Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7363

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **7 (2):** 169-181 (2019)

Review Article

International Journal of Pure & Applied Bioscience

Post Harvest Technology of Papaya Fruits & its Value Added Products - A Review

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Received: 15.02.2019 | Revised: 22.03.2019 | Accepted: 1.04.2019

ABSTRACT

Papaya (Carica papaya) is a tropical fruit having commercial importance because of its high nutritive and medicinal value. Papaya is a power house of nutrients and is available throughout the year. It is a rich source of threes powerful antioxidant vitamin C, vitamin A and vitamin E; the minerals, magnesium and potassium; the B vitamin pantothenic acid and fiber. Handling papaya fruit post harvest is to prepare the fruits for market and also to preserve the fruits quality so it can present on market as it demands. Food preservation has long been an on-going challenge for human with the methods like, drying, salting and fermentation being traditionally done for preservation. The process of impregnation with sugar must not be hurried because otherwise, the fruit would shrivel an unfit for glazing and crystallizing. The preservation of food in common salt or in vinegar is known as pickling. It is one of the most ancient methods of preservation of fruits. Drying may contribute to the deterioration of both the eating quality and the nutritive value of a food product.

Key words: *Papaya fruit and value added products.*

INTRODUCTION

Papaya (*Carica papaya*) is a tropical fruit having commercial importance because of its high nutritive and medicinal value. Total annual world production is estimated at 6 million tones of fruits. Alone in Andhra Pradesh the total area under cultivation is 11.2 thousand hectare and productivity is 100 MT/ Hectare. Despite large acreage of land devoted to papaya the fruit loss is reported to be between 40-100 per cent of total annual produce (*Source : Database of National Horticulture Board, Ministry of Agriculture , Govt. of India*). Papaya is a power house of nutrients and is available throughout the year. It is a rich source of threes powerful antioxidant vitamin C, vitamin A and vitamin E; the minerals, magnesium and potassium; the B vitamin pantothenic acid and fiber.

Cite this article: Kumar, V., Singh, J., Chandra, S., Kumar, R., Sunil, Singh, K., Chaudhary, V. and Kumar, P., Post Harvest Technology of Papaya Fruits & its Value Added Products - A Review, *Int. J. Pure App. Biosci.* **7(2):** 169-181 (2019). doi: http://dx.doi.org/10.18782/2320-7051.7363

Papaya fruit is a rich source of nutrients such as pro vitamin A carotenoids, vitamin C, B vitamins, lycopene and dietary minerals. Danielone is a phytoalexin found in the papaya fruit. By the mid-19 century, papaya had spread over the tropical region, from India, Sri Lanka, Malaysia, Indonesia, to Africa[49]. The use of fresh-cut papaya in food service institutions is very limited owing to the many technical problems involved in maintaining its quality and microbiological safety during storage. A recent study by[63]. determined the effects of cutting shape (cubes or slices) and storage temperature (5, 10 or 20^{0}C) on the overall quality of fresh cut papaya. Water removal is the main task while preserving food[41], reducing the moisture contents to a level, which allows safe storage over an extended period of time. Dried foods also present low storage and transportation cost when compared to the fresh ones. Different types of solutes such as fructose, corn syrup, glucose, sodium chloride and sucrose are used as osmotic agent for OD[6]. Low molar mass saccharides (sucrose, glucose and fructose) make easy the sugar uptake due to high diffusion of molecules.

Uses of Papaya;

Papaya provides significant amounts of vitamin C. Typically, this fruit is consumed when ripe, soft, and sweet. It is eaten in fruit salads, with yogurt, or blended as juice. Unripe papaya is used in cooking, particularly curry and stew dishes. Because it has a high pectin content, papaya is also prepared as jelly, jam, and preserves. Papaya (*Carica papaya* L.) is well known for its exceptional nutritional and medicinal properties throughout the world. In the present review article, a humble attempt is made to compile all the strange facts available about this tasty fruit. This tasty fruit of Papaya is popular among family members of all ages for the delicious dishes derived from it[55].

