Subject: Processing of Horticultural crops 3(1+2)

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Practical-1

Equipment & Machinery Used in Fruit and Vegetable Processing Units

Objective: To familiarize the students with the machineries and equipments used in fruit and vegetable processing.

The following equipments and important chemicals are used in different unit operation in horticulture processing industry is as under:

Apparatus/machineries/equipments used in horticulture processing industry

A. Basic equipment/ accessories

1. Weighing Balance (1-10kg) & Electronic Balance (For Chemical Weighing)
2. Cutting Knife, Coring Knife, Pitting Knife, Peeling Knife
3. Abrasive Peeler
4. Working Table
5. Buckets, Tubs, Jugs
6. Fruit /Vegetable Blancher
7. Bottle Washer
8. Citrus Fruits Sorting Machine
9. Potato Peeler

B. Heating equipment

1. Hot Plate
2. LPG Bhatti / Gas Stove
4. Boiler
5. Microwave oven

C. Juice extraction/pulping

Hand operated /motor driven

1. Fruit Grater/ Fruit Mill
2. Basket Press
3. Hydraulic Press
4. Screw type juice extractor
6. Pulper

D. Machineries for canning unit

1. Can Reformer
2. Flanger
3. Double Seamer
4. Coding Machine
5. Retort
6. Sterilization Tank
7. Lye Peeling Tank
8. Steam Jacketed Kettle
9. Exhaust Box/Tunnel
10. Empty Can Tester
11. Vacuum/Pressure Gauge

E. Containers

1. Glass /Plastic Bottles- 200ml
2. Squash Bottle- 650ml
3. Lug Cap Jar/Glass Jars
4. Plastic Barrels
5. Beer Bottles
6. PP (Pilfer Proof) Caps
7. Jar Screw Type
8. Tin Cans
9. Crown Cork

F. Sealing/closing

1. Crown Corking Machine
2. Pilfer Proof (PP) Cap Sealing Machine
3. Pouch Sealer
4. Can Cutter/ Cork Opener

G. Drying/Dehydration:

1. Mechanical (Cabinet) Drier
2. Solar Drier
3. Spray Drier
4. Sulphur Fumigation Chamber
5. Vacuum Drier
6. Freeze Drier

H. Oil extraction

1. Mechanical Decorticator

2. Power Ghani (Oil Press)
3. Table Oil Expeller
4. Filter Press
5. Pouch Packing Machines

I. Instruments for analytical purposes

1. Refractometer
2. Salometer
3. pH meter
4. Pressure Tester
5. Pipette
6. Burette
7. Conical Flask
8. Beaker
9. Volumetric Flask
10. Pestle Mortar

J. Common chemicals

1. Citric acid
2. Sodium hydroxide (NaOH Pelletes)
3. Sodium Benzoate
4. KMS (Potassium Metabisulphite)
5. Acetic Acid
6. Alcohol (Rectified spirit)
7. Pectin
8. Salt
9. Cupric Sulphate
10. Potassium Sodium Tartrate
11. Methylene Blue (Aqueous) Staining Solution
12. Lead Acetate
13. Potassium Oxalate
14. Penolphthalein Solution
15. 2,4-Dinitrophenylhydrazine
16. Trichloroacetic Acid
17. Coal Tar Dyes (Carmosine, Tatartrazine)
18. Flavour / Essences (Apple, Peach, Strawberry essence, Raspberry essence, Orange and Alphonso essence etc.)

Laboratory Glassware: The laboratory equipment used for testing fruit and vegetable products includes glass beakers, pipettes, flasks and a burette. Pipettes are used to suck a known volume of a chemical and drop it into a sample of juice. Care is needed not to suck chemicals into the mouth. The burette is used to accurately measure the amount of a chemical that is added to a sample of juice when testing the amount of acid in the juice. Glassware should be cleaned with detergent and bottle brushes, rinsed with clean water and then rinsed again with distilled water.

Brief detail and operation of important machineries:

Rotary Fruit and Vegetable Washing Machine: This machine is useful for washing the fruits and vegetables. The capacity varies between 15 to 20 kg per batch with a cycle time of 5 to 10 minutes depending on condition of fruit or vegetable. It is made of stainless steel tank with wire mesh basket, water circulation pump and agitation equipment and works with 3 HP motor. For washing, the commodities are subjected to strong water agitation for removing the dirt and dust. Roller brushers are used for proper washing. Fresh water is also sprayed in the second stage washers. These machines are capable of washing fruits, vegetables and most suitable for washing fruits like mango, pears, apples, tomatoes, potatoes, carrots and other root vegetables.

Rotary Fruit and Vegetable Washing Machine

Bottle Washing Machine: The bottle washing machine is primarily used in food, beverages, spices and pharmaceutical industry, for rinsing and washing glass bottle before filling. Bottle washers are provided with revolving brushes to which bottle/jar is placed for automatic washing action. Bottle washers are provided with revolving brushes to which bottle/jar is placed for automatic washing action. A great advantage of this method is that it reduces the labor intensity by saving a lot of human resources. The

Bottle Washing Machine

machine also saves a lot of water by saving water resources and by increasing the reuse of water.

Citrus Fruits Sorting Machine

Citrus Fruits Sorting Machine: The machine is applicable to sorting of citrus fruits with a maximum production output (orange) of 35T/h. The general configuration of the machine is three levels and four grades. The level interval of every level can be adjusted and the interval is gradually bigger from the material inlet end. The fruit will move forwards under the driving of the moving belt and the rotary rolling rail will also drive the rotation.

Fruit grater: The fruit grater is used for grating of fruits for its further use in extraction of juice by passing through a basket or hydraulic press. The grater consists of a heavy steel cylinder fitted with cirrated knives with moving hammer. Apples are fed whole or halves into the hopper and are crushed between cylinder and knives and crushed material fall into a receptacle below. Other fruits like pear, aonla after removal of seeds etc can also be crushed in the grater.

Fruit crusher

Fruit crusher: The crusher consists of two fluted or grooved roller made of wood, and revolves towards each other arranged horizontally. The fruit fed through the hopper, falls between the rollers and get crushed. The grapes are crushed by using grape crusher.

Juice extractor

Juice extractor (Hand operated): The machine is used to extract the juices from soft fruits like orange, grapes etc. The machine is conical screw feeder type with top feeding arrangement and bottom discharge separately for juice & pulp. All the contact parts are made up of stainless steel. The capacity of the machine is 30 -50 Kg/h.

Basket/hydraulic press: The basket press consists of a strong cylindrical basket made of wood and rests on a wooden or metal base on a frame. There is a strong screw at the top of the frame. The sliced fruits are folded in a nylon cloth and placed inside the basket along with wooden frame. The screw is turned either by hand or fruit pieces are pressed by using a hydraulic pressure exerted by the hydraulic press which cause the juice to ooze out with a hydraulic pump. The basket/hydraulic press are useful in extracting juice from the apple, pear, grape, jamun, pomegranates, phalsa etc.

Basket/hydraulic press

Fruit and vegetable pulper: It is useful for extracting pulp of most fruits & vegetables like mango, apple, tamarind, custard apple, plum, apricot, peach, kiwi, tomato etc. They are available as coarse pulper, fine pulper, pulper cum finisher and baby pulper. The capacity varies from 50-100 kg/ h or even 500kg/h or larger depending upon type, size and quality of product. The main body (available in brush type or canvas screw type model) is stainless steel and stand is of milled steel (MS) with motor. The pulper consists of two brushes & two beaters which give a combined beating and brushing action. They are also available with four beaters or four brushes depending upon the fruits to be handled. The gap/clearance between the sieve and beaters/brushes can be adjusted to suit different sizes and qualities of products to be pulped. The sieve is provided with perforations of different sizes and is easily removable for cleaning. All contact parts are of stainless steel. All parts can be easily dismantled and reassembled to facilitate easy inspection, proper washing, cleaning and periodic maintenance. Fruit/vegetables with or without heating are fed from

Fruit and vegetable pulper

the hopper and after pulping action, the extracted pulp and separated seeds/peel are collected from different ends.

Steam jacketed kettle

Steam jacketed kettle: It is mainly used for heating of pulp/juice, syrup, brine etc. Generally double jacketed stainless steel boiling pan is used. Steam from boiler is supplied in the space between the outer jackets to heat the inner pan in which product is placed for heating. Steam-jacketed kettles are used to prepare a variety of food products like jams, jelly, fruit drinks, sauces, ketchup etc. Different types of kettles are: steam jacketed kettle (tilting type), Steam jacketed kettle (fixed type) and fixed type kettle with stirrers.

Fruit and vegetable blancher/Hot water blancher

Fruit and vegetable blancher/Hot water blancher: Hot water blanchers are boiling pans/tank that is used for blanching of fruit and vegetables. They are made up of stainless steel or aluminum. The steam from the boiler is connected to the blanching tank to heat the water. A perforated basket is used to place the fruit/vegetables in the blancher for predetermined period and removing the same after the process. In steam blanchers, the conveyor belt is used which is covered with steam chamber. The product is carried by a belt conveyor whose speed is adjustable by manual speed reducer to optimize the processing times according to the production rates. The blancher creates a heating-process, in which the products are exposed to hot steam, with an estimated temperature of 90 to 100^0C. The products are moved by a belt and proceed through the steaming process for an estimated 6-10 minutes. Belt speed and amount of steam is adjustable, enabling to customize the blanching process depending upon the commodity. The main components of the blancher are Belt for supporting/holding the product;

Electrical gear motor with variable speed; Provision for hot water/steam and its recirculation in the heat exchanger and Control panel.

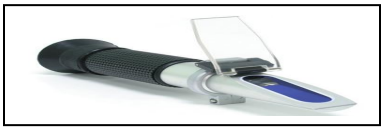
Crown corking machine: The crown corking machine is hand operated and can cork 20-25 bottles per minute. It is suitable for sealing the juice bottles with crown corks.

Crown corking machine

Pilfer proof (PP) cap sealing machine: It is used for sealing of bottles in which screw type caps are used squash bottles are sealed by using PP caps.

Cap sealing machine

Hand Refractometer: Hand refractometer measures total soluble solids (TSS) as 0Brix, which corresponds to % sugar. These are available in three ranges 0-320Brix, 28-620Brix and 58-920Brix and used for measuring total soluble solids in fruit juices, sauces, syrups, jams, jellies, squashes, preserves etc. Abbe refractometer measures TSS in the range of 0-1000Brix. Abbe refractometer is expensive instrument but it gives an accurate measurement of TSS and can also be used for standardization of hand refractometer.

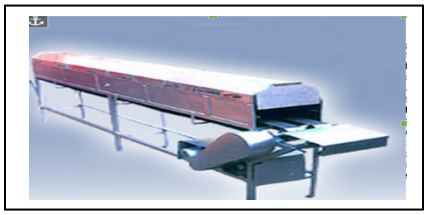


Hand refractometer

Weighing Balance/Scales: Small scales (0-2kg), medium portable scales (up to 10kg) and large scales (up to 100kg) are used to weigh small amounts of ingredients or laboratory chemicals, weighing of ingredients and products and 0weighing of fruit and vegetables respectively. Care is needed to properly clean scales if they have been used to weigh chemicals. The small scales can be operated using batteries or mains power supply.

Weighing Balance/Scales

Exhaust Box: The exhaust box is suitable for exhausting the air from filled cans before seaming. The purpose of exhausting and creation of vacuum is to create an



Exhaust Box

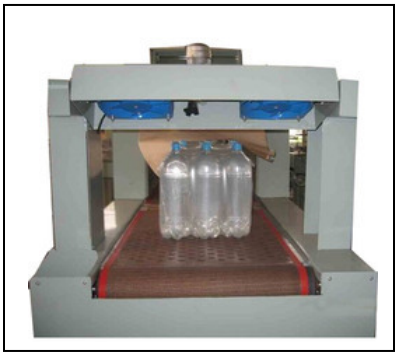
anaerobic environment inside the can that would inhibit microbial spoilage. The can covered with the lid or loosely sealed are exhausted at about 82-87^{o}C or on a moving belt through a covered steam box. The time of exhaust varies from 5 to 25 min depending upon the nature of the product. At the end of the exhausting, the temperature at the centre of the can should be about 79^{o}C.

