REVIEW OF LITERATURE
CHAPTER II

REVIEW OF LITERATURE

Many scientists who have worked on papaya fruits are reviewed below under suitable headings.

2.1 Physical properties

Akamine and Goa (1971) reported that papaya fruits are not harvested until the skin colour shows some yellowing. Matured papaya harvested when they are still hard and green but turning yellow. Less mature fruits ripen poorly with lower T.S.S.

Pantastico (1973) reported that as soon as the trace of yellow appears on the apex or between ridges the fruits should remove from trees. Fruits harvested at this stage ripen within 4-5 days.

Pal et al. (1980) studied the different physical properties and concluded that the avg. fruit weight ranges from 0.48 to 1.92 kg. The pulp content ranges from 73.01 % to 88.70 %. The fruit density varies from 0.90 to 1.12. Length, breadth of fruit and seed cavity (cm) ranged from 8.8 to 28.6, 6.7 to 15.9 and 6.5 to 23.9 respectively. Desirable characters for processing of papaya are large in size, fewer or no fidges on surface, small seed cavity and thick and firm flesh.

Yusof and Salleh (1992) revealed the physiochemical responses of papaya to waxing. Papaya cv. Exotica fruit were classified into 6 stages at
maturity and coated either fresh (0 sucroce ester preparation at 0.65, 1.0 or 1.4 per cent) or a polyethylene wax emulsion (1:2, 1:4 or 1:6 wax : total vol. of water). Fruits were stored at 10°C temperature and changes in their physiochemical parameters recorded. Moisture loss and color changes were delayed by the coating particularly at the mature green (M2), green (G), quarter ripe stage but there were no significant differences between the two types of coating, although super fresh coated fruits were glossier in the appearance. The brix value and titratable acidity increased with storage and were higher in the super fresh treated fruits.

2.2 Physico-chemical properties

Munsell (1950) reported for two samples of Guatemalan fruits 0.025 and 0.030 mg of thiamin. 0.029 and 0.38 mg of riboflavin and 0.238 and 0.399 mg of niacin per 100 g of fruit.

Chan et al. (1971) observed that papaya contains mainly citric and malic acid and smaller quantities of ascorbic acid and a-ketoglutaric acid.

Awada and Suchisa (1973) observed that, the most abundant mineral in papaya is potassium, which is found combined with organic acids. The elemental composition of papaya flesh from Hawaii, was observed as 0.12 % N, 0.01 % P, 0.21 % K, 0.03 % Ca, and 0.02 % Mg.

Flath and Florrey (1977) identified 106 volatile compounds in papaya. Linalool, a major component has odor characteristics very close to fresh
papaya. Another major component benzyl isothiocyanate, has a pungent off-
flavor compounds in papaya puree were identified as butynic, hexanoic, and 
octanoic acids and their corresponding methyl esters.

Pal et al. (1980) examined 12 papaya varieties for their chemical 
composition as T.S.S., dry matter, sugars, vitamins, etc. They observed the 
wide variations in these constituents when 1/3 of skins colour turned yellow. 
The fruits were harvested and kept at room temperature for ripening which took 
normally 3 to 5 days to reach ripe eating stage.

Maclead and Pieris (1983) reported the presence of an additional 18 
compounds , of which methyl butanoate was found to be responsible for the 
fresh papaya flavor, was found to be formed by enzymatic activity during cell 
disruption.

Jagtiani et al. (1988) observed that papaya contains no amount of acid. 
The pH of papaya ranges from 5.5 to 5.9. The total titratable acidity calculated 
as citric acid was 0.09 %.

Selvaraj and Pal (1992) studied the changes in the four cultivars of the 
papaya during growth and development and observed that ripening is 
characterized by the increase in sucrose and increase in vitamin A and trend of 
changes in most of the chemical constituents during growth and development.

Mitra et al. (1994) reported that the fruits of papaya cv. Washington 
showed double sigmaoid growth curve. The period from flowering to skin
colour turning stage required 145-150 day and 160-165 day to reach eating ripe stage. Fruit weight, pulp weight, peel and seed increased throughout the period of fruit development and there after decreased until ripening. The total soluble solids and the total and reducing sugar content were low at early stages of fruit development and therefore increased sharply during ripening. The sugar acid ratio of fruit also increased up to 140 days of the fruit growth at a slower rate, which thereafter increased sharply. The concentration of titratable acidity declined with the advancement of maturity.

