Papaya - An Innovative Raw Material for Food and Pharmaceutical Processing Industry

Boshra V, Tajul AY*
Food Technology Division, School of Industrial Technology, Universiti Sains Malaysia, 11800, Pulau Pinang, Malaysia.

*Corresponding author: taris@usm.my

ABSTRACT: Papaya (*Carica papaya*), an herbaceous fruit crop belonging to the family Caricaceae, has garnered popularity among researchers due to its nutritional and pharmaceutical value. Mostly grown in tropical and subtropical regions it is a single stemmed plant which bears a crown of large palmate shaped leaves. Being polygamous, the plant is either male or female or hermaphroditic. An estimated 5.7 million metric tons of fruit were harvested in 1995 and this figure has almost doubled from 1980 indicating that papaya has important economical value. Literature has studies show that, papaya is not only known for its nutritional benefits but also considered to possess medicinal properties. It is low in calories and rich in natural vitamins and minerals, like vitamin C, vitamin A, thiamine, iron and fibre. Many biologically active phytochemical have been isolated from papaya and studied for application. Almost all parts of the plant (leaves, latex, seed, fruit, bark, peel, roots) have important biologically active substances that can be isolated for application predominantly in the pharmaceutical industry. Papain found in papaya latex has natural digestive properties beneficial to the human digestive system. Papaya has been much studied in pharmaceutical and has wide applications in the food industry. Nutritional value of fruits and medicinal properties of various part of papaya are discussed in this review.

Keywords: Nutritional value, *Carica papaya*, food industry, pharmaceutical, medical properties

Introduction

Papaya (*Carica papaya* L.) belongs to the family Caricaceae grown in Australia, Hawaii, Philippines, Sri Lanka, South Africa, India, Bangladesh, Malaysia and other countries in tropical America (Anuara, 2008). Ripe papaya is consumed fresh as a dessert fruit while green (unripe) papaya is added into fresh salads. Papain is an important bioactive substance recovered from the latex of the green fruit. Fairly easy to grow, the plant is commonly planted in home gardens using seeds. Papaya fruit can be harvested in approximately 9-12 months after sowing seeds and constantly bears fruit all year round. It is herbaceous and polygamous growing from a single stem bearing a crown of large palmate-shaped leaves. Flowers are produced at the axils of the leaf petiole (Manshardt *et al.,* 1992;Gonsalves, *et al*., 2006). Papaya plants grow as high as 7-8 m tall and a trunk of about 20 cm in diameter (Anibijiwon and Udeze, 2009). Since they are fast growing (they can be 12 feet tall in a year), commercial yearly production range from 125,000 to 300,000 lbs per hectare when the plants are grown at a density of 1500 to 2500 plants per hectare. Harvesting is done anywhere from 1 to 2 years, when the trees become too tall for proper reaping (Gonsalves, 1998).

Parts of the plant that have use include leaves, fruit, seed, latex, and root, **Table 1.** Some of these parts are known to be analgesic, amoebicidic, antibacterial, cardiotonic, cholagogue, digestive, emenagogue, febrifuge, hypotensive, laxative, pectoral, stomachic and vermifugic

(Anibijuwon and Udeze 2009). The papaya fruit is rich in vitamins A and C (Manshardt *et al*., 1992). Due to its fragile nature, postharvest study and shipping technologies are necessary in aiding marketability of this crop. In total production, papaya ranks above strawberries and below grapefruit (Manshardt *et al*., 1992). FAO estimated that about 5.7 million metric tons of papaya fruit were harvested in 1995, a figure that was twice as much when compared to the 1980 harvest (Gonsalves *et al.,*2006). Major producers of papaya are Brazil, India, and Mexico. In the United States, Hawaii is its primary papaya producer; approximately 66% of the total fresh production is exported, primarily to the US mainland and Japan (Gonsalves *et al.*, 2006).

Table 1: constituents of different parts of the papaya tree (Nadkarni and Nadkarni 1954; Rehman *et al*., 2003; Krishna *et al.,* 2008).

Part	Constituents
Fruits	Protein, fat, fiber, carbohydrates, mineral: calcium, phosphorous, iron, vitamin C, thiamine, riboflavin, niacin and carotene, amino acids , citric and malic acids (green fruit)
Juice	N-butyric acids, n-hexanoic and n-octanoic acids, lipids, Myristic, planets, stars , linolec, linolenic and *cis*-vaccenic and oleic acid
Seed	Fatty acids, crude protein, crude fiber, papaya oil, carpaine, benzylisothiocynate, benzylglucosinolate, glucotropacolin, bemzylthiourea, hentriacontane, β - sitostrol, caressing and enzyme myrosin
Root	Carposide and enzyme myrosin
Leaves	Alkalodis carpain, pseudocarpain and dehyrocarpaine and ,choline, carposide vitamin C and E
Bark	β-sitosterol, glucose, fructose, sucrose and xylitol
Latex	Proteolytic enzymes, papain and chemopapain, glutamine, cyclortransferase, chymopapains A, B and C, peptidase A and B and lysozymes.