Can Sterilizer/Autoclave/ Retort

Can Sterilizer/Autoclave/ Retort: After sealing, the cans are placed in sterilization tank for sterilization/processing of cans. Sterilization tank is made up of milled steel or stainless steel which is connected with steam pipe to supply steam from the boiler. Similarly, retort/autoclave can also be used for sterilization of sealed cans of vegetables and mushroom which are processed under steam pressure.

Vacuum Packing Machine

Vacuum Packing Machine: Vacuum packing is a method of packaging that removes air from the package prior to sealing. This method involves placing items in a plastic film package, removing air from inside, and sealing the package. Shrink film is used to have a tight fit to the contents. Vacuum packing reduces atmospheric oxygen, limiting the growth of aerobic bacteria or fungi, and preventing the evaporation of volatile components. It is also commonly used to store dry foods over a long period of time, such as cashew nut, almonds, cured meats, cheese, smoked fish, coffee.



Shrink Wrapping Machine

Shrink Wrapping Machine: Shrink wrap, also shrink film, is a material made up of polymer plastic film. When heat is applied, it shrinks tightly over whatever it is covering. The product and film can pass through a heat tunnel on a conveyor. The most commonly used shrink wrap is polyolefin. When foods are packaged in

polyolefin shrink film, it allows them to be stored more efficiently, be it in containers or on the shelves of a fridge. The shrink wrap machinery ensures that the products take up as little room as possible during storage, and the strong level of protection greatly reduces cross-contamination issues, this can save time and money on your storage costs.

Bottle Filling Machine

Bottle Filling Machine: Bottle Filling Machine is manufactured using high quality stainless steel. These bottles are used for filling liquids such as medicines, syrups, ketchups, solutions and others in bottles. The machine consists of two/four filling heads with vacuum pump and ½ H.P motor.

Practical -2

Determination of Total Soluble Solids

Objective: Determination of total soluble solids in fresh fruits and processed products by refractometer.

Theory and Principle: The TSS content of the fruit is usually obtained from assessing the degree brix of the fruit. The TSS includes the carbohydrates, organic acids, proteins, fats and minerals of the fruit. It represents from 10-20% of the fruit's fresh weight and increases as fruit matures to produce a less acidic and sweeter fruit. The brix scale measures % of total soluble solids in a substance (per 100 gram). The content of solids dissolved, is determined by refractive index. This is measured using a refractometer and is referred to as the degrees brix. Brix is usually considered equivalent to the percentage of sugar in the solution (60 degree Brix is equivalent to a sugar content of 60%). Abbe refractometer gives refractive index as well as degree brix. The Refractive index of the test solution is measured at 20°C using a refractometer and the soluble solid content is determined by the use of tables correlating refractive index with soluble solids. Generally, hand refractometer is used for determining TSS in food samples in fruit processing units. TSS of different products varies as under:

Fruit products	**Min. TSS (^{0}Brix)**
Most fruit juices	10-15
Lime juice	6-14
Lemon Juice	5-9
RTS	10
Cordial	30
Sauces	15
Ketchup	25
Squashes	40
Jam	68
Jelly and Marmalade	65
Syrups/Sharbats	65
Preserve and Candies	68

Apparatus/machinery/equipments required:

- Hand refractometer
- Abbe-refractometer
- Distilled water

Procedure for estimation

1. Calibrate the refractometer with a drop of distilled water; adjust the scale to 0 %.
2. Wipe the prism with a cotton swab.
3. Cut a piece of fruit and squeeze a drop of juice on the prism of the refractometer or Place a drop of juice/squash/syrup on the prism.
4. Read the value directly through eyepiece of refractometer towards the light at room temperature.
5. Correct the readings to standard temperature of 20°C if readings are made at temperature other than 20^{o}C.

Temperature correction for the standard model of sugar refractometer calibrated at 20^{o}C

Temperature ^{0}C	**Scale reading for soluble solids contents, %**									
	5	10	15	20	25	30	40	50	60	70
	Corrections to be subtracted									
15	0.29	0.31	0.33	0.34	0.34	0.35	0.37	0.38	0.39	0.40
16	0.24	0.25	0.26	0.27	0.28	0.28	0.30	0.30	0.31	0.32
17	0.18	0.19	0.20	0.21	0.21	0.21	0.22	0.23	0.23	0.24
18	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15	0.16	0.16
19	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08
	Corrections to be added									
21	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08
22	0.13	0.14	0.14	0.15	0.15	0.15	0.15	0.16	0.16	0.16
23	0.20	0.21	0.22	0.22	0.23	0.23	0.23	0.24	0.24	0.24
24	0.27	0.28	0.29	0.30	0.30	0.31	0.31	0.31	0.32	0.32
25	0.35	0.36	0.37	0.38	0.38	0.39	0.40	0.40	0.40	0.40

Practical- 3

Determination of Moisture Content and Total Solids

Objective: To determine the moisture content in fresh and processed products.

Theory: Estimation of moisture in fresh and processed fruit and vegetable products is important for evaluating their nutritive composition as well as to optimize method for their processing like drying, preparation of different products viz jams, preserve, candies etc. Moisture is determined by drying the weighed sample to a constant weight in hot air oven and measuring the loss in weight to express the moisture content in per cent. This method is used for estimation of moisture in all food products which do not decompose at 100ºC. Moisture content of some commodities (Table 3.1) is as under:

Table 3.1: Moisture content of some fruits, vegetables and food products

Commodity/ products	Moisture (%)
Apple	85-90
Avocado	65
Berries	81-90
Citrus fruit	86-89
Guava	81
Melons	92-94
Olives	72-75
Raw nuts	3-5
Radish	93
Sweet potato	69
Honey	20
Grape juice	70-85
Lime juice	89-90.3
Lemon Juice	81.1-92.4
Fruit juices and nectars	85-93
Fruit Jellies, jams, Marmalade and preserve	30-35
Syrups	20-40

Apparatus/equipments/ machinery required

- Hot air Oven
- Weighing balance
- Moisture dishes/Petri plate
- Desiccators

Procedure for determination: Moisture content may be determined by

1. Drying in an oven
2. By distillation with an immiscible solvent
3. Chemical and physical methods

Calculation: These methods rely on measuring the mass of water in a known mass of sample. The moisture content is determined by measuring the mass of a food before and after the water is removed by evaporation.

$$\textbf{Moisture (\%)} = \frac{M_{INITIAL} - M_{DRIED}}{M_{INITIAL}} \times 100$$

Here, $M_{INITIAL}$ and M_{DRIED} are the mass of the sample before and after drying, respectively. The basic principle of this technique is that water has a lower boiling point than the other major components within foods, e.g., lipids, proteins, carbohydrates and minerals. The total solids content or dry matter content is a measure of the amount of material remaining after all the water has been evaporated.

$$\textbf{Total Solids (\%)} = \frac{M_{DRIED}}{M_{INITIAL}} \times 100$$

$M_{INITIAL:}$ Mass of the sample before drying/ total weight of fresh sample.
$M_{DRIED:}$ Mass of the sample after drying.

Practical- 4

Determination of pH in Food Products

Objective: To determine the pH of food samples.

Theory: pH is defined as the negative logarithm of its hydrogen-ion concentration in gram per litre. It can be measured by using pH meter. The hydrogen-ion concentration of a food is a controlling factor in many chemicals and microbiological reactions. Pure water has equal concentration of H^+ and OH^- ions that is why water is regarded as neutral. The pH of pure water is 7.0; the solution having pH below 7.0 is regarded as acidic, while solution with pH above 7.0 is alkaline. Most fruits and fruit products have pH below 4.0 while vegetable; milk and meat products have pH more than 4.0 or above. Thus, with the increase in acidity in the solution, pH value decrease and vice-versa. However, presence of buffer salts helps in maintenance of pH. Estimation of pH of the food is important as the processing conditions for different food products are categorized on the basis of their pH.

pH value of some fruits and processed products

Commodity	**pH value**	**Commodity**	**pH value**
Apple	3.2-3.7 (3.4)	Apple cider	3.3-3.5 (3.3)
Black berries	3.3-3.5 (3.4)	Carrot Puree	4.9-5.2 (5.1)
Carrot	5.0-5.4 (5.2)	Corn, brine packed	6.1-6.8 (6.3)
Cherry	3.3-3.5 (3.3)	Cherry Juice	3.4-3.4 (3.4)
Grapes	3.1	Grapes juice	3.0-3.4 (3.2)
Grapefruit	3.0-3.4 (3.2)	Grapefruit juice	3.0-3.4 (3.3)
Mushroom	5.8-5.9 (5.8)	Lemon Juice	2.7-3.3 (2.9)
Potato	5.4-5.6 (5.5)	Pine apple juice	3.4-3.5 (3.5)
Raspberry	3.2-4.1 (3.7)	Sauerkraut	3.4-3.7 (3.5)
Tomato	4.0-4.6 (4.4)	Tomato Puree	4.0-4.3 (4.2)

Principle: Working of a pH meter is based on the principle of measuring the Electro Motive Force (EMF) or potential formed from a reference electrode, test solution and a glass electrode sensitive to H+ ions. The potential developed is directly proportional to the concentration of the H+ ions in the given solution.

Apparatus and reagent's required

1. pH meter
2. Standard buffer solution (pH 4.0 and pH 7.0)

Procedure for measurement of pH

1. Weigh a known quantity of the sample
2. Macerate with known volume of distilled water
3. Allow the mixture to stand for 30 minutes
4. Decant the supernatant in a beaker. (In case of juice, squash, cordial, measure pH directly without dilution/maceration).
5. Calibrate the pH meter with the help of standard buffer solutions (pH 4.0 and 7.0)
6. Wash the electrode with distilled water and wipe with tissue paper
7. Dip the electrode in the test solution; keep stirring the solution with a glass rod till a constant pH is recorded.

Note: For rough measurement, the pH indicator paper can be used. Indicator papers of different pH ranges are available. The indicator paper slip is dipped in the test solution and change in colour of the paper is compared with colour of indicator paper to note the pH. The pH meter directly gives the pH value of the product and can be calculated directly by taking average of three values.

Practical- 5

Estimation of Titrable Acidity

Objective: To estimate the titratable acidity of fresh and processed fruit and vegetable products.

Theory: Most of the fruit, vegetables and their products contain acid or mixture of acids. The acids may occur naturally in the fruit and vegetables or may be added during manufacture of different products or by lactic acid or acetic acid fermentation. Generally citric acid is added in most fruit products while in pickles, sauces and ketchup acetic acid is used. The acids are mainly responsible for the tartness or sour taste, thus estimation of acidity is used as the measure of tartness.They also helps in preservation by lowering the pH of the finished products.

Principle: Acidity in the sample is measured by titrating a given sample against a standard alkali solution of known concentration using phenolphthalein as an indicator to a light pink colour. However, for highly coloured products like tomato, mixed fruit jam, accurate determination of end point may be difficult by using indicator, thus for such samples, acidity is measured by titrating the sample against a standard alkali to a pH 8.1 using pH meter or using electrometric titrimeter or the sample is further diluted to almost colourless. The acidity is expressed in terms of predominant acid present in the product using standard expression. The list of common predominant acids and their equivalent weight present in different fruit and fruit products is as under:

Predominant acids in some fruits and processed products

Acid	Fruit/vegetable/products	Equivalent weight
Acetic acid	Sauce, ketchup, pickle in vinegar	60.05
Citric acid	Citrus fruit, most fruit products, mango, guava	64.04
Lactic acid	Curd and sauerkraut	90.08
Oleic acid	Olive	282.46
Malic acid	Apple, pear, apricot, peach, plum	67.05
Tartaric acid	Grapes, tamarind	75.04

Apparatus, reagents and glassware required

1. Sodium hydroxide - 0.1 N
2. Phenolphthalein solution -1.0 %
3. Volumetric flask - 100 ml capacity
4. Conical flask - 250 ml capacity
5. Burette - 10-100ml capacity
6. Magnetic stirrer
7. pH Meter

Preparation of reagents

1. **N/10 Sodium hydroxide:** 0.1 N or N/10 NaOH solution is prepared by dissolving 4 gram NaOH pellets in water and dilute to one litre in a volumetric flask.
2. **1% Phenolphthalein solution:** Dissolve 1gram phenolphthalein in 100ml ethanol.