Ghanta (1994) noted that the fruit of papaya cv. Ranchi showed a double sigmoid type of growth curve, skin colour turning stage was attained at 130-135 days and the fruits took 155-160 days to gain eating ripe stage. The fruit weight, weight of pulp, peel and seeds and the thickness of pulp increased throughout the period of fruit development. The pulp peel ratio of fruit increased upto 140 days of growth and thereafter decreased until ripening. The dry matter content of fruit remained relatively stable at early stages of fruit growth and increased with attainments of color turning stage. Total soluble solids, total sugar, reducing sugar contents and sugar acid ratio of fruit were low during early stage of fruit development and thereafter increased sharply until ripening. The concentration of titratable acidity declined at the fruit maturity while the ascorbic acid content in fruit was almost same in ripe fruit and 10-30 days old fruit. The dry matter content, TSS and total sugar contents of fruit were positively correlated with fruit weight while titratable acidity was negatively correlated with it. Titratable acidity declined with increasing fruit
maturity. Ascorbic acid content declined from 33.30 mg/100 g 10 days after anthesis to 10.64 mg/100 g 60 days after anthesis then gradually increased to 49.92/100 g 160 days after anthesis.

Firmin (1997) reported physical and chemical changes during maturation of the local and Solo variety of papaya. No change was observed in total acidity, though there was a slight increase in the pH of both types. Starch content decreased while total sugar, reducing sugar and ascorbic acid increased. A sensory panel preferred Solo, confirming that it is suitable for the local and international markets.

2.3 Maturity standards

Selvaraj et al. (1982) harvested (Coorg Honey Dew, Pink Flesh Sweet, Sunrise and Washington) four varieties of papaya at various development stages and analysed for sugar organic acid, amino acid, vitamins and minerals and found that the dry matter content increased from 7 % at 15 days after flowering to 13 % at harvest. During this time there was a steady decrease in alcohol insoluble solids, starch and several minerals and an increase in total sugars. The concentration of total nonvolatile acidity, citric acid and malic acids decreased to a minimum at the ripe stage. Seventeen amino acids were identified in all stages, the concentration of individual amino acids changing from flowering to ripening. Ripe samples and 15 days old samples have almost the same level of vitamin C. The colour break stage was characterized by increase in vitamin A and proteins. Ripe Washington fruits had the highest
vitamin A and C contents, potassium (K) and Ca contents were high at first and no clear trend was observed in the later stages of development. The contents showed little changes during development.

Selvaraj et al. (1982) analyzed the five varieties of papaya fruits shown that all five varieties took 145 to 165 days to attain ripe stage from the date of flowering and fruits take 10 days more if they are allowed to ripen on the plant itself.

Birth et al. (1984), used body transmittance spectroscopy and analytical measurement of chlorophyll, cartooned and soluble solid concentration to develop a non-destruction technique for estimating maturity of papayas. Optical measurements were taken between 500-900 mm with a scanning monochromatore. Immature and mature fruits which were indistinguishable by visual examination could be separated by body transmittance spectroscopy into non ripening and ripening groups.

Forbus et al. (1987), harvested 28 papaya in Hawaii at 5 different stages of maturity were examined for difference in delayed light emission (DLE) as well as for colour and for chlorophyll and β-carotene content. The DLE intensity was found to correlate well with physico-chemical properties that related to maturity of the papayas. The result indicates that DLE measurement can be used as a rapid method for determining papayas that are half or more ripe.
Brown (1987) reported that papaw fruit derived from an experimental breeding program, were harvested from two locations at 8 maturities ranging from small dark green fruit to fully colored tree-ripened fruit. Dark green fruit developed yellow skin color during ripening of the same rate as pale green breaker fruit but they did not have the same extent of skin-color development at eating ripe as the more mature fruit. Overall unripe fruit which had reached or closely approached full maturity on the tree, had better eating quality when ripened than immature fruit. Therefore papaw fruit should not be harvested before reaching full maturity (pale green to tinge of color). Low correlation coefficients were found for all maturities (even mature fruit).