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)[79]. 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[34]; or used in the manufacture of rubber[4,8].

Table 1: Constituents of different parts of the papaya tree:

Part	Constituents
Fruits	Protein, Fat, Fiber, Carbohydrates, Mineral: Calcium, Phosphorous, Iron,Vvitamin 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, sitostrol, caressing and enzyme myrosin
Root	Carposide and enzyme myrosin
Leaves	Alkalodis carpain, pseudocarpain and dehyrocarpaine and ,choline, carposide vitamin C and E.

Source: [50,61,40,8]

Post Harvest Management:

Handling:

Handling papaya fruit post harvest is to prepare the fruits for market and also to preserve the fruits quality so it can present on market as it demands. The objectives of post harvest technology applications are to maintain quality in terms of appearance, texture, flavor and nutritive value, to maintain food safety and also to reduce losses along the supply chain (between harvest and consumption).

http://www.itfnet.org/v1/2016/05/papaya-post-harvest-processing.

Packaging:

There were two type of packaging, one for the export markets and secondly for local markets. For export markets, the fruits will be wrapped with white polyurethane sleeves, which serve as cushioning material preventing the fruits from bruising during transportation. Mean while, for local markets, the fruits are not wrapped. As a common practice the fruits were packed in bamboo or plastic baskets which are normally lined with newspapers. (**http://www.itfnet.org/v1/2016/05/papaya-post-harvest-processing/). Fruit processing has three major aims:**

1. To make fruit safe (microbiologically & chemically).
2. To provide good quality products with good flavor, color, texture and taste.
3. To make convenient fruits products.

Cleaning and washing:

Fruits often contain a great diversity of microflora and are frequently involved in food-borne outbreaks. Since fruits and vegetables are mainly consumed uncooked or minimally-processed (such as in ready-to-eat salads), microbiological safety becomes an important issue to minimize consumers risks[64]. Recently, a number of outbreaks have been traced to fresh-cut fruits and vegetables, which were caused due to inadequate sanitary conditions. The investigations of these outbreaks showed that the quality of water used for washing was crucial[9]. It is well known that disinfection is one of the most critical processing steps in fresh-cut fruits and vegetable production[27]. This step commonly affects the quality, safety and shelf-life of the end product. Washing is designed to remove dirt, selected pesticides and to detach microorganisms to enhance quality[83]. Sanitization is the killing of contaminated microorganisms after washing. Chemical methods of cleaning and sanitizing involve the application of mechanical washing in the presence of sanitizers[5]. Sanitizers can reduce the growth of natural microbial populations on the surface of fresh-cut produce by 2–3 log units and can reduce contaminated pathogens[30,67,78].

Sorting and grading:

To achieve a uniformly sized product, fruits and vegetables are sorted immediately after cleaning according to their size, shape, weight or color. Sorting by size is especially important if the products are to be dried or heated, because their size will determine how much time will be needed for these processes. Sorting and grading are important process to maintain quality of products. In present common scenario, sorting and grading of fruit according to maturity level are performed manually before transportation. This manual sorting by visual inspection is labor intensive, time consuming, and suffers from the problem of inconsistency and inaccuracy in judgment by different human[10]. To increase the accuracy, precision, continuity, and uniformity of sorting and grading, the development of novel technology is needed[56,2].

Peeling:

Many types of fruits have to be peeled in order to be preserved. This can easily be done with a stainless-steel knife. It is extremely important that the knife be made of stainless steel because this will prevent the discoloration of the plant tissues. Peeling is one of the integral parts of a food processing, and the majority of agricultural crops need to be peeled in order to remove at the initial stage of food processing[52]. Peeling removes inedible portion (peel, seeds, and stalk) of fruits. However, the susceptibility to spoilage increases due to acceleration of physiological process and the exposure of the tissues to microorganisms. The shelf-life and quality of fresh-cut produces could be compromised with the peeling. The goals of optimum peeling operation are Peeling operation can be grouped under following categories:

• Manual peeling (knife or blade).

