FRUIT JUICE PROCESSING

Introduction

•A wide range of drinks can be made using extracted fruit juice or fruit pulp as the base material.

•Many are drunk as a pure juice without the addition of any other ingredients, but some are diluted with sugar syrup.

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•The types of drink made from fruit can be separated into two basic types;

- •- those that are drunk straight after opening
- •- those that are used little by little from bottles which are stored between use

Types of Fruit Juices

Type	Description
Juices	Pure fruit juice with nothing added
Nectars	Normally contain 30% fruit solids and are drunk immediately after opening
Squashes	Normally contain at least 25% fruit pulp mixed with sugar syrup. They are diluted to taste with water and may contain preservatives
Cordials	Are crystal-clear squashes
Syrups	Are concentrated clear juices. They normally have a high sugar content

Each of the above products is preserved by a combination of natural acidity, pasteurisation and packaging in sealed containers. Some drinks (syrups and squashes) also contain a high concentration of sugar which helps to preserve them.

Method of production

For all the fruit based beverages, the first stage is the extraction of juice or pulp from the fruit. The following are the key manufacturing stages:

Selection and preparation of raw material
Juice extraction
Filtration (optional)
Batch preparation
Pasteurisation
Filling and bottling.

Any fruit can be used to make fruit juice, but the most common ones include pineapple, orange, grapefruit, mango and passion fruit. Some juices, such as guava juice, are not filtered after extraction and are sold as fruit nectars.

Preparation of raw material

•Select mature, undamaged fruits. Any fruits that are mouldy or under-ripe should be sorted and removed.

•Wash the fruit in clean water. It may be necessary to chlorinate the water by adding 1 tablespoon of bleach to 5 litres of water.

•Peel the fruit and remove stones or seeds. If necessary, chop the fruit into pieces that will fit into the liquidiser or pulper. Remember that at this stage, you are exposing the clean flesh of the fruit to the external environment.

•Make sure that the utensils are clean.

•Do not leave the cut surfaces exposed to the air for long periods of time or they may start to turn brown and this will discolour the juice. The fruit pieces can be placed in water that contains lemon juice (250ml lemon juice per litre of water) to stop them browning.

Juice extraction

There are several methods to extract juice depending on the type of fruit you use.

For citrus fruits which are naturally juicy, the best option is to use a hand presser (see figure 1) or a revolving citrus 'rose'.

Some fruits such as melon and papaya are steamed to release the juice.

Apples are pressed and

Fruits such as mango, guava, sour sop, pineapple, strawberry must be pulped to extract the juice. The fruit pieces are pushed through a perforated metal plate that crushes and turns them into a pulp.

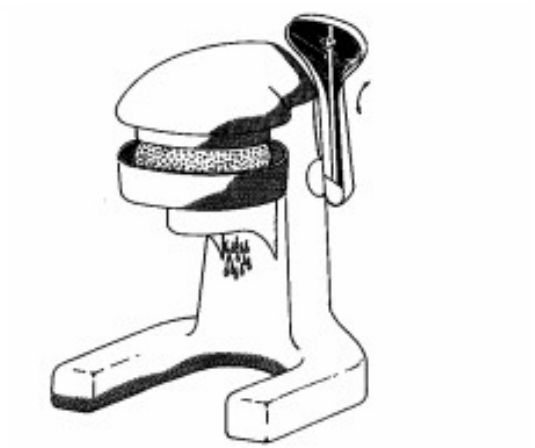


Figure 1: Hand presser

•Some fruits can be pulped in a liquidiser and then filtered to remove the fruit pieces. There is a range of equipment available that varies in size and in the type of power supply (some are manual while the larger ones require electricity).

•For the small scale processor, the Mouli Legume or a hand-powered pulper/sieve which force the fruit pulp down through interchangeable metal strainers (figures 2 and 3) is sufficient.