Sample preparation: Crush the sample (fruit, vegetable, jam, pickle etc) in a pestle & mortar and mix thoroughly to obtain pulp. Weigh the material, add some water and boil for 1hr replacing the water lost in evaporation. Cool and transfer to a volumetric flask, make up to a known volume. Filter if necessary. For juice, squash, cordial etc dilute (if necessary) without boiling or crushing.

Flow sheet for determination of acidity *(Colourless or slightly coloured solutions)***:**

100ml volumetric flask is taken

↓

5ml pulp is transfer into the 100ml volumetric flask (by using a pipette)

↓

Volume is made up to 100ml by adding distill water

↓

5ml sample is taken (from volume made up) for titration in conical flask (Aliquot)

↓

Add few drops of 1% phenolphthalein as an indicator

↓

Titrate with N/10 NaOH to faint **pink colour** using burette or pipette

↓

Note the titre value and calculate % titratable acidity as predominant acid

Note: For highly coloured products, dilute small volume of the sample (5 ml) with large volume of distilled water (300-400ml). The colour becomes so pale that the indicator colour change during titration can be observed easily.

Procedure for determining acidity of coloured products using pH meter:

1) Pipette 10ml of sample in 250ml beaker and add 90ml distilled water.
2) Agitate diluted sample using magnetic stirrer.
3) Immerse electrode of pH meter into the solution and titrate with N/10 NaOH from a burette to a pH value 8.1. At this pH, phenolphthalein turns from colourless to pink.
4) Note the titre value and calculate titratable acidity as percent of predominant acid.

Calculation

$$\% \text{ Acidity} = \frac{\text{Titre value} \times \text{Normality of alkali} \times \text{Volume made up} \times \text{Equivalent weight of acid} \times 100}{\text{Wt or Volume of sample taken} \times \text{Volume of aliquot taken} \times 1000}$$

Normality of alkali: 0.1N NaOH

Equivalent weight of acid: 64.04 (Citric acid)

Practical- 6

Estimation of Total, Reducing and Non-reducing Sugars

Objective: Estimation of total, reducing and non-reducing Sugars in fresh fruits, vegetables and processed products by using Lane and Eynon method.

Theory: Sugars are inherently present in different fruits and vegetables or added during preparation of different products. They are added to the fruit products to improve the taste and also to act as a preservative. Glucose and fructose in the fruits represent reducing sugars while sucrose or cane sugar added represents the non-reducing sugar. Invert sugar is produced by hydrolysis of sucrose. The mixture of glucose and fructose produced by hydrolysis of sucrose is named invert sugar. The mixture consists of equal parts of glucose and fructose. They are estimated by using ***Lane and Eynon method*** which measures **sugar** as reducing sugar and total sugar.

Principle: Invert sugar reduces the copper in Fehling's solution to red, insoluble cuprous oxide. The sugar content in a food sample is estimated by determining the volume of the unknown sugar solution required to completely reduce a known volume of Fehling's solution. Glucose are capable of reducing oxidizing agents and are called reducing sugars and this property is used for the estimation of sugars. The **cupric** ion in Fehling's solution is reduced to **cuprous** state which precipitates as **red cuprous oxide (Cu_2O)**. Only reducing sugars reduce the copper solution. The method is suitable for estimation of sugars in fruit and fruit products.

$CuSO_4 + 2NaOH \rightarrow Cu(OH)_2 + Na_2SO_4$
$Cu(OH)_2 \rightarrow CuO$ (Cupric oxide)
$2CuO + CHO \rightarrow Cu_2O$ (Cuprous oxide) + COOH

Apparatus, reagents and glassware required

- Beakers - 250ml
- Volumetric flasks - 250ml
- Measuring cylinder- 250ml
- Pipette - 10ml
- Hot plate

Preparation of Reagents

1. **Fehling's solution-A:** Dissolve 69.28g copper sulphate (CuSO4.5 H2O) in water, dilute to 1 litre and filter.
2. **Fehling's solution-B:** Dissolve 346g of Rochelle salt (Potassium Sodium Tartrate, KNa $C_4H_4O_6.4H_2O$) and 100g NaOH in water, make volume to 1 litre.
3. **Methylene blue indicator (1%):** Dissolve 1g Methylene blue in 100ml water.
4. **45% Neutral lead acetate solution:** Dissolve 225g of neutral lead acetate in water and make up to 500ml. It is used as clarifying agent.
5. **22% Potassium oxalate solution:** Dissolve 110g Potassium oxalate ($K_2C_2O_4$. H_2O) in water and make volume to 500ml. This is used for neutralizing excess of lead acetate.
6. **Standard invert sugar:** Weigh 10g of sucrose into 1 litre flask, add 100ml water and 5ml concentrated HCl for hydrolysis. Allow to stand for 3 days at 20-25^{0}C or 7 days at 15^{o}C inversion to take place and then make up to volume.
7. **Glucose solution (1%):** Dissolve 1g Glucose in 100ml water.

Standardization of Fehling's solution: Mix 5ml Fehling A + 5ml Fehling B solution in 250ml conical flask. Add 25-50ml water and heat the flask. Add standard invert sugar solution from the burette drop-wise till the solution turns brick red. Add few drops of Methylene blue indicator and add drop-wise invert solution, when the blue color disappears, note the titre value of invert solution and calculate factor for Fehling's solution as under:

$$\textbf{Factor for Fehling solution (g of invert sugar)} = \frac{\text{Titre} \times 2.5}{1000} \times 100$$

Flow sheet for estimation of sugars

(Lane and Eynon Method)

Take 20 gram sample/Juice/Squash in 100 ml conical flask

or

Take 25 g of sample (fresh fruit or fruit product) and grind in a pestle and mortar

↓

Add 50 ml water and neutralize with 1 N NaOH

↓

Add 2ml 45% lead acetate

↓

Shake well and keep for 10 minutes

↓

Add 5 ml 22% potassium oxalate solution to remove excess of lead acetate

↓

Make volume to 100ml with water (dilution) and filter

↓

Reducing sugar

↓

Take 5 ml sample + Pipette 10ml of mixed Fehling's solution (5 ml each of Fehling A and B) into 250ml conical flask

↓

Heat the flask containing mixed Fehling's solution on hot plate (Boil for 1-2 minutes)

↓

Titrate with 1% glucose solution drop wise from the burette till cloudy blue colour remains

↓

Add 2-3 drops of *Methylene blue* indicator and complete the titration till the color changes to ***brick red*** precipitates

↓

At the end point, note the readings and calculate the reducing sugars

↓

Total sugar

Take 5 ml sample/ filtrate

↓

Add 2-3 drop concentrated HCl (50%)

↓

Keep overnight (24 hr)

↓

Add 1-2 drop of phenolphthalein indicator

↓

Neutralize with 40% NaOH (Add drop by drop)

↓

Sample colour change from *colourless to dark pink colour*

↓

Pipette 10ml of mixed Fehling's solution (5 ml each of Fehling A and B) into 250ml conical flask

↓

Heat the flask containing mixed Fehling's solution on hot plate (Boil for 1-2 minutes)

↓

Titrate with 1% glucose solution drop wise from the burette till cloudy blue colour remains

↓

Add 2-3 drops of *Methylene blue* indicator and complete the titration till the color changes to **brick red** precipitates

↓

Note the titre value and calculate the total as well as non–reducing sugars from the following equations

Calculations

$$\textbf{Reducing sugar (\%)} = \frac{\text{Factor (0.052)} \times \text{Dilution} \times 100}{\text{Titer value} \times \text{Wt or volume of the sample}}$$

$$\textbf{Total sugar (\%)} = \frac{\text{Factor (0.052)} \times \text{Dilution} \times 100}{\text{Titer value} \times \text{Wt or volume of the sample}}$$

Sucrose or non-reducing sugar (%) = (Total sugar ¬ Reducing sugar) x 0.95
Factor for Fehling = 0.052

Note: Fruit contain more reducing sugar (Glucose and fructose) while fruit product prepared by using sucrose (cane sugar) contains more non-reducing sugars. Non-reducing sugar is determined by subtracting the total sugar from reducing sugar and multiplying the *remainder with 0.95 factors.*

Problem: 25gm of onion juice was neutralized with 1N NaOH and made to 100 ml and filtered. The sample was utilized for estimation of reducing sugar whose titer was 5.0ml. The sample was utilized for estimation of total sugar, the titer value of which was found to be 1.8 ml. Calculate reducing, total and non-reducing sugars of the given onion juice. Factor for Fehling's solution is 0.052.
Solution:

$$\textbf{Reducing sugar (\%)} = \frac{\text{Factor (0.052)} \times \text{Dilution} \times 100}{\text{Titer value} \times \text{Wt or volume of the sample}}$$

$$\textbf{Reducing sugar (\%)} = \frac{0.052 \times 100 \times 100}{5.0 \times 25}$$

= 4.16%

$$\textbf{Total sugar (\%)} = \frac{\text{Factor (0.052)} \times \text{Dilution} \times 100}{\text{Titer value} \times \text{Wt or volume of the sample}}$$

$$\textbf{Total sugar (\%)} = \frac{0.052 \times 100 \times 100}{1.8 \times 25}$$

Total sugar as invert sugar = **11.56 %**

Sucrose or non-reducing sugar (%) = (Total sugar ¬ Reducing sugar) x 0.95

Sucrose or non-reducing sugar (%) = (11.56 ¬ 4.16) x 0.95
= 7.39 x 0.95
= 7.02%

Total sugar= % reducing sugar + % non-reducing sugars
= 4.16+7.02
= 11.18%

Result: Thus, the sample of onion juice contained **4.16% reducing sugars**, **7.02% non-reducing sugars** and **11.18% total sugars**.

Practical-7

Estimation of Ascorbic Acid

Objective: To estimate ascorbic acid in fresh and processed fruit and vegetable products.

Theory and Principle: Fruit, vegetables and their products are important sources of ascorbic acid. The ascorbic acid is present in sufficient quantity in aonla, guava, grapefruit, lemon, pineapple, strawberry fruits etc. Barbados cherry is the chief source of vitamin C. The products manufactured from these fruits are also considered as rich in ascorbic acid and the contents available in the commodities can be detected by using 2, 6 dichlorophenol-indophenol visual titration method.

2, 6 dichlorophenol-indophenol visual titration method: The method is based on reduction of 2, 6 dichlorophenol–indophenols dye. The dye, which is blue in alkaline solution and red in acidic solution, is reduced by ascorbic acid to a colourless form. The reduction is quantitative and specific for ascorbic acid in solutions in the pH range of 1.0 - 3.5. In estimation of ascorbic acid, the prepared sample is titrated against standard 2, 6 dichlorophenol–indophenols dye to a *pink end point*. The titre is then used to calculate the ascorbic acid in the sample.

Reagents

1. **3% metaphosphoric acid (HPO_3):** Dissolve 3.0 g sticks or pellets of metaphosphoric acid in 80 ml of distilled water and make to 100 ml with distilled water and store at 4°C between uses. **0.1% oxalic acid** can also be used in place of metaphosphoric acid. Take (5 ml) the HPO_3 extract of the ***sample*** **for titration.**

2. **Standard Ascorbic acid solution:** Weight 100 mg L-ascorbic acid and dissolve in 3% HPO_3 and make volume up to 100 ml with HPO_3. Dilute 10 ml ascorbic acid solution to 100 ml with 3% HPO_3 (1ml=0.1mg ascorbic acid). Used only 5ml sample for standardization of **dye factor**.