Shanmugavelu et al. (1987) reported that CO2 cultivar of papaya took 137 days to reach maturity from the date of anthesis. They further reported that usually papaya fruit is harvested when yellowing becomes evident on 10 to 15% of its surface.

Simic (1998) reported that sweet cherry (Prunus avium) cultivars Francoska and Papavka were harvested 9 times at 3 day intervals between 27 May and 4 July 1994 in an experimental orchard in the Primorska region of Slovenia. The influence of harvest time on fruit weight, flesh firmness, soluble solids, total acids, skin colour and glucose, fructose, sucrose and organic acid contents was investigated. Fruit weight, total soluble solid content and contents of individual sugar increased during fruit maturation, but decreased slightly during storage. Flesh firmness and decreased during fruit maturation while
titratable acidity increased initially before declining. The greatest colour changes occurred between 9 to 13 June, when the colour measurements can provide a simple non-destructive method for determination of the optional harvest date for cherries.

2.4 Chemical composition

Heid and Curl (1948) reported that, sugars are important constituents of papaya fruit. They act as flavorants as well as sweetener. The sugar content in papaya fruit varies considerably, depending on cultivar and cultural conditions. The sugar content in papaya grown in Florida has been reported to range from 5.65 to 7.1 %.

Lal G. (1961) observed that Indian cultivars were reported to have 10.0-10.2 % soluble solids.

Brown (1946) proposed that papaya fruit in general are good source of sugar and vitamin and fair source of iron but it is poor in calcium. The sugar content increases with the age of fruits.

Chan (1971) reported that the acidity of ripe fruit changes from 0.062 to 0.116 percent. The Solo papaya had shown 0.42, 0.46 and 0.525 mg of betaglutaric acid, citric acid and malic acids respectively. The fruit contains about 85 percent water, 10-13 percent sugar, 0.6 percent protein, much vitamin A and fair amounts of vitamin B1, B2, and C. It contains practically no starch. He also reported that TSS percent, acidity and sugar content in different
cultivars of papaya varies from 11.15 - 12.85 percent, 0.064 to 0.096 percent, 1.38 to 9.92 percent respectively. According to Story (1992), the Ca content (% mg) of Thailand, Washington, Coorg Honey Dew were 8.41, 12.02 and 14.70 respectively.

Chitrraiselvan and Shannugavelu (1977) revealed that ripening phase in CO-2 papaya fruit was characterized by the increase in level of total sugars. Fractionation of sugars revealed that sucrose, fructose and glucose were present in papaya fruit.

Selvaraj et al. (1982) reported increasing pulp/peel ratio with increased age of fruit. This ratio decreased in ripe stage in cultivars like Croog Honey dew, Sunrise, Thailand stand varied between 8.5 and 9.5. The concentration of total, non-volatile acidity citric, malic acids decreased to a minimum at ripe stage. Glucose is a predominant sugar at all stages of development except at full ripe stage where fructose is predominant.

Selvaraj et al. (1982) studied the chemical composition of the four cultivars of the papaya and found that ripening of papaya fruit is characterized by and increase in sucrose rather than glucose and fructose and increase vitamin A, Vitamin C, dry matter and falling acidity levels. They differ somewhat in number of days taken to reach the eating ripe stage from the day of enthesis.

Selvaraj et al. (1982) revealed that concentration of total and non volatiles acids decreased during fruit development reaching minimum at ripe
stage. Citric acid, calic acid and tartaric acid have been further identified in papaya.

Malathi et al. (1986) studied the nutritive value of fully mature unripe papaya and ripe papaya. Analysis for energy, fat, protein, vitamin A, C, calcium, phosphorous, reducing sugars, total sugars was done. The nutrients are reported as per 100 gm of edible portion. Energy (k. cal) for unripe and ripe papaya is 31.3 and 26.3 respectively. Fat content does not show significant changes total sugars and reducing sugars are higher in ripe papaya, it amounts 9.70 and 8.28 respectively.

