Chapter 1
Introduction
INTRODUCTION

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1.10 OBJECTIVES
Food is defined as anything solid or liquid which when swallowed, digested and assimilated nourishes the body (Srilakshmi, 2010). In other words food is defined as a substance which when taken into the body, supply the necessary elements for promoting growth, repairing its broken tissues, and furnishing it with heat and power for muscular work. True food contains the same elements as those are found in the human body, and thus they are able to build and maintain the body structure (Singh & Bhardwaj, 2012). Food provides essential nutrients that are needed for life, as well as, some other bioactive compounds required for health promotion and disease prevention (Liu, 2003).

1.1 FUNCTIONS OF FOOD

Food performs many vital functions in the body.

1.1.1 Energy Yielding is one of the chief functions of food for carrying out various physical activities and for working of different organs within body. Human body performs several important functions such as body movement, respiration, digestion, excretion, etc. which require energy and the foods, rich in nutrients carbohydrate, fat and protein provide this energy (Gaur, 2012). One gram of carbohydrate provides 4 calories, one gram of fat provides 9 calories of energy and one gram of protein provides 4 calories of energy.

The foods rich in these nutrients are broadly divided into two groups -

One, that includes cereals, pulses, roots and tubers (wheat, rice, rice flakes, black gram dhal, whole green gram, rajmah, soybean, potato, sweet potato, carrots etc.) and the other includes pure carbohydrates (sugar, jaggery, honey, etc.) and fats and oils (vegetable oil, ghee, butter, etc.)
1.1.2 **Body Building** is the second main function of the food. A new born baby weighing 2.7 to 3.2 kg has a capacity to grow up and achieve its potential adult size of 55 to 70 kg if proper kind and amount of food is consumed from birth to adulthood. It helps in maintaining the structure of an adult body, and in replacing the worn out tissues of the body (Mudambi & Rajagopal, 1990). Foods rich in protein are called body building foods and are classified into two groups -

The one that includes milk, egg, meat and fish, provides proteins of high biological value and the other one that includes pulses, oilseeds and nuts provide proteins that lack in one or the other essential amino acids required by the human body (Srilakshmi, 2010).

1.1.3 **Protection and Regulation** is the third most important function of the food. Protective foods include milk, egg, fish, liver, green leafy vegetables and fruits. Some functional foods like, whole grains, soybean, leafy vegetables, coloured fruits and spices. Play an important role in the prevention of cancer, cardiovascular diseases and in controlling diabetes mellitus (Srilakshmi, 2010). Foods rich in protein, vitamins and minerals help in carrying out regulatory functions of the body. Fruits and vegetables, if consumed in good amount, play an important role in lowering incidence of degenerative diseases, *viz.* heart disease, cancer, arthritis, inflammation, decline in immune function, cataracts and the dysfunction of brain (Leong & Shui, 2002). This is because fruits and vegetables contain certain phytochemicals and antioxidants which help in preventing degenerative diseases. There are two types of metabolites present in fruits and vegetables known as primary and secondary plant metabolites. Primary plant metabolites mainly contribute to
energy metabolism and to the structure of plant cells like, carbohydrate, dietary fiber, protein and fat. Secondary plant metabolites are non-nutritive dietary components (excluding vitamins) which are referred to as phytochemicals (Mann & Tuswell, 2007). Phytochemicals are non-essential nutrients that have disease preventive properties, but are not required for sustaining life. Recent researches demonstrate that they can protect humans against diseases. Some of the well-known phytochemicals are lycopene in tomatoes, isoflavones in soy and flavanoids in fruits (www.phytochemicals.info). Phytochemicals are chemical compounds that are found in the plants and help in protecting them against bacteria, fungi and viruses. Intake of food products rich in phytochemicals, viz. brightly coloured fruits and vegetables (orange, yellow, red, white, green, blue, purple) and whole cereals/beans in good amount may decrease the risk of developing diabetes, hypertension, heart disease and cancer. The action of phytochemicals varies with the type of food consumed and its colour and may act as antioxidants or prevent carcinogens (www.cancer.stanford.edu). Antioxidants are the substances that prevent or delay oxidative damage of lipids, proteins and nucleic acid caused by reactive free oxygen radicals (Lim, et al., 2006). Medical and nutritional researches have emphasized on benefits by consuming fruits and vegetables (Rekhy & McConchie, 2014).