3. **Dye solution:** Dissolve 50 mg of the Sodium salt of 2, 6 dichlorophenol indophenol dye in 150 ml hot glass distilled water containing 42 mg of Sodium bicarbonate. Cool and dilute with distilled water to 200 ml. Store in refrigerator and standardize.

4. **Sodium bicarbonate**

Glassware required

1. Beakers - 100, 250ml
2. Volumetric flasks - 100, 250ml
3. Measuring cylinder - 250ml
4. Pipette - 10ml

Procedure for standardization of dye factor:

Take 5 ml of **standard ascorbic acid solution (1ml=0.1mg)**. Titrate this solution with the dye solution to a *pink colour* which should persist for 15 seconds. Determine the dye factor i.e. ascorbic acid per ml of the dye.

Sample preparation:

1. **Fresh Fruits/vegetables:** Crush/grind fruit or vegetable parts (known weight) along with 3% HPO_3 make to volume (100 ml) with HPO_3. Filter or centrifuge.
2. **Fruit Juices:** Take 10-20 ml juice add 3% HPO_3 and make volume to 100 ml. Filter or centrifuge.
3. **Solid and semi solid food:** Take 10 g sample, blend with 3% HPO_3 and make up to 100 ml with HPO_3. Filter or centrifuge.

Procedure for titration: Take (5 ml) the HPO_3 extract of the ***sample*** and titrate with the standard dye to a *pink end point* persisting for at least 15 seconds. The titre of the sample should be such that titre should not exceed 3-5 ml.

Samples containing sulphur dioxide: Sulphur dioxide when present in fruit products like squash, jam, drinks etc reduces the indophenol dye and this interferes in the ascorbic acid estimation. To eliminate the SO_2 interference use formaldehyde condensation method as under:

Take 10ml filtrate in a test tube, add 1ml of 40% formaldehyde and 0.1ml of HCl, keep for 10 minutes and titrate as earlier. Record titre and calculate ascorbic acid.

Problem: 10g of guava squash sample was made up 250ml using 3% metaphophoric acid and filtered. 10ml of the filtrate was titrated against standard 2,6 dichlorophenol dye having dye factor of 0.1mg ascorbic acid/ml dye. Calculate ascorbic acid in the guava squash when titre value was 5 ml.

Solution:

- Given wt of sample = 10g
- Volume made up = 250 ml
- Sample/ filtrate /**Aliquot** taken for estimation = 10ml
- Dye factor = 0.1
- Titre value = 5ml

$$\textbf{mg Ascorbic acid/100 gram} = \frac{\textbf{Titre value X Dye factor X Volume Make up X 100}}{\textbf{Aliquot taken X Wt. of sample}}$$

$$= \frac{5 \times 0.1 \times 250 \times 100}{10 \times 10}$$

mg ascorbic acid/100g = 125mg/100g

Result: The given sample of guava squash contained 125mg/100g ascorbic acid.

Practical-8

Estimation of Pyruvic Acid

Objective: To estimate pyruvic acid in fresh onions.

Theory: Total pyruvic acid (P_T), Non-enzymatic pyruvic acid (P_C) and enzymatically released pyruvic acid by allinase (P_E) were determined by the method of **Anthon and Barrett (2003)** and expressed as **µ moles per gram fresh weight**.

Reagents

1. **0.0125% 2, 4-dinitrophenyl hydrazine (DNPH) reagent:** 12.5 mg of 2, 4 DNPH was dissolved in 100 ml of 2N HCl and filtered through Whatman filter paper No.1.
2. **2 N HCl:** Dilute 16.6 ml concentrated HCl to 100 ml solution.
3. **0.6 N NaOH:** 24 gram NaOH dissolves in one liter of distilled water.
4. **40 percent trichloroacetic acid (TCA):** 400 gram TCA dissolve in one liter of distilled water.

Total pyruvic acid (P_T): One gram of fresh tissue was homogenized in distilled water in a chilled pestle and mortar. The homogenate was transferred to 100 ml volumetric flask and was allowed to stand for 10 minutes at 30^{o}C to allow enzymatic action to develop. Then 1.25 ml of 40 percent TCA was added and volume was made to 100 ml with distilled water and mixture was allowed to stand for 20-30 minutes. The contents were centrifuged for 20 minutes at 10,000 rpm.

Non-enzymatic pyruvic acid (P_C): One gram of fresh tissue was homogenized in 15-20 ml boiling water and transferred to 100 ml volumetric flask. The mixture was boiled for 5 min, cooled. Then 1.25 ml of 40 percent TCA was added and volume was made to 100 ml with water and contents were centrifuged for 20 minutes at 10,000 rpm.

Procedure: One ml of supernatant was transferred from total (P_T) and control (P_C) sample extract into test tubes and 3 ml of distilled water + 1 ml of 0.0125 per cent DNPH reagent were added. The contents were allowed to stand at 38 ^oC in a water bath for 10 minutes, then 5 ml of 0.6 N NaOH was added to the test tubes. Tubes were allowed to stand for 10 minutes and immediately their absorbance was measured at 420^{nm} against blank.

Standard curve was prepared by using standard **sodium pyruvate solution of 0.1 µ mole ml^{-1}**.

Total pyruvic acid (P_T)

One gram of fresh tissue was homogenized in distilled water in a chilled pestle and mortar.

↓

Transferred to 100 ml volumetric flask and allowed to stand for 10 minutes at 30^oC

↓

1.25 ml of 40 percent TCA was added and volume was made to 100 ml with distilled water and mixture was allowed to stand for 20-30 minutes.

↓

Contents were centrifuged for 20 minutes at 10,000 rpm.

↓

One ml of supernatant was transferred from total (P_T) sample extract into test tubes

↓

3 ml of distilled water + 1 ml of 0.0125 per cent DNPH reagent were added

↓

Contents were allowed to stand at 38 ^oC for 10 minutes

↓

5 ml of 0.6 N NaOH was added

↓

Test tubes were allowed to stand for 10 minutes

↓

Immediately their absorbances were measured at 420nm by Spectrophotometer against blank and

↓

P_T reading note down.

Non-enzymatic pyruvic acid (P_c)

One gram of fresh tissue was homogenized in 15-20 ml boiling water

↓

The homogenate was transferred to 100 ml volumetric flask

↓

The mixture was boiled for 5 min, cooled

↓

1.25 ml of 40 per cent TCA was added and volume was made to 100 ml.

↓

Contents were centrifuged for 20 minutes at 10,000 rpm.

↓

One ml of supernatant was transferred from control (P_C) sample extract into test tubes

↓

3 ml of distilled water + 1 ml of 0.0125 per cent DNPH reagent were added

↓

Contents were allowed to stand at 38 ^oC for 10 minutes

↓

5 ml of 0.6 N NaOH was added

↓

Test tubes were allowed to stand for 10 minutes

↓

Immediately their absorbances were measured at 420^{nm} against blank by Spectrophotometer and P_C reading note down.

Calculations: The amount of pyruvic acid was determined from standard curve. The difference between P_T and P_C represented enzymatically produced pyruvate (P_E) and expressed as μ moles of sodium pyruvate per gram of fresh tissue.

Practical- 9

Canning of Fruit and Vegetables

Objective: To perform canning of fruit and vegetables.

Theory: Canning refers to a process which involves heating food stuff in hermetically sealed containers for a specific time at specific temperature to eliminate microbial pathogens that endanger public health as well as enzymes that deteriorate food during storage. Broadly canning is a method of preservation of food for achieving longer shelf-life.

Principle of canning: Destruction of spoilage causing micro-organisms and enzymes within the sealed containers by means of heat.

Machinery/equipments required for canning

1. Can Reformer, Flanger, Double Seamer, Exhaust box, Sterilization tank, Retort, Lye peeling tank and Coding Machine, Refractrometer, gas Bhatti /Boiler.
2. Empty flat cans.
3. Fruits and vegetables suitable for canning.
4. Peeling and coring knives.
5. Salt or sugar.
6. Sodium hydroxide.

Canning process:

1. **Raw material selection:** Select ripe but firm, evenly matured fruits, free from blemishes, insect damage and malformation. Select vegetables when tender except tomatoes.
2. **Washing:** Wash the fruits/vegetables with running water to remove dust, dirt, debris and any adhering surface micro-flora.
3. **Sorting and grading:** Sort out any bruised, inferior or damaged fruits either manually or by using sorting belt.

4. **Peeling, coring and pitting/halving:** Peeling of fruits and vegetables can be done in many ways: 1. by hand or with knife 2. by machine 3. by heat treatment (Scalding) 4. by lye solution i.e. peaches, apricot, sand pear (dipping the fruits and vegetables in a solution of boiling 2% sodium

hydroxide or caustic soda solution for 30 seconds to 2 minutes followed by dipping in 1-2% citric acid or 0.5% HCl solution to neutralize lye then wash in running tap water.

- ✓ Cut peeled peaches and apricot into halves and remove the pit/stone. Kept in 2% salt solution to check browning.
- ✓ Peel apple manually and slice, keep in 2% salt solution to avoid browning.
- ✓ Cut whole pineapple into 5mm thick slices, remove peel and core by using pineapple corers.
- ✓ Peel potatoes manually or using abrasive peeler and cut into slices. Keep slices in 2% salt solution to check browning.

5. **Blanching:** Place mushroom and vegetables in boiling water or in blanching tank for 2-5 minutes followed by dipping in cold water prior to canning, is called 'blanching'. Blanching is done with the objective of:
   - ✓ Loosening the skin of the fruit or vegetable.
   - ✓ Eliminate the no. of microorganisms.
   - ✓ Inactivating the enzymes, thus preventing the possibility of discoloration.
   - ✓ Improving the flavor by reducing the astringency in some foods.
6. **Preparation of cans:** The cans are washed and subjected to a steam jet remove any adhering dust or foreign matter.
7. **Filling into cans:** In India, filling by hand using rubber gloves is the common practice.
8. **Syruping & Brining:** The cans are filled with hot sugar syrup for fruits (concentration 35- 40%) and hot brine for vegetables (concentration 1-2%). The syrup or brine should be added to the can at a temperature of 79°C to 82°C, leaving a headspace in the can so that when the filled can is closed on the double seaming machine, the headspace left inside ranges from o.32 cm to 0.47 cm. Use 40% sugar syrup containing 0.3% acidity for peach canning.
9. **Exhausting**: Immediately after filling of syrup or brine, place loose lid on the can passed through the exhaust box. Lidding is now replaced by clinching in which the lid is partially seamed to the can by a single first roller action of double seamer. Exhaust the cans till a temperature at the centre of can reaches 79^0C. Cans are passed through a trough of water at 82-87°C or a moving conveyor belt through a steam box. The time varies from 5-25 min. on the nature of the substance. During exhausting, expelling of all the gases takes place which prevents spoilage of the canned product by ceasing the chemical reactions and also the bulging of can.

10. Double seaming: Immediately after exhausting, the cans are sealed by special closing machines known as double seamers. There are hands operated as well as semi- automatic and fully automatic seamers.

11. Heat Processing/sterilization: Place the sealed cans in boiling water in sterilization tank for 25-30 minutes depending upon the type of fruit being canned. All fruits can be satisfactorily processed at 100°C. Process canned vegetables in autoclave at 10-15 psi pressure (116-121^{o}C) for 25-30 minutes.

12. Cooling: Cool the heat processed cans immediately in cold running tap to about 35-40^{o}C to prevent stack burning.

13. Storage: Stack cans one above other to allow the outer surface to dry to avoid rusting. Keep the cans for about a week in the store. Label the cans manually or by using labeling machine. Store in cool and dry place.