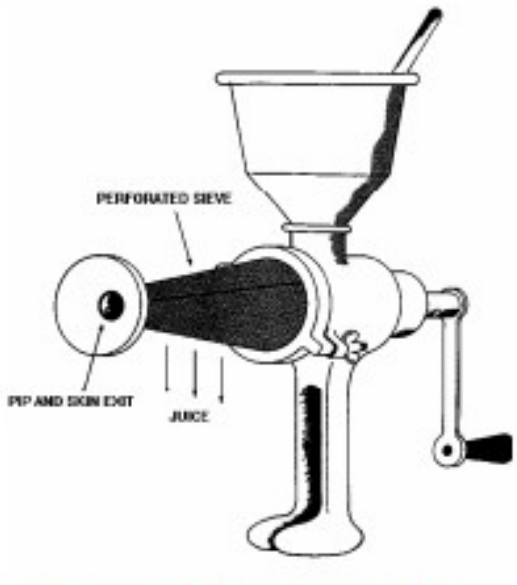


Figure 2: Hand powered pulper


Figure 3: Hand powered pulper

Filtering

- To make a clear juice, the extracted juice or pulp is filtered through a muslin cloth or a stainless steel filter.

- Some of the larger filter presses have a filter included.

- Although juice is naturally cloudy, some consumers prefer a clear product.

- It may be necessary to use pectic enzymes to break down the pectin and to help clear the juice. Pectic enzymes may be difficult to find and expensive and therefore should only be used if really necessary and readily available.

Batch preparation

•When the juice or pulp has been collected, it is necessary to prepare the batch according to the chosen recipe.

•This is very much a matter of choice and judgement, and must be done carefully to suit local tastes. Juices are sold either pure or sweetened.

Fruit squashes would normally contain about 25% fruit material mixed with a sugar syrup to give a final sugar concentration of about 40%.

Squashes are diluted with water prior to use and, as the bottle is opened, partly used and then stored, it is necessary to add a preservative (for example 800ppm sodium benzoate).

Another popular product is fruit nectar, which is a sweet mixture of fruit pulp, sugar and water which is consumed on a 'one shot' basis. Essentially, these consist of a 30% mix of fruit pulp and sugar syrup to give a final sugar level of about 12-14%.

The Pearson Square

The Pearson Square is a method that processors can use to calculate the amounts of two components that should be mixed together to give a final known concentration.

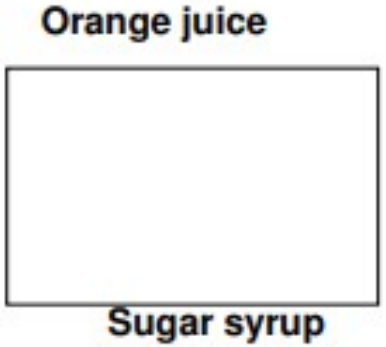
For example, it can be used to calculate the amounts of fruit pulp and sugar syrup to make a fruit drink.

The method can only be used for blending two components. When more than two components are involved, it becomes more complex.

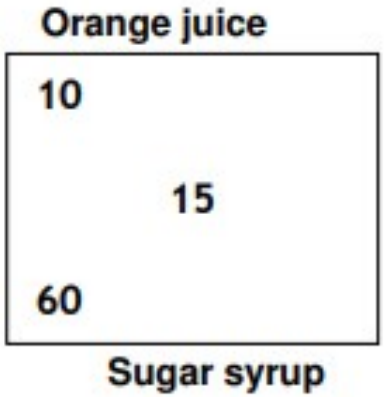
Example of how to use the Pearson Square

You wish to produce a sweetened fruit juice with a final sugar content of 15%. You use orange juice (that contains 10% sugar), mixed with a 60% sugar syrup (that contains 60% sugar).