• Mechanical peeling (abrasive devices, devices with drums, rollers, knifes or blades and milling cutters).

Manual Peeling:

Manual peeling is performed using stationary or rotatory hand peelers or knives against the surface of fruits and vegetables. Fresh-cut fruit and vegetables with good microbiological quality can be obtained by this method[39]. reported that knife peeling caused less wounding in comparison to abrasion peeling in carrots. This can result lower microbial contamination after processing.

Mechanical Peeling:

Mechanical peeling includes different types of process that interact directly with skin and then removes the skin. Common commercial mechanical peelers are abrasive devices, drums, rollers, knives and milling cutters[74]. Developed a power operate batch type mechanical peeler for potato peeling[75].

Cutting:

Cutting is important in order to get uniform pieces for heating, drying and packing. Fruits are usually cut into cubes, thin slices, rings or shreds. The cutting utensils have to be sharp and clean to prevent micro-organisms from entering the food. Cutting, slicing, dicing, and shredding are non-thermal food operation for size reduction. This process reduces the preparation time by consumers. Cutting removes inedible and discolored portions from foods using knife, chopper and slicer[13]. However, in this food processing injured tissues are removed so that these are unavailable for microbial spread. The cut tissues results in reduced respiration and enzymes activity, thus retarding rapid spoilage and increases shelf life[11]. The cutting process accumulates fluids on the cut surface, increases microbial load and enzymes activity[15].

Blanching:

Blanching is a unit operation prior to freezing, canning, or drying in which fruits or vegetables are heated for the purpose of inactivating enzymes; modifying texture; preserving color, flavor, and nutritional value; and removing trapped air. Gas removal is the main benefit of blanching before canning because it allows easier can fill, reduces strain on can during heating, and reduces can corrosion. Although, in this case, enzyme inactivation also takes place, it is not relevant because any remaining activity is destroyed on retorting[21]. After blanching, vegetables are quickly chilled by spraying with cold water, or by conveying them to a flume of cold water that often serves to transport them to the next part of the process. Blowing cold dry air has also been used to take advantage of evaporative cooling; using the water adhered to the surface of the product[36].

Water Blanching; Water blanching is performed in hot water at temperatures ranging typically from 70^{o}C to 100^{o}C. However, low temperature long-time (LTLT) blanching and combinations of LTLT with high-temperature short-time (HTST) blanching have also been studied[59,76,45]. Water blanching usually results in a more uniform treatment, allowing processing at lower temperatures[36].

Steam Blanching: In steam blanchers, a product is transported by a chain or belt conveyor through a chamber where ‘‘food-grade’’ steam at approximately 100 ^{o}C is directly injected. Usually temperature in the headspace is measured and the flow rate of steam is controlled[36].

Microwave Blanching: Microwave technology has been combined with water blanching to further reduce heating time[18]. Despite the tremendous potential of microwave blanching to improve product quality and minimize waste production[36].

Gas Blanching: Hot gas blanching using combustion of flue gases with addition of steam to increase humidity and prevent product dehydration has been studied. This type of blanching has the advantage of reducing waste production, is comparable to conventional blanching with respect to nutrient retention, but often results in product weight loss. This approach is not currently used in industry and needs further research[21,36].

FRUIT PRESERVATION:

Food preservation has long been an on-going challenge for human with the methods like, drying, salting and fermentation being traditionally done for preservation[51]. They are the most effective for a longer shelf life and stop or delay the growth of bacteria, suppress the reaction when food comes in contact with oxygen or heat, they also prevent the loss of some essential amino-acids and some vitamins enhance the food flavors and colors[71].

PRESERVATION METHODS

Drying: Fruits and vegetables contain nearly 70% to 95% of moisture which make them highly perishable[35]. If this moisture is reduced to some extent, bulk transportation of the final product can be made to other parts of the county where it is not available. Also the shelf life of the product is increased. Conventionally sun drying and hot air drying is used to dry and preserve the product. Drying may contribute to the deterioration of both the eating quality and the nutritive value of a food product[82,14,68].