1.2 FRUITS

Fruits form an essential part of a balanced diet and play a significant role in human nutrition especially as a good source of micronutrients like vitamin C (ascorbic acid), vitamin A, thiamin, niacin, pyridoxine, folacin, vitamin E, minerals and dietary fiber (Kader et al., 2001). Fruits are fleshy or pulpy or juicy in character and usually sweet with aromatic flavours (Srilakshmi, 2010). They are an important
part of the world agriculture food production, even though their production volume is small as compared with grains. Fruits are important source of digestible carbohydrates (Idah et al., 2010) and provide the necessary nutrition supplements to the body and also improve the body condition. They are rich in antioxidants like vitamins, phytoestrogens and carotenoids that help in lowering incidence of degenerative diseases, inflammation, brain dysfunction and acceleration of the aging process (Palmero et al. 2013). Suzuki et al., 2013 too proposed fruits to have potential anti carcinogenic substances, which have preventive effects against cancer. WHO (2002), reported that lower consumption of fruits causes about 19 per cent of gastrointestinal cancer, 31 per cent of ischemic heart disease and 11 per cent of stroke. Therefore, a change in dietary behaviour such as increased consumption of fruits will significantly be effective in reducing the incidence of the chronic diseases.

Fruits are classified on the basis of their shape, cell structure, and type of seed or natural habitat. One of the systems classify them into the following groups-

- Berries (strawberries, gooseberries, blackberries, etc.)
- Citrus fruits (sweet lime, oranges, tangerines, lime, lemon, etc.)
- Drupes (apricot, sweet cherry, peach, plum, etc.)
- Grapes (green grapes, black grapes, seedless grapes, etc.)
- Melons (musk melon, water melon)
- pomes (apple, pears)
- Tropical and subtropical fruits (Indian gooseberry (amla), avocado, banana, dates, mango, papaya, passion fruit, pineapple, pomegranate, custard apple (seetaphal) (Srilakshmi, 2010).
1.2.1 Tropical Fruits

Most of the tropical fruits grow during dry season and ripen at the end of dry season or in the beginning of wet season (Tyler, eHow.com). These fruits have remarkable qualities like firm texture, juiciness, colour, etc. and are important source of carbohydrate, vitamins, minerals and fiber. Some of the tropical fruits are avocado, banana, gooseberry, jackfruit, sweet orange, water melon, musk melon and papaya (www.fruitsinfo.com).

1.3 PAPAYA

Botanical name: *Carica papaya*

Genus: *Carica*

Family: Caricaceae

Common name: Papaya, Paw Paw, Kates, Papaw

Source - www.livingcropmuseum.info

**Figure 1.1: Plantation of papaya fruit in field**

Southern Mexico and Costa Rica are the countries from where the papaya has probably originated and subsequently introduced as a plantation crop in Hawaii,
Philippines, Australia, South Africa, Sri Lanka, India and in all the tropical and subtropical regions. This fruit is native of tropical America, but it is currently disseminated throughout the tropics. Papaya is a polygamous species (Krishna et al., 2008) and its fruit is found in different shapes - cylindrically long, pear or in round shape, because of varietal difference (www.bpi.da.gov.ph/bpioldsite1/guide.papaya.php). More than 40 varieties of papaya are available with different coloured flesh like red flesh, yellow flesh and orange flesh (Adedeji & Oluwalana, 2013). According to Nwofia et al., 2012, carotenoids are responsible for the flesh colour of papaya fruit. Another study conducted by Dutta et al., 2005 also reported that the distinctive colour of fruit is due to the natural pigments like chlorophylls, carotenoids, anthocyanins and betalaines.