Pal and Selvaraj (1987) studied biochemistry of 5 papaya varieties at 5 developmental stage viz. 110 days (i.e. green peel and white pulp) 120 days after antithesis (pulp turning yellow), 145 days, 150 days and reported that ripening was characterized by an increase in activities of many enzymes.

Pal et al. (1990) examined the 12 papaya varieties for their chemical composition as T.S.S., dry matter, sugars, vitamins, etc. He observed the wide variations in these constituents when 1/3 of the skin colour turned yellow, the fruits were harvested and kept at room temperature for ripening which took normally 3-5 days to reach ripe eating stage. He also studied the physical characteristics of papaya like weight of fruit, weight of pulp, weight of peel, weight of seeds, west index, shape index, etc.
<table>
<thead>
<tr>
<th></th>
<th>Ripe papaya</th>
<th>Unripe papaya</th>
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<tr>
<td>Vitamin C</td>
<td>56.6 mg</td>
<td>11.4 mg</td>
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<tr>
<td>Calcium</td>
<td>17.1 mg</td>
<td>27.8 mg</td>
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<tr>
<td>Phosphorous</td>
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<td>39.2 mg</td>
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<tr>
<td>Energy</td>
<td>23.6 K. cal</td>
<td>31.3 K. cal.</td>
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The pro-vitamin A carotene is highest in ripe papaya is 665.8 mg.

2.5 Storage temperature

Thompson and Lee (1971) studied the various factors affecting the storage behavior of papaya fruits. Fruits of papaya cv. Solo 63/2 were damaged when stored at or below 45°F (7°C), wrapping the fruit in polyethylene bags reduced weight loss during storage but increased the development of saprophytic fungi. Perforated polyethylene bags similarly reduced weight loss but did not increase fungal development. Careful harvesting significantly reduced fungal infecting, thus giving the fruits better flavor and longer storage life. The optimum stage of maturity for satisfactory storage and subsequent ripening was when the yellow color was just beginning to develop in the funicles. Fruit from hermaphrodite trees were superior in flavor to those from female trees but behaved similarly during storage.

Abou Aziz et al. (1975) studied the effect of different temperature on the storage of papaya fruits and respirational activity during storage. Mature papaya fruits were stored at 10 and 15°C to study the effect of these temperature on the storage and respirational activity during storage. Per cent weight loss of fruit increased with prolonged storage period and the increase
was greater in fruits stored at 15°C than 10°C. The per cent decay was greater at the higher temp. than at the lower temp. Total soluble solids showed a slight and gradual increase upto the end of storage period. The higher storage temperature accelerated colour development, in the peel and total carotenoids in both the peel and the pulp as storage period was increased and the rate of increase was greater at the higher temperature. The respiration rate was relatively low at the beginning of ripening and tended to level off until the 11th and 12th day of storage, which were followed by a striking increases until it reached its maximum rate at the overripe storage.

Nazeeb and Broughton (1978) reported the storage conditions and ripening of papaya. The optimum storage and ripening temperature for the two cultivars was approximately 20°C. Both the cultivars ripened earlier after exogenous applications of C₂H₄ combined with the removal of CO₂. The storage life of the fruits could be extended by maintaining them in an atmosphere devoid of C₂H₄ but containing 5 per cent CO₂ and with a high relative humidity. Chilling injuries occurred at temperature below 15°C. When the papayas were stored for more than 7 days. The nutritional value of ripe fruits decreased rapidly with prolonged storage.

An and Pauli (1990) reported that, fruits of pawpaw cv. Sunset were harvested when there was a break in fruit colour or when 10 % of the fruit surface was yellow and were stored at 10° C for 14 days. They were then ripened for 5 or 10 days at temperatures of 17.5°, 20°, 22.5°, 25°, 27.5°, 30°, or
32.5°C and compared with fruits ripened at the same temperatures for similar periods but without prior cold storage. At 32.5°C, fruits failed to ripen normally. Between ripening temperatures of 22.5°C and 27.5°C, fruits softening, the development of a yellow skin colour and the development of flesh colour exhibited a quadratic response to the length of the ripening period. In fruits which were not subjected to prior cold storage, flesh colour did not change during the first 6 days at ripening temperatures and then increased rapidly. Ripening was faster in fruits which had been in cold storage than in those which had not. At ripening temperatures > 27.5°C, problems of weight loss and external abnormalities were more significant than at lower ripening temperatures. The optimum ripening temperature was 22.5-27.5°C with fruits taking 10-18 days to develop a full yellow colour from the colour break stage, irrespective of whether they were given cold storage or not. Exposure of immature fruits to approximately 100 ul ethylene for 14 or 48 h did not result in complete ripening. Ethylene reduced the coefficient of variation for skin colour, softening rate and flesh colour development, increased the rate of skin degreening and hastened the rate of carotenoid production and softening in the outer mesocarp but had little effect on the inner mesocarp tissue.