Refrigeration: The purpose of refrigeration for food is to retard deterioration by micro-organisms, chemical and physical processes. By cooling at temperatures just above freezing it is possible to achieve a limited extension of storage time which is often sufficient for safe distribution and marketing. By freezing to temperature as low as -30ºC, deterioration can be slowed down further and this increases the storage time[57].

Vacuum packing: It is the most viable packaging method to get better shelf-life[19]. Vacuum packaging can be supplement to ice or refrigeration to delay spoilage, extend the shelf-life of fishery products[69]. Vacuum packaging involves the removal of air from the packaging, and then extends the viable shelf-life of many cooked foods. It should be stressed that vacuum packaging must be used under strict conditions of hygiene and control. This could be applied to cook-chill food systems to increase food quality and microbiological assurance[60,66].

Freezing: Like most food preservation methods, the freezing process for food has evolved over a significant period of time. Frozen food can be transported for longer distances and the process has contributed to making foods available on a worldwide basis. The purposes of food freezing is preservation of food, reducing the activity of enzymes and microorganisms, reducing the amount of liquid water for microbial growth and reducing water activity of foods[44,12,84,29]. Freezing is still the best way to preserve food when is carried out properly and allows production of food without any chemical preservatives. Thermo physical properties of frozen food are used to estimate the rate of heat transfer and to calculate the heat load in process such as freezing and thawing[17].

Pasteurization: A process named after scientist Louis Pasteur which uses the application of heat to destroy human pathogens in foods. For the dairy industry, the terms "pasteurization", "pasteurized" and similar terms shall mean the process of heating every particle of milk or milk product, in properly designed and operated equipment, to one (1) of the temperatures given in the following chart and held continuously at or above that temperature for at least the corresponding specified time in table 2.

Table 2:

Temperature	Time	Pasteurization Type
63ºC (145ºF)	30 minutes	Vat Pasteurization
72ºC (161ºF)	15 seconds	High temperature short time Pasteurization (HTST)
89ºC (191ºF)	1.0 second	Higher-Heat Shorter Time
90ºC (194ºF)	0.5 seconds	Higher-Heat Shorter Time
94ºC (201ºF)	0.1 seconds	Higher-Heat Shorter Time
96ºC (204ºF)	0.05 seconds	Higher-Heat Shorter Time
100ºC (212ºF)	0.01 seconds	Higher-Heat Shorter Time
138ºC (280ºF)	2.0 seconds	Ultra Pasteurization (UP)

Source: IDFA, June[32]

Canning: Shephard[73]**.** described the process of canning thus: the food is peeled, cured, and diseased portions are removed. For canning, containers are evacuated and placed in a pressurised steam sterilizer, similar to an autoclave at 121°C. This removes especially Bacillus and Clostridium spores. If canning is defective, foods may become contaminated by anaerobic bacteria which produce gas. These are species of Clostridium and coliform bacteria (a group of Gram-negative nonspore-forming rods which ferment lactose to acid and gas at 32°C in 48 hours).

Fermentation: Fermentation is a naturally occurring chemical reaction by which a natural food is converted into another form by pathogens. It is a process in which food "goes bad," but results in the formation of an edible product. Perhaps the best example of such a food is cheese. Fresh milk does not remain in edible condition for a very long period of time. Its pH is such that harmful pathogens begin to grow in it very rapidly. Early humans discovered, however, that the spoilage of milk can be controlled in such a way as to produce a new product like cheese, etc[53].

Controlled use of micro-organism: Some foods, such as many cheeses, wines, and beers will keep for a long time because their production uses specific micro-organisms that combat spoilage from other less benign organisms. These micro-organisms keep pathogens in check by creating an environment toxic for themselves and other micro-organisms by producing acid or alcohol. Starter micro-organisms, salt, hops, controlled (usually cool) temperatures, controlled (usually low) levels of oxygen and/or other methods are used to create the specific controlled conditions that will support the desirable organisms that produce food fit for human consumption[81,72].