1.3.1 Cultivation Conditions of Papaya Fruit

Papaya trees are fast growing trees and grow in an upright pattern. In tropical conditions, within 6 months after planting they start blooming and continue to bloom whole year. In the subtropical conditions, when the temperature in night falls below 12°C, the growth of the plant and production of flowers stops. A mature papaya tree is able to withstand a temperature up to –2°C, however, production of papaya trees is recommended only in the areas where average minimum temperature does not go down below 5°C. The optimum range of temperature for growing papaya fruit is between 25°C and 28°C. The temperature above 36°C and less than 17°C for long durations adversely affects the growth of papaya trees. It takes around 6 months for a papaya flower to turn into the fruit at an average day temperature of ± 23°C. If the temperature is low, it will take a longer time for the fruit to ripen. After the winter climate, the tree recovers its stage and flowers start growing.
Production of papaya normally peaks from September to November. Papaya grows well on a wide variety of soil and produces good number of fruits. The papaya tree has a strong taproot which can under favourable conditions go deep in the soil up to a depth of 2 m. The part of the root responsible for nutrient uptake from soil is found in the top layers of soil (500 mm). Papaya trees grows best in soil where there is slight slope, as it prevents water logging and helps in draining away of excess water. Papaya roots die where there is poorly drained soils because of lack of proper aeration. Impermeable layers of soil affect growth and production of the papaya plant adversely and sometimes lead to infection in the root. For papaya cultivation the best soil texture is that of a sandy loam or loam soil (with a clay content ranging from 15per cent to 30per cent), however soils having clay content of up to 50per cent are also good. Calcium and phosphate are the two elements which move down in the soils very slowly. If there is lack of any one of these elements, then it should be added during preparation of soil. If lime needs to be incorporated in the soil, it should be incorporated 6 months prior to plantation.

Variation in plantation time affects the size of the tree and the time when fruit sets for the first time. The best plantation time for papaya is between February and March. Plantation of papaya during March - August has an advantage that the first crop is harvested from mature trees, which provides better quality of papaya fruits, with higher sugar content (Agriculture, Forestry & Fisheries Department Report, 2009).
1.4 PAPAYA FRUIT PRODUCTION

Papaya is tropical fruit which is considered in daily diet because of its high antioxidant, vitamins, minerals and dietary fiber content. Papaya is additionally a rich source of Papain enzyme. Significant increase in production of papaya has been observed round the world during last few years and has become an important agricultural crop for export in the developing countries. This fruit is being produced in about 60 countries, and its major production is taking place in the developing countries (Evans & Ballen, 2012).

1.4.1 Global Production

Papaya is an invaluable plant, prevalent throughout tropical Africa, and Nigeria is the largest producer globally (Nwofia et al., 2012). Carica papaya is the predominant plant in tropical areas of Africa and Moreso. Nigeria has been identified as the 3rd largest producer in the world (Chukwuka et al., 2013). In 2010, production of papaya took place in bulk, which was estimated to be 11.22 Mt.
Introduction

The annual rate of papaya production was reported to be 4.35 per cent in between 2002 and 2010. In 2010, worldwide production was higher by 7.26 per cent in comparison to that produced in 2009. When compared with the production in 2002, it was 34.82 per cent more. Asia is leading papaya producing section and accounts 52.55 per cent of global level production among 2008 and 2010, South America *i.e.* 23.09 per cent, Africa *i.e.* 13.16 per cent, Central America *i.e.* 9.56 per cent, Caribbean *i.e.* 1.38 per cent and North America *i.e.* 0.14 per cent (Evan & Ballen, 2012).

Worldwide production of papaya fruit has been given in the Table 1.1, with ten countries producing maximum percentage of the papaya fruits (86.32 per cent) in between 2008 and 2010. India is one of the chief papaya producer country and shares 38.61 per cent total global production in 2008 – 2010. Brazil comes second with almost half of the production as compared to India (17.5 per cent), followed by Indonesia (6.89 per cent), Nigeria (6.79 per cent) and Mexico (96.18 per cent). Production by some of the other countries like Ethiopia, Democratic Republic of the Congo, Colombia, Thailand and Guatemala ranged between 2.34% and 1.85% (Evans & Ballen, 2012).
Table 1.1: Global Production Percentage of Papaya during 2008 - 2010

<table>
<thead>
<tr>
<th>Countries</th>
<th>% Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>38.61</td>
</tr>
<tr>
<td>Brazil</td>
<td>17.50</td>
</tr>
<tr>
<td>Indonesia</td>
<td>06.89</td>
</tr>
<tr>
<td>Nigeria</td>
<td>06.79</td>
</tr>
<tr>
<td>Mexico</td>
<td>06.18</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>02.34</td>
</tr>
<tr>
<td>Democratic Republic of the Congo</td>
<td>02.12</td>
</tr>
<tr>
<td>Colombia</td>
<td>02.08</td>
</tr>
<tr>
<td>Thailand</td>
<td>01.95</td>
</tr>
<tr>
<td>Guatemala</td>
<td>01.85</td>
</tr>
<tr>
<td>Other</td>
<td>13.68</td>
</tr>
</tbody>
</table>