Wills (1995) reported results in pawpaw fruits held at 20, 25 or 30°C. Fruits at 20°C showed a respiratory climacteric after about 5 days, at which time peel colour was 20-50% yellow. The peak in ethylene production occurred about 1 day after the climacteric. The major physicochemical changes were increases in ascorbic acid and total carotene and a decrease in benzyl
isothiocyanate (BITC). Maximum sensory characteristics were attained 2 days after peel showed a full yellow.

Yahia and Kader (1997) reviewed the research on modified atmosphere (MA) and controlled atmosphere (CA) storage of papaya. No commercial use for MA or CA storage is reported at present. The optimum atmosphere composition is not yet fully defined but is approximately 2-5% O$_2$ and 5-8% CO$_2$. It is not yet known whether there are potential applications of CA or MA for pawpaws and further studies are needed to establish beneficial applications and adequate atmospheres.

Wills and Widjanarko (1997) reported that Australian papaya fruits (grown in Queensland) were held at 5-15°C for 7-21 days then at ambient temperature (20°C). No fruits ripened while at subambient temperatures but all showed a longer total time to ripen than fruits held continuously at 20°C, with the delay in ripening related to the time and extent of subambient temperature exposure. However, ripe fruits with increasing exposure to subambient temperature showed decreasing levels of yellow skin colour and increasing chilling injury symptoms. An increasing proportion of fruits failed to ripen due to the prior onset of rotting. Fruits stored continuously at 17°C showed delayed ripening over fruits held at 20°C and exhibited reduced development of yellow skin colour. The results have implications for the efficient marketing of pawpaws in southern Australia during the winter.
2.6 Pretreatments

Akamine and Avisumi (1953) reported that, the incidence of post-harvest storage delay on ethylene dibromics treated papayas was materially reduced in treating the fruit with hot water at temperature of 100°F to 120°F for 20 min. prior to fumigation. This treatment has some surface sterilization effect which reduces the incidence of external fungus growth on the button of the fruits. The rate of ripening, aroma, taste, and appearance of the fruit were not materially effected by excessive to the hot water. It is believed that, the hot water treatment may afford a practical solution to the problem of storage of ethylene dibromide treated fresh papayas.

Madhava Rao and Ramar Rao (1979), studied the post harvest changes in banana Cv. Robusta. Banana bunches harvested at ¾ and full maturity and the hands separated and dipped in aqueous solution of TBZ 500 PPM or wax emulsion containing TBZ 500 PPM in combination with different growth regulator were kept in open or in polyethylene bags at room temperature or at 15°C and 80-90 per cent relative humidity. The fruits not only remained from at the early ripe stage but had prolonged shelf life with green and unshrivelled peels having narrow pulp/peel weight ratio and perfect peeling condition till the end of shelf life. When stored in polyethylene bags at 15°C and 80-90 per cent loss in fruit weight during pre and post ripening stages was less when treated with 8-HQ and stored in polyethylene bags. Colour development and fruit ripening were delayed when the fruits were treated with wax emulsion and
stored in polyethylene bags. The shelf life and fruit quality were greater and the spoilage due to fungal infection and stored in polyethylene bags containing KmnO₄ and Ca (OH)₂ and the shelf life and quality were further enhanced. When stored at 15°C and 80-90 percent relative humidity.

Couey and Hayes (1986) studied the quarantine procedure for Hawaiian papaya using fruit selection and two stage hot-water immersion. The procedure involved selecting fruits less than one-quarter ripe and subjecting the fruit to a 30 or 40 min. immersion in water at 42°C followed immediately by a second immersion for 20 min. in water at 49°C.

Maharaj et al. (1986) reported that, post-harvest treatment of pawpaw fruits with GA₃ vitamin K, silver nitrate, kinetin or cobalt chloride extended the shelf-life appreciably without any adverse effect on palatability. The suppressed levels of succinate and malate dehydrogenase activity during the post-harvest ripening of the treated fruits indicated lower levels of mitochondrial respiratory activity and retardation of ripening.

Robert and Nancy (1989) studied the waxing and plastic wraps influenced water loss from papaya fruit during storage and ripening. The effect of waxes and plastic shrink wraps on weight loss from papaya fruit during ripening was determined. The major mode of weight loss was the skin, because of it’s larger surface area. The stomata did not appear to function in ripening fruit. The skin’s resistance to water movement increased at the start of ripening then declined with no apparent change in the weight of total water loss. Part of
the decline in resistance was associated with the disruption of the cuticle with latex, specially after the 50 per cent ripe stage. This results suggest that the major site of resistance to weight loss changed late in ripening fruit waxing reduced wt. Loss by 14 per cent to 40 percent. While plastic shrink wrap reduced loss by 90 percent. The loss of water was the major component of wt. loss. Some waxes and wrap delayed ripening by 1 to 2 days at ambient temps. After storage for upto two weeks at 10°C vocationally, off flavors occurred in waxed and wrapped fruit when the fruit cavity CO2 level exceed 7 per cent at full ripe stage.

Smith et al. (1989) reported that plastic shrink wrap reduced weight loss in papaya fruits by 90 per cent same wrap delayed ripening by 1-2 days at a ambient temperature.

Robert and Nancy (1989) studied on waxing and plastic wrap influence water loss from papaya during storage and ripening, they used fruits with 10% yellow skin which were harvested at the colour break stage.

Maharaj and Sanket (1990) reported that, pawpaw fruits (cv. Tainung No.1) were harvested at the colour break stage, washed, dipped in hot water (48°C for 20 min.), treated with benomyl at 52° for 2 min., air-dried and stored at 16°. Prior to storage, the fruits were either untreated, waxed, coated with Nutri-save film [a water-soluble polysaccharide] or individually wrapped in stretch-film. Two groups of fruits (waxed and untreated) were kept in controlled atmosphere conditions (1.5-2.0 % O2 and 5 % CO2, 16°C). Fruits
wrapped in stretch-film, and untreated fruits stored in a controlled atmosphere had the longest storage life (up to 29 days), Untreated fruits stored in air at 16° were unacceptable after approximately 17 days in storage.

Lazan et al. (1990) reported that, mature-green pawpaw fruits (cv. Backcross Solo) were seal-packaged by wrapping in low density polyethylene film. The fruits were ripened at ambient temperature (24-28°C). Seal-packaging retarded the development of peel colour and reduced the increase in titratable acidity during ripening. Fruit softening was also retarded; this was attributable partly to decreases in polygalacturonase (PG) activity and in polyuronide solubilization. The loss of insoluble polyuronides, however, was not affected by the treatment. Enzymes other than PG appeared to be involved in the apparently extensive modification of the cell wall pectin. Seal-packaging also retarded the development of water stress in the fruit tissues as well as modifying both the internal and external (in-package) atmospheres. A substantial reduction in internal O2 and a concomitant decrease in internal ethylene concentration appeared to be instrumental in delaying ripening of the sealed fruits.

Bal et al (1992) reported the effect of ethaphon on ripening and quality of papaya fruits Cv. CO-1 and CO-2 were picked when green to greenish yellow and immersed in a solution of ethaphon at 0,400,500, or 600 ppm for half hour after which they were wrapped in paper and kept at room temperature. Fruit colour changed to light yellow or golden yellow, indicating
ripeness; 4 days after treatment with ethaphon at 500 or 600 ppm. Fruit flavor was best and T.S.S., total sugar content were highest with ethaphon at 500 ppm, vitamin C was highest ethaphon concentration.

