Chapter 1

INTRODUCTION

Mango (*Mangifera indica*) is called the king of fruits. It is also a delicious fruit. It is most ancient and popular fruit in our country. There are many varieties of mango are cultivated in our country. Besides, having delicious taste, captivating flavor with multifarious color, it is an excellent source of nutritive values. Bangladesh is one of the major mango producing countries along with India, Pakistan, Mexico, Brazil, the Philippines, etc. (Alexander, 1989). In Bangladesh, mango occupies about an area of 50,491 ha with a production of 187220 tones according to BBS, 2003. It is now in an increasing trend in area by 112% and in production by 116% in the year of 2000-01 compared to 1984-85 (BBS, 2002).

Due to the lack of post-harvest facilities losses as high as 18% (Srinivas, et al.,1977). The main constituents of mango are water 75- 82%; sugar 8.7-20%; protein 0.51%; citric acid 0.14- 0.71%; vitamin –C 8.5-50 mg per 100g and ash 0.38-0.635 (Singh,1968). Thus mango is a good source of energy and nutrient. Mango leather has very low protein content ranged from (1-2%) (Pramanik and Segupta,1978). Protein content can be increased by adding shrimp flavor and rice flavor when protein is isolate and 50% protein isolate (Reddy, G. V. and H. Das, 1993).

Cultivation of papaya has gained immense popularity among the farmers of the district from the last few years. It has important sources of income generation leading to economic self-reliance in the area. The fruit has more nutrition properties than that of common fruits. An important quick growing fruit of Bangladesh, India and others country. Present production is 105000 tons from 7700 ha in Bangladesh. Very rich in vitamins like Vitamin A, B & C and minerals like Phosphorus & Calcium. It Possesses high medicinal value. The ripe fresh fruits are used as dessert and green fruits are used as vegetable. Jam, soft drinks, ice-cream flavoring etc can be prepared from ripe fruit.

Pineapple is one of the most important commercial fruit crops in the world. It is the third most important tropical fruit in the world and in Bangladesh, pineapple ranks 4th in terms of total cropping area and production (BBS 2007). The production of fruits including pineapple is increasing day by day in Bangladesh. Also, the world pineapple demand has been expanding rapidly. Pineapples have exceptional juiciness and a vibrant tropical flavor that balances the tastes of sweet and tart Pineapple is an excellent source of vitamin C and manganese. It is also a very good source of copper and a good source of vitamin B1, vitamin B6, dietary fiber, folate and pantothenic acid (Pratt, D.S. and J. I. Del Rosario. 1913).

The study is to make mixed fruit leather by using these three fruits. Leather is a traditional product prepared from ripe fruits. Traditionally sun drying is employed for preparing mango leather from ripe fruit pulp (Reynolds S. 1994). But sundried leather is discolored and the process is unhygienic and lengthy. Cabinet drying has been carried out for making mango leather (Heikal, et al, 1972; Mir and Nath. 1995) resulting with better color and flavor. Nature and available in large quantity during the peak season. But this fruit is perishable item and not be fresh for longer time after harvesting. So, adequate preservation facilities are necessary for removal of damage/spoilage of a large quantity of its valuable fruits. If post-harvest losses could be prevented thus farmer would get proper price of their products. Fruit leathers are made by drying a very thin layer of fruit puree to produce a product with a texture similar to soft leather. That is why the name 'Leather''. They are tasty and chewy.

There are many advantages of making fruit leathers. The simple lowcost preparation method can save money. Over ripen fruits used as raw material leads to reduce wastage of fruits. Rich in vitamins due to low temperature drying method used. In cabinet drier 55℃ temperature is used. Fruit leathers made without using sugars are a healthy choice for diabetic adults and children.

The objectives of proposed study was:

- To develop product, mixed fruit leather by using mango pulp, pineapple juice and papaya pulp.
- To analyze the major constituent of raw materials.
- To analyze the Physico-Chemical composition, mineral content and microbial load of final product.

Chapter 2

REVIEW OF LITERATURE

The first contributions (1976) that described the preparation of fruit leathers were written by extension services of various universities in the United States. These techniques were aimed at promoting homemade preparation of leathers from several fruits, in part as a hobby and in part to preserve leftover ripe fruit. Along with this trend, some companies offered practical, small-sized electric dehydrators to carry out the drying-forming stage. Scientific production in the topic began around 1978 and, despite the healthy character of fruit solids consumption, has kept an irregular pace until the beginning of the XXI century, from which fruit leathers began to receive more attention from researchers. Table 1 shows a list of countries where some research has been carried out and the fruit utilized to prepare the leathers, according to its availability and abundance in the different regions.

Table 1. List of countries where scientific studies have been performed on fruit leathers and studied fruits:

Country	**Raw material**
Australia	Strawberry
Argentina	Tomato, apple
Brazil	Mango
Canada	Apple
Greece	Orange juice concentrate
India	Guava, mango
Malaysia	Durian
Thailand	Gold kiwifruit, longan
Turkey	Grape
United States	Papaya, rosehip, strawberry, pear

2.1 What is Fruit Leathers?

Fruit leathers are made by drying a very thin layer of fruit puree to produce a product with a texture similar to soft leather. It's a homemade fruit rolls. They are tasty chewy dried fruit product. Fruit leathers are made by pouring pureed fruit into a flat surface for drying when dried the fruit is pulled from the surface and rolled. It gets the name "Leather" from the fact that when pureed fruit is dried. It is shiny and has the texture of leather.

2.2 Nutrition information of fruit leathers

Fruit leathers are eaten as a snack and are often targeted at health food markets, using a marketing images such as "Pure". "Sun dried" or 'Rich in vitamins" such claims are not unreasonable given that results in less loss of nutrients than for example, canning in which up to 65% of minor nutrients can be destroyed. Losses of vitamin A and C. however high, of the fruit is dried in direct sunlight. For the diabetic adults or child fruit leathers made without sugar are healthy choice for snacks or desserts. Individual fruit leathers should contain the amount of fruit allowed for the fruit exchange. Fruit leathers are delicious, nutrition high energy snacks for backers, campers and active children. They are relatively light in weight, easy to prepare and a good way to use left over canned fruit slightly over ripe fruits. Frozen or drained canned fruits can be used as raw materials.

According to Jacob (1959) beverages are characterized by two principal charters. Firstly they are liquid or are consumed in a liquid state. Secondly, they are generally used to quench the thirst. One of the groups of beverages is the still beverage such as fruit drinks and fruit juices.

Hulme (1971) stated that all juices are inherently unstable microorganisms already present on the fruit or gaining access to the product during processing. Rapidly attack them; they are also subject to enzymatic and non-enzymatic chances. It is thus essential to destroy the micro-organisms at an early stage or to prevent their development and to restrict chemical change by heat treatments to inactivate enzymes or by refrigeration. In food industry fruit juice is defined as the liquid expressed by manual or mechanical means (pressure) from the edible portion of the fruit. Frequently the juice may be turbid, contain cellular components in colloidal suspension width variable amounts of finely divided tissue. It sometimes may contain oily or waxy material and carotenoid pigments (Hulme, 1971).

Roy et al., (1997) observed that homogenization affects the viscosity, acceptability and storage properties of mango pulp and mango juice beverages such as squash, nectar etc. He showed that storage at 4±1°C ensured maximum retention of chemical and sensory properties.

2.3 Fruits combinations:

Single fruits or combination of fruits can be used. Bananas, Mangos, Pineapples, Papayas, Orange, Pear, Berries, Apples, Grapes, Lemons, Wood apples like fruits can be used for combination. Fruit combinations make a variety of flavors possible. Ex. Banana with strawberry. Can add favorites seasonings by blending them with the puree or sprinkling them before drying. Can be added toppings such as coconut, slivered almonds or chopped filberts before leathers are dry. Yogurt, spices, flavors can be added to the fruit leather. Cinnamon, cloves, ginger, mint, nutmegs can be added to the fruit puree to give taste variance. Almond extract, Lemon juice. Lemon peel, Lime juice, Lime peel, Orange extract, Orange juice, Orange peel, Vanilla extract can be added to the fruit puree as flavorings. Shredded coconut, chopped dates, dried chopped fruits, chopped nuts sesame seeds, sunflower seeds can be added as delicious additions. Fillings like melted chocolates, softened cream, cheese, cheese spreads, jams, peanut butter can be spreaded on the fruit leather after it is dried and then roll. Advantages of making fruit leathers are to save money use less sugar and to mix fruit flavors. It's a simple low cost methods. In my study I use mango, pineapple, papaya fruits for making leather by using several combination.

Mango and its nutrient content: Jain (1961) had reviewed the chemical composition of mango. It is rich of carbohydrate as well as vitamin A and C. The following is the chemical constituent present in mango (25 varieties). Sugar constitutes main bulk of the carbohydrates and most of the soluble solids in ripe mango.

Table 2.1: Nutrient Content of Ripe Mango

Chemical Constituent	Quantity
Moisture	73.9-86.75%
Carbohydrate	11.6-24.31%
Protein	0.3-1.0%
Fat	0.1-0.8%
Minerals	0.3-0.7%
Vitamin-C	650-25940 I.U.
Vitamin A	3.0-8.3mg/100g

Source: USDA nutrient database 2001, Marr et al., 2007

Pineapple and its nutrient content:

Pineapples have exceptional juiciness and a vibrant tropical flavor that balances the tastes of sweet and tart Pineapple is an excellent source of vitamin C and manganese. It is also a very good source of copper and a good source of vitamin B1, vitamin B6, dietary fiber, folate and pantothenic acid.

Table 2.2: Nutrient Content of Pineapple

Moisture (%)	87.3
Ash content (mg/100g)	1.8
Total soluble solids (%)	13.3
Crude fibre(g/100g-fw)	0.41
Total sugars (%)	8.66
Reducing sugars (%	10.5
Non-reducing sugars (%)	7.4
Titratable acidity (%)	2.03
Ascorbic acid (mg/100g)	21.5

Source: USDA nutrient database 2001, Marr et al., 2007

Papaya and its nutrient content:

Chemical components of per 100 g oranged-freshed papaya fruit (the data from USDA Nutrient database)

Table 2.3: Nutrient Content of Papaya

Water	88.83g
Energy	39Kcal
Protein	0.61g
Fat	0.14g
Ash	0.61g
Carbohydrate	9.81g
Fibre	1.8g
Sugar	5.9g

Source: USDA nutrient database 2001, Marr et al., 2007

BCSIR laboratories in Rajshahi (Anonymous, 1975) investigated the compatibility of ripe mango juice is mixture with other fruit juice such as pineapple, lemon, guava etc. It has been observed that the mixed fruit juice had great consumer appeal. The Central Food Technological Research Institute (CFTRI) proposed a recipe for the preparation of a mango squash as follows; mango pulp 1 kg; water 1 kg; sugar 1 kg; citric acid 30 g; edible mange yellow color and Potassium Metabisulphate (KMS) at the rate of 610 mg per kg of finished product (Anonymous, 1975).

2.4 Production of fruit Leather

Production of fruit leathers are at these scales from a very small simple home made system, through cottage industry to small industrial production.

The following basic steps are involved at all levels of production:

I. Selection and preparation of the fruit including preservation to allow production
II. To continue out of season.
III. Preparation of the puree
IV. Batch preparation
V. Drying
VI. Packing and
VII. Storage

2.4.1 Selection of fruits for fruit leather

A high quality product can only be made from good quality raw materials and production should not, as too often happens be based on second grade fruit that is not suitable for the fresh market. Fruit that has been rejected for being too large, too small or because of surface blemishes is however usually acceptable. Fully ripe soft fruits are very susceptible to bruising when handled and bruised areas will quickly begin to rot. It is these better to purchase semi-ripe fruit (which is usually 5 heaper) and allow it to fully ripen in the processing area. This also has the advantage of allowing the daily selection of fruits of equal ripeness. Fresh, Frozen or drained canned fruit can be used. Ripe or slightly over ripe fruits can be used. Incoming fruit should be selected and any unsuitable materials removed front the processing area and properly disposed of not simply put in and open bin outside. Selected fruits that are ripe but not spoiled we can use fruits with minor blemishes and bruises that are not suitable for canning or freezing which remove the imperfections. Then fruits were sorted.

2.4.2 Preparation of fruits for blending

Sorted and selected fruits are washed in chlorinated water (one teaspoon of bleach per gallon of water) and then pare or peel if necessary. ex: banana, papaya, mango etc., pit or core or remove seeds if necessary. If necessary destined those functions depending on the type of fruits. Being used only stainless steel knives should be used as mild steel will corrode and stain the flesh. Some fruits require special attention. Banana has very low level of acidity and is also subjected to what is known as enzymatic browning which results in rapid discoloration after peeling and cutting. After peeling bananas should be quickly immersed in a water containing a small quantity of chemical, Sodium Metabisulphite which control such browning. The solution should have a concentration of 400 parts 6 per million of Sulpher Dioxide. We can used fruits with minor blemishes and bruises that are not suitable for canning or freezing if you remove the imperfection.

2.5 Cooking and Uncooking Methods:

Fruits can be pureed when hot (Hot break method) or when cold (cold break method). The results will be different.

2.5.1 Cooking / Steaming of fruits (Hot break method)

Increasing concerns with bacteria such as Escherichia Coli. Being able to survive the drying process if present. So it is best to heat fruits to 160°C before drying. Preheating also stops the maturing action of enzymes in the fruits. Helps preserved the fruits natural color and speeds the drying process.

2.5.2 Steaming methods / Hot break method

Steaming of fruits can be done in two ways. One is using a double boiler. Other method is using a micro wave oven method. Hot break method retain more of the natural fruit flavor and preserved the light colors of fruits.

2.5.3 Double boiler steaming

Cut fruits into chunks and place in the top of a double boiler to avoid scorching water in the bottom of the boiler and bring to boil. Cover the steam for 15 to 20minutes or until the fruit is soft and a thermometer placed in the fruit mixture registers of at 90°C. Drain off juice well lifting fruit from sides of strainer to allow all the juice to rum out freely more juice that is

strained out, the quicker the process of "leather making will be drain juice or save it to drink. Allow to cool the fruit crunch.

2.5.4 Microwave oven cooking

Fruit crunch can be cooked in the micro eave oven also. Place cut fruits in a glass casserole cover and microwave on full power (high) for 6 to 8 minutes per two cups of fruits stirring every 2 minutes.

2.5.5 Uncooked method\Cold break method

Cold break method is faster. Puree pieces of fruit in a blender, using appropriate speed, or grind in a food mill, using finest blade. Immediately place fruit in the top of a double boiler cover and cool over boiling water 10 minutes.

2.6 Preparation of the batch

Many products mix with semi - ripe banana. This reduce the cost of the product and the high solids of the banana reduce the drying time. Other ingredients such as sugar, nuts, honey, corn syrup etc are added

2.7 Flavoring of the fruit leathers

In many cases the flavor of fruits leathers is improved if the acidity is increased by adding a small amount of lemon or lime juice. Ascorbic acid also can be added to increase the soure taste. Almond extract, lemon juice, lemon peel. lime juice, lime peel, orange extract, Orange juice, Orange peel, Vanilla extract like flavor can be added to increase the flavour of the fruit leather.

FAO and WHO Jointly defined "food additive" as non-nutritive substances added intentionally to food, generally in small quantities, to improve its appearance, flavor, texture or storage properties. Some chemicals added to food to impart a desired quality or for some other functional purpose may be of nutritive value.

2.8 Increase the sweetness of the fruit leather

Sugar, Honey, corn syrup can be added to increase the sweetness. Corn syrup or honey is best for longer storage because it prevents crystals. Sugar is fine for immediate use or short storage. Saccharin based sweeteners could also be used to reduce tartness without adding

calories. Aspartame sweeteners may loss sweetness during drying. Honey makes a stickier leather.

2.9 Improve the taste variation

Small amount of all spices can be added for taste difference. Cinnamon, cloves, coriander, ginger, nutmeg, miii can be added as spice. Start with 1/8 tea spoon for each 2 cups of puree.

2.10 Preserving fruit color

Light color fruit leather (such as apple, banana) tends to darken during drying. We can preserve color by adding lime juice, lemon juice or ascorbic acid according to the following directions.

Ascorbic acid (vitamin C) use one of three methods

I. Crystals - Available from some pharmacies, Add 1/4 tea spoon crystals to 2 cups of puree and mix well.

2. Tablets - Crush 750mg add 2 cups of puree and

3. Commercial mixture containing ascorbic acid

These mixture (often used to prepared fruits for freezing) are not as effective as pure ascorbic acid. Following label instructions fruit juice, adding pineapple juice of lemon juice may help prevent browning. (Orange juice tends to cause browning) The flavour of dried fruit will depend on the type of juice used.

2.10.1 Use of sulphur dioxide ($S0_2$)

Use of Sulphur dioxide ($S0_2$ is a another method that use to prevent browning. $S0_2$ has been widely used in fruit and vegetable products to control enzymatic colour changes such as the darkening of the fresh cut frits. It also acts as a preservative, controlling the growth of moulds and yeasts. $S0_2$ is produced by either burning a small piece of sulplur or by dissolving sodium metahisuiphite in water. The second method is more controllable. The levels of $S0_2$ used are measured in parts per million or ppm. Concentrations of 400 to 1000 ppm are used for dips to control colour changed and retard the growth of moulds and yeasts. A 400 ppm bath for example is made by dissolving 6g of sodium tabisulphite in 10 liters of water.

Rangana and Bajaj (1990) reported that $S0_2$ is widely used throughout the world principally for treating food of plant origin. It is used in the preservation of fruit juices, pulps, beverages

and concentrates; concentration used may vary from 350 to 2000 ppm. Soluble sulphite salts (e.g. KMS) are usually used in treating fruits products. The activity is higher at pH below 4.0.

2.11 Preparation of puree

At the simplest level fruit may be pulped to a puree by hand using a food mill or high speed electronic blender in which the food is pushed through a mesh by a rotating paddle. If electric power is available a food liquidizer, followed by sieving will greatly increase production outputs. At large scale, powered high speed blender wands are recommended. Lab samples can be prepared by using a blender. Cooked or uncooked fruits and other ingredients like sweeten ingredients, colour preserving agents flavours, spices and blend property.

2.11.1 Preserving of fruit puree:

The most convenient production plan for very small producers is to use fruits that are in season at any given time. This does however, have disadvantages that include. One particular flavor of fruit leather may be much more popular that others. It will only be possible to produce small quantities of product in a short season. It is, however, possible to produce all year by preserving prepared fruit (or fruit puree) is sealed drums with added SO_2 at a level of 600 ppm. Fruit may be stored for many months in this way. Intermediate preservation.

Joslyn et al.,(1961) investigated that the effects of length and temperature of storage and the relationship of oxygen, light, sugar, pH and ascorbic acid to deteriorative changes in color or these factors. Storage temperature and oxygen content were the most specific for color injury of both juices and isolated pigments. Adjustment of acidity within the range of pH 2 to 4.5 or sugar addition had little effect on color retention in fruit juices during storage.

2.11.2 Fruit combinations

Combine 2 or more fruits for a unique flavor law sweeten fruits can combine high sweeten fruits like Banana can combine with Strawberry, Pineapple Orange like products. Fruits with strong flavors can combine with fruits with week flavors. High cost fruits can be combine with low cost and available fruits like banana. Fruit combinations make a variety of flavors possible. For example Bananas with strawberries.

2.11.3 Making canned fruit puree

Canned fruit including baby food without tapioca is suitable for fruit leather. Drain whole fruit and puree in a blender, using a appropriate speed, or grinding in a food mill, using the finest blade. Then can concentrate juicy puree.

2.11.4 Leathers from frozen fruits:

Home preserved or store - bought frozen fruit can be used. Drain fruit, save liquid. Use I point of fruit for each 13" x 15" leather purse fruit until smooth. If thick, add liquid add two tea spoons of lemon juice or 1/8 tea spoon ascorbic acid (375 µg) for each 2 cups of light colored fruit to prevent darkening can be dried alone or added to any fresh fruit purse as an extender. It decreases tartness and makes the leather smoother and more pliable.

2.11.5 Concentrating the Puree :

Can concentrate juicy puree to shorten the drying time. Place the ground or pureed fruit in a heavy, deep saucepan (if desired add I table spoon sugar to each 11/4 cups of puree to decrease cooking time) Cook the puree over low heat, stirring constantly, until the mixture thicken. Remove from the heat and cool.

2.12 Preparation of batch:

In many cases the flavor of fruit leathers is improved if the acidity is increased by adding a small amount of lemon juice. Many producers mix fruit with same ripe banana. This reduces the cost of the products and the high solids of the banana reduces the drying time. Other ingredients such as sugar, nuts etc., are added.

2.13 Preparing the tray:

For drying in the oven a 13"x15" cookie pan with edges works well. Line pan with plastic wrap being careful to smooth out wrinkles. Do not use waxed paper or aluminum foil. To dry in dehydrator, specially designed plastic sheets can be purchased or plastic trays can be lined with plastic wrap. Trays with vegetable oil can also be used.

2.14 Pouring the leather:

Fruit leather can be poured into a single large sheet(13" x 15") or into several small sizes. Spread puree evenly about 1/8 inch thick onto drying tray. Avoid pouring purse too close to the edge of the cookie sheet. The larger fruit leather take longer to dry approximate drying times are 6 to 8 hours in a dehydrator up to 18 hours in an oven and I to 2 days in the sun. Any of above puree is poured in a thin layer. approx 3 to 6 mm thick wooden tray or plastic trays can be used. Some procedure carry the whole of the tray and cut the dry product into squares. Spillage of the puree to be avoided two cups of puree is enough to cover a 12 by 17 inch cookie sheet.

Making canned fruit puree:

Canned applesauce and strained baby fruit will not need to be pureed. Other canned fruits will need to be drained and puree in a blander fruit grained or by hand. Canned fruits are already processed which destroyed bacteria and stops enzyme actions. Thus the addition of ascorbic acid or lemon juice is not necessary. Canned fruits such as apple sauce can mixed with more expensive fresh fruits to help stretch the fruit concentrate and soften the flavour of sharp - tasting fruits such as cranberries the addition of apple souse to juicy fruits also easy drying.

2.15 Leather Drying

Normally fruit leathers are dried at (60 —62)°C. Leathers dries from the outside edges toward the center. Test for dryness by touching center of leather, indention should be evident. While warm, peel from plastic and roll allow to cool and rewraps the roll in plastic.

2.16 Methods of drying

There are several methods of drying each has advantages and disadvantages.

a) Sun drying
b) Solar Drying
c) Oven drying
d) Dehydrator Drying
e) Microwave oven drying

2.16.1 Sun drying

Sun drying is depends on the temperature and the relative humidity outside. If the area where the temperature is in 90°C with low humidity and low air pollution, sun drying can be used. A major advantage is low cost. Drying trays need to protect against bugs and the fruits are the only investment. Another possible advantage is the sun's sterilizing effect caused by ultraviolet trays that may slow the growth of some organisms. Sun drying is depended on the weather. It is sunny one day and not the next, you have to finish drying your fruits by one of the other methods before it is spoils. Also when it cools at night you have to bring the food inside. Spoilage can occur while the fruit still has enough moisture for microbial growth. Another disadvantage is time. What would take 6 to 8 hours to dry using another method may take 2 to 4 days in the sun. On plastic wrapped trays or cookie sheets spread fruit into 61/2 circle or rectangle ¼ this cover pans with cheese cloth. Place pans in direct sunlight for 12-24 hours until dry. Fruit leather is done when edges pull back from plastic and center is no longer sticky

2.16.2 Solar drying

Solar drying is like sun drying only things is better. The sun's rays are collected in a solar box, drying temperature is higher and drying time is shortened. With a shorter drying time, microorganisms have less chance to course spoilage. If you don't want to buy or build a solar box, the back window ledge of an automobile where the sun shines through can be used as a solar dryer. Crack the windows slightly to allow some air flow so it does not get too hot. Stack the trays like you would for other methods. Cover the trays so infects don't ruin the foods.

2.16.3 Oven drying

To dry small amounts at one time, the oven drying method is a good choice. There is little or no investment in equipment. You don't have to depend on the weather. Most foods can be dried in an oven. One disadvantage to oven drying is the cost of the energy used. Oven drying takes 2 or 3 times longer to dry foods than a dehydrator. The food dried in an oven is more brittle, usually darker, and less flavor than food dried in a dehydration. Test the temperature of the oven for about one hour with a thermometer. Prop the oven door open as you would when actually drying fruit. The oven should maintain (60 - 62)°C. If the oven can not maintain this temperature, it may not work for drying. If the oven is too hot, your food will begin to cook instead of dry. If it is too cool, it may not dry fast enough and food will spoil. lf

your oven doesn't go this low use lowest setting. If using an oven leave oven door slightly open so air can circulate. Drying time depend on how juicy fruits. Set the oven at the lowest setting (60 - 62) °C place the trays of puree or the oven rack and leave the door open 2 to 6 inches depending on the oven door checked the oven temperature periodically with a thermometer to be sure the air temperature of the oven is at the desired level. If necessary, turn off the oven for a short time to reduce the desired level. The fruit concentrate should dry in 10 to 18 hours. Test frequently for dryness.

2.16.4 Dehydrator drying

Electric dehydrators can be purchased or made. A dehydrator should have a heat source, a thermostat and some method of air-circulation. Dehydrators yield a better quality dried product than any other method of drying. They also allow greater flexibility because they don't depend on the weather or tie up your oven. Follow the directions that come with the dehydrator. Many of the basic principles that apply to oven drying also apply to using a dehydrator. Place heats or trays of fruit concentrate in the dehydrator. Set temperature control at (60 – 62)°C or follow manufactures directions. Test frequently for dryness drying time will be 10 —18 hours.

2.16.5 Microwave oven drying

Lay a piece of microwave safe plastic wrap on a 10 inch microwave safe plate. Evenly spread ¼ cup fruit mixture to a 6/2" diameter circle. Make sure edges are not too thin or they will scorch. Elevate plate on to of inverted (upside down) microwave safe saucer. Microwave or until leather is no longer sticky in center. If more cooking time is needed, cook at medium in 25 second increments, watching closely so that leather does not burn. Carefully place plastic wrap with fruit leather on wire rack to cool. Let stand at room temperature overnight to dry. It is recommended that fruit leathers are not dried in direct sunlight as there will be considerable loss of colour and vitamins A and C. Indirect dryers, either solar or mechanical suitable for drying these products are described in ITDG's Technical brief small scale food dryers. After about dry or so, in a solar dryer, or S hrs, in an artificial dryer, it will be found possible to lift the leather sheet away from the tray. At this stage the product should be turned over and dried on the other side. Prior to packing fruit leathers are frequently lightly dusted with starch to reduce their thickness.

2.17 Test for dryness

Properly dried fruit leather will be translucent and slightly tacky to the touch. But easily peeled from the pan or plastic wrap. Test for dryness by touching the leather in several places, No indication should be evident lift the edge of the leather, which will adhere tightly to the surface and peel it back about an inch. If it peels readily it is properly dried. If the leather has cooled it may need to be warmed in an oven at 150°F for a few minutes to help it peel away more easily. If the leather cracks like chips it has dried for too long but is still edible.

2.18 Packaging of fruit leathers

When leather is dry, lift foil and fruit leather out of baking pan. Remove by holding foil with one hand and peeling fruit leather off with other. Roll up fruit leather from one of the short sides. Then wrap in plastic wrap or waxed paper in one piece. Stone the roll in one piece or cut into 1 inch strips. Place the strips or rolls of leather in a plastic bag glass container paper bag or other container. Until the leather is completely dry the container lid should not be tightened or the bag opening twisted tightly. If the leather has not dried completely it may become stickly or develop mold growth during airtight storage. Normally grease proof papers are used as inner wrappers for leather strips and leather rolls to avoid sticking together. Proper outer wrapper to be selected to reduce moisture absorption and light protection. The product should be clearly labeled stating as a minimum the name of the product Nut weight ingredients list and the name and address of the manufacturer where available self adhesive labels are recommended. Shelf life of the fruit leathers.

EI-Nernr et al., (1989) reported that the freshly prepared and bottled juice was analyzed for various volatile aroma compounds including esters, carboxyl compounds, alcohols and lactose. The bottling process resulted in a sharp decrease in the content of all volatile fractions, especially esters. During subsequent storage, the contents of these fractions, especially alcohols and lactoses, increased to levels higher than those in freshly prepared juice.

Table 3. Summary of information provided by research carried out on fruit leathers:

FRUIT	PRETREATMENT	FORMULATION	DRYING METHOD	COMPLEMENTARY DATA
Papaya	Steaming whole fruit (1 min), peeling, slicing, pulping, acidifying, heat inactivation of enzymes	Papaya puree, sugar (10%w/w), sodium bisulfite (552 – 1105 ppm)	Hot air oven at 74°C (4,5 h), 84°C (3,9 h) and 94°C (3,1 h)	Final product characteristics: pH= 3,5; a_w= 0.50-0.52; m.c.= 12-13% w.b.
Apple	Washing, peeling, coring and pulping	Apple puree (no additives added)	Hot air tray dryer, 90-121°C (3 h) Turbulent air regime	First electron microscope image of fruit leather cross section.
Apple	None	Commercial fruit puree: Apple puree 82%, Apricot puree 16.5%, Apple juice 1.5%	Forced-air circulation cabinet dryer at 70 – 94°C and two stage hot air drying (2 h at 120°C plus 3.22 h at 85°C).	The two stage method reduces total drying time compared with one stage method
Durian	Peeling, Steam blanching (85100°C, 5 min), pulping	Durian puree, sucrose 7%, water 10%, sorbic acid 200 ppm.	Forced-air cabinet dryer, 47°C (8h)	Final product characteristics: pH= 5,8; aw= 0,57; m.c.= 17% w.b. Optimal storage time at 28°C: 12 weeks
Mango	Washing, peeling, pulping and blanching 80°C (5 min)	Mango puree, potassium metabisulfite 2%, soy protein concentrate, skim milk powder, sucrose at tree concentration	Hot air cabinet dryer 60°C; 3.5 m/s	Additives significantly reduced the drying rate of mango leather. Sucrose improved its color and the product containing 4.5% skim milk powder and 4.5% sucrose.

Table 3. Summary of information provided by research carried out on fruit leathers:

FRUIT	PRETREATMENT	FORMULATION	DRYING METHOD	COMPLEMENTARY DATA
Pear	Not described	Commercial pear juice concentrated, corn syrup, pectin and water	Convection oven 70°C; 0.4 m/s (8 h)	Temperature was measured and its value was not useful to predict microbiological attributes but correlated well with some textural parameters. Correlation between instrumental and sensory data was found.
Mango	Washing, peeling, pulping, sieving	Mango puree (no additives added)	Hot air oven 60-80°C	Final product characteristics: pH= 3.8; a_w= 0.62. Minimum drying time (120 min) resulted from drying a puree load of 0.5 g/cm2 at 80 °C.
Strawberry	Not described	Not reported. Commercial fruit leather (product name: School Straps; taste: strawberry; brand name: Sun ripe)	Not reported.	Comparison of Thermal Temperature (-58°C) and Rheological Temperature(-44°C).
Tomato	Washing, cutting, seeds removal and heating 100°C for 5 min	Tomato puree 84.3 g; aqueous solution of polydextrose (44.4%w/w) 12.95 g; highmethoxyl pectin 1 g; citric acid 0.25 g	Hot air tray dryer 60°C; 2 m/s (6.5 h)	Final product characteristics: pH= 3.7; a_w= 0.85; m.c.= 0.42 d.b. Mass-transfer based- mathematical model model for drying

Table 3. Summary of information provided by research carried out on fruit leathers:

FRUIT	PRETREATMENT	FORMULATION	DRYING METHOD	COMPLEMENTARY DATA
Model Pectic gel (From Concentrated orange juice)	Not described	Glucose 14.2%, Fructose 15.8%, Sucrose 27.6%, Citric acid 1.2%, Pectin 2.8%, Water 38.4%	Microwave/vacuum drying on petri dishes (700, 800 W) and hot air dryer 60°C, 4.5 m/s	Comparison of drying rate, isotherms and color change of leathers obtained by both methods
Mango /Guava	Guava: washing, crushing, pulping	Mango leather: canned mango puree, sugar, potassium metabisulfite equivalent to 1000 ppm SO2. Guava leather: guava puree, pectolitic enzyme, maltodextrin, sucrose, pectin, soluble starch, wheat flour, antibrowning agent	Cross-flow hot air dryer at 50°C, 2.5 m/s (18 – 22 h)	The mango leather is made overlapping thin layers of puree on already dried layers. Final Product m.c.= 14-15% w.b.

Chapter-3

METHODS AND MATERIALS

The experiments were conducted in the laboratory of the department of Food Processing and Engineering and Poultry Research and Training Centre lab at Chittagong Veterinary and Animal Sciences University (CVASU).

3.1 Preparation of fruit leathers

For preparing mixed fruit leather at first all of the raw materials were collected then materials were processed and tested for producing final product. All of the processed raw materials were blended and dried in cabinet dryer at 55℃. After producing final product this was stored at normal temperature.

3.1.1 Materials

a) Plastic trays
b) Plastic wrap
c) Packaging materials
d) Pineapple
e) Mango
f) Papaya
g) Sugar
h) Sodium Benzoate
i) Aluminium foil

Equipments:

a) Shallow pans
b) Stainless steel knife
c) Chopped board
d) Balance
e) Stainless steel spoon
f) Electric oven
g) Electric blender(CB-B312P)

3.1.2 Preparation of Mango pulp:

At first mango pulp was prepared for preparing mango pulp fresh ripe mango was taken then mango was washed with potable water for removing dust and foreign particles. Then mango was peeled and cut. After peeling and cutting Mango was blended in electric blender. Then blanching at 80°C for 10min then pulp was cooled for 10 minutes at ambient temperature. Mango pulp was prepared. Prepared pulp need to store at normal temperature.

3.1.3 Preparation of Pineapple juice:

Preparation of Pineapple juice is very much important for leather development. For preparing Pineapple juice fresh ripe Pineapple was taken then Pineapple was washed with potable water for removing dust and foreign particles. Then Pineapple was peeled and cut. After peeling and cutting Pineapple was blended in electric blender. Then blanching at 80°C for 10min then pulp was cooled for 10 minutes at ambient temperature. Pineapple juice was prepared. Prepared juice need to store at normal temperature.

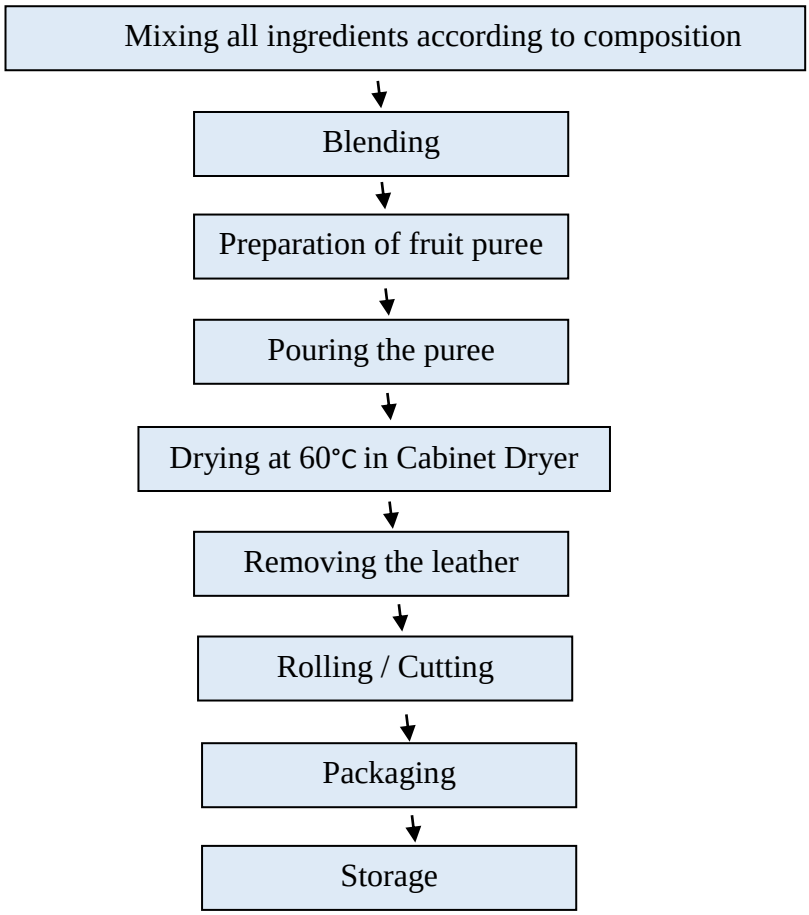
3.1.4 Preparation of Papaya Pulp:

Preparation of Papaya Pulp is very much important for leather development. For preparing Papaya Pulp fresh ripe Papaya was taken then Papaya was washed with potable water for removing dust and foreign particles. Then Papaya was peeled and cut. After peeling and cutting Papaya was blended in electric blender. Then blanching at 80°C for 10min then pulp was cooled for 10 minutes at ambient temperature. Papaya pulp was prepared. Prepared pulp need to store at normal temperature.

3.1.5 Formulation of Mixed Fruit Leather:

Ingredients	Samples			
	F_1	F_2	F_3	F_4
Mango pulp (%)	40	45	48	35
Pineapple pulp (%)	25	19	14	30
Papaya pulp (%)	19	20	22	19
Pectin (%)	1	1	1	1
Sugar (%)	14.75	14.75	14.75	14.75
Sodium benzoate (%)	0.25	0.25	0.25	0.25

3.1.6 Process Flow Diagram for Preparing Mixed Fruit Leather:



Ref: Fruits and Vegetables Preservation: Principles and Practices, R.P Srivastava, Sanjeeb Kumar

Description of Process steps for Preparation of Mixed Fruit Leather:

1. Selecting and Cleaning:

Ripe fruits (Pineapple, Mango and Papaya) were selected. Any unsuitable materials, damaged fruits and spoiled fruits were removed. Selected fruits were washed in potable water and peeled for seeds removal.

2. Mixing:

Product was developed by following formulation. According to formulation all of the raw materials were added.

3. Blending:

All of the materials were added and blended until puree was smooth. Puree was made immediately to avoid excessive browning.

4. Cooking and Steaming:

Blended puree was placed in the top of an induction cookware. Water was added into the bottom. Pan was covered and steamed for 15 - 20 minute until the fruit is soft. Total soluble solid and acidity of the mixed fruit were tested.

6. Pouring the Puree:

Puree was poured on Aluminium foil which was kept on a tray. Puree was poured and spread on Aluminium foil then this puree was transferred in dryer for drying.

7. Drying:

Cabinet dryer Temperature was set at 60°C. Trays was placed on the oven rack. Dryer temperature was checked periodically using a thermometer to sure the air temperature of the dryer was at desired level. If temperature was high dryer was turn off for short time to reduce the temperature. Dryness of the fruit leather was checked periodically after 10hour. Center of the fruit leather was touched and checked the dryness. If fruit puree was not stick with finger leather was peeled from the plastic wrap and turned again upside down.

8. Removing and Cutting:

After 12hour, 13hour, 14hour, 15hour and 16 hourly edges of the leathers were lifted and peeled (removed). Final moisture content, pH value of the product and final weight of the product was tested. Then rolled, cut into strips or pieces. Fruits rolls, fruit strips or pieces were wrapped with laminated metalized Al foil. Selected samples were used for further improvements and other studies.

3.2 Product testing

Ripen and slightly over ripen fruits were selected by removing deteriorated, damaged fruits and unsuitable materials which adhere with fruits.

3.2.1 Test for Raw Materials:

3.2.1.1 Determination of Total Soluble Solid (TSS) for Raw materials:

TSS refers to the total amount of soluble constituents of the juice. Total Soluble Solid of a solution can measure by Index of Refraction. This is measured using a Refractometer.

Materials and Equipment:

- Fruit Puree
- Filter Papers
- Conical Flask
- Refractrometer

Procedure:

Fruit juice was taken one after another on the prism surface of the refractometer. Few drops of mango pulp, Pineapple juice and Papaya pulp samples were kept on the prism surface of the refractometer. Prism surface with the sample was covered by the flap. Above test was repeated three times and average reading was taken for each sample.

3.2.1.2 Moisture Content Determination:

The moisture content of the samples was determined by the standard AOAC method (AOAC, 2003). Firstly, five grams (5 g) of fruit was dried in an air-circulated oven at 105ºC to constant weight. Experiments were performed in three independent runs.

$$MC(\%) = \frac{P_1 - P_2}{P_0} \times 100$$

Where,

MC (%) = Percentage of Moisture Content;

P_1 = Initial weight of the sample + Weight of crucible;

P_2 = Weight of the dried sample + Weight of crucible;

P_0 = Initial weight of sample before drying.

3.2.1.3 Determination of pH:

The pH of samples was measured by the standard AOAC method using a pH meter (AOAC, 2003). Briefly, 10 g of each fruits were suspended in 75 ml of distilled water and allowed to macerate for 30 min. The suspension was filtered and the pH of the dispersion obtained was measured. Experiments were done in three independent runs.

3.2.1.4 Determination of Titratable Acidity:

The Titratable (or total) acidity of samples was estimated by the standard AOAC method (AOAC, 2003). A total 10 g of samples were suspended in 75 ml of distilled water and allowed to macerate for 30 min. Then the mixture was filtered and 10 ml aliquots were titrated with 0.1 N NaOH using phenolphthalein indicators for end-point determination.

$$N(\%) = \frac{n \times v}{V} \times 100$$

Where,

N (%) = Acidity Percentage;

n = Normality of NaOH;

v (ml) = Quantity of 0.1 N NaOH needed for acid titration;

V (ml) = Quantity of flour dispersion.

3.2.2 Test for Final Product:

Physio-Chemical Characteristics analysis

Mineral content analysis

Microbial analysis

3.2.2.1 Physio-Chemical Characteristics analysis:

1. Moisture (%)
2. Ash
3. Fat
4. Protein
5. Fiber
6. pH
7. TSS
8. Acidity as citric acid, %m/m
9. Total sugar

3.2.2.1.1 Determination of moisture content:

The moisture content of the samples was determined by the standard AOAC method (AOAC, 2003). Firstly, five grams (5 g) of leather sample was dried in an air-circulated oven at 105ºC to constant weight. Experiments were performed in three independent runs.

$$MC(\%) = \frac{P_1 - P_2}{P_0} \times 100$$

Where,

MC (%) = Percentage of Moisture Content;

P_1 = Initial weight of the sample + Weight of crucible;

P_2 = Weight of the dried sample + Weight of crucible;

P_0 = Initial weight of sample before drying.

3.2.2.1.2 Determination of total minerals or ash (%):

The ash content of the samples was determined by the standard AOAC method (AOAC, 2003). Briefly, five grams (5 g) of dry leather sample was put into muffle furnace with crucible and ignited at 550ºC for 18 hrs. Experiments were done in three independent runs.

$$AC(\%) = \frac{P_1 - P_2}{P_0} \times 100$$

Where,

AC (%) = Percentage of Ash Content;

P_1 = Weight of the ash + Weight of crucible;

P_2 = Weight of crucible;

P_0 = Initial weight of sample before ashing.

3.2.2.1.3 Determination of Crude Protein by Kjeldahl Method

Crude Protein was estimated by using micro-kjeldahl method. Briefly, ten ml concentrated H_2SO_4, 0.2 g of sample (bun) and three g digestion mixture was taken in digestion tubes. Digestion system was switched on and the initial temperature of 100ºC was set by pressing the temperature controller keys. The temperature controller was reset to 420ºC. Mixture was heated till digested and proper water flow was regulated to ensure absolute removal of acid fumes. After digestion contents were cooled and distillated in classic-DX (VA). Distillation unit was switched on and green indication was ensured. The hose was connected to the steam release outlet and let it to the drain. Boric acid and alkali were filled in the bottles in required quantity. Sample to be digested was loaded and door was closed before switching on the power in control panel. System was ready for operation after receiving ready indication and the programme was selected by pressing 'run' key. Addition of boric acid and alkali was done. The distillate was then titrated with 0.1 N hydrochloric acid (HCl) to determine the ammonia absorbed in boric acid.

$$\text{Crude Protein } (\%) = \frac{14.01 \times (S - B) \times N \times 100}{W \times 1000}$$

Conversion factor of 6.25 was used to calculate percent protein.

Crude Protein (%) = Nitrogen (%) × 6.25

Where,

N = Normality of acid used for titration (0.1 N HCl)

S = Volume of standard acid used for titration (ml)

B = Volume of 0.1 N HCl used for blank (ml)

3.2.2.1.4 Determination of Crude Fat by Continuous Solvent Extraction Method (Soxhlet Apparatus Method)

Crude fat was determined by standard AOAC method (AOAC, 2000) using soxhlet extraction apparatus. Briefly, a weighed amount (2 g) of dried sample was transferred to an extraction thimble dried overnight at 60ºC temperature. The thimble was placed in a Soxhlet extractor fitted with a condenser and flask containing sufficient petroleum ether (BP 60-80ºC). After 6 hrs extraction, thimble was removed from the extraction apparatus and dried in the hot air oven to a constant weight, cooled in a dessicator to room temperature and weighed. Loss of weight of thimble indicated the amount of fat in the sample (bun).

$$\text{Crude Fat (\%)} = \frac{\text{Loss of weight} \times 100}{\text{Weight of Sample (bun)}}$$

Wt. of crude fat = (X-Y) gm

% crude fat = (X-Y) ×100/5×63%

3.2.2.1.5. Determination of Crude Fiber Content

Crude fiber was estimated by standard AOAC method of analysis (AOAC, 2000). Briefly, one g of fat free dried sample was weighed and put in one litre tall beaker and 200 ml of 1.25% H_2SO_4 was added. The solution was kept boiling for 30 minutes under bulb condensors. Beaker was rotated occasionally to mix the content and removed the particles from the sides. Content of the beaker was filtered through funnel. Sample was washed back into tall beaker with 200 ml, 1.25 per cent sodium hydroxide, brought to boiling point and boiled exactly for 30 minutes. All insoluble matter was transferred to the sintered crucible by means of boiling water until it became acid free, washed twice with alcohol, three times with acetone, dried at 100ºC to constant weight, reweighed and ashed in a muffle furnace at 550 ºC

for 1 hr. Crucible was cooled in a dessicator, reweighed and percentage of crude fiber in the samples (Leather) was calculated.

$$\text{Crude Fiber}\ (\%) = \frac{(W_2 - W_3) \times 100}{W_1}$$

Where,

W_1 = Weight (g) of Sample (Leather)

W_2 = Weight (g) of insoluble matter

W_3 = Weight (g) of ash

3.2.2.1.6. Determination of Reducing sugar

Reducing sugar content for prepared sample was determined adopting AOAC (2005) method. The method was as follows:

Reagents:

1. **Fehling's solution A:** Dissolve 69.28 g of copper sulfate in water, dilute to 1000 ml and if necessary filter through No.4 whatman paper.
2. **Fehling's solution B:** Dissolve 346 g of Rochelle salt and 100 g NaOH in water and make up to 1000 ml.
3. **Methylene blue indicator:** Dissolve 1 g methylene blue in 100 ml of water.
4. **45% neutral lead acetate solution:** Dissolve 225 g of neutral lead acetate solution in water and dilute to 500 ml.
5. **22% potassium oxalate solution:** Dissolve 110 g potassium oxalate in water and dilute to 500 ml.

Standardization of Fehling's solution:

10 ml of both Fehling's solution A and Fehling's solution B were mixed together in a beaker. 10 ml of mixed solution was pipette into a 250 ml conical flask and 25 ml distilled water was added to it. Standard sugar solution was taken in a burette. The conical flask containing mixed solution was heated on a hot plate. When the solution began to boil, three drops of methylene blue indicator solution was added to it without removing the flask from 1 kg hot

plate. Mixed solution was titrated by standard sugar solution. The end point was indicated by decolorization of the indicator. Fehling's Factor was calculated by using the following formula:

$$\text{Fehling's Factor (g of inverts sugar)} = \frac{\text{titre X 2.5}}{1000}$$

Preparation of sample:

10gm of sample was mixed with 100ml of distilled water and 5ml of neutral lead acetate solution. Stand for 10minute and homogenized. The blended material was transferred to a 250ml volumetric flask. The volume was made up to the mark with distilled water. The solution was filtered.

Titration for reducing sugar:

10ml of mixed Fehling's solution was taken in a 250ml conical flask and 250ml distilled water was added to it. Purified sample solution (filtrate) was taken in a burette. Conical flask containing mixed Fehling's solution was heated on a hot plate. Three to five drops of methylene blue indicator were added to the flask when boiling started and titrated with solution taken in the burette. The end point was indicated by decolorization of indicator. Percent reducing sugar was calculated according to the following formula:

$$\%\ \text{Reducing sugar} = \frac{I \times D \times 100}{T \times W \times 100}$$

Where,

I = mg of invert sugar required to reduce known volume of Fehling's Solution.

D = Dilution Factor

T = Titration

W = Weight of Sample

3.2.2.1.7 Determination of pH:

pH is the measurement of H+ ion activity. It measures active acidity. pH meter is standardized using standard pH buffers. Use homogenized sample for the determination of pH.

Procedure:

At first sample was homogenized after homogenization the electrode was immersed to ensure that there was adequate contact between probe and samples after that reading was taken when the meter reading was stable. The extreme readings should not differ by more than 0.15 pH units.

3.2.2.1.8. Determination of Titratable Acidity:

The Titratable (or total) acidity of samples was estimated by the standard AOAC method (AOAC, 2003). A total 10 g of samples were suspended in 75 ml of distilled water and allowed to macerate for 30 min. Then the mixture was filtered and 10 ml aliquots were titrated with 0.1 N NaOH using phenolphthalein indicators for end-point determination.

$$N(\%) = \frac{n \times v}{V} \times 100$$

Where,

N (%) = Acidity Percentage;

n = Normality of NaOH;

v (ml) = Quantity of 0.1 N NaOH needed for acid titration;

V (ml) = Quantity of flour dispersion.

3.2.2.1.9. Determination of total soluble solids (TSS):

Hand refractometer was used for determination of TSS. It is based on the principle of total refraction. Few drops of distilled water was placed on the prism. The distilled water reading should be zero then chamber was cleaned with muslin cloth. A drop of sample was placed on the prism. Percentage of dry substance in it read directly at 20°C.

3.2.2.2 Mineral Content (Fe, Mg, Ca, K) Analysis:

Mineral Content was analysis for major minerals which present in raw materials. For minerals wee analysis for final product and the minerals are Iron(Fe), Magnesium(Mg), Calcium(Ca) and Potassium(K).

Analysis of minerals

The contents of Ca, Mg, Fe and K were measured after digestion in HNO_3/H_2O_2 by atomic absorption spectrophotometry (Shimadzu modelAA-7000) similar to a study carried out by AOAC,2016.

Apparatus

A) Atomic Absorption Spectrophotometer (AAS) with air-acetylene burner for flame and appropriate background correction
B) Hollow cathode or electrodeless discharge lamps
C) Microwave oven
D) Teflon digestion vessels 100mL, withstanding a pressure of at least 1.4 MPa
E) Volumetric flask
F) Funnels
G) Plastic bottles
H) Drying oven

Reagents

A) Deionized Water
B) Nitric acid 65% (w/w)
C) Nitric acid 3M
D) Hydrogen peroxide 30% (w/w)
E) Iron Standard solution 1mg/mL, 1.000 g Fe were dissolved in 14 mL water + 7 mL HNO_3 in 1L volumetric flask and dilution was carried out to volume with water.
F) Magnesium Standard solution 1mg/mL, 1.000 g Fe were dissolved in 14 mL water + 7 mL HNO_3 in 1L volumetric flask and dilution was carried out to volume with water.
G) Calcium Standard Solution 1mg/mL, 1.000 g Zn were dissolved in 14 mL water + 7 mL HNO_3 in 1L volumetric flask and dilution was carried out to volume with water.
H) Potassium Standard Solution 1mg/mL, 1.000 g Ca were dissolved in 14 mL water + 7 mL HNO_3 in 1L volumetric flask and dilution was carried out to volume with water.

Procedure

A) Pre-treatment: For analyzing leather, homogenization was carried out using noncontaminaing equipment.

B) Drying: Leather samples were then dried in drying oven at 105^0C to constant weight.

C) Digestion: 0.2 g dry leather samples were weighed into digestion vessel. Then 5 mL HNO_3 and 2 mL 30% H_2O_2were added. Vessels were then closed and placed in holder. Vessel holder then placed in microwave oven and exposed to defined program parameters 250 watts for 3 min, 630 watts for 5 min, 500 watts for 22 min and final 0 watts for 15 min. Then removed digestion vessels from microwave oven and cooled thoroughly before opening them. Vessel were then opened and rinsed down lid and walls into container. The solution were then transferred to 25 mL volumetric flask and dilute to mark with deionized water. Then solution transferred to plastic container. For blank, same procedure was carried out.

D) Dilution: Further dilution for test solution was done with 3M HNO_3.

E) AAS determination: The concentration of Fe, K, Mg and Ca were determined by Flame techniques in AAS.

3.2.4 Microbial Analysis:

1. TVC test
2. Fungal test

Microbial Analysis of the samples was done in the Poultry Research and
Training Centre (PRTC), Chittagong Veterinary and Animal Sciences University,

3.2.4.1. Determination of Total Viable Count for presence of Micro-organisms

Total viable count also known as (TVC) gives a quantitative idea about the presence of microorganisms such as bacteria, yeast, and mold in a sample. To specific, the count actually represents the number of colony forming units (cfu) per gram (or per ml) of the sample. A TVC is achieved by plating dilutions of the culture until 30-300 colonies exist on a single plate. A high TVC count is usually attributable to poor quality. Procedure was followed from Modern Food Microbiology Jay, J.M. (1995)

TVC was done by maintaining following procedure:

Materials Required:

a) Diluents: The diluents recommended for general use is a peptone saline solution of composition 0.1% peptone and 0.85% sodium chloride in distilled water. The solution is referred to as maximum recovery diluents (MRD).
b) Plate count agar (PCA)
c) Food sample
d) Cotton

Others:

a) Pipette
b) Test tubes
c) Glass spreader
d) Wooden rack
e) Incubator

Procedure:

At first a series of test tubes each containing of 9 ml diluents were taken. 50 gram/ml food sample was homogenized in 450 ml diluents and making suspension in a beaker. From the original sample, 1ml was transferred in the test tube no. 1 and mixed thoroughly. Transferred 1 ml from 1^{st} test tube to 2^{nd} test tube and continue up to last one & 1ml discarded from the last test tube. From each test tube 3 petri dishes were taken containing PCA media. Then transfer 0.5 ml mixture from each of the test tube to the corresponding petri dish separately. One pipette should be used for one tube. Tips of the test tube should be touched gently to the media. Diluted samples should be spread over the surface of the media using glass spreader. The petri dishes were marked (sample no, date etc) and kept in incubator in inverted position at 37°C for 2/3 days. After 1 day interval up to 3 days after incubation the colonies were observed. In which plate colony counted are 30-300 should be included and others should be discarded. The three petri dish colony of each tube is counted and made average to them.

Calculation:

Average count will be multiplied to that multiplying factor which results the number of organisms.

If in 10^4dilution average count is 46 then

CFU will be 46×10^4/0.5 ml of sample

$= 2 \times 46 \times 10^4$/ml sample

$= 92 \times 10^4$/ ml sample

3.2.4.2 Fungal test:

Fungal test was done for prepared product. Procedure was followed from Modern Food Microbiology Jay, J.M. (1995)

For fungal test Sabouraud Dextrose Agar and following procedure was used:

Media/ Agar: Sabouraud Dextrose Agar

Agar Preparation:

65gm agar was dissolved in 1litre distilled water. Then boiled it completely it was sterilized by autoclaving at 121 °C for 15 minutes. Then poured it onto the petri dish.

Test procedure:

Just few sample was set up in center of the petri dish then it was incubate at 25 °C for 5 to 7 days after incubation the result was observed.

CHAPTER-4

Results

Composition of Raw Materials:

The mango pulp, Papaya pulp and Pineapple juice was prepared as per the method described in section 3. These was analyzed for TSS, moisture, p^H, acidity. The results are shown in table 4.1.

Table 4.1: Proximate composition of Raw Materials

Quality Parameters	Amount		
	Mango	Pineapple	Papaya
TSS	17.33 ± 0.58^{a}	15.33 ± 1.53^{a}	11.67 ± 1.15^{ab}
Moisture %	74.57 ± 0.62^{b}	87.53 ± 1.35^{a}	85.13 ± 1.75^{a}
p^H	4.64 ± 0.08^{a}	3.7 ± 0.10^{b}	4.71 ± 0.18^{a}
Acidity %	0.80 ± 0.24^{b}	1.74 ± 0.16^{a}	1.20 ± 0.18^{ab}

a-b means different subscript alphabet in each row are significantly different ($p<0.05$) for all raw materials

4.1.1. TSS:

Total Soluble Solid (TSS) measure the sugar content of sugar solution. TSS helps to measure solid concentration. For raw materials TSS was determined. A one way ANOVA showed that the samples were significantly different ($p< 0.05$). Here from the result we can see that TSS content for mango was highest and the value is 17.33 and for Papaya TSS content was lowest.

4.1.2. Moisture:

Moisture analysis was carried out and the result revealed that there were significant variations in moisture among the samples. A one way ANOVA showed that the samples were significantly different ($p< 0.05$). For Pineapple moisture percentage was highest which was 87.53% and the value is lowest for Mango, 74.57%.

4.1.3. P^H:

A one way ANOVA showed that the samples were significantly different ($p< 0.05$).From the result there was difference in pH among raw materials. Highest pH was for Papaya, 4.71 and lowest p^H was for Pineapple, 3.7.

4.1.4. Acidity:

Acidity is a total amount of acid in solution which was determined by titration using a standard solution of Sodium Hydroxide. A one way ANOVA showed that the samples were significantly different ($p< 0.05$). Highest acidity was observed for Pineapple, 1.74% and lowest acidity was for Mango, 0.80%.

Table 4.2: Physico-Chemical Properties of Final Product

Physico-Chemical Characteristics	Amount			
	F_1	F_2	F_3	F_4
Moisture	10.33 ± 0.25^{b}	11.43 ± 0.31^{ab}	13.33 ± 0.31^{b}	10.25 ± 0.15^{b}
Protein	3.58 ± 0.10^{a}	1.85 ± 0.07^{b}	1.78 ± 0.09^{b}	1.78 ± 0.18^{b}
Fat	0.03 ± 0.00^{a}	0.03 ± 0.00^{a}	0.03 ± 0.00^{a}	0.03 ± 0.00^{a}
Reducing Sugar	10.66 ± 0.05^{a}	11.35 ± 0.04^{a}	10.43 ± 0.03^{a}	9.55 ± 0.03^{a}
Ash	1.78 ± 0.03^{a}	1.71 ± 0.04^{a}	1.64 ± 0.18^{ab}	1.51 ± 0.08^{b}
Fiber	6.02 ± 0.04^{b}	6.02 ± 0.02^{b}	6.13 ± 0.02^{b}	6.14 ± 0.03^{b}
TSS	37 ± 1^{a}	29.67 ± 0.58^{b}	30 ± 1^{ab}	35 ± 1^{ab}
P^H	4.25 ± 0.03^{ab}	4.59 ± 0.02^{a}	4.19 ± 0.02^{b}	3.96 ± 0.01^{b}
Acidity	2.36 ± 0.01^{b}	2.20 ± 0.01^{c}	2.46 ± 0.01^{b}	2.81 ± 0.01^{a}

a-b means different subscript alphabet in each row are significantly different ($p<0.05$) for all raw materials

4.2.1 Moisture:

Moisture analysis was carried out and the result revealed that there were significant variations in moisture among the samples. Considering the data on moisture, the highest observed value was in case of sample F_3 which was 13.33. The lowest preference in terms of moisture was in case of sample F_1 which was 10.25. Moisture is a very important for preservation of food products. If drying time is less then moisture content is high. Beside this if moisture content of raw material is high then moisture content of final product is also high (Giner S. A. 2008).

4.2.2 Protein

A one way ANOVA showed that the samples were significantly different ($p< 0.05$). It is apparent from the result that there was highly significant difference in terms of protein of the mixed fruit leather. The result indicates that the protein of the sample F_1 was in highest (3.58). The lowest preference in terms of protein was in case of sample F_3 (1.78) and F_4 (1.78).

4.2.3 Fat:

A one way ANOVA showed that the samples were significantly different ($p< 0.05$). Fat percentage was very low in leather samples. Leather sample was prepared with combination of three fruits sample. Fruits contain very low fat which we can ignore. The fat percentage of all samples were only 0.03%.

4.2.4 Reducing Sugar:

In case of Reducing sugar, a one way ANOVA showed that the samples were significantly different ($p< 0.05$). The samples showed that sample F_2 (11.35) possesses highest value and the lowest value was obtained for the sample F_4 (9.55).

4.2.5 Ash:

From the result there was difference in ash among four samples. The result exhibits that the ash of the sample F_1 (1.78) was in the highest position. The lowest preference in terms of ash was in case of sample F_4 (1.51).

4.2.6 Fiber:

From the result there was difference in fiber among four samples. The result exhibits that the fiber of the sample F_1 and F_2 (6.02) was in lowest position. The highest preference in terms of fiber was in case of sample F_4 (6.14).

4.2.7 Total soluble solid (TSS):

A one way ANOVA showed that the samples were significantly different ($p< 0.05$). From the result there was difference in fiber among four samples. The result exhibits that the TSS of the sample F_3 (29.67) was in lowest position. The highest preference in terms of TSS was in case of sample F_4 (37.00). TSS is very much important for product preparation if TSS is low then drying time of product reduce TSS of another two samples are 32 and 29.67.

4.2.8 pH:

A one way ANOVA showed that the samples were significantly different ($p< 0.05$). From the result there was difference in pH among four samples. The result exhibits that the pH of the sample F_4 (3.96) was in lowest position. The highest preference in terms of pH was in case of sample F_2 (4.59). pH of another two samples are 4.19 for the sample F_3 and 4.25 for the sample F_1.

4.2.9 Acidity:

A one way ANOVA showed that the samples were significantly different ($p< 0.05$). From the result there was difference in Acidity among four samples. The result exhibits that the acidity of the sample F_4 (2.81) was in highest position. The lowest preference in terms of acidity was in case of sample F_1 (2.13). Acidity of another two samples are 2.20 for the sample F_2 and 2.46 for the sample F_3.

Table 4.3: Mineral Content(Fe, Mg, Ca, K) in Final Product

Minerals	Amount			
	F_1	F_2	F_3	F_4
Iron(mg)	0.16 ± 0.01^{ab}	0.13 ± 0.01^{b}	0.17 ± 0.01^{a}	0.13 ± 0.01^{b}
Magnesium(mg)	6.01 ± 0.03^{b}	6.32 ± 0.01^{ab}	6.62 ± 0.01^{b}	6.62 ± 0.00^{a}
Calcium(mg)	9.12 ± 0.13^{b}	9.71 ± 0.04^{b}	11.8 ± 0.09^{a}	10.3 ± 0.02^{ab}
Potassium(mg)	54.62 ± 0.09^{b}	60.22 ± 0.11^{a}	55.11 ± 0.07^{b}	56.9 ± 0.56^{ab}

a-b means different subscript alphabet in each row are significantly different ($p<0.05$) for all raw materials

Mineral content of this product was high. The major minerals which were present in final product were Iron, Magnesium, Calcium and Potassium. From result we can see that Potassium content was highest and Iron content was lowest for leather sample. This mineral content was varied for both raw materials composition and Composition for Preparing Four Samples.

4.4 Microorganism test

Due to the least amount of preservative products had comparatively short shelf life of samples. Fungal test was seen positive for the samples. That means, yeast, mold and fungus was grown in sample. TVC test was negative in the samples.

Table 4.4: Microorganism test for All Samples

Name of the Test	F_1	F_2	F_3	F_4
TVC	negative	negative	negative	negative
Fungal	Positive	positive	positive	positive

Chapter-5

DISCUSSIONS

The type of ingredients and their appropriate levels in the formulation are crucial to the development of an acceptable product (Singh et al., 2008). The proximate analysis of the developed leathers in this study showed that the products in this study contains comparatively high level of protein. Mineral content is also high due to the raw materials use for producing fruit leathers.

Moisture content of the product was varied for four samples. The highest moisture content was for F_3 which was 13.33 and lowest was for F_4 which was 10.25 The moisture result of the developed product was agreed with the reported by Rajani et.al.,(2008) This low moisture helps to store product for long time. Physico-Chemical content of the final product mainly depends of the raw materials used. Protein content was comparatively low due to raw materials used. Protein was highest for F_1(3.58) and lowest for F_4(1.78). Fat content was very much low for the leather sample which was 0.03 the result was agreed with the reported by Sreedam, 2011. Reducing sugar content was highest for F_2 sample which was 11.35 and lowest for F_4 which was 9.55. Ash content was agreed with Sreedam, 2011 which was 1.71 for F_2 sample. Fiber content was also varied for raw materials use fiber content was comparatively high. Highest fiber was for F_3(6.14) sample. TSS content of the sample was agreed with Rajani et.al.,(2008). In his result TSS was 36.82 which was almost same as this result for F_1 sample where the result was 37. P^H and Acidity are reverse to each other P^H content was lowest for F_4 sample(3.96) where acidity content was highest for F_4(2.81).

Mineral content of this sample was high. Major minerals Which were present in raw materials were tested. The major minerals were Iron, Magnesium, Calcium and Potassium. From these Potassium was the highest. Potassium is an important component of cell and body fluids, helps controlling heart and blood pressure. Comparetively Calcium content was also high Calcium is a major mineral which helps form and maintain healthy teeth and bone. Magnesium content was also high. Highest amount was for sample F_3 Magnesium helps to maintain normal nerve and muscle function, support a healthy imune system. Iron content was low in this sample.

From the above composition and from microbial analysis shelf life of the leather sample will high for sample F_4. Because in F_4 moisture content was low, microbial contamination was absent. But in other three samples microbial contamination was high this was due to high sugar content (Barooah, S. 1987).

In fruit leather vitamins, minerals and bioactive compounds are high as fresh fruits and vegetables are known to be excellent sources of energy, minerals, vitamin and bioactive compounds (phenolics, carotenoids). In those days children do not want to take several nutritious fruits and vegetables if it is possible to develop this type of products then children will take it willingly and they can get easy nutrition from this type of products.

Chapter-6

CONCLUSION

Some products are preferred by all classes of people. Leather is such kind of product which is preferred by all classes of people as a good desert. If this type of product can develop by using several fruits then it becomes a nutritious food as low temperature drying process is used for preparing this. Attempt was given to produce fruit leathers with sugar without any colors or any other preservative (only Sodium Benzoiate was used). So, this product is safe for the consumption. Pectin in Papaya, Pineapple and mango was act as a binding agents. Sugar was the sweetener of the fruit leather. Steaming also helped to retard the microbial load and prevent the enzymatic browning. Mainly Mango and Papaya were given the sweet taste and pineapple was improved the sour taste of the product. Fat percentage is very low than other products. So, the products provide low calories. Fiber content was comparatively high. High fiber diet is more important for digestion and absorption. Mineral content was comparatively high due to raw materials.

Cost per unit product is also less. So, it can be easily marketed. Slightly over ripen fruits can be used and can be prevented the wastage. According to the above all, fruit leathers are low caloric, healthy and nutrition rich Product. Low cost easy and very simple method that can be done in domestically. So, this recipe can be recommended for making of quality mango, pineapple and papaya mixed fruit leather.

Chapter-7

SUMMARY AND SUGGESTIONS FOR FURTHER WORK

The present investigation entitled as “Preparation, Quality Evaluation & Storage Stability of Mixed Fruit Leather” Was carried out in the laboratory of the department of Food Processing and Engineering and Poultry Research and Training Centre lab at Chittagong Veterinary and Animal Sciences University (CVASU).

The Main objective of the present investigation were to standardize the blend ratio of Mango, Pineapple and Papaya pulp for preparation of better quality mixed fruit leather and to find out its acceptability during storage. The investigation was carried out with several treatment combinations consisting of four (4) different ratios of mango, pineapple and papaya pulp (F_1 to F_4). Composition for these four samples was F_1(40% Mango + 25% Pineapple + 18.75% Papaya + 14% Sugar + 1% Pectin + 0.25% Sodium Benzoate), F_2(40% Mango + 25% Pineapple + 18.75% Papaya + 14% Sugar + 1% Pectin + 0.25% Sodium Benzoate), F_3(40% Mango + 25% Pineapple + 18.75% Papaya + 14% Sugar + 1% Pectin + 0.25% Sodium Benzoate), F_4(40% Mango + 25% Pineapple + 18.75% Papaya + 14% Sugar + 1% Pectin + 0.25%). Product was developed according to the composition and then chemical, microbial and nutritional analysis was done.

Suggestions for further work :-

The following suggestion are made for future research work on the basis of present studies :-

1) The present investigation may be repeated for the conformation of the results.

2) Variation in sugar and acid concentration must be tried with best fruit pulp ratio.

3) Large scale preparation of Mango, Pineapple and Papaya mixed fruit leather can be proposed as it will make the availability of both fruits in off season and it contains high nutritive value.

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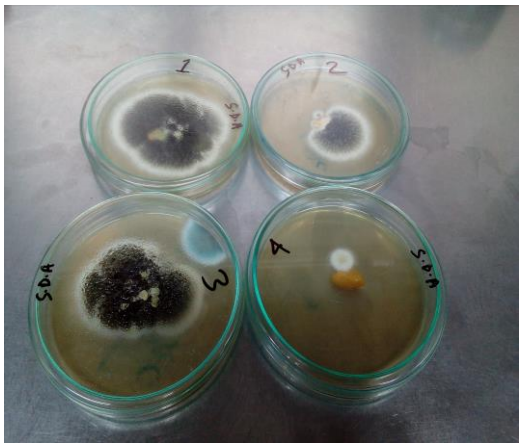
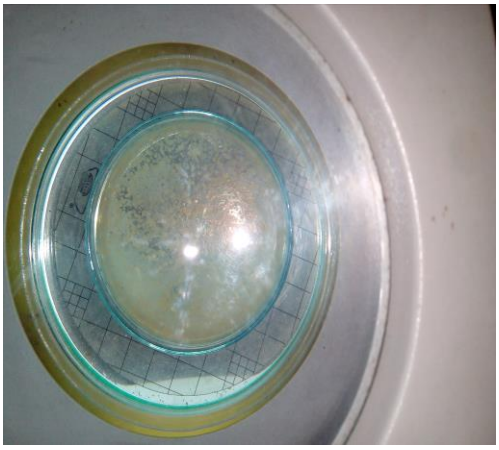
Appendix A

Photo Gallery

Final Product of Laboratory Processed Mango Leather



Fungal Test



Test for TVC

Filtration for Reducing Sugar test

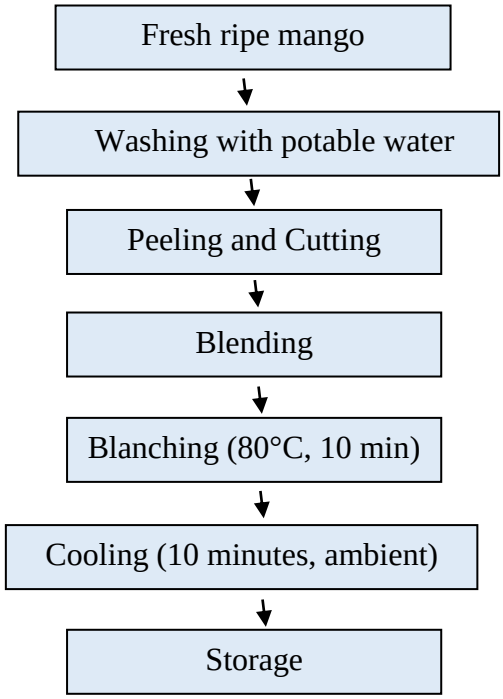
Solvent in Volumetric Flask for Reducing Sugar test

p^H test

TSS test in Refractometer

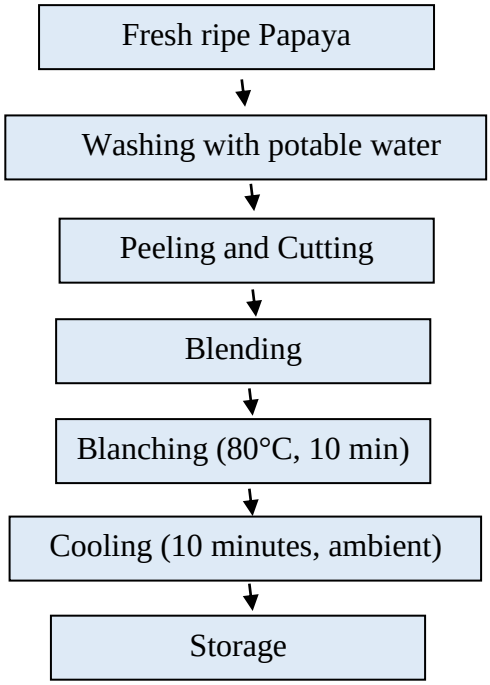
Appendix B: Process flow diagram for preparation of Mango Pulp, Papaya Pulp and Pineapple Juice

Process Flow Diagram for Preparation of Mango Pulp:

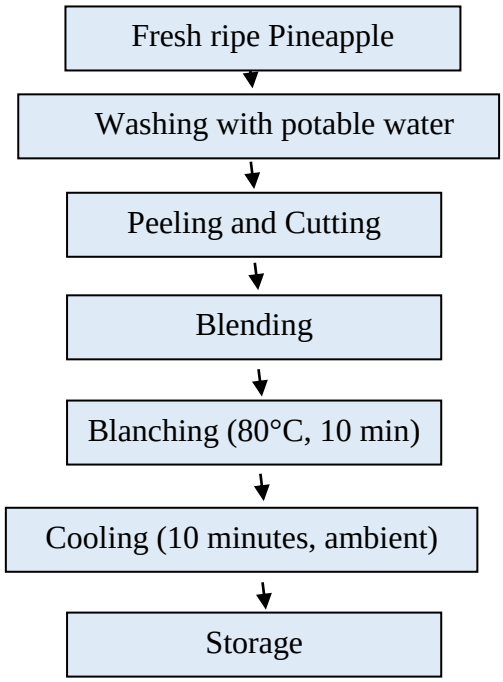


Ref: Fruits and Vegetables Preservation: Principles and Practices, R.P Srivastava, Sanjeeb Kumar

Process Flow Diagram for Preparation of Papaya Pulp:



Process Flow Diagram for Preparation of Pineapple Juice:



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BRIEF BIOGRAPHY

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