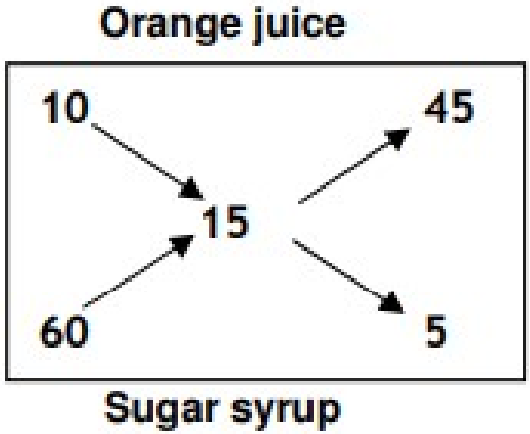
1. Draw a rectangle and label the two horizontal lines with the names of the two products to be blended (fruit juice and sugar syrup)



2. Enter the sugar composition of each product in the rectangle as shown below and put the desired final concentration of sugar in the centre of the box:



3. Mix the two components by crossing diagonally through the centre of the rectangle.



4. Following the arrows, subtract the smaller number from the larger one to give two new numbers (45 and 5) in the opposite corners of the rectangle. These numbers (45% orange juice and 5% sugar syrup) are the amounts that need to be mixed to give a fruit drink with a final sugar concentration of 15%.

Pasteurisation

- All the products mentioned above need to be pasteurised at 80-95°C for 1-10 minutes prior to hot-filling into bottles.

- At the simplest level, this may be carried out in a stainless steel, enamelled or aluminium saucepan over a gas flame, but this can result in localised overheating at the base of the pan, with consequent flavour changes.

All fruits contain sugar, usually around 8-10%. The actual levels vary from fruit to fruit and with the stage of ripeness of the fruit.

The Pearson Square is a useful tool to use to help with batch formulation (see the appendix) and to calculate the amount of sugar to be added for preservation.

Another option is to pasteurise the juices once they have been bottled. The bottles are placed in a hot water bath which is heated to 80°C. The bottles are held in the hot water for the given amount of time until the contents reach the desired temperature.

Bottle size (litres)	Pasteurisation time at 80°C (minutes)
0.33	10
0.5	15
0.75	20

Table 1: Pasteurisation times at 80°C for different bottle sizes

Benefits	Problems
Juice is pasteurised within the bottle so the chance for re-contamination of the juice is reduced	Difficult to ensure the internal temperature of the bottles reaches the desired pasteurising temperature
No need for large stainless steel pans for pasteurisation	Require glass bottles for pasteurising

Table 2: The pros and cons of pasteurising within after bottling

The next industrial jump in pasteurisation is an expensive option that involves the purchase of a double-jacketed steam kettle in stainless steel and a small boiler.

Filling and bottling

In all cases, the products should be hot-filled into clean, sterilised bottles.

A stainless steel bucket, drilled to accept a small outlet tap, is a very effective bottle filler. The output can be doubled quite simply by fitting a second tap on the other side of the bucket.

After filling hot, the bottles are capped and laid on their sides to cool prior to labelling.