FPO specification for canned fruits and vegetables

Specifications	**Canned fruits**	**Canned vegetables**
Drained weight	Not less than 50% Exception: berry fruits 40%	Not less than 55% Exception: canned tomato 50%
Appearance	Free from blemishes, stalks, leaves *etc*.	Free from pods, stalks, roots and blemishes *etc*.
Texture	Free from disintegration and damage from bruises.	Free from disintegration and damage from bruises.
Added colour	No colour except strawberry and cherry	Not permitted, except for peas
Organoleptic quality	Characteristic taste	Characteristic taste
Preservatives	Not permitted	Not permitted
Incubation condition	No positive pressure when incubated at 37^{0}C for one week	No positive pressure and sign of bacterial growth when incubated at 37^{0}C and 55^{0}C for one week.

Canning Flowchart:

Selection

↓

Shorting/Grading

↓

Washing

↓

Peeling, Coring, Pitting and cutting

↓

Blanching

↓

Can filling (filling into plain A2 or A2½ tin can of 550 gram)

↓

Syruping (Hot syrup of 40 per cent TSS with 0.25 percent acidity, leaving 0.3-0.5 cm head space) or brining (2 per cent salt solution)

↓

Lidding or clinching

↓

Exhausting (at the centre of can temperature reaches 79^0C for 6-10 minutes)

↓

Sealing

↓

Heat Processing/sterilization (In boiling water at 100^0C for 25 minutes)

↓

Cooling (at 37^0C)

↓

Labeling and Storage

Practical-10

Preparation of Fruit Beverages

Objective: To prepare fermented and unfermented beverages from fruit juice.

Theory: India's diverse climate ensures availability of all varieties of fresh fruits & vegetables. It ranks second in fruits and vegetables production in the world, after China. As per National Horticulture Database published by National Horticulture Board, during 2015-16, India produced 90.2 million metric tonnes of fruits and 169.1 million metric tonnes of vegetables. The area under cultivation of fruits stood at 6.3 million hectares while vegetables were cultivated at 10.1 million hectares. India's exports of Processed Food was Rs. 31111.90 Crores in 2018-19, which including the share of products like Mango Pulp (Rs. 657.67 Crores/ 93.97 USD Millions), Processed Vegetables (Rs. 2473.99 Crores/ 354.75 USD Millions), Cucumber and Gherkins (Prepd. & Presvd) (Rs. 1436.08 Crores/ 205.84 USD Millions), Processed Fruits juices & Nuts (Rs.2804.97 Crores/ 402.52 USD Millions), Alcoholic Beverages (Rs. 2103.97 Crores/ 301.71 USD Millions).

In India the wastage of fresh produce is estimated at 20 – 22 per cent due to absence of facilities like transportation and know - how for proper post harvest handling, storage, marketing, processing and distribution system before utilization. Further more massive amount of perishable fruits produced during a particular season result in glut in market and become scarce during off season. Neither can be consumed in fresh from nor at economically viable prices. Processing and preservation technology helps to save excess fruit and vegetable during the glut season. The technology has become a necessity to improve the food safety and strengthen nation’s food security. There are about 4000 small and large scale processing units in the country which process less than 4 per cent of the total fruits and 2 per cent of fresh vegetable produce are processed. In sharp contrast to

the extent of processing of fruit and vegetables in several other developing countries such as Brazil 70 per cent , Malaysia 83 per cent , Philippine 78 per cent and Thailand 30 per cent respectively. For every one percent reduction in loss will save 5 million tonnes of fruit and vegetable per year. Fruit processing activities can be improving nutrition of the poor farmers by allowing them to consume value added fruit and vegetable products during off season. It can also generate new sources of income for both rural and urban masses with concomitant reduction in fruit and vegetable losses. Production of fruit beverages on commercial scale was practically unknown until 1930 but since then it has gradually become an important part in the industry.

Fruit Beverages: Fruit based beverages are relished when served chilled, particularly during summers. These are delicious as well as nutritious containing the goodness of fresh fruit, appetizing, easily digestible and thirst quencher. Processing of fruits and vegetables into quality beverages provide delicious cold drink, fruit based drinks contain vitamins (A, B and C) minerals (calcium, iron etc). Thus fruit based drinks are far superior to many synthetic drinks. In India fruit beverage are in demand for the greater part of the year, which can be served indoor or at special occasion to people of various tribes and tradition.

Beverages can be classified into two groups:

1. **Non-alcoholic or unfermented beverages:** Fruit juices which do not undergo alcoholic fermentation by yeasts are termed as non-alcoholic or unfermented beverages. They include pure or natural juice, ready to serve (RTS), nectar, squash, crush, syrup, cordial, barley water, fruit juice concentrate and fruit juice powder and carbonated beverages.
2. **Alcoholic or fermented beverages:** Fruit juices which have undergone alcoholic fermentation by yeasts are termed as fermented beverages. They

include **Wine** (grape juice), **Cider** (apples juice), **Neera** (palmyrah palm juice), **Feni** (cashew apples), **Port** (red wine), **Sherry** (white wine of Spain), **Tokay** (fortified grape wine in Hungary), **Champagne** (French wine), **Muscat**, **Perry** (pear wine).

- ✓ **Quality of fruit for beverages:** Firm ripe fruit with high pulp and low fiber content, excellent flavour, taste and pulp colour and high total soluble solids with low acidity.

FRUIT BASED UNFERMENTED BEVERAGES

1. JUICES

a) Natural / pure juice: Juices extracted from ripe fruits and contains only natural sugars.

b) Sweetened juice: 85 per cent fruit juice and 10 per cent TSS.

- ✓ **FPO specification** for sweetened juice is TSS 10 per cent and fruit juice 85 per cent.

c) Blended juice: Sometimes two or more fruit juices are mixed to yield a well balanced, rightly flavoured, highly palatable and refreshing drink.

- ✓ Juices are blended so as to utilize a too sweet fruit (grape), a bitter fruit (grape fruit), too acidic or tart fruits (sour lime), insipid tasting fruit (apple and pear) and strongly flavoured fruits (guava and banana).

2. Ready-to-Serve: RTS contains at least 10 per cent fruit juice, 10 per cent TSS and 0.3 per cent total acidity. It is not diluted before serving; hence it is known as ready-to-serve (RTS).

- ✓ **FPO specification:** Minimum per cent of TSS 10 per cent and minimum per cent of fruit juice 10 except lime juice (5 per cent). The permissible limit of

preservatives as sulpher dioxide (KMS) 70 ppm and as benzoic acid 120 ppm.

3. **Nectar:** Nectar contains at least 20 per cent fruit juice/ pulp and 15 per cent TSS and 0.3 per cent acidity. It is not diluted before serving.

- ✓ **FPO specification:** Minimum percent of TSS 15 and fruit juice 20 per cent except pineapple and Orange (40 per cent). The permissible limit of preservatives as sulpher dioxide (KMS) 70 ppm and as benzoic acid 120 ppm.

4. **Squash:** Squash contains at least 25 per cent fruit juice / pulp, 40-50 per cent TSS and 1 per cent acidity.

- ✓ The permissible limit of preservatives as sulpher dioxide (KMS) 350 ppm and as benzoic acid (in coloured juices) 600 ppm. It is diluted before serving. It is diluted three times with chilled water before serving.
- ✓ **FPO specification:** Minimum percent of TSS 40 and fruit juice 25.

Raw material, ingredients, machinery and equipments required

1. Fruits like mango, orange, lemon, lime, litchi, pear, apricot and pineapple are used for making squash.
2. Machineries and equipments like pulper, juice extractor, pan and refractometer.
3. Stainless steel knives, de-corers, spoon and utensils for cooking and mixing, glass bottles, sterilization tank, LPG stove/diesel bhatti etc.

Extraction of pulp/juice

i) **Lime and lemon**: Take fresh, fully ripe, sound fruits and wash them in fresh water. Cut them into halves with stainless steel knife. Express juice with juice squeezer and strain through muslin cloth to remove seeds. **ii) Orange:** Peel oranges, separate segments, pass segments through screw type juice extractor. Collect juice and strain through muslin cloth.

iii) Mango: Select fresh and ripe fruits. Wash in fresh water and extract the pulp by pressing in hands or extract pulp by passing through the pulper.

iv) Litchi: Peel litchi fruits and remove seeds, extract juice by passing through juice extractor or pulper. Strain through muslin cloth.

v) Plum/apricot/jamun: Wash the fruits, boil with small quantity of water, passs through pulper to extract the pulp and separate the seeds.

Flow sheet for preparation of blended RTS and Nectar:

BLENDING OF PULP
(AS PER FORMULATION)
↓
MIXING WITH STRAINED SYRUP
(SUGAR, CITRIC ACID, WATER)
↓
ADDITION OF PRESERVATIVE
↓
BOTTLING
↓
CROWN CORKING
↓
PASTEURIZATION
(In boiling water on a false bottom for 25 to 30 minutes)
↓
COOLING
↓
LABELLING
↓
STORAGE
(AT ROOM TEMPERATURE)

Flow sheet for preparation of blended squash:

BLENDING OF PULP
(AS PER FORMULATION)
↓
MIXING WITH STRAINED SYRUP
(SUGAR, CITRIC ACID, WATER)
↓
ADDITION OF PRESERVATIVE
↓
BOTTLING
↓
CAPPING
↓

LABELLING

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STORAGE
(AT ROOM TEMPERATURE)

Method of preparation: For preparing the fruit beverages like RTS, nectar and squash the total soluble solids and acidity in fruit juice / pulp were first analyzed to know the amount of sugar and citric acid present in them. Total soluble solids were estimated at ambient room temperature by hand refractometer (0-32 per cent), and the values were expressed as percent TSS after correcting at 20^0C temperature. Acidity was analyzed by titration against 0.1 N NaOH as described by Ranganna (2003). Based on this analysis, requisite quantities of sugar and citric acid dissolved in water were added to fruit juice / blends for the adjustment of required TSS and acidity in their beverage. RTS, nectar and squash drink was then filled in sterilized bottles of 200 ml capacity leaving 2.5 to 3.0 cm head space, sealed with crown corks and processed in boiling water on a false bottom for 25 to 30 minutes. The processed glass bottles were then cooled in air and stored at room temperature for six months.

Note: In case of **orange juice**, the removal of astringency is important. For this purpose dip the segments in hot 2% NaOH for 2-3 minutes followed by dipping in 0.5% citric acid solution. This treatment results in removal of astringency.

FPO Specifications:

	Fruit RTS	**Fruit Nectars**	**Fruit Squash**
Juice content	Lime- Not less than 5% Other fruits - Not less than 10%	Orange/pineapple - Not less than 40% Other fruits -Not less than 20%	Not less than 25%
TSS	Not less than 10%	Not less than 15%	Not less than 40%
Acidity	Not more than 1.5%	Not more than 1.5%	Not more than 3.5%
Preservatives	Sulpher dioxide (KMS) 70 ppm and as Benzoic acid 120 ppm.	Sulpher dioxide (KMS) 70 ppm and as Benzoic acid 120 ppm.	Sulphur dioxide (Not more than 350 ppm) and as Benzoic acid (Not more than 600 ppm)

5. **Cordial:** Cordial is a *sparkling clear sweetened fruit juice from which pulp and other insoluble materials* are completely removed. Cordials contain at least 25 per cent fruit juice, 30 per cent TSS and 1.5 per cent acidity. Lime and lemons are most suitable fruit for preparation of cordial. Cordial is very suitable for blending with wines.

✓ **FPO specification:** Minimum percent of TSS 30 and fruit juice 25. The permissible limit of preservatives as sulpher dioxide (KMS) 350 ppm and as benzoic acid 600 ppm.

6. **Barley water:** A type of fruit beverage which contains at least 25 per cent fruit juice, 30 per cent TSS, 0.25 per cent barley starch and 1 per cent acidity. Citrus fruit particularly lime and lemons are most suitable for barley water preparation.

FPO specification: Minimum percent of TSS 30 and fruit juice 25 + 0.25 per cent barley starch. The permissible limit of preservatives as sulpher dioxide (KMS) 350 ppm and as benzoic acid 600 ppm.