Yusof and Salleh (1992) revealed the physiochemical responses of papaya to waxing. Papaya cv. Exotica fruit were classified into 6 stages at maturity and coated either fresh (0 sucroce ester preparation at 0.65, 1.0 or 1.4 per cent) or a polyethylene wax emulsion (1:2, 1:4 or 1:6 wax: total vol. of water). Fruits were stored at 10°C temperature and changes in their physiochemical parameters recorded. Moisture loss and color changes were delayed by the coating Particularly at the mature green (M2), green (G), quarter ripe stage but there were no significant differences between the two types of coating, although super fresh coated fruits were glossier in the appearance. The brix value and titratable acidity increased with storage and were higher in the super fresh treated fruits.

Kodikara et al. (1995) observed that, storage diseases of papaya (Carica papaya) in Sri Lanka are due to fungal pathogens, with Colletotrichum gloeosporioides (Glomerella (ingulata), C. capsicum (anthracnose), Phomopsis Carica-papaya, Botryodiplodia theobromae and Cladosporium cladosporioides (stem-end not) dominating. A hot water double dip treatment (42°C for 30 min. followed within 3 min by 48°C for 20 min) was assessed for its ability to control disease. Changes, in pH, the total titratable acidity (TA), total and reducing sugars (TS and RS, respectively), and total soluble solids (TSS) in peel and
pulp tissues, were determined at 3 ripening stages 1, 3 and 5 days after treatment, corresponding to the 'colour break' (CBS), 'half fruit yellow' (HFY) and 'entire fruit yellow' (EFY) stages. Peroxidase is enzyme pattern (by PAGE) and electrolyte leakage (Using a conductivity meter) of the peel were determined. A total disease reduction of 55% was observed, with anthracnose, stem end rot, wet rot, cladosporium rot and other diseases being reduced by 32, 54, 55, 34 and 100 %, respectively, 6 days after treatment. Shelf life was increased by c. 3 days. With ripening, no change in TA was observed, although a significant (P=0.05) reduction in pH of pulp occurred; TS and RS in pulp and peel and TSS in the peel increased. Treatment did not change TA or TSS significantly, but the pH of treated pulp at CBS and treated peel at EFY were significantly higher. Ripening was slightly accelerated, but there was no significant weight loss. An increase in TS, which was significant only at CBS of pulp and HFY of peel and a slight increase in RS was seen due to treatment. Electrolyte leakage was significantly reduced; electrophoresis with ionically bound peroxidase extracts, indicated an extra band in treated peel. It is suggested that this may be evidence of peel strengthening and adaptation to stress. Hot water treatment appeared to be a simple, safe and effective method of replacing fungicides as it did not significantly alter the physical and biochemical attributes of the fruit tested in the edible portion of the fruit (i.e. pulp of EFY).
2.7 Processing

2.7.1 Papaya Jam

Rao and Yadav (1983) worked on mixed fruit jam. The swith pear and queen pineapple varieties were analysed.

Donchenko et al. (1984) studied the effect of pH on structure of jam and jelly. The pectin/sugar solution was prepared in a ratio of 1.5. At pH 3.2 the str. was 40 kg papaya and at pH 2.8 was 53.2 kg papaya. pH values in range 2.8 to 3.2 are considered optimum for maximum str. of jelly. He also reported that jams could be stored at 95 % relative humidity and 20° C for two months in boxes and paper cups. Storage in polythene reduced shelf life in 10 days.

Malathi et al. (1986) studied the processing of papaya products like papaya oil pickel, candy, jam, papaya-sheet, toffee, bar etc were prepared. The papaya pickel treated with cacl2 and citric acid kept good for three months. Papaya candy can be stored by 4 months when packed in polyethylene film of 200 gauge. Jam was acceptable with a shelf life of a month in sterilized bottles. Papaya toffee can be stored just upto 3 months when wrapped in butter paper and kept in plastic containers.

Ainn and Adesina (1991) presented chemical sensory and storage properties of jam produced from 2 tropical fruits.