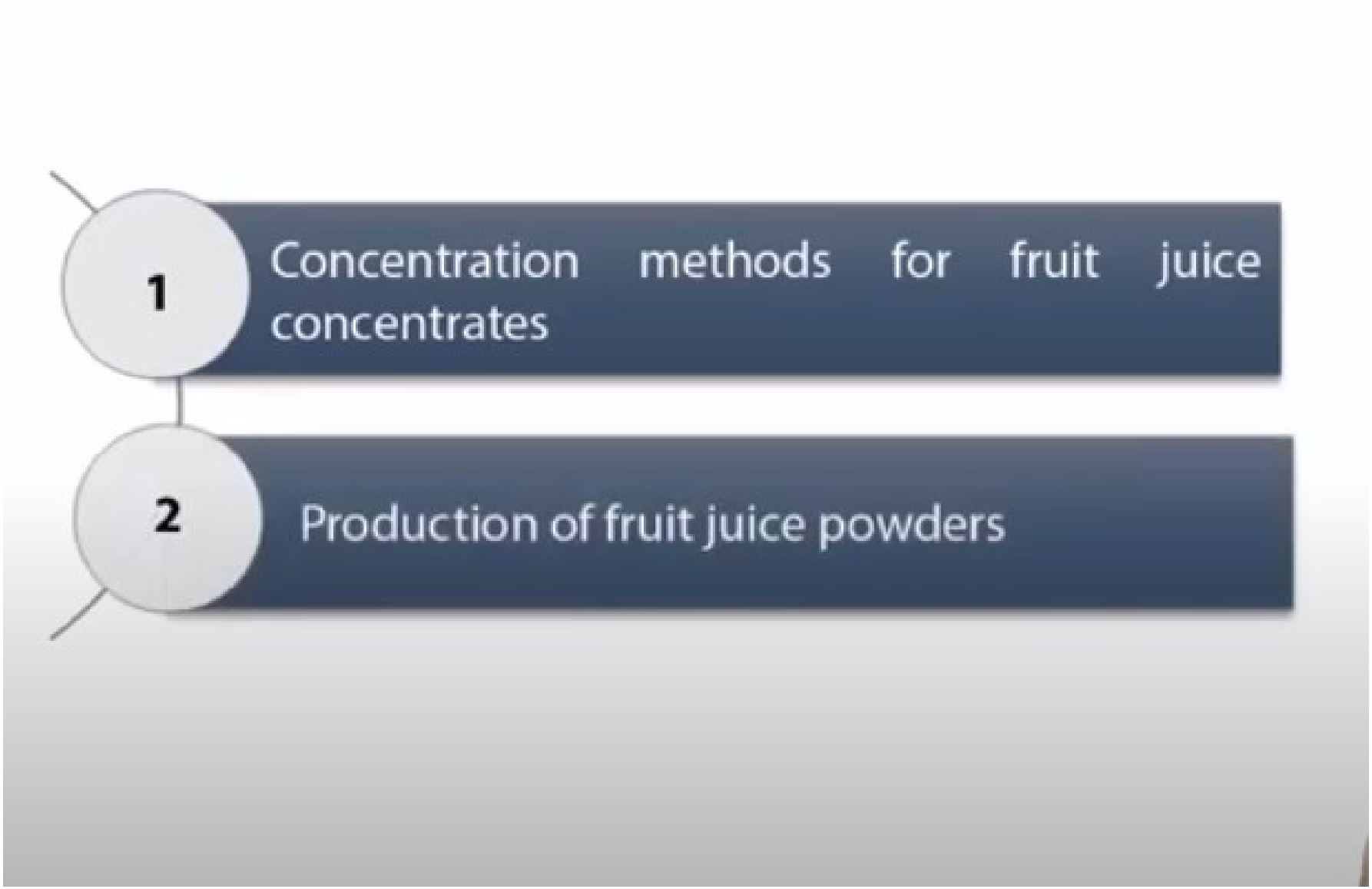
Quality control

- Only fresh, fully ripe fruit should be used; mouldy or insect damaged fruit should be thrown away. All unwanted parts (dirt, skins, stones etc) should be removed.
- All equipment, surfaces and floors should be thoroughly cleaned after each day's production.
- Water quality is critical. If in doubt use boiled water or add one tablespoon of bleach to 5 litres of water to sterilise it. If water is cloudy, a water filter should be used.
- Pay particular attention to the quality of re-usable bottles, check for cracks, chips etc and wash thoroughly before using. Always use new caps or lids.
- The concentration of preservative should be carefully controlled for correct preservation of squashes and cordials, and may be subject to local laws. Check first and use accurate scales to measure the preservative.
- The temperature and time of heating are critical for achieving both the correct shelf life of the drink and retaining a good colour and flavour. A thermometer and clock are therefore needed.
- The correct weight should be filled into the bottles each time.