7. **Crush:** This type of fruit beverage contains at least 25 per cent fruit juice/pulp, 55 per cent TSS and 1.0 per cent acidity. It is more or less similar to squash and is diluted before serving.
8. **Syrup:** This type of fruit beverage contains at least 25 per cent fruit juice/pulp, 65 per cent TSS and 1.3-1.5 per cent total acidity and is diluted before serving.
9. **Fruit Juice Powder:** Fruit juice can be converted into a free flowing, highly hygroscopic powder. The powder has long shelf life and is soluble in cold water. Fruit juice powder can be prepared from various fruit such as guava, banana, bael, mango and orange. Fresh fruit flavour is lost during the

drying process.The technique of preparation of fruit juice powder can be classified into two groups:

1. Vacuum drying (freeze drying and vacuum puff drying).
2. Air drying (drum drying, spray drying and foam mat drying).

10. Raw Mango Squash (Panna): A traditional drink that could be prepared fresh in homes and consumed can also be stored under ambient conditions. Pulp is extracted after boiling hard green fruits (1kg) in 1 liter water. Different ingredients viz., common salt (120g), black salt (80g), roasted cumin seeds powder (40g), fresh mint leaves (200g) and citric acid (65g) are added. Mixture is strained and consumed fresh; if required to be preserved sodium benzoate (1g) dissolved in small quantity of water is added. To prepare sweet squash, 450g sugar is added, while for sour squash 450g water is added. Squash is filled into clean and sterilized glass / plastic bottles and sealed; product has shelf-life of about 9 months. Served by diluting one part of squash with seven parts of chilled water.

Fruit Based Fermented Beverages

Wine: The word "wine" strictly signifies fermented alcoholic beverage produced from grape juice without distillation. Wine occupies a unique position among foods and beverages. It becomes not only a regular part of the diet but a social beverage used for celebrating, feasting and entertaining guests. To utilize the surplus and physically damaged unmarketable fruit for production of wine would be a novel dish to the Indian cuisine apart from its export to the user countries. The wine industry in India will provide considerable opportunities for value addition, income and employment generation in the agro processing sector.

Wine can broadly be classified into two major groups:

a) Natural wine having *9 to 14 per cent* alcohol.

b) Desert and appetizer wine having *15 to 21 per cent* alcohol.

1. **Grape Wine:** The variety suitable for wine making are **Arka Shyam, Beauty Seedless, Tompson Seedless, Concord, Country Banglore, Pusa Navrang** etc. Grape wine are of two kinds, *dry and sweet*. *Dry wines* are those which contain very *little or no sugar* that can be detected by testing. In *sweet wines*, the sugar content is high enough to be detected by taste. The alcohol content of Grape wines ranges from *7 to 20 per cent*. Wines with 7 to 9 per cent alcohol are known as "*light*", those with 9 to 16 percent "*medium*", and those with 16 to 21 per cent "*strong*". Grape is an ideal fruit for making wines because of high content of fermentable sugar and natural association of fermenting yeast with the grape berry, the wine prepared from grape are *often named after the variety* such as:

2. **Muscat Wine**: Muscat wines are prepared from **Muscat grape variety** in Italy, California, Spain and Australia. The colour of the wine range from golden to amber to pale amber red, alcohol per cent in Muscat wine is 12.
3. **Port Wine** (Red Wine): Port wine is a type of wine made from **dark colour grape** varieties, colour range from intense violet, brick red for mature wine and brown for older red wine. Port has a richer, sweeter and heavier texture than other wine since it is a fortified, sweet red wine made originally in Portugal. Red wine contains 0.15 per cent malic acid, 0.6 per cent tartaric acid, 15 per cent ethanol and pH 3.0 had a strong **bactericidal effect**, alcohol content in port wine range from *19.5 to 22 per cent*. Consumption of red wine, which contains the polyphenol resveratrol, has been associated with reduced risk of cardiovascular disease.
4. **Sheery Wine:** Made from **white grape variety Delight** in a town of Spain, Sherry wine is dry in texture, since it is fortified after fermentation process. The alcohol present in Sherry wine is *11 to 12 per cent*.
5. **Champange Wine:** Champagne was developed in France about 300 years ago. "*Champagne*" come from the champagne region of France in US most Champagne like wine are called "*sparkling wine*". The alcohol contain in champagne is *11.5 to 12.5 per cent*.
6. **Tokay Wine:** Tokay wine is made from the *grape variety Takay in Hungary,* it is a fortified wine. *Fortified wine is wine to which extra manufactured alcohol has been added*, the most common being brandy. Originally, the reason for fortification was to preserve wine from turning acetic (Vinegar) help keep the wines for longer. Adding the extra alcohol during the fermentation process stops the fermentation by killing the yeast. This leaves the wine with residual sugar and much higher alcohol content, thereby helping to preserve the wine.

7. **Perry Wine:** Wine made from pear fruits are known as *perry*. The alcohol present in perry wine is *7 per cent*.
8. **Feni Wine:** Cashew feni is prepared from the pure fermented juice of *cashew apple* without addition of any extraneous matter. In India *Goa* is famous for the preparation of alcoholic beverages feni. The feni is obtained by the distilling arrack. One liter arrack contains 14 per cent alcohol. To get 1 litre of arrack 12 to 15 kg of cashew apple and for *1 litre of feni 3o to 35 kg cashew apple* are required. The alcohol content in Feni is *11.25 per cent*.
9. **Litchi Wine:** Litchi is a distinctly delicious, aromatic and fascinating fruit having good source of mineral and vitamins. The TSS of the litchi fruits is about 20^0 brix, with 27 per cent reducing sugar and 0.5 per cent acidity is highly suitable for preparation of wine. A quality litchi wine with about *11 percent alcohol*, typical rosy flavour and high nutritional value can be prepared by adjusting the fermentation process of the juice by using *wine yeast* (*Saccharomyces cerevisiae var. bayamus*).
10. **Jackfruit Wine:** Earthen pots, wooden vessels, bamboo baskets, sieves and stone stabs are required for preparation. Ripe fruits are selected; the skin is peeled off and discarded. The seeds are removed. The fruit pulp and sections are soaked in water and the materials are ground in bamboo basket. The extract is collected in earthen pots. The extract is allowed for fermentation using already fermented wine as inoculums. The pots are covered with banana leaves. The fermentation occurs at 18 - 30°C for 1 week. The liquid portion is obtained by decantation. The fruit sections and pulp yields 53-60 percent of juice by weight with 12-12.4^0 brix total soluble solids. Sucrose content is 4-4.9 per cent, reducing sugars are 4.5-5.2 per cent and pectin content is about 3.5-4 per cent. The pH of the wine is between 3.5 - 3.8. The alcohol content in the wine 7-8 per cent.

Cider: Cider is mostly prepared by fermentation of apple, which have a high tannin content of 0.1-0.3 per cent. *Fruit cider with 5 to 8 per cent alcohol and total soluble solids/acid ratio of 25 to 30 per cent is most ideal*. Cider is very healthy (like apples) and having large amounts of phenolics and antioxidants, helpful in preventing heart diseases and cancer.

1. **Apple Cider:** Cider making is an art as old as the cultivation of apple trees. Cider is made from fermenting apple juice, which relies on natural yeast present in the apples for fermenting. Firm-ripe apples those are ripe enough use make the best cider and give the highest yield. Immature or over ripe apples lower the quality. The best cider is usually made from a blend of different varieties of apples. A blend provides an appealing balance of sweetness, tartness, and tang as well as aromatic overtones. *McIntosh* has been used alone successfully, but only at the peak of their maturity. Equipment for grinding and pressing is usually combined into one machine the cider press. As soon as the juice is pressed from the fruit pulp, strain it to remove coarse particles. The length of time for proper sedimentation may vary. Most juices take 12 to 36 hours to settle. Apple cider has about *5.5 to 7 percent of alcohol*. 50 Kg of apples is sufficient to make about 30 to 35 liter of cider. In the *United States*, fermented alcoholic apple juice is called "*hard cider*" while freshly pressed, non alcoholic cider is called "*sweet cider*".

2. Aonla Cider: A sweet fermented and highly refreshing drink from aonla having 10^0 brix TSS, 4.0 per cent alcohol, 0.4 per cent tannins and 66 mg/100 gram ascorbic acid. The cider can be stored for more than one year and its taste improves during storage. Keeping increasing production of aonla and its nutraceutical value in view, aonla cider is a health drink that can fetch both national and international market. Unit cost is Rs. 20/- per bottle of 750 ml capacity.

3. Guava Cider: This mild fermented beverage has 13^0 brix total soluble solids, 4.0 per cent alcohol, 0.45 per cent acidity and 32.8 mg per 100 ml ascorbic acid with natural guava flavour. The cider can be stored up to one year under ambient conditions. Guava is one of the richest natural sources of vitamin C and is often called *poor man's apple*. However, unlike apple, its cider is not yet available. Keeping in view the nutritional and sensory qualities of guava cider, it may prove as a potential guava product. Unit cost is Rs. 30/- per bottle of 750 ml capacity.

Practical-11

Fermentation in fruits and vegetables

Objective: To study about fermentation in fruits and vegetables.

Theory: Fermentation is the process of converting carbohydrates into ethanol, producing alcoholic drinks such as wine, beer, and cider using microorganisms yeasts or bacteria under anaerobic conditions. Fermentation usually implies that the action of microorganisms is desired. The science of fermentation is known as zymology. As world population increases, lactic acid fermentation is expected to become an important role in preserving fresh vegetables, fruits, and other food items for feeding humanity in developing countries. However, several fermented fruits and vegetables products (Sauerkraut, Kimchi, Gundruk, Khalpi, Sinki, etc.) have a long history in human nutrition from ancient ages and are associated with the several social aspects of different communities. Among the food items, fruits and vegetables are easily perishable commodities due to their high water activity and nutritive values. These conditions are more critical in tropical and sub-tropical countries which favour the growth of spoilage causing microorganisms. Lactic acid fermentation increases shelf life of fruits and vegetables and also enhances several beneficial properties, including nutritive value and flavours, and reduces toxicity. Fermented fruits and vegetables can be used as a potential source of **probiotics** as they harbour several lactic acid bacteria such as *Lactobacillus plantarum, L. pentosus, L. brevis, L. acidophilus, L. fermentum, Leuconostoc fallax, and L. mesenteroides.* The fermentation of *milk to yoghurt* (probiotic) involves a specific group of bacteria called the lactic acid bacteria (*Lactobacillus* species). In the case of milk, the acid causes the precipitation of milk protein to a solid curd.

Organisms responsible for fruit and vegetable fermentations: The most common groups of micro-organisms involved in fruit and vegetable fermentations are:

A. **Bacteria**
B. **Yeasts**
C. **Moulds**

A. Bacteria: Several bacterial families are present in foods, the majority of which are concerned with food spoilage. The most important bacteria in desirable food fermentations are the *Lactobacillus,* which have the ability to produce lactic acid from carbohydrates. Other important bacteria, especially in the fermentation of fruits and vegetables, are the acetic acid producing bacteria *Acetobacter* species.