Two potent biochemically active compounds of the papaya are chymopapain and papain, which are known to aid digestion. Papain is active over a wide pH range and is employed in treating arthritis, dyspepsia and other digestive disorders, and prepared in liquid form for reducing enlarged tonsils. Dietary papaya intake reduces human urine acidity. Chymopapain has been, of lately, by the Food and Drug Administration (FDA) for intradiscal injection in patients with documented herniated lumbar inter-vertebral discs. Papaya leaves are smoked for asthma relief and its leaves poultice have been administered onto nervous pains and elephantoid growths. Young leaves (also some other parts albeit lesser amounts) contain carpain an active bitter alkaloid which has a depressing action on heart.

The Javanese believe that eating papaya prevents rheumatism. Papaya flowers have been therapeutic on jaundice (Anibijuwon and Udeze, 2009). Effectiveness of these treatments however, is reliant on the quantity of the different compounds in the preparations. In Indonesia, papaya leaves are used as feed for animals after treatment which includes boiling leaves. Leaf extracts is also used as a profilaxis against malaria (Satrija *et al.,* 1994). In Nigeria, it is used for smooth upper respiratory tract ailment and tumour (uterus). In Ivory Coast, it is used for treating madness. In Trinidad, it is used for treating scorpion bites and hypertension. In cote d'Ivoire and Sama, it is used for toothache and tuberculosis in Mexico. In Honduras and Turkey, it is used for liver ailments, constipation and laxative. In the Philippines, India, Malagasy and Malaysia, it is used for treating arthritis and rheumatism. In Java, Panama, Sri Lanka and Turkey, it is used for treating abortifacient. In Honduras, Japan,

Panama and West Africa, it is used for the treatment of diarrhea and dysentery (Anibijuwon and Udeze 2009).

Nutritional value

Papaya is a common fruit, which is reasonably priced and has high nutritive value, especially when the fruits ripe, **Table 2**.

Table 2: Proximate analysis of ripe and unripe papaya fruits (Krishna *et al.,* 2008)

Chemical composition	Ripe papaya	Unripe papaya
Protein	0.6g	O. 7g
Fat	0.1g	0.2g
Crude fibre	0.8g	0.9g
Carbohydrate	7.2g	5.7g
Energy	32 Kcal	27 Kcal
Total carotene	2,740µm	0
Beta carotene	888µm	0
Minerals	0.5g	0.5g

The fruits are low in calories and rich in natural vitamins and minerals. Papaya places the highest among fruits for vitamin C, vitamin A, riboflavin, folate, calcium, thiamine, iron, niacin, potassium and fiber, **Table 3**. The comparative low calorie content (32 kcal /100 g of fruit) makes it a favorite fruit for obese people who are on a weight reducing regime. Also, papaya ranks the highest per serving among fruits for carotenoids, potassium, fiber, and ascorbic acid content (Liebman 1992; 2008). Papaya contains 108 mg ascorbic acid per 100g of fresh fruit, which is higher than oranges (67 mg/100 g). Papaya fruit is highly appreciated world-wide for its flavour, nutritional qualities, digestive properties and serotonin content (Fernandes *et al.*, 2006). Papaya is a good source of serotonin (0.99 mg/100 mg), which has been associated with enabling the gut to mediate reflex activity and also decreasing the risk of thrombosis (Santiago-Silva *et al.,* 2011)

Table 3: Nutritional value of fresh papaya (USDA 2011)

Nutritional value per 100 g (3.5 oz)	
Protein	0.61 g
Fat	0.14g
Carbohydrate	9.81 g
Sugar	5.90 g
Dietary fibre	1.8 g
Energy	163 kJ (39 kcal)
Vitamin A	328 µg (41%)
Thiamine(vit B_1)	0.04 mg (3%
Riboflavin (vit B_2)	0.05 mg (4%)
Niacin (vit B_3)	0.338 mg (2%)
Vitamin B_6	0.1 mg (8%)
Folate (vit B_9)	38 µg (10%)
Vitamin C	61.8 mg (74%)
Calcium	24 mg (2%)

Iron	0.10 mg (1%)
Sodium	3 mg (0%)
Magnesium	10 mg (3%)
Phosphorus	5 mg (1%)
Potassium	257 mg (5%)
Percentages are relative to US recommendations for adults	

Medicinal and pharmacological properties of papaya

Various pharmacological actions and medicinal uses of different parts of the papaya are reported with the crude extracts and different fractions from crude extracts of different parts of papaya. They have been used as traditional medicine for the treatment of various diseases.

Many biologically active phytochemical from different parts of papaya tree (latex, seed, leaf, root, stem, bark and fruit) have been isolated from papaya and studied for their potency, **Table 4**. Antifungal chitinase has been genetically cloned and characterized from papaya fruit. Classified a class IV chitinase based on amino acid sequence homology with other plant chitinase, the recombinant chitinase also exhibit antibacterial activity. Commercially available spray dried latex of papaya fruits has isolatable chamopapain which exhibit immunological properties. (Krishna, Paridhavi *et al.,* 2008). Papaya fruits are used as topical ulcer dressing in some hospitals including the Spanish town hospital, Kingston public hospital and university hospital in the West Indies, Jamara. The dressing preparation from papaya promotes desloughing, granulation and healing and also reduces odour in chronic skin ulcer. Some hospitals use it as burn dressing which is tolerable by children and is economical and widely available (Krishna, Paridhavi *et al.,* 2008)

Table 4: medical function in papaya plant.(Krishna *et al.*, 2008)

part	Medicinal uses
Latex	Anathematic, relieves dyspepsia, cures diarrhoea, pain of burn and topical use, bleeding haemorrhoids, stomachic , whooping cough
Ripe fruit	Stomachic, digestive, carminative diuretic, dysentery and chronic diarrhoea, expectorant, sedative and tonic ,relieves obesity, bleeding piles, wound of urinary tract, ringworm and skin disease psoriasis
Unripe fruit	Laxative ,diuretic, dried fruit reduces enlarged spleen and liver, use snakebit to remove poison, abortifaciant, anti- implantation activity and antibacterial activity
Seeds	Carminative , emmenagogue , vermifuge, abortifaciant, counter irritant, as paste in the treatment of ringworm and pasoriasis ,anti-fertility agent in malic
Seed juice	Bleeding piles and enlarged liver and pectoral properties
Root	Abortifacient, diuretic, checking irregular bleeding from the uterus, piles, anti-fungal activity
Leaves	Young leaves as vegetable , Jaundice(fine paste), urinary complaints &gonorrhoea (infusion) dressing wound fresh leave, antibacterial
flower	Jaundice, emmenagogue, febrifuge and pectoral properties
Steam bark	Jaundice, anti-haemolytic activity, STD , store teeth(inner bark) ,anti-fungal activity

Anti-malarial property

Aqueous and organic solvent extracts obtained from *Carica papaya* and two other species were tested on malaria strain *Plasmodium falciparum* FCK 2 *in vitro.* The results showed petroleum ether extract of the rind of raw *Carica papaya* fruit exhibited significant anti-malarial activity. The bioactive anti-malaria element has important commercial potential since the fruit grows in abundance in the tropics (Bhat and Surolia, 2001).

Antimicrobial property

Antimicrobial activity of papaya has also been documented from the fruit and the seed. Seed antimicrobial activity was documented against *Trichomonas Vaginalis trophozoties* although careful care was suggested when using the seed extract for urinogenital disorders due to its toxicity (Calzada *et al.*, 2007). Both the seed and pulp were reported to show bacteriostatic properties against several enteropathogen such as *Bacillus subtilis, Salmonella typhi, Staphylococous aureus, Proteus vulgaris, Pseudomonas aeruginosa and Klebsiella pneumoniae* determined via agar cup plate method. (Osato *et al.,* 1993). Aqueous extract of papaya was reported to exhibit not only antimicrobial activity but also encouraged therapeutic effect in healing wounds in diabetic rats. At any stage of fruit maturity, papaya seeds seem to possess bacteriostatic properties on gram positive and gram negative bacteria, a trait useful in treating chronic and skin ulcers. Crushed papaya seeds exhibited clinical potential on Conjugal R plasmid transfer from *Salmonella typhimurium* to *Escherichia coli in vitro* and *in vivo* of genotobiotic mice (Vieira *et al.*, 2001; Leite *et al.*, 2005).

Anthelmintic property

Antihelmintic activity of papaya seed has been predominantly attributed to carpaine (an alkaloid) and carpasemine (later identified as benzyl thiourea). Carpaine has an intensively bitter taste and a strong depressant action on health. It is present not only in papaya fruit and seed but also in its leaves. Pharmocological reports show that papaya seeds contain benzilsothiocyanate; an anthelmintic bio-substance in papaya seeds (Kermanshai *et al.*,2001; Osato, Santiago *et al.*, 1993) . Air dried papaya seeds with honey showed significant effect on human intestinal parasites with out significant side effect. Consumption of papaya seed is cheap, natural, harmless, readily available, mono-therapeutic, and prevent against intestinal parasitosis especially in tropical communities (Okeniyi *et al.*, 2007). However, according to Krishna *et al.* (2008) normal consumption of ripe papaya during pregnancy may not be dangerous, however unripe or semi-ripe papaya (which contains high amount of latex that produces marked uterine contraction) could be unsafe for consumption during pregnancy (Krishna *et al.,* 2008).

Papaya Enzymes

Papain, also known as vegetable pepsin, is present in high amounts in unripe papaya and plays an important role in digesting protein in food. Papain can aid dyspeptic patients who cannot digest wheat protein gliadin but can tolerate it when treated with papain. Also useful for tenderizing meat, papain can be used to prepare raw meat rendering it more tender and digestible (Krishna *et al.,* 2008). Fermented papaya fruit has promising nutraceutical value as an antioxidant for elderly patients at dire antioxidant deficiency levels at a dose of 99g/day orally (Marotta *et al.*, 2006). Dried papaya fruit skin is a source of dietary consumption for broiler chickens. Two primary enzymes from papaya are papain and chymopapain, both are known to be able to reduce the negative or toxic effects of drugs. Known as papaya proteinase

I, a relatively simple enzyme containing 212 amino acids residue chains, from the peptidase C1 family, papain (cysteine protease) is primarily found in the plant latex, fruit, leaves and roots. Extraction of papain from unripe papaya gives around 80–90% activity and showed degradation capability on Levetiracetam and Granisetron HCl drug constituents both of which are known to adversely effect cellular systems (Hitesh *et al.*, 2012)

Pectin

Pectin is extracted mainly from papaya fruits for as in gelling agent or in filling and sweets (May, 1990). Pectin works in a way that it increases viscosity in intestinal tracts, reducing cholesterol absorption from bile or food thus reducing overall blood cholesterol levels. Microorganisms further degrade pectin releasing short chain fatty acids that are also beneficial to health (prebiotic effect) in the large intestines and colon (Srivastava and Malviya, 2011).

Papaya and industry usage

Among the purified plant proteins used commercially, important plant-derived enzymes include papain and chymopapain (enzymes derived from papaya that are used medicinally and as meat tenderizers) (Tyler *et al.,*1981). Papain is also used as hair conditioner. Leaves of *Carica papaya* is used as soap substitute which are able to remove stains. Papain has milk clotting (rennet) and protein digesting properties. Among many other myriad of uses papain among others as; beer chill-haze removal; degumming natural silk; cleaning silks and wools before dying; removing hair from hides during tanning; meat- tenderizer added into chewing gums; extracting oil from tuna liver; added in dentifrices, shampoos and face-lifting preparations (James and McCaskill 1983); or used in the manufacture of rubber (Anibijuwon and Udeze 2009).

Conclusion

Each part of the papaya plant has seen usefulness in one way or another; from its fruit to its stem and leaves. The delicious papaya fruit has nutritional values that make it potent as a raw material in the food processing industry beyond mere raw consumption. Pharmaceutically important bioactive compounds from papaya have proven its importance through a myriad of therapeutic applications. The use of papaya extends beyond just as a raw material in the food and pharmaceutical industry; it has further potential applications and uses yet to be fully explored, derived and understood.

Reference

1. Anibijuwon, I. and A. Udeze.(2009). "Antimicrobial activity of Carica papaya (pawpaw leaf) on some pathogenic organisms of clinical origin from South-Western Nigeria." *Ethnobotanical Leaflets,* 2009(7): 4.

2. Anuara, N. S., Zaharia, S.S., Taiba, I.A. and M.T. Rahman .(2008). " Effect of green and ripe Carica papaya epicarp extracts on wound healing and during pregnancy. ." *Food and Chemical Toxicology*, 46(7): 5.

3. Bhat, G. P. and N. Surolia .(2001). "In vitro antimalarial activity of extracts of three plants used in the traditional medicine of India." *The American journal of tropical medicine and hygiene,* 65(4): 304-308.

4. Calzada, F., L. Yépez-Mulia, et al. (2007). "Effect of Mexican medicinal plant used to treat trichomoniasis on< i> Trichomonas vaginalis</i> trophozoites." *Journal of ethnopharmacology*,113(2): 248-251.

5. Fernandes, F. A. N., Rodrigues,S. et al. (2006). "Optimization of osmotic dehydration of papaya followed by air-drying." *Food Research International*,39(4): 492-498.

6. Gonsalves, D. (1998). "Control of papaya ringspot virus in papaya: a case study." *Annual Review of Phytopathology*, 36(1): 415-437.

7. Gonsalves, D., A. Baldé, et al. (2006). Method to control the ripening of papaya fruit and confer disease resistance to papaya plants, Google Patents.

8. Hitesh, P.,Bhoi Manojbhai, N., Borad Mayuri, A., Dalvadi Ashvinkumar, A., Dalsania Kiranben, V. (2012) "Extraction and Application of Ppapain Enzyme on Degradation of Drug". Pharmaceutikal Sciences,IJPBSI 2(3):113-115.

9. James, A. and D. McCaskill .(1983). "Handbook of Energy Crops." Unpublished, Purdue online.

10. Kermanshai, R., B. E. McCarry, et al. (2001). "Benzyl isothiocyanate is the chief or sole anthelmintic in papaya seed extracts." *Phytochemistry*, 57(3): 427-435.

11. Krishna, K., M. Paridhavi, et al. (2008). "Review on nutritional, medicinal and pharmacological properties of papaya (Carica papaya Linn.)." *Nat Prod Radian,* 7: 364-373.

12. Leite, A. A. M., R. M. D. Nardi, et al. (2005). "Carica papaya seed macerate as inhibitor of conjugative R plasmid transfer from Salmonella typhimurium to Escherichia coli in vitro and in the digestive tract of gnotobiotic mice." *The Journal of General and Applied Microbiology,* 51(1): 21-26.

13. Liebman, B. (1992). "a papaya a day nutrition action healthletter." Nutrition Action Healthletter .

14. Manshardt, R., F. Hammerschlag, et al. (1992). "Papaya." Biotechnology of perennial fruit crops.: 489-511.

15. Marotta, F., K. Pavasuthipaisit, et al. (2006). "Relationship between aging and susceptibility of erythrocytes to oxidative damage: in view of nutraceutical interventions." *Rejuvenation research,* 9(2): 227-230.

16. May, C. D. (1990). "Industrial pectins: sources, production and applications." Carbohydrate Polymers, 12(1): 79-99.

17. Nadkarni, K. M. and A. Nadkarni. (1954). Indian Materia Medica: With Ayurvedic, Unani-tibbi, Siddha, Allopathic, Homeopathic, Naturopathic & Home Remedies, Popular Book Depot.

18. Okeniyi, J. A. O., T. A. Ogunlesi, et al. (2007). "Effectiveness of dried Carica papaya seeds against human intestinal parasitosis: a pilot study." *Journal of medicinal food,* 10(1): 194-196.

19. Osato, J. A., L. A. Santiago, et al. (1993). "Antimicrobial and antioxidant activities of unripe papaya." *Life sciences,* 53(17): 1383-1389.

20. Rehman, R., M. Israr, et al. (2003). "In vitro regeneration of witloof chicory (Cichorium intybus L.) from leaf explants and accumulation of esculin." In Vitro Cellular & Developmental Biology-Plant 39(2): 142-146.

21. Santiago-Silva, P., R. A. Labanca, et al. (2011). "Functional potential of tropical fruits with respect to free bioactive amines." Food Research International 44(5): 1264-1268.

22. Satrija, F., P. Nansen, et al. (1994). "Effect of papaya latex against Ascaris in naturally infected pigs." Journal of Helminthology 68: 343-346.

23. Srivastava, P. and R. Malviya. (2011). "Sources of pectin, extraction and its applications in pharmaceutical industry− An overview." Indian Journal of Natural Products and Resources 2(1): 10-18.

24. Tyler, V., L. Brady, et al. (1981). "Pharmacognosy, 8th eds." Lea & Febiger, Philadelphia: 157-158.

25. "USDA National Nutrient Database for Standard Reference"(2008). from http://www.nal.usda.gov/fnic/foodcomp/search/.
26. USDA (2011). "National Nutrient Database for Standard Reference Release 25." Nutrient data for 09226, Papayas, raw. Retrieved 25.10.2012, 2012, from http://ndb.nal.usda.gov/ndb/foods/show/2321?fg=&man=&lfacet=&count=&max=100&sort=&qlookup=raw+papaya&offset=&format=Full&new=1.

27. Vieira, R. H. S. F., D. P. Rodrigues, et al. (2001). "Microbicidal effect of medicinal plant extracts (Psidium guajava Linn. and Carica papaya Linn.) upon bacteria isolated from fish muscle and known to induce diarrhea in children." Revista do Instituto de Medicina Tropical de São Paulo 43(3): 145-148.