Anaerobiosis: Packaging of food products under anaerobic conditions-anaerobiosis is effective in preventing aerobic spoilage process. Vacuum packing in an airtight container is used to eliminate air[24,72].

Controlled atmospheres: Such atmospheres containing 10% CO2 are used to preserve stored food products as apples and pears. This checks fungal growth. Ozone can also be added[3].

Modified atmosphere: Modified atmosphere is a way to preserve food by operating on the atmosphere around it. Salad crops which are notoriously difficult to preserve are now being packaged in sealed bags with an atmosphere modified to reduce the oxygen (O_2) concentration and increase the carbon dioxide (CO_2) concentration. There is concern that although salad vegetables retain their appearance and texture in such conditions, this method of preservation may not retain nutrients, especially vitamins. Grains may be preserved using carbon dioxide. A block of dry ice is placed in the bottom and the can is filled with grain. The can is then "burped" of excess gas. The carbon dioxide from the sublimation of the dry ice prevents insects, mold, and oxidation from damaging the grain. Grain stored in this way can remain edible for five years. Nitrogen gas (N_2) at concentrations of 98% or higher is also used effectively to kill insects in grain through hypoxia. However, carbon dioxide has an advantage in this respect as it kills the organisms[62,72].

STORAGE:

Food storage is the process in which both cooked and raw materials are stored in appropriate conditions for future use without any entry or multiplication of microorganisms. It allows food to be eaten for some time (typically weeks to months) after harvest rather than solely immediately. Food preservation, storage, and transport, including timely delivery to consumers, are important to food security, especially for the majority of people throughout the world who rely on others to produce their food. Many fruits have medical purpose; Proper food storage helps maintain food quality by retaining flavor, color, texture and nutrients, while reducing the chance of contracting a food-borne illness[38].

Nutritional value:

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. 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[43]. 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[22]. 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[65,8].

Table 3: Proximate analysis of ripe and unripe papaya fruits

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

Source: [40,8]

Table 4: Nutritional value of fresh papaya[80,8]

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 g (41%)
Thiamine(vitamin B_1)	0.04 mg (3%)
Riboflavin (vitamin B_2)	0.05 mg (4%)
Niacin (vitamin B_3)	0.338 mg (2%)
Vitamin B_6	0.1 mg (8%)
Folate (vitamin B_9)	38 g (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%)

SOME VALUE-ADDED PRODUCTS OF PAPAYA FRUIT;

Papaya candy:

A fruit impregnated with cane sugar and glucose, and subsequently drained and dried is called a candy. A higher percentage of sugar is used than in preserves. The total sugar content of the impregnated fruit is kept at about 75% to prevent fermentation. The process of impregnation with sugar must not be hurried because otherwise, the fruit would shrivel an unfit for glazing and crystallizing.

Ingredients: Fully matured but unripe papaya, sugar to bring to 70°Brix, approximate half to 3/4th the weight of the fruit and essence (desired flavour and colour).

METHOD:

1. Harvest fully mature but unripe papaya.
2. Make a few streaks with a knife on the papaya and allow the latex to flow out. Wash thoroughly and wipe dry.
3. Peel the papaya, Cut and remove the seeds.

4. Cut the papaya into small, pieces of uniform size, Soak it in cold water containing salt (2 g/100 ml) and calcium chloride (1 g/100 ml)) for 1/2 an hour.
5. Drain and wash with cold water.
6. Add sugar (1/4 the weight of the pieces) and cook for 5 minutes with colour and flavour.
7. Cool and keep aside for 4 hours.
8. Add a little more extra sugar and citric acid (1 g/100 ml) and cook for 5 minutes.
9. Repeat the procedure till the final Brix reaches 70°.
10. Drain the syrup and dry the candy under shade.
11. Pack it in sterilized jars or polythene bags.
12. This papaya candy can be used in the preparation of bakery products[47].