1. **Lactic acid bacteria:** The lactic acid bacteria are a group of gram positive bacteria, non-respiring, non-spore forming, cocci or rods, which produce lactic acid as the major end product of the fermentation of carbohydrates. They are the most important bacteria in desirable food fermentations, being responsible for the fermentation of sorghum beer, all fermented milks, cassava (to produce *gari* and *fufu*) and most "pickled" (fermented vegetables). Lactic acid bacteria carry out their reactions - *the conversion of carbohydrate to lactic acid plus carbon dioxide and other organic acids without the need for oxygen.* They are described as micro-aerophilic as they do not utilise oxygen. Because of this, the changes that they effect do not cause drastic changes in the composition of the food. Some of the family are homo-fermentative, that is they only produce lactic acid, while others are hetero-fermentative and produce lactic acid plus other volatile compounds and small amounts of alcohol. *Lactobacillus acidophilus, L. bulgaricus, L. plantarum, L. caret, L. pentoaceticus, L brevis* and *L. thermophilus* are examples of lactic acid producing bacteria involved in food fermentations. All species of lactic acid bacteria have their own particular reactions, but overall, *L. plantarum a homo-fermenter produces high acidity in all*

vegetable fermentations and plays the major role. All lactic acid producers are non-motile gram positive rods that need complex carbohydrate substrates as a source of energy. The lactic acid they produce is effective in inhibiting the growth of other bacteria that may decompose or spoil the food; the whole groups are referred to as *lactic acid bacteria.* Despite their complexity, the whole basis of lactic acid fermentation centers on the ability of lactic acid bacteria to produce acid, which then inhibits the growth of other non-desirable organisms. All lactic acid producers are micro-aerophilic, that is they require small amounts of oxygen to function. The hetero-fermentative species of *Lactobacillus* which produce intermediate amounts of acid. Homo-fermenters, convert sugars primarily to lactic acid, while hetero-fermenters produce about 50% lactic acid plus 25% acetic acid and ethyl alcohol and 25% carbon dioxide. These other compounds are important as they impart particular tastes and aromas to the final product. *Leuconostoc mesenteroides is a bacterium associated with the sauerkraut and pickle fermentations.* This organism initiates the desirable lactic acid fermentation in these products. It differs from other lactic acid species in that it can tolerate fairly high concentrations of salt and sugar (up to 50% sugar). *L. mesenteroides* initiates growth in vegetables more rapidly over a range of temperatures and salt concentrations than any other lactic acid bacteria. It produces carbon dioxide and acids, which rapidly lower the pH and inhibit the development of undesirable micro-organisms. The carbon dioxide produced replaces the oxygen, making the environment anaerobic and suitable for the growth of subsequent

species of *lactobacillus*. Removal of oxygen also helps to preserve the colour of vegetables and stabilizes ascorbic acid that is present.

Sauerkraut: Lactic acid bacteria are the primary group of organisms involved in sauerkraut fermentation. The optimum temperature for sauerkraut fermentation is around 21ºC. A variation of just a few degrees from this temperature alters the activity of the microbial process and affects the quality of the final product. Therefore, temperature control is one of the most important factors in the sauerkraut process. A temperature of 18º to 22º C is most desirable for initiating fermentation since this is the optimum temperature range for the growth and metabolism of *Leuconostoc mesenteroides*. Temperatures above 22ºC favour the growth of *Lactobacillus* species. *Lactic acid bacteria are most active at about 30 ^{o}C.*

Important products prepared by lactic acid fermentation are given below along with predominant microorganisms concerned:

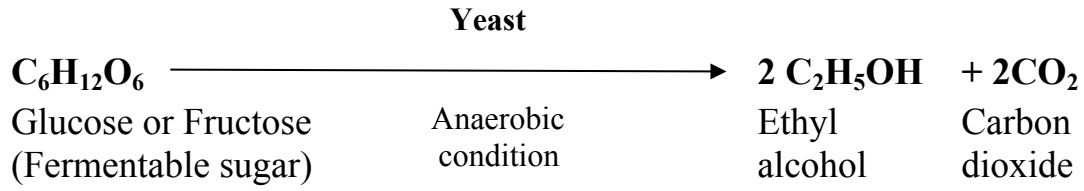
Raw material	**Predominant organism**	**Product**
Cabbage	*Leuconostoc mesenteroides, Lactobacillus plantarum, Lactobacillus brevis*	Sauerkraut
Cucumber, Tomato, Lemon, Mango, Cauliflower	*Leuconostoc mesenteroides, Lactobacillus plantarum, Lactobacillus brevis, Streptococcus faecalis, Pediococcus cerevisiae*	Pickles

2. **Acetic acid bacteria:** A second group of bacteria in fruit and vegetable fermentations are the acetic acid (vinegar) producers from the *Acetobacter* species. The most desirable action of acetic acid bacteria is in the production of vinegar. The vinegar process is

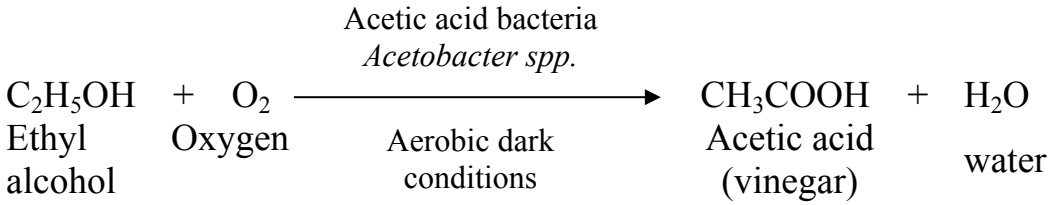
essentially a two stage process, where yeasts convert sugars into alcohol, followed by *Acetobacter*, which oxidise alcohol into vinegar (acetic acid).

Steps involved in vinegar production: The vinegar process is essentially a two stage process, where yeasts convert sugars into alcohol, followed by *Acetobacter*, which oxidise alcohol into acetic acid (vinegar).

1. **Conversion of fruit sugar into alcohol by yeast (alcoholic fermentation):** The most common yeasts for fermentation of fruit sugar into alcohol are *Saccharomyces cerevisiae* (best for starchy substances) and *Saccharomyces ellipsoideus.* The most favourable temperature for the growth of yeast is 25-27^{o}C. The chemical reaction involve in alcoholic fermentation is as under:



2. **Conversion of alcohol into vinegar by acetic acid bacteria (acetification):** *Acetobacter* convert alcohols into acetic acid in the presence of oxygen. *Acetobacters* are strongly aerobic bacteria but whose activity is greatly reduced by light. The most desirable action of *Acetobacter spp.* (acetic acid bacteria) is in the production of vinegar (acetic acid).



B. **Yeasts:** Yeast is a unicellular fungus, which reproduces asexually by budding or division, especially the genus *Saccharomyces,* which is important in fruit and vegetable fermentations. Yeasts and yeast-like fungi are widely distributed in nature. They are present in orchards and vineyards, in the air, soil and in the intestinal tract of animals. Like bacteria and moulds, yeasts can have beneficial and non-beneficial effects in products. The most beneficial yeasts in terms of desirable fruit and vegetable fermentation are from the *Saccharomyces* family, especially *Saccharomyces cerevisiae*. In general, yeasts are larger than most bacteria. Most yeast require an abundance of oxygen for growth, therefore by controlling the supply of oxygen, their growth can be checked. In addition to oxygen, they require a basic substrate such as *sugar*. *Some yeast can ferment sugars to alcohol and carbon dioxide in the absence of air but require oxygen for growth. They produce ethyl alcohol and carbon dioxide from simple sugars such as glucose and fructose.* In conditions of excess oxygen and in the presence of bacteria (*Acetobacter aceti),* the alcohol can be oxidized to form acetic acid (vinegar). This is undesirable, if the end product is a *fruit alcohol*, but is a technique employed for the production of fruit vinegars. Yeasts are active in a very broad temperature range - from 0 to 50^{o}C*,* with an *optimum temperature range of 20 ^{o}C to 30 ^{o}C.* The optimum pH for most micro-organisms is near the neutral point (pH 7.0). Moulds and yeasts are usually acid tolerant and are therefore associated with the spoilage of acidic foods. Yeasts can grow in a pH range of 4 to 4.5 and moulds can grow from pH 2 to 8.5. In terms of water requirements, yeasts are intermediate between bacteria and moulds. Bacteria have the highest demands for water, while moulds have the least need. Normal yeasts require a minimum water activity of 0.85 or a relative humidity of 88%.

Products of Yeast Fermentation: The major products of yeast fermentation are alcoholic drinks e.g. wine. With respect to fruits and vegetables, the most important products are alcoholic beverage. The process is well known being essentially an alcoholic fermentation of sugars to yield alcohol and carbon dioxide.

C. **Moulds:** Moulds are also important organisms in the food industry, both as spoilers and preservers of fruit and vegetable products. Certain moulds produce undesirable *toxins* and contribute to the spoilage of fruit and vegetable products. The *Aspergillus* species are often responsible for undesirable changes in foods. These moulds are frequently found in fruit and vegetable products and can tolerate high concentrations of salt and sugar. Moulds do not play a significant role in the desirable fermentation of fruit and vegetable products. However, others impart characteristic flavours to foods and others produce enzymes, such as amylase for bread making. Moulds from the genus *Penicillium* are associated with the ripening and flavour of cheeses. Moulds are aerobic and therefore require oxygen for growth.

Practical-12

Preparation of Cordial

Objective: To prepare cordial from lemon and lime.

Theory: Cordial is a sparkling clear sweetened fruit juice from which pulp and other insoluble materials are completely removed. Cordials contain at least 25 per cent fruit juice, 30 per cent TSS and 1.5 per cent acidity. Lime and lemons are most suitable fruit for preparation of cordial. Cordial is very suitable for blending with wines.

Raw material, ingredients and utensils required

1. Lemon and lime are used for making cordial.
2. Stainless steel knives, juicer/screw type juice extractor, utensils for cooking and mixing, glass bottles, sterilization tank etc
3. Recipe for preparation of cordial

Procedure for preparation of fruit juice cordial

1. Extract the juice from lime or lemon as in case of squash and store in glass bottles after adding potassium metabisulphite @ 1.5g/kg of the juice.
2. Allow the juice to settle for a month.
3. Decant the clear juice without disturbing sediments and strain it through fine muslin cloth.
4. Prepare sugar syrup by mixing sugar in water, heat, filter and cool.
5. Mix clarified juice in syrup to prepare cordial.
6. Strain the cordial through muslin cloth if necessary.
7. Add KMS and fill into bottles.
8. Store in cool and dry place.

Note: Juice can also be clarified by using tannin-gelatin mixture.

FPO Specification for cordial

Juice content	Not less than 25%
Total soluble solids	Not less than 30%
Acidity	Not more than 3.5%
Preservatives	Sulphur dioxide (Not more than 350 ppm) Benzoic acid (Not more than 600 ppm)
Clarity in cordial	Clear, free from pulp and other cellular matter
Fermentation test	Negative at 37ºC
Organoleptic quality	Free from objectionable taste and flavour

Practical-13

Preparation of Jam, Jelly and Marmalades

Objective: To prepare Jam, Jelly and Marmalades from different fruits.

Theory:

Jam: Jam is prepared by boiling the fruit pulp with a sufficient quantity of sugar to a thick consistency, firm enough to hold fruit tissues in position. Jam contains 0.5-0.6 percent acidity and 68 % TSS.

FPO specifications: Minimum per cent of TSS in final product shall not be less than 68% (w/w) and minimum per cent of fruit juice in final product should be 45.

Jelly: Jelly is prepared by boiling the fruit with or without addition of water, straining the extract and mixing the clear extract with sugar followed by boiling the mixture to a stage at which it will set to a clear gel. The optimum pH value for the jelly is 3.2. In preparation of jelly Pulp & water ratio: 1kg :1.5lit, Pulp & Sugar ratio : 1 kg : 750 gram.

Qualities of Jelly: Clear, transparent, sparkling, attractive colour, keep its shape in which it is cut not breaking or flowing. Jelly contains TSS not less than 65 per cent and acidity 0.5 to 0.7 %. Guava jelly is the commercial product available in the market however jelly can be prepared from sour apple, karonda, jamun, loquat etc.

Pectin: Pectin substances present in the form of **calcium pectate** are responsible for the firmness of fruits. **Pectin** is most important constituent of jelly. In early stage of development of fruits, the pectic substance is a **water insoluble protopectin** which is converted into **pectinic acid** by the enzyme protopectinase during ripening of fruit. In over ripe stage due to the presence of pectic methyl estrase (PME) enzyme, the pectin gets largely converted to **pectic acid which** is water insoluble. This is one of the reasons that both immature and over-ripe fruits are not suitable for making jelly and only ripe firm fruits are used. Usually 0.5 – 1.0 percent of pectin of good quality in the fruit extract is sufficient to produce good jelly. If the pectin content is higher a firm and tough jelly is formed and if it is less the jelly may fail to set. The water soluble **pectinic acid** under suitable condition forms a gel with sugar and acid.