Source: FAOSTAT (2012a, 2012b)

1.4.2 Production in India

In India, the total area of 1,026,000 hectares was under papaya cultivation in 2009-2010, and the produce was estimated to be 3,911,600 tons. State of Andhra Pradesh, in India, is the major papaya producing state and contributes nearly 38 per cent of total production. Its yearly yield is 1.5 million tons which produce 80 tons per hectare. Gujarat comes second and had produced 8,32,000 tons of papaya in 2009 – 2010, followed by Karnataka, West Bengal, Chhattisgarh, Madhya Pradesh, Assam, Kerala and Tamil Nadu states (Thamaraikannan & Sengottuvel, 2012). According to National Horticulture Board (NHB) 2013, Andhra Pradesh (31.70 per cent) and Gujarat (23.05 per cent) are the largest producers of papaya fruit in India, however, in Rajasthan production of papaya is very low, only 1 per cent.
Table 1.2: Areas, Production and Productivity of Papaya across Indian States

<table>
<thead>
<tr>
<th>State</th>
<th>2008-09</th>
<th>2009-10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (\textquoteleft 000 hectare)</td>
<td>Production (\textquoteleft 000MT)</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>19.80</td>
<td>1581.20</td>
</tr>
<tr>
<td>Gujarat</td>
<td>14.10</td>
<td>721.70</td>
</tr>
<tr>
<td>Karnataka</td>
<td>05.50</td>
<td>409.00</td>
</tr>
<tr>
<td>West Bengal</td>
<td>10.80</td>
<td>314.30</td>
</tr>
<tr>
<td>Chhattisgarh</td>
<td>08.10</td>
<td>148.10</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>01.60</td>
<td>53.80</td>
</tr>
<tr>
<td>Assam</td>
<td>07.10</td>
<td>128.50</td>
</tr>
<tr>
<td>Kerala</td>
<td>17.70</td>
<td>80.70</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>00.40</td>
<td>72.30</td>
</tr>
<tr>
<td>Others</td>
<td>12.70</td>
<td>119.20</td>
</tr>
</tbody>
</table>

Source, Indian Horticulture Database, 2012
MT- Metric Ton, HT- Hectare

1.5 NUTRITIONAL VALUE OF PAPAYA FRUIT

Papaya has highest content of carotenoids, potassium, fiber and ascorbic acid per serving, among all fruits (Parker et al., 2010). It is considered to be a neutraceutical plant because of presence of wide range of enzymes, vitamins and minerals in it. It is available round the year and is known as powerhouse of the nutrients. It is an affluent source of antioxidants like, vitamin A and vitamin C, minerals like, potassium and magnesium and fiber (Aravind et al., 2013). The carotenoids present in the fruit are responsible for the colour of its flesh. The red fleshed papaya contains four beta carotenes: beta- crytoxanthin, zeta carotene, beta carotene - 5- 6 - epoxide and lycopene, while the yellow fleshed fruit contains only
three of these, i.e. beta carotene, zeta-carotene and beta-cryptoxantain. The content of beta carotene, however, may vary between maturation stages and varieties (Nwofia et al., 2012). The extract of unripe papaya contains alkaloids, terpenoids, flavonoids, glycosides, saponins, carbohydrates and steroids. Besides this, it also contains several proteolytic enzymes including papain and chymopapain, which helps in protein digestion. Papain, is an enzyme is similar to a digestive enzyme pepsin, which secreted in our body. Danielone, a phytoalexin viz. found in papaya fruit, has high antifungal activity against Colletotrichum gloesporioides, which is a pathogenic fungus, present in papaya (Aravind et al., 2013).

### Table 1.3: Nutritional Composition of Papaya

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (g/100g)</td>
<td>90.8</td>
</tr>
<tr>
<td>Proteins (g/100g)</td>
<td>0.6</td>
</tr>
<tr>
<td>Fat (g/100g)</td>
<td>0.1</td>
</tr>
<tr>
<td>Fiber (g/100g)</td>
<td>0.8</td>
</tr>
<tr>
<td>Carbohydrate (g/100g)</td>
<td>7.2</td>
</tr>
<tr>
<td>Calcium (mg/100g)</td>
<td>17.0</td>
</tr>
<tr>
<td>Potassium (mg/100g)</td>
<td>69.0</td>
</tr>
<tr>
<td>Magnesium (mg/100g)</td>
<td>11.0</td>
</tr>
<tr>
<td>β-carotene (µg/100g)</td>
<td>880.0</td>
</tr>
<tr>
<td>Vitamin C (mg/100g)</td>
<td>57.0</td>
</tr>
</tbody>
</table>

Source - Gopalan, et al., 1989
1.6 HEALTH BENEFITS AND USES OF PAPAYA FRUIT

1.6.1 Health Benefits

The whole papaya has its own medicinal value. It provides vitamins, like A and C, necessary for good health and maintenance of good eyesight and helps in prevention of early age blindness among children. The nutrients present in papaya also improve cardiovascular system, prevent heart diseases, and protect colon against cancer. Papaya fruit, being an excellent source of β-carotene, an antioxidant, prevents damage caused by free oxygen radicals. Presence of other antioxidants viz. vitamin C and vitamin E reduces severity of asthma, osteoarthritis and rheumatoid arthritis. Papaya lowers high cholesterol level, improves lung health and binds the cancer causing toxins in the colon. The fruit treats all types of disorders of digestive and abdominal tract, viz. dyspepsia, hyperacidity, dysentery and constipation. Being rich in lectins, saponins and flavonoids, it prevents diabetic heart disease as well as complications of diabetes mellitus (Aravind et al., 2013).

Papain and chymopapain present in papaya helps in lowering inflammation and improve healing from burns. Besides this, an alkaloid, carpain, reduces blood pressure by slowing down the heart rate in humans. This alkaloid also kills worms and amoebas in the intestine. Papaya has lycopene, a cancer fighting compound, in abundance. Fibrin is another useful compound found in papaya that improves the quality of blood flow through the circulatory system by checking formation of blood clots. Fibrin is also important in preventing stroke. Many phytochemicals have been extracted from papaya fruit to study their action, and recently chitinase, an antifungal compound have been identified in papaya fruit. Moreover, crude extracts
of different parts of papaya have been used as traditional medicine for the treatment of various diseases (Krishna et al., 2008).

1.6.2 Uses

Papaya is a common man’s fruit because of its reasonable price and high nutritional value. Traditionally it has been used in preparation of salads, sherbets, juices and confectionaries like tutti-frutti, candies, etc. It has great nutritional, economic, medicinal, organoleptic and traditional importance. It is produced in abundance during a particular season but all is not utilized fully. Consumer trend towards papaya products has emphasized the need of its value enhancement with fortification of novel ingredients to promote it as a high valued product (Boghani et al., 2012). Papaya fruit also has a unique pharmacological uses like, ripe papaya fruit can be used as a laxative which assure regular bowel movement. The folic acid, present in papaya is required for converting homocysteine into cysteine or methionine amino acids. The black seeds of papaya have a sharp spicy taste and used as black pepper substitute. The papaya vinegar with lemon juice is used to remove dandruff and its peel is used in cosmetics and in many home remedies. Presence of vitamin A in papaya enhances restoration and rebuilding of damaged skin. Papaya peel, on the other hand, lightens up the skin and peel when mixed with honey, acts as a soother and moisturizer (Aravind et al., 2013). Papaya fruit is also used as a topical ulcer dressing, which promotes healing. It is also used to reduce the odour in chronic skin ulcers (Hewitt et al., 2002). Papaya fruit is a major component of burn dressings for children because it provides great relief (Starley et al., 1999).
Introduction

According to health reports of developing countries, deficiency of vitamin A is a major public health problem. Some of the signs of vitamin A deficiency affecting eyes are night blindness, xerosis of conjunctiva, bitot’s spot, xerosis of cornea, keratomalacia and ulcers of cornea (www.lvpei.org). In many studies it is showed that papaya is a rich source of beta carotene or carotenoids, which are the precursors of vitamin A, so papaya can be also, be helpful to combat vitamin A deficiency.

1.7 CULTIVARS OF PAPAYA FRUIT

In India, around fifteen cultivars of papaya have been developed. From these, nine have been widely adopted. Some common cultivars of papaya fruit are Coorg Honey Dew, Pusa Dwarf, Pusa Giant, Pusa Majesty, Pusa Delicious, CO1, CO2, CO3, CO4, CO5 and CO6. The cultivar enhancement of this fruit based on tolerance for frost, resistance towards disease and quality improvement of fruit, is under progress.