Pauli and Chen (1997) observed that, the stage of pawpaw fruit ripening suitable for minimal processing and the effect of processing on physiology
were determined. Wounding during slicing and deseeding led to an increase in ethylene production and respiration, earlier skin degreening and flesh softening. Fruits at the 10-50% skin yellow ripening stage showed higher wound-induced ethylene production and respiration when sliced and deseeded than riper fruits. Fruits with 60-80% skin yellowing when halved and deseeded had higher initial ethylene production and respiration than other ripening stages. When halved and deseeded fruits were stored at c. 40°C, ethylene production and respiration declined rapidly within one day. Fruits with 55-80% skin yellowing and less than 50 N flesh firmness had more than 50% edible flesh and easily removed seeds. These fruits were suitable for minimal processing when combined with low storage temperature (c.40) to inhibit ethylene production and respiration.

2.7.2 Papaya leather

Nanjudaswamy et al. (1978) have introduced the new categories of the dehydrated products. He further prepared the leathers to apple and papaya in cross air flow dryer at a drying temperature of 70°C.

Harvey and Catherine (1978) have shown the effect of drying temperature (74°C, 84°C, and 94°C), storage time (1, 2, 3 months) storage temperature (18°C, 24°C and 38°C) and sulfur dioxide on quality of papaya lather and concluded that 84°C temperature and added SO₂ can just produce the papaya leather.
Mackenzie and Strachan (1980) have studied the possibilities of processing of mountain papaya on New Zealand and prepared papaya leather. Papaya pulp was mixed with sucrose (15 per cent) and KMS (0.07 per cent) and dried and on trays at 75°C in an tunnel drier to about 15 per cent moisture which shown to be attractive rich orange colour with strong pleasant flavour and good texture having eight month shelf life.

2.7.3 Papaya Jelly

Kumar (1952) reported that, fully mature but unripe fruit is peeled and the seeds are removed. The flesh is cut into 7.5 × 7.5 cm pieces which are pricked with a fork. These are then kept immersed in dilute water (15 g of lime per liter of water) for 3-4 h. The pieces are washed three or four times with fresh water and then boiled in sugar syrup of 40°C Brix. The process is repeated until the residual syrup strength reaches 70-75° Brix. The syrup is then drained off. The pieces are further cut to the desired size and shape so that the individual pieces of the finished product are crisp, juicy, and almost transparent. The product is also packed in sterilized wide-mouthed bottles or tin cans, which are then hermetically sealed.

Lal and Das (1956) reported that, fully developed but somewhat raw fruits are thoroughly cleaned, peeled, deseeded and cut into pieces. They are cooked in water to extract pectin. The extract is cooled immediately and allowed to settle for about 2 h. The clarified extract is then syphoned out or decanted and filtered through thick cloth. From the clarified extract, papaya
Jelly can be prepared by mixing the extract with sugar and then cooking until a satisfactory sheeting test or a temperature of 106 °C is obtained. The product is packed hot in sterilized dry glass jars, cooled, covered with a thin layer of wax and the lid is closed tight.

Norris (1980) reported that, raw papayas can be used for making salted pickles by brine curing and adding spiced vinegar in the traditional way. Papayas are peeled, sliced, and blanched in boiling water for 3 min. The blanched slices are sprinkled with common salt and allowed to dry to some extent. These slices are placed in a jar, covered with vinegar, and one teaspoon of dehusked mustard seed is added to every 500 g of the fruit slices. Then turmeric powder is added. The jar is closed air tight. The slices are cured in 2-3 weeks to give good pickles.

Levi et al. (1983) studied the blanching. They reported that there was slight caramalization of the sugar syrup, and the slight browning at 75-90 min. and dark brown syrup; and the slices in treatments longer than 90 minutes. There was significant loss of the typical papaya flavor with treatments longer than 30 minutes and papaya flavour disappeared completely after 60 min. of treatment.

Zara (1985) reported that, Slightly ripe papaya blended with calamansi, fresh pineapple, green and ripe tamarind yielded good jellies. Also, papaya blended with an equal part of fresh pineapple received a higher rating than jam made from papaya alone. On the other hand, candied papaya prepared from
slightly under ripe fruits obtained the highest rating in terms of appearance, texture, color and taste. Slightly ripe fruits was still the best maturity for canning, especially when packed in 35 8 syrup. Form was retained, syrup was clear and the product was sediment-free. Addition of small amount of citric acid further improved its flavor. For canned papaya in brine, pre treatment of green papaya fruits by soaking them in lime solution greatly improved the texture.