Compound	Comments	Commonly used levels
Sulphites and sulphur dioxide	Sulphur dioxide gas and the sodium or potassium salts of sulphite, bisulphite or metabisulphite are the most commonly used forms. Sulphurous acid inhibits yeasts, moulds and bacteria. Sulphur dioxide is mainly used to preserve the colour of fruits during drying.	0.005-0.2%
Sorbic acid	Sorbic acid and sodium and potassium sorbate are widely used to inhibit the growth of moulds and yeasts. The activity of sorbic acid increases as the pH decreases. Sorbic acid and its salts are practically tasteless and odourless in foods when used at levels less than 0.3%.	0.05-0.2
Benzoic acid	Benzoic acid, in the form of sodium benzoate is a widely used preservative. It occurs naturally in cranberries, cinnamon and cloves and is well suited for used in acid foods. It is often used in combination with sorbic acid at levels from 0.05-0.1% b y weight.	0.03-0.2%
Citric acid	Citric acid is the main acid found naturally in citrus fruits. It is widely used in carbonated beverages and as an acidifier of foods. It is a less effective anti-microbial agent than other acids.	No limit

Table 3: Permitted preservatives used in fruit juices and beverages.

Production of fruit juice concentrates and powders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Concentration methods for fruit juice concentrates
2
Production of fruit juice powders

Production of Fruit Juice Concentrates

Fruit juice concentrate is now a well-known product in the market which can be produced after removal of certain proportion of water from juice mostly by simple evaporation, freezing or other acceptable and economically feasible processes.

The consumers are moving away from the alcoholic products to healthier fruit juice based products or products formulated incorporating fruit juices.

Consumers are demanding healthier options while at the same time have increased concerns about food safety risks, two trends that may often conflict with each other in juice concentrate processing.

Production of Fruit Juice Concentrates

The following steps are generally followed properly for the concentrate preparation from fresh juice-

Preparation steps (reception, washing, stem elimination, selection)

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Liquid extraction (chopping, preparation, pressing, diffusion, deaeration)

↓

juice Clarification (Straining, filtering, clarification)

↓

Concentration (evaporation, freezing, reverse osmosis)

↓

Filling + heat treatment (pasteurization, sterilization)

↓

Storage or further processing (drying)

Production of Fruit Juice Concentrates

Peeling is done if required.

For some fruits pitting is also done which is employed to remove the pits from cherries, peaches, apricots, olives, and plums.

Mechanical expression is a widely used process for extracting fruit juices, in which high pressures are applied to fruits using a pressing action to rupture cell walls and express juices.

Before concentrating of natural fresh juice it should be clarified and filtered properly, however opal juice can also be concentrated.

Production of Fruit Juice Concentrates

- Along with sterilization is also done for some fruits which consist of five unit processes:
  - Filling,
  - Exhausting,
  - Sealing,
  - Heat sterilization, and
  - Cooling.
- Pasteurization is a mild thermal treatment process used for liquids, such as fruit and vegetable juices, in which the liquids are heated to below 100°C and product is hold for sufficient time to destroy the all possible pathogenic organisms.
- Cold storage and frozen storages are involved for the storage of products at specific temperatures at several stages of fruit processing.

Concentration Methods for Fruit Juice Concentrate

The main aim of concentrate production is to increase the total solid or dry matter content by removal of certain proportion of water.

Products have longer shelf life and easy to handle or store.

The methods mostly used for production of fruit juice concentrate are- **(i) evaporation (ii) freezing and (iii) membrane filtration.**

Concentration Methods for Fruit Juice Concentrate

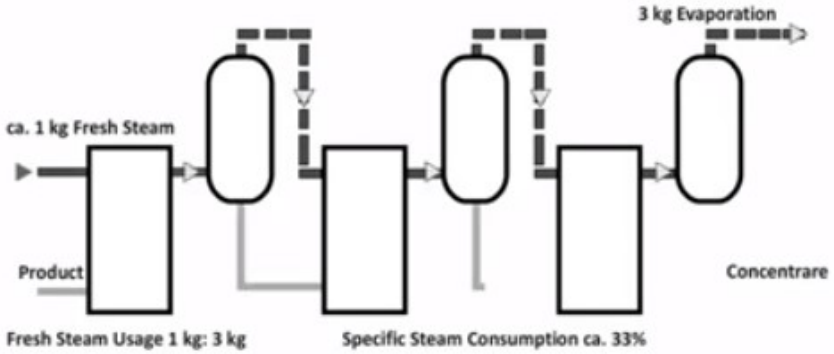
Evaporation

- This is the most popular concentration method for the food products.
- Concentration by evaporation of water is performed in steam heated evaporators where steam provides the energy required for evaporation.
- Water evaporated during this process is then exhausted out from the system and condensed.
- To take care of the heat sensitive valuable component of products, evaporation is done at low boiling point and under vacuum.
- To minimize energy cost or for better steam economy and continuous operation usually more numbers of effects are applied in sequence that means continuous type multiple effect evaporators are used instead of single effect or simple evaporator.