According to ICAR, Government of India (1999-2000), the variety Red Indian has recorded maximum fruit weight and total soluble solids (TSS) of 13.0° Brix. Hybrid cultivars of papaya - Surya has medium-sized fruits (600-800 g), red flesh, high TSS of 14° Brix and good keeping quality. This hybrid fruit is gynodioecious and for pollination does not require male plant. The strategies for the development of papaya varieties/cultivars have been changed to address the needs of the changing markets. New breeding objectives have been incorporated into the papaya breeding plan, and these were geared towards the development of industrial type varieties which are suitable for latex/papain production for use in the
manufacture of cosmetics and, processing types that are red-fleshed and big or small fruited export types that are tolerant to papaya ringspot virus (PRSV). F1 hybrids from different crosses of highly inbred parents were also generated. Of various hybrids or cultivars developed in India, three promising hybrids (Red lady, Sinta and F1 cultivars) with suitable industrial criteria (bright red flesh, big-fruited, thick flesh) and fruit qualities (sweet, firm, high edible portion, pleasant flavour and aroma) plus tolerance to PRSV were identified and selected for the present study (www.Papayasvarieties.htm, 1987).

1.7.1 *Carica papaya* Linn. cv Red Lady

The cultivar Red lady is a vigorous, productive and tolerant to papaya ring spot virus. Plants start bearing fruits when it reaches the height of 60 - 80 cm and contain 30 fruits per plant in season. The fruits that grow on female plants are short and oblong and that grows on bisexual plants are long-shaped, weighs about 1.5 to 2.0 kg, with thick and red flesh, 13% sugar content and aromatic. Red lady papaya plant has the advantage of cultivation time, which is relatively short i.e. six months from seed to harvest, while other papaya could take nine months time (www.eastwest.com).

1.7.2 *Carica papaya* Linn. cv Sinta

Sinta cultivar is the first Philippine hybrid papaya. The plant is gynodioecious, semi-dwarf, and highly prolific. It has an average of three fruiting cycles in two years, averaging 20 fruits or more per fruit cycle. The cultivar Sinta papaya plant produces higher quality fruits and is an early maturing plant yielding fruits within 8 to 9 months after transplanting. The fruits are sweet with firm flesh,
weighing 1.2 - 2.0 kg/piece, easy to transport and sell. The storage life is seven to ten days. It has fairly tolerance to papaya ring spot virus (PRSV), the most devastating disease problem of papaya, not only in the Philippines but also in other papaya growing areas of the world (PCARRD report, 2006).

1.7.3 *Carica papaya* Linn. cv F1

F1 is dwarf, high yielding papaya cultivar and is widely adapted in various agro climatic conditions. The fruit weights around 1.6 to 2.5 kg. The flesh is thick, reaching a yellow-orange skin colour when the fruit becomes ripe. The pulp colour is red salmon, solid and sweet with 11° - 12° Brix. The fruits are highly prized because of its consistency and flavour. Under ideal conditions, F1 can yields around 225-250 tons/hectare (www.harvext.com).

1.8 PROCESSING OF FRUITS

Fruits are the group of vital nutrients, but because of high perishability, nearly 20 to 40 per cent of the total production goes waste in harvest time, till they reach to customers. Processing required making them available throughout the year for consumption, either in form of processed or preserved and in turn save generous amount of loss. Fruits and vegetables have great potential for value addition and diversification to give a boost to food industry. Though India’s agricultural production base is reasonably strong but wastage of agricultural produce is sizeable because of low fruits and vegetables processing which is, only 2 per cent (http://www.dnb.co.in/food%20processing/overview.asp). For processing two methods are use commonly *i.e.* chemical (water activity, pH, additional chemicals etc.) and physical (sterilization, pasteurization, blanching, microwaving, freezing etc.).
1.8.1 Blanching

Blanching is a process that is carried out prior to canning, freezing or drying, wherein fruits are first exposed to heat for inactivation of enzymes, for altering texture, for conserving colour, flavour, and nutritional value, and for removing trapped air (Corcuera, 2004). Fruits, vegetables and other biological materials are considered ‘living’ even after harvesting. They undergo various biochemical and physiological changes, unless until the changes causing substrates are inactivated by different means, such as blanching. Blanching is a pre-processing step where fruits and vegetables are subjected to high temperature, generally either in the form of hot water or steam. Blanching, leads to the disintegration of cell wall, which prevents moisture transfer, aids in diffusion of moisture from center to the surface of the product, resulting in reduction of drying time and better quality product (Mahapatra & Mishra, 2011).

1.8.2 Drying

Drying or dehydration is one of the ancient methods and important unit operations for preserving food. Considering its importance, it is imperative to pay attention to the end product quality and cost associated with it, as more and more health conscious consumers are demanding for better quality product. Sun drying, a renewable source of energy has been used since time immemorial, but the product quality and storability is not satisfactory owing to its longer drying time. Moreover, this process is weather dependent and possible in places where, abundant sunshine is available like Rajasthan. Convective air drying is an alternate method which can be used, as it is economical but takes excess time and does not contribute to uniform product quality (Mahapatra & Mishra, 2011). On the other hand, microwave drying
offers opportunities to shorten drying time, improves the final quality and retention of nutrients of dried products and reduces energy consumption (Yan et al., 2010).

1.9 PRODUCT DEVELOPMENT

Product development is an inventive and interdisciplinary activity that transforms a market opportunity and technological innovation into successful products. Product development processes are organized by strategic planning, marketing, product design, manufacturing and budgeting. Product development is based on two characteristics, quality and profitability, where quality means level of satisfaction the customer needs, and profitability means how much profit it can make with limited budget and schedule (Liu, 2003).

Product development is considered as nutrition improvement approach which can provide nutritional needs of specific target groups, preschool age children, moderately malnourished individuals, pregnant and lactating women and population suffering from micronutrient deficiencies. Meeting all target groups nutritional needs is important for their survival, as well as for development of good health. For this purpose, product development gives an opportunity for availability of specially formulated foods all round the year (Pee de et al., 2010).

1.10 SIGNIFICANCE OF THE STUDY

Yellow/orange/red fruits and vegetables are the rich sources of β-carotene and should be consumed daily, especially by the vegetarians. Which helps to combat vitamin A deficiency. All these fruits are also good sources of antioxidants / phenolic compounds like carotenoids, lycopene, flavonoids and phenols which help to reduce the risk of cancer and cardiovascular diseases. Processing of these fruits
can make them available off season as well, and their perishability also reduces. According to many studies processing improves rheological properties of fruits, like texture, colour and bulk density. Products formulated by incorporating these fruits and vegetables, can be consumed any time of the day and in between meals. Also they are likely to be preferred by people of all age groups. Processing of fruits can improve their shelf life and digestibility in comparison to raw fruits. Papaya is a tropical fruit and tempting because of red-orange flesh colour with sweet flavour. Carotenoids are responsible component for red - orange colour of papaya fruit and it act as antioxidant. Papaya is a seasonal fruit, so it’s available in plenty quantity with season but not utilized to the desired extent. For its proper utilization value added products i.e. jams, jellys, snacks with papaya fruit, biscuits, can be develop. This fruit is richest source of Β-carotene, potassium and fiber. Vitamin A deficiency causes much early age blindness among children. Papaya consumption can prevent vitamin A deficiency in community, improve digestibility and cancer prevention. Vitamin A deficiency causes blindness and high mortality in children. For combating vitamin A deficiency, should increase the availability of vitamin A rich food products by the fortification technique and introduce in community. Papaya fruit has antifungal and antibacterial properties because of phytochemicals, which is the reason of high storage capacity of this fruit in comparison to other flesh fruits. In the present study an effort made to formulate value added products, using papaya fruit.

Also, the development of a wide range of products from papaya will create more interest among the processors to diversify their processing lines and to produce value added products with their better presentation, packaging and improved overall
appearance. This will not only reduce the importation of other fruit products which have been flooding Indian markets, but will also help to capture international markets. The development of value added products for commercialization will provide new scope for the expansion of the local fruit industry.

Keeping this in mind, present study has been undertaken with the following objectives-

1.11 OBJECTIVES

- To estimate nutrient content and analyze rheological properties of pre and post processed three cultivars of papaya (*Carica papaya* Linn. cv Red lady, Linn. cv Sinta and Linn. cv F1).
- To compare the nutrient content of fresh and processed selected papaya cultivars.
- To formulate and standardize value added (β-carotene rich) products, using processed papaya cultivar, selected on the basis of maximum β-carotene retention.
- To study the rheological properties, nutritional composition and shelf life and calculate the price of the most accepted product/s.