Papaya pickle:

The preservation of food in common salt or in vinegar is known as pickling. It is one of the most ancient methods of preservation of fruits. Pickles are good appetizers and add to the palatability of the meal. They stimulate the flow of gastric juices and thus help in digestion.

Ingredients: Peeled papaya pieces, Salt, Red chilli powder, Mustard, Fenugreek, Asafoetida (powdered), Vinegar.

Method:

1. Wash and peel mature green papayas.
2. Remove the seeds and cut them into pieces.
3. Boil them in hot water and drain the water.
4. Mix with salt and add spices.
5. Fill in jars and add vinegar[47].

Osmo-dried papaya sweets:

The papaya was washed and cut into 2.5x2.5x2.5 cm slices. The papaya slices were put in to the chemical solution for 30 minutes and after 30 minutes the sample were removed in to the chemical solution and put in room temperature for 15 minutes and then weighted by electrical balance. After that the samples were treated with sugar solution (55^{o}Brix and 65^{o}Brix) for 180 minutes at 50^{o}C temperature and then the osmotically papaya slices were dried in tray drying.

Ingredients: Peeled papaya slices, sugar concentration (55^{o}Brix and 65^{o}Brix), dryer etc.

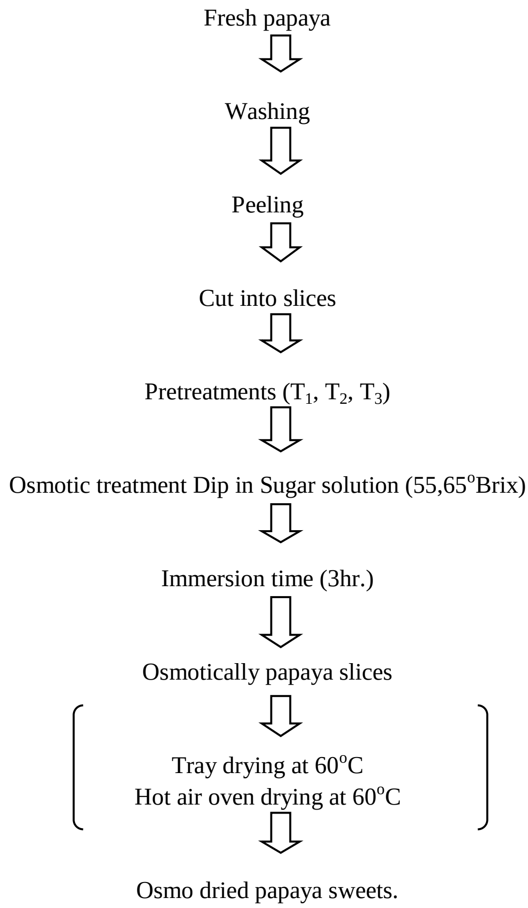

Fig. 1: Flow chart of osmo-dried papaya sweets

Papaya Shake:

Papaya milk shake was prepared by following the procedure as described by[70]. with slight modification. The buffalo milk was standardized to 4 per cent fat. Stabilizer (sodium alginate) was added @ 4 per cent.

Ingredients: Papaya pulp, buffalo milk Sugar etc.

Papaya
⇩
Pulp
⇩
Heat to 80 °C/15 min.
⇩
Cool to room temperature
⇩
Store in refrigeration for further use
⇩
Buffalo milk (standardized 4 % fat)
⇩
Add papaya pulp @ 10 %, 15 % and 20 %)
⇩
Add of sugar (at 15 %)
⇩
Blend well
⇩
Fill in the glass bottle
⇩
Pasteurization at 85 °C in water bath
⇩
Cool
⇩
Store at room temperature

Fig. 2: Flow Chart for preparation of papaya milk shake[54]

CONCLUSION

In this report presents *carica papaya* L. as an important and promising natural medicinal plant which could be utilized in several pharmaceutical and medical applications because of its effectiveness, availability and safety. The papaya fruit is available in only seasonal. That is why process and value added products of papaya are available in off season, the shelf life of processed papaya fruit product is more than the unprocessed papaya fruit products.

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