Concentration Methods for Fruit Juice Concentrate

Evaporation

- The evaporation processes in different type evaporators have been shown in figures below.
- Evaporators should be chosen according to the juice properties because during condensation process those properties play important role.



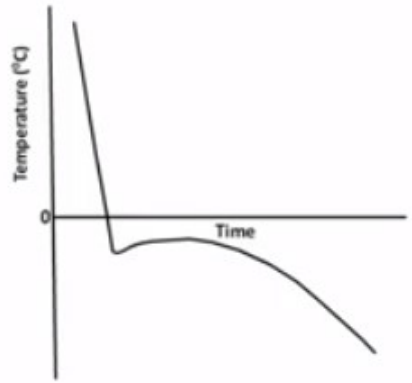
Multiple (Triple) Effect Evaporation

(Source: Handbook of Fruits and Fruit Processing by Y.H.Hui)

Concentration Methods for Fruit Juice Concentrate

Concentration by Freezing

- Concentrate can be prepared by freezing of the watery portion of juice.
- By freezing ice crystals of clean water forms which means loss of solvent and formation of more concentrated solution.
- At first stage the removal of sensible heat from the food and then at next stage removal of the latent heat of fusion leading to a change of state and the formation of ice crystals.
- High energy consumption and lower concentration efficiency are the major disadvantages of this process.



Concentration Methods for Fruit Juice Concentrate

Membrane Filtration (mainly Reverse Osmosis)

- This membrane is a barrier which allows some of its components to pass through the membrane, some cannot.
- The stream containing components passing through the membrane is called permeate (or filtrate) and stream containing the retained materials is called retentate (or concentrate).
- By this pressure driven process concentrates up to 30 Brix can be produced.
- Mainly reverse osmosis is used for this purpose however microfiltration, ultrafiltration and nanofiltration can also be used.

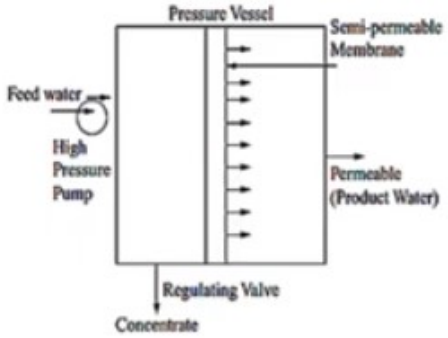


Fig.5. Reverse Osmosis

(Source: Handbook of Fruits and Fruit Processing by Y.H.Hui)

Concentration Methods for Fruit Juice Concentrate

Membrane Filtration (mainly Reverse Osmosis)

Apart from the above process low-temperature vacuum evaporation is also popular in the field of concentration of heat sensitive commodities like juice, milk etc.

Concentration is performed in a liquid-filled container under reduced pressure which is at lower value than the vapour pressure of the liquid, causing the liquid to evaporate at a lower temperature hence dry matter content increase in the remaining product.

Concentration Methods for Fruit Juice Concentrate

Examples of different fruit juice concentrate products

- **Orange juice** concentrate is generally prepared by removing most of the water (juice contain 85-90% water) either from fresh and pasteurized single-strength juice or from a stored and pasteurized single-strength juice.
- Multiple effect falling film type evaporator is mostly used for this type of concentrate preparation.
- **Lime juice**, **grapefruit juice**, **lemon juice** can also be concentrated using freeze concentration and vacuum evaporation methods.
- **Cranberry juice**, black currant and gooseberry juice involves reverse osmosis and evaporation etc.

Concentration Methods for Fruit Juice Concentrate

Examples of different fruit juice concentrate products

- **Guava juice** concentrate is generally prepared by falling film, rising film evaporator.
- Guava juice concentrate is suitable for drying it to guava juice powder as well as for the preparation of RTS beverages.
- **Mango Juice** Concentrates can be produced by the heat treatment of fresh mango puree (75^0C; 1 min).
- After centrifugation (at 5000 rpm), decantation of the cooled product is done to separate the serum and the pulp portions.
- **Passion fruit juice** concentrate was obtained by partial evaporation of the water at a short residence time in the evaporator, to prevent thermal damage of heat sensitive volatile flavours.

Production of Fruit Juice Powder

- That further removal of water from concentrated juice or other way around enriching the dry matter by removing watery portion to such an extent where product can be converted to its powder form.
- Fruit juice powders have many functional benefits and economic potentials over their liquid counterparts .
- The fruit juice powders are natural sources of bioflavonoids, fibres, minerals and vitamins and on supplementation they can enhance the nutritional benefits of other products.
- The solids of many juices and their physico-chemical properties implies that they are better for carrying both fat and water soluble nutrients.
- Fruit powders are mostly used in fresh juice preparation, milk shakes, drinks, ice-creams, confectioneries, baby foods, bakeries, jam and various other food preparations.

Production of Fruit Juice Powder

- Several techniques have been developed to prepare powder from mango, orange, lemon, guava, passion-fruit, banana, avocado, tomato, etc.
- These components can contribute to the total antioxidant capacity of juice solids and provide added benefits in food product application.
- The fruit juice powders are significant sources of Vitamins. Orange, lemon and lime juices are rich in vitamin-C whereas, carrot and cantaloupe juices are rich in vitamin A.
- The anthocyanin, carotenoid, chlorophyll and tannin pigments found in fruit provide natural colorant is a value added approach to design cereal products for health conscious consumers.
- Carrot juice powder can be used to produce a vibrant orange colour and sunset yellow colour by orange juice powder by orange juice powder.

Production of Fruit Juice Powder

- Beet juice powder has been used to provide products with natural colour ranging from peach to purple.
- To get blue violet colour of blue berries blue berry juice powders can be formulated in cream, cheese spread and muffins for consistent diffusion throughout the mixture.
- The naturally rounded flavour notes and floral overtones of juices are difficult to mimic in formulated flavour compounds.
- As major components of fruit fillings for cereals bars and tropical coatings for cereal flakes, fruit juice powders can be used to lend familiar flavour notes to provide a more produced flavour, juice powders should be used in acidic systems.
- Freeze dried fruit juice powders retain the humectant properties of sugars and fibres originally present in the juice, making them a great adjuvant for moisture control in fillings and batters.

Drying Methods for Fruit Juice Powders Production

- The fruits based slurry mixed with gelatinized cereal paste (after heating and agitating) enriched with starch and other ingredients (after adjusting pH and acidity) are applied as a thin film to the outer surface of the slowly revolving hallow drum heated internally by steam.
- The thickness of the film can be adjusted by changing the gap setting.
- The dryer may be classified according to numbers of drums (single, double or twin drum) or pressure surrounding the product (atmospheric or vacuum) or feeding arrangement (nip feed, splash feed, dip feed or roller feed).

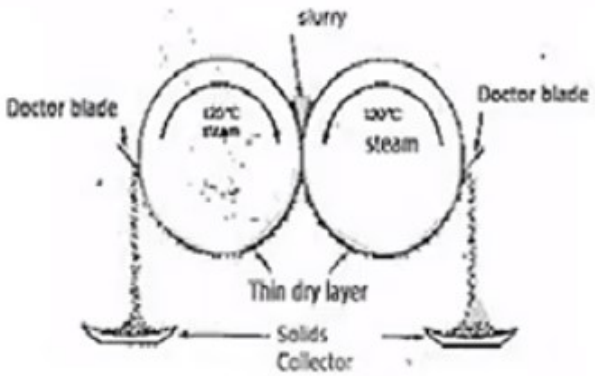


Fig.6: Roller Dryer

Drying Methods for Fruit Juice Powders Production

Spray Drying

- Spray drying is the transformation of feed from fluid state into a dried particle form by spraying the feed by means of atomizer into a hot drying medium.
- The droplets are subject to a stream of hot air flowing either co-currently or counter currently in relation to the falling droplets.
- The final product consists of spherical particles of a fairly uniform size are fallen down towards the bottom of the drying chamber from where it is removed.

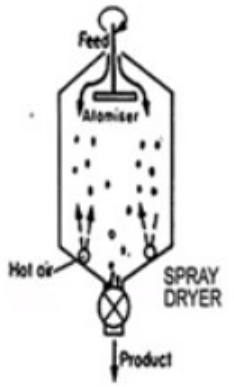


Fig.7.Spray Dryer

(Source: http://www.nzifst.org.nz/unitoperations/drying.htm)

Drying Methods for Fruit Juice Powders Production

Freeze Drying

- Freeze drying (also known as lyophilisation, lyophilisation, or cryo-desiccation) is a dehydration process used mostly for valuable and heat sensitive food materials in which drying process is accomplished by four stages namely: pre-treatment, freezing, primary drying, and secondary drying.
- In freezing material is cooled below its triple point, the lowest temperature at which the solid, liquid and gas phases of the material can coexist.
- The freezing phase is the most critical in the whole freeze-drying process, because the product quality depends on proper freezing and formation of ice crystals.

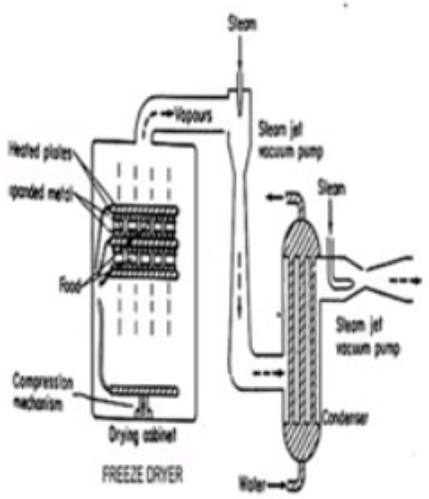


Fig.8.Freeze Dryer

(Source: http://www.nzifst.org.nz/unitoperations/drying.htm)

Drying Methods for Fruit Juice Powders Production

Puff Drying

- This process produces a product of porous structure.
- This is due to the application of vacuum which increases the volume of the concentrate by about 20 times.
- Ordinarily a pressure of 2 to 6 mm Hg is required.
- Drying may be done either in vacuum shelf drier or a belt drier.
- At the end of drying the product is cooled to prior releasing vacuum in order to prevent the possible collapse of the puffed structure.

Drying Methods for Fruit Juice Powders Production

Co-Crystallization

Preparation of fruit juice powders for use in pharmaceutical industry.

Crystallization of sucrose in the presence of a second ingredient created an infinite dispersion of this ingredient over the entire surface of the new aggregate.

Drying Methods for Fruit Juice Powders Production

- Pineapple juice (Ananas comosus) powder
- Fruit juice beverage powder
- Mango (Magnifera indica) powders
- Passion fruit (Passiflora edulis) powder
- Guava powder (Psidium guajava L)
- Papaya (Carica papaya L) Powder
- Banana powder
- Lemon Powder

Drying Methods for Fruit Juice Powders Production

- Notter et al. (1958) described the production of powder from pineapple juice (Ananas comosus) concentrate by vacuum tray drying.
- Freeze drying is also a very common method for the powder production from pineapple juice.
- Various dried mango (Magnifera indica) products are available to produce powders.
- Dehydrated passion fruit (Passiflora edulis) powder by freeze drying or by vacuum puff freeze drying.
- Banana pulp can be dried to produce powder by simple sun drying or by drum drying.
- Lemon Powder by vacuum tray drier and orange powder puff drying and foam mat drying. Several researches on spray drying of orange juice have been reported.

THANK YOU!