (*C. papaya*) is both nutritive and therapeutic due to the many vitamins and enzymes contained in it. The papaya has a diverse variety of medicinal qualities. Papaya is referred as "angel fruit." According to FAO, the worldwide consumption of papaya and its products is expanding every year because of its various applications. Papaya naturally contains papain. Researchers could discover more powerful uses by researching the mechanism and functions of papain. Farmers can earn a lot of money by growing papayas for the extraction of papain. Studies show that papaya may contribute significantly to the healthcare, pharmaceutical, food processing, herbal cosmetic, and economic development of many nations.

## Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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