INTRODUCTION

CHAPTER I

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Papaya, a native of tropical America, has now spread all over the tropical world. It is known by different names, such as papaw (England), mamao (Brazil), lechoso (Venezuela), and fruta bomba (Cuba). Papaya is grown mostly for fresh consumption or for production of proteolytic enzyme papain from the fruit latex. It is consumed in large amounts in most areas of the tropics and is thought to contribute greatly to vitamin A and C components of the diet. Latex production is labor intensive and concentrated mainly in the areas where the cost of labor is low. Brazil, Mexico, Thailand, Indonesia and India are the leading producers of papaya (Table 1). In addition, Hawaii, Taiwan, Puerto Rico, Peru, Bangladesh and Australia also cultivate this crop commercially. Hawaii and Latin American countries also export papayas to the United States.

Table 1 Major Producers of Papayas in the World

Country	Production (1000 MT)	Country	Production (1000 MT)
Brazil	1560	China	120
Mexico	650	Colombia	80
Thailand	536	Mozambique	45
Indonesia	354	Cuba	40
India	280	South Africa	39

Papaya is a native of Southern Mexico and Costa Rica. It is grown all over India and is available round the year in the country. However, Karnataka, Orissa, Assam, West Bengal and Gujarat provide ideal climatic conditions for its growth. At one time, India was a leading producer of papaya in the world. Today, it is not because, it's production in other countries has gone up dramatically while it rose at a much lower rate in India.

At present, India is producing about 13-14 lakh tones of papaya from an area of 61,000 hectares. Karnataka accounts for more than 50 per cent of India's total output of papaya.

Table 2 Area, output and yield of papaya in India

Year	Area (Lakh Ha.)	Output (Lakh m.t.)	Yield (kg/ha)
1990.91	0.37	4.51	12,360
1991-92	0.37	3.90	10,610
1992-93	0.38	4.24	11,300
1993-94	0.40	4.85	12,183
1994-95	0.41	4.90	11,823
1993-94*	0.56	12.66	22,650
1994-95*	0.61	13.73	22,510
1995-96*	0.61	13.29	21,830

(Source : Dir of Eco.& Stat, Ministry of Agriculture/*National Horticultural Board) 2003.

Table 3 State wise area, output and yield of papaya

(Area : Lakh Hectare, Output: Lakh M.T., Yield : Kg../Hectare)

State	1994-1995			1995-96		
	Area	Output	Yield	Area	Output	Yield
Andhra Pradesh	734	55,050	75.00	771	57,825	75.00
Arunachal Pradesh	560	1,016	1.80	571	1,940	3.40
Assam	7,832	1,15,372	14.73	7,273	1,09,610	15.07
Bihar	3,520	44,400	12.69	3,760	45,120	12.00
Gujarat	5,000	2,50,000	50.00	3,208	1,27,510	39.75
Karnataka	4,888	4,33,956	88.78	5,472	7,46,064	87.00
Kerala	13,026	57,578	4.42	12,785	55,311	4.33
Madhya Pradesh	1,433	35,000	24.42	1,505	37,000	24.58
Maharashtra	1,140	16,090	14.11	1,667	15,091	9.05
Manipur	1,638	9,010	5.50	1,654	9,100	5.50
Meghalaya	455	3,757	8.21	500	4,000	8.00
Mizoram	168	1,503	8.95	238	2,184	9.18
Orissa	13,241	1,56,000	11.78	39,980	1,81,200	12.96
Rajasthan	359	9,700	27.00	382	11,160	30.00
Uttar Pradesh (Hills)	104	1,046	10.46	110	1,230	11.18
Uttar Pradesh (Plains)	584	15,669	25.80	598	15.889	26.57
West Bengal	5,400	1,55,700	28.83	5,500	1,66,500	30.27
Andaman & Nicobar	224	1,825	8.15	225	1,826	8.12
Total	**60,982**	**13,73,001**	**22.51**	**60,921**	**13,29,68**	**31.83**

(Unit Conversion: 10 Lakh – 1 million; 10 Million = 1 Crore)

(Source: National Horticultural Board, 2003)

India exports small quantities of papaya mainly to Baharain, Kuwait, Qatar, Saudi Arabia, UAE, and etc. In 1996-97, India exported 607 tones of papaya valued at Rs. 82 lakhs against 317 tones valued at Rs. 30 lakhs in 1995-96.

Table 4 India's country-wise export of fresh papaya

(Quantity: M.T. ; Value : Rs. Lakhs)

Country	1995-96		1996-97		1997-98	
	Quantity	Value	Quantity	Value	Quantity	Value
Bahrain	30.10	2.75	26.73	3.29	55.40	7.29
Belgium	-	-	-	-	56.86	8.18
Kuwait	32.18	4.57	19.71	2.89	152.74	17.57
Malaysia	20.00	23.57	-	-	-	-
Qatar	10.70	0.84	37.76	5.25	56.38	6.62
Saudi Arabia	64.07	5.80	193.10	3.01	204.93	21.21
South Africa	-	-	-	-	34.00	9.81
UAE	140.61	9.17	301.57	35.69	226.94	25.95
UK	-	-	-	-	6.46	2.39
USA	-	-	15.48	2.89	1.60	0.16
Total*	316.85	29.69	606.63	82.39	826.65	104.02

* Including others

(Unit Conversion : 10 Lakh = 1 Million; 10 Million = 1 Crore)

(Source : DGCIR, 2003)

Papaya (*Carica Papaya* L.) is a small, unbranched, soft-wooded tree, almost a herb, with latex vessels in all apart. The plant is usually dioecious, with either male or female flowers. However, trees with hermaphrodite flowers also occur. Papaya fruit is a large, fleshy, hollow berry weighing 0.5-2.0 kg. It is usually cylindrical or nearly cylindrical on hermaphrodite trees and more round on female trees. The central cavity is surrounded by numerous small seeds which are arilated with slippery sercotesta. Seedless fruits also occur, which develop parthenocarpically. The genus Carica. to which papaya belongs, is a member of the small family Caricaceae which is comprised of four genera . The chromosome number of eight species of Carica is 2n = 18. The Caricaceae are predominantly dioecious, with male and female flowers born on separate plants, However, papaya has pistillate and staminate forms, and a third type, adromonoecious plants may be phenotypically ambivalent, producing staminate, perfect, and pistillate flowers under different seasonal or environmental condition.

Fruits play an important role in the balanced diet of human being by providing not only the energy food but also promise vital protective nutrients. Fruits enrich health by toning up energy and vigor.

The papaya is an important fruit of tropical and subtropical regions of country, deserving greater attention due to its high productivity and multipurpose uses. Papaya was introduced in India in early part of 16^{th} century from Philippine.

Papaya is a table fruit in most of the tropical countries. It is consumed as a part of breakfast dessert and as fruit salad. It is used in soft drinks, jams, ice-cream flavoring, and crystallized fruit and also sold as canned cubes and juice in some countries. In India it is mostly consumed as a table fruit.

The papaya tree yields fruits within a year of planting. It can be planted under diverse soil and climatic conditions. A large varieties are grown in India, some of which are dioecious (male and female types with only female types bearing the fruits) and others hermaphrodite (having the male and female features combined in the single tree and all yielding fruits).

In dioecious plants, the male species do not bear fruit and it is not possible to make out the gender by seeing the seeds alone. The gender is known only after the plant flowers. The tree is propagated from seeds. The seedlings are raised in plastic bags or seedbeds and transplanted when 45 to 60 days old and watered daily till well established.

In the case of dioecious varieties, the male types are identified and removed when they start flowering after 4-5 months of planting. For pollination, one male tree for every twenty female trees is sufficient. The male tree is well dispersed uniformly to be surrounded by female trees. The hermaphrodites do not require weeding out. Therefore they are preferred in kitchen gardens.

A papaya tree starts flowering and bearing fruits within a period of 6 months and lasts for 2-3 years. Thereafter, it is removed and replaced with new

plantings. A single tree can yield as many as few 100 fruits in its life cycle if properly maintained through watering and mannuring.

The Papaya fruit is a large fleshy hollow berry. Marketable fruits weigh from 0.5 kg to 2 kg and are 10-20 cm long. The thin green skin turns yellow at the bottom when maturity sets in. The flesh is yellow to orange, in some cultivars reddish and has a pleasant flavor. Around the cavity lie a thousand or more black seeds but seedless fruits occur too.

The ripe fruits of papaya are eaten throughout the tropics and subtropics. As papaya a fresh tropical fruit, it is important component of diets of people. Besides being liked for their exotic flavor and color, they are rich sources of vitamin A, B1, B2 and C, minerals, carbohydrates and carotenoids and hence important element of human nutrition (Jayraman, 1988).

Composition of fresh papaya fruit is water (85-90 %), sugar (10-13 %), protein (0.6 %), vit. A (1750 IU), vit. B1 (0.04 mg), vit. B2 (0.4 mg), vit. C (56 mg) food energy (165 KJ) (Mitra et al. 1994).

Twelve papaya varieties were examined for their physical characters like size, pulp, colour, texture and density, fruit and seed cavity dimensions and chemical composition viz. T.S.S., acidity, dry matter, alcohol insoluble solids, starch, sucrose, glucose, fructose, minerals and vitamins. Wide variation in these constituents was observed. Varieties with desirable physical characters and high nutritional value are suggested as promising in terms of quality and their scope of utilization. (Pal et al., 1980) four papaya varieties were also

examined of their chemical composition. The absence of adequate modern facilities for handling, transportation and storage of papaya and lack of technical training and infrastructure for their processing and preservation causes loss of around 30 percent in production. In some cases it exceeds of 50 percent (Jayraman, 1988).

The ripe fresh of papaya are eaten throughout the tropics; unripe fruits are commonly used as vegetables for cooking. Papaya is very wholesome fruit, and Aykroyd (1951) ranked it second only to mango as a source of carotene. It is relished for the attractive pulp color, flavor, succulence, and characteristic aroma. The typical composition of papaya is presented in Table 5.

Table 5 Composition of Fresh Fruit of Papaya

Constituent	Content
Moisture (%)	89.6
Proteins (%)	0.5
Fat (%)	0.1
Carbohydrates (%)	9.5
Calcium (mg/100 g)	10.0
Phosphorus (mg/100 g)	10.0
Vitamin A (U/100 g)	2020
Vitamin C (mg/100 g)	40
Nicotinic acid (mg/100 g)	0.2
Riboflavin (mg/100 g)	0.25

The Papaya fruit is a fairly rich source of vitamin C, pro-vitamin A and minerals. Papaya fruit is processed both in the raw as well as ripe stage to produce commercially important products.

Papaya contains many enzymes which have important roles in quality and stability of processed papaya products. These enzymes include papain, invertase, polygalactu- ronase, myrosinase, and acid phosphatase. Ripe papaya fruit contains about 50-60 mg/100 g of fresh fruit as ascorbic acid. The carotene content in ripe papaya is reported to range from 2 to 2.5 mg.

Papaya is an unusually interesting plant producing fruit of many uses. The ripe fresh fruits of papaya are eaten throughout tropics and subtropics. They are used in preparation of canned nectar, jam, jelly, soft drinks, ice-cream, crystallized fruits and in syrup. The seeds are used for their medicinal value. Unripe fruits are commonly used as vegetable for cooking. Extraction of papain from papaya fruits has medicinal value. Papain, from the dried latex of immature fruits is proteolytic enzyme similar in action to Pepsin and is used as meat tenderizing preparation.

Careful post-harvest handling of fruit is essential to minimize losses, mishandling of fruits during harvesting treatments and packaging results in bruised fruits. Bruised fruits develop abnormal discoloration which begins to manifest as fruit ripens. Such fruits are unattractive and prone to the attack of post-harvest diseases, Wills (1995) reported that, post-harvest handling techniques are extensively potential for extending market life by delaying

ripening and avoiding undesirable physiological, biochemical and physical changes.

Papaya fruits are highly susceptible for decay rapid spoilage after harvesting. As papaya is a perishable commodity a commonly encountered physiological disorder in papaya fruit is chilling injury. The decline in quality due to chilling injury may be significant enough to cause complete rejection of the produce by consumer. Injuries such as inability to ripen normally, lack of colour development in flesh, persistence of green colour in skin, abnormal loss of firmness, accumulation of water in tissues and increased susceptibility of fruit to fungal attack may be encountered.

As papaya being a perishable commodity and growing urgent need for its storage and processing to make them available to regions away from places of abundant production and during lean season with preserving its quality parameters. Extended storage life of papaya can be obtained by storing at low temperature or by using retardant. Papaya fruits at colour turning stage can be stored at 7°C and will have normal ripening. Papaya should be stored at temperature of 55°F if they are mature green to ¼ ripe in colour, stored at 50°F if they are partially ripe (1/4 to 1/2 ripe in colour) and should be stored at 45° F when they are more than ripe in colour. The humidity required for storage of papaya fruit should be more than 80 percent and there should be no mist.

Ambient temperature (28-32°C) is found to be practically unsuitable for storage of fruits. The fruit exhibit chilling injury at refrigerated storage temperature. (Broughton et al 1977)

Post-harvest treatment i.e. wax emulsion coating (6 percent) to fruits increased the shelf life and sensory properties as the liquid wax covers the pores of peel and forms a coating to the fruit peel and helps in reducing the moisture loss from the peel which results extending shelf life of papaya as the used wax is edible so it is not harmful to human being.

Wrapping film is made up from low density polyethylene co-polymer film which is having property to stick on fruit intactly and this film prevents moisture loss from fruit and improves it's quality and shelf- life. In case of both wax emulsion and wrapping film during post harvest treatments, the fruit slow down it's respiration rate during storage due to unavailability of atmospheric oxygen but continue it's ripening with slow rate with presence of ethylene produced by fruit itself.

The fruits can be stored for short periods in perforated polyethylene films, Newspapers, box liners and by using wax etc. Storage performance of these fruits has improved by wrapping in polyethylene bags which has added advantage of reducing water loss from the fruit thereby reducing weight loss and preventing skin wrinkling. The storage life of papaya fruit can also extended by wrapping in intact film and newspaper. Intact film wrap showed superior effect than other treatment. The minimum loss of moisture content of

fruit in case of intact film wrapping may be due to reduction in evaporative loss due to nature and characteristics of packaging material i.e. low water vapor transpiration rate. Use of paper wrap was exhibited good effect regarding extension of storage life of fruit.

In order to ensure better economical returns to growers and to reduce post-harvest losses it is essential to develop suitable farm level appropriate and operational feasible technology for storage of papaya.

The shelf life of fruit can be extended by storage at optimum refrigerated temperature and humidity, however certain fruits exhibits damage when stored at a temperature lower than optimum. These fruits develop a disorder known as chilling injury. Storage and ripening temperature is approximately 20 degree centigrade for papaya. The wrapping in polyethylene bags reduces the respiration rate and consequently the speed of ripening, making the decrease in oxygen subsequently increasing carbon dioxide. (Thomson and Lee, 1971)

Wrapping in polyethylene has the added advantage reducing the water loss from the fruit, thereby reducing weight loss and preventing skin wrinkling. The absence of adequate modern facilities for handling, transportation and storage of papaya and lack of technical training and infrastructure for their processing and preservation causes loss around 30% in production in some cases it exceeds 50 % (Jayraman, 1988).

As papaya being perishable commodity, there is urgent need for its storage and processing so that it can be made available in off season to the

consumers also if the fruits for export there are problems of pre mature ripening, chilling injury and fungal wastage. Wholesale traders in importing nations prefer to receive fruit in a hard green condition so that they can be ripened and distributed as needed (Nazeeb and Broughton, 1978). Papaya may be converted into main products like papaya leather, Jam, Jelly, Toffee etc.

Now a days farmers are inclined to grow papaya instead of any other irrigated crop because of high yield and good monitory return. However due to glut in market some times they have to sale it out at throw away rates, and are forced to face financial loss. The general trend of farmers is to sale raw fruit instead of processed product. Due to lack of storage facilities and processing technique around 30 % production is lost therefore it is need of time to develop necessary processing technique and storage facilities. Considering above points study was undertaken at Department of Agricultural Processing Engineering, College of Agricultural Engineering, Marathwada Agricultural University, Parbhani to study following objectives.

Objective

1. To standardize the maturity level of papaya.
2. To study the physico- chemical properties of papaya.
3. To study the effect of Post harvest treatments on shelf life of papaya.
4. To study the effect of physico-chemical properties on processing of papaya.