Pectic substances		
Maturity	**Form of Pectin present in fruits and vegetables**	**Texture of fruit and vegetable**
Under ripe	Protopectin (water insoluble)	Hard
Ripe	Pectin or pectinic acid (water soluble)	Tender-crisp
Over ripe	Pectic acid (water insoluble)	Mushy
Only pectin will form a gel for making good Jelly. Protopectin and pectic acid are not good for making jelly.		

Marmalade: Marmalade is a fruit jelly in which the slices/shreds of peel are suspended. The marmalades are prepared generally from citrus fruits like orange and lemon. The pectin and acid contents of the marmalades are kept slightly higher than that for jellies. They shall contain minimum of 45% fruit and 65% total soluble solids.

Raw material, ingredients and utensils required

1. Fruits like Apple, apricot, mango, plum, peach, guava, pineapple, pear and kiwifruit etc either singly or in combination.
2. Stainless steel knives, ladle utensils for cooking and mixing, glass bottles, sterilization tank, juicer/basket press, bhatti/LPG stove/boiler, Refractometer etc.

Flow sheet for preparation of Jam:

Ripe fruit

↓

Washing

↓

Peeling & Cutting (seed removal)

↓

Blanching & pulping (Mixie)

↓

Cooking up to desired consistency
(Pulp: Water: Sugar :: 1 : 1: 1)

↓

Addition of citric acid (2 gram per kg of fruit)

↓

Judging the end point by sheet test or TSS (68-70%)

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Filling hot into clean and sterilized bottles

↓

Cooling

↓

Capping

↓

Storage in a cool and dry place

Sheet or flake test: A small quantity of jam is taken out during boiling in a spoon or wooden ladle. It is allowed to drop after slight cooling. If the product falls off like a sheet instead of flowing like syrup, indicates the end point. Otherwise, continue boiling till the sheet test is positive.

Flow sheet for preparation of Jelly:

Only ripe firm not over ripe

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Washing

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Peeling

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Cutting into thin slices and seed removal

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Boiling with water

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Addition of citric acid while boiling (2gram/ Kg fruit)

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Straining of extract

↓

Pectin test for addition of sugar or jell meter test

↓

Addition of sugar

↓

Cooking

↓

Judging the end point by sheet or drop test or TSS (65%)

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Removal of scum foam

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Filling hot into clean and sterilized bottles

↓

Cooling

↓

Capping

↓

Storage in a cool and dry place

Flow sheet for preparation of Marmalade:

Ripe fruit: Oranges and Lemons (2:1)

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Washing

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Peeling outer portion (Flavedo)

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Cutting peel into fine shreds 2 cm long and 0.1 cm thick

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Cutting of peeled fruit 0.4cm thickness

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Addition of water in the ratio of 2:1

↓

Boiling for 40-50 minutes

↓

Straining of extract

↓

Pectin test for addition of sugar or jell meter test

↓

Addition of sugar

↓

Cooking to 105 ^{0}C temperature

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Addition of prepared shred (Peel boiled for 15 min for 3-4 times by changing the water for softening and removing bitterness)

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Judging the end point by sheet or drop test or TSS (65%)

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Cooling and filling sterilized bottles

↓

Capping/ sealing

↓

Storage in a cool and dry place

Problems in Jam Production:

Problems	Causes	Precaution
Crystallization	Percent of invert sugar less then 30	Add corn syrup or glucose along with cane sugar
Sticky Jam (Gummy Jam)	High percentage of TSS	Add pectin or citric acid
Premature setting	Low TSS and High Pectin	Add more sugar
Surface graining and shrinkage	Evaporation of moisture during storage	Storing in cool place
Microbial spoilage	Moulds cause spoilage	Add 40 ppm KMS

Problems in Jelly Making :

Problems	Causes
Failure to set	Cooking below the end point, Lack of acid or pectin, Slow cooking for a long time, Addition of too much sugar.
Cloudy /Foggy jellies	Use of immature fruits, Non-clearified juice, Over -cooking, Over -cooling, Non removal of scum.
Crystal formation	Use of excess sugar.
Synersis or weeping of jelly	Excess of acid, Too low concentration of sugar, Insufficient pectin.
Fermentation	Caused by mould due to not covering the jelly properly.

Practical- 14

Preparation of Fruit Chutneys

Objectives: To conduct practical on preparation of chutney from different fruits.

Theory: Good quality chutney should be palatable and appetizing. Mango chutney is an important food product exported from India to many countries. Apple and apricot chutneys are also very popular in the country. The method of preparation of chutney is similar to that for jam except that spices, vinegar and salt are added. In comparison to jam, chutney contains less total soluble solids than jam.

The fruits/vegetables are peeled, sliced or grated, or cut into small pieces and cooked in water until they become sufficiently soft. The quality of chutney depends to a large extent on its cooking which should be done for a long time at a temperature below the boiling point. To ensure proper thickening, cooking is done without a lid even though this results in some loss of volatile oils from the spices. Chopped onion and garlic are added at the start to mellow their strong flavours. Spices are coarsely powdered before adding. Vinegar extract of spices may be used instead of whole spices. Spice and vinegar are added just before the final stage of cooking, because prolonged boiling cause loss of some of the essential oils of spices and of vinegar by volatilization.

Raw material, ingredients, equipments and utensils required

1. Stainless steel peeling/cutting knives, pulper for extraction of pulp.
2. Utensils for cooking and mixing, ladle, glass jars, sterilization tank, diesel or LPG stove/bhatti etc

Procedure:

1. Peel and cut selected healthy fruit into slices of suitable size.
2. Soften by dipping in boiling water along with 10% of water and pass through pulper to extract pulp or strain pulp by using strainer.
3. Mix sugar to pulp and cook on medium flame. (Slow cooking is preferred to yield better product than that of bristle heating at high temperature).
4. Add onion and garlic at the start to mellow their strong flavour.

5. Add coarsely powdered spices. Vinegar extract of spices can also be added.
6. Add vinegar just little before final stage of boiling.
7. Pack product after adding sodium benzoate in clean pasteurized jars/bottles.
8. Glass jars/bottles can also be processed at 82^0C for 30 minutes.
9. Cool and store in cool and dry place.
10. Label jars before sending to the market.

FPO specifications for fruit chutney

- Fruit content - Not less than 40%
- TSS - Not less than 50% (w/w)
- Total acidity - Not more than 2.1%
- Total ash - Not more than 5.1%
- Acid insoluble in HCl - Not more than 0.51 % (w/w)
- Mould count - Not more than 40% of field examined
- Preservatives - Sulphur dioxide – Not more than 100 ppm
- Benzoic acid – Not more than 250
- Sign of fermentation - Negative when incubated at 28-30^0C and 37^0C

Table: Recipe for preparation of chutney from different fruits

Ingredients	**Mango**	**Apple**	**Plum**	**Apricot**	**Papaya**	**Mixed Fruit Apple+Plum+ Peach (1:1:1)**
Sugar, g	500	500	500	750	500	750
Cumin and black pepper, (g)	10	10	10	10	10	10
Cardamom, Red chilies, (g)	10	10	10	10	10	10
Salt, (g)	40	40	40	40	40	40
Onion chopped, (g)	50	250	50	50	100	250
Garlic and ginger chopped, (g)	15	15	15	15	15	15
Vinegar, (ml) or Acetic acid (ml)	170	200	150	130	200	200
Clove No's	4-5	5	5	5	5	5
Sodium Benzoate, (ppm)	250	250	250	250	250	250

Practical- 15

Preparation of Preserve and Candies

Objective: To conduct practical on preparation of preserve and candies from fruits.

Theory:

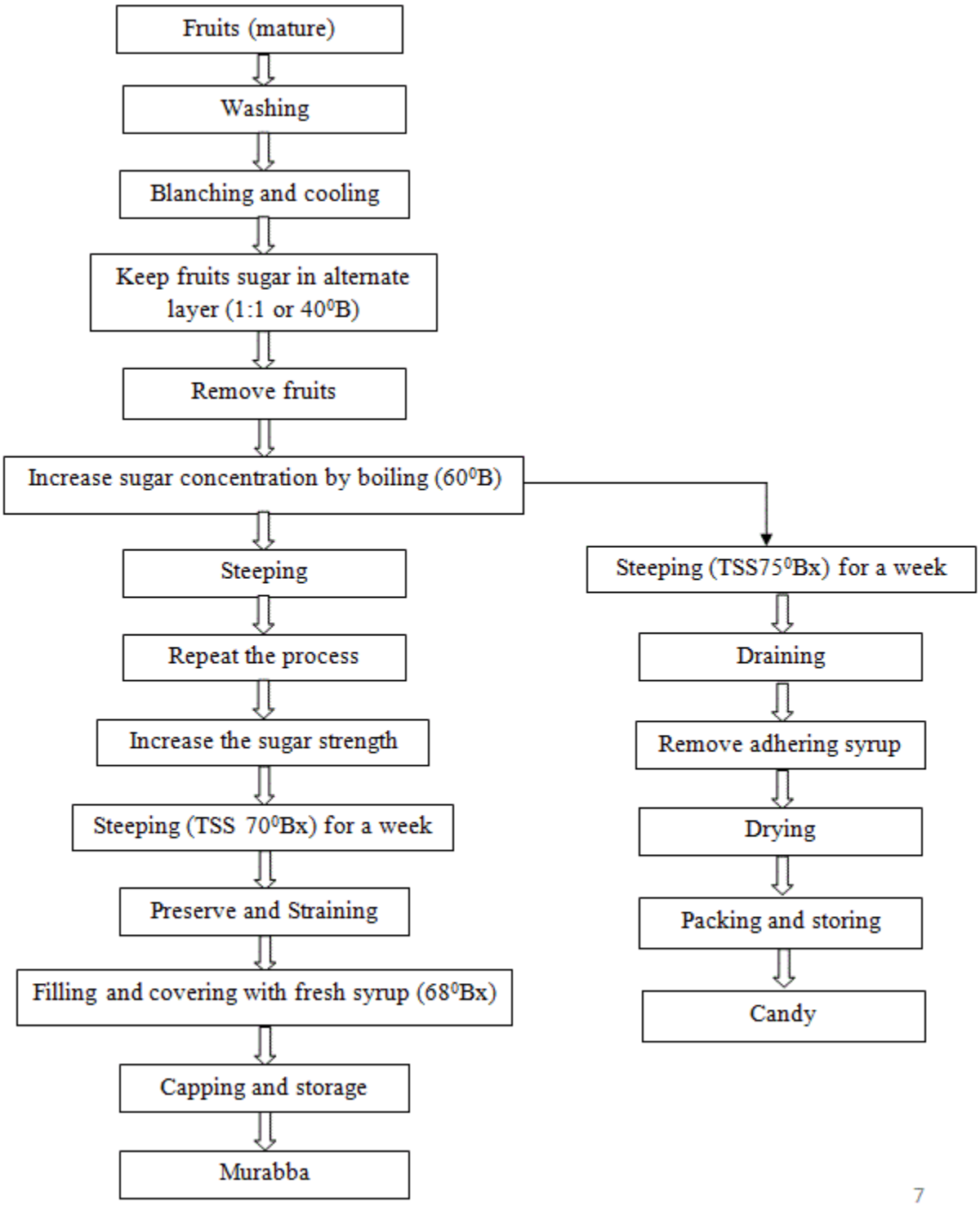
Preserves: A mature fruit/vegetable or its pieces impregnated with heavy sugar syrup till it becomes tender and transparent is known as a preserve. Aonla, bael, apple, pear, mango, cherry, karonda, strawberry, pineapple, papaya, etc. can be used for making preserves. Preserves (murraba) are made by cooking the entire fruit or its slices/pieces in sugar syrup of higher concentration (68-70^{0}Brix).

Candy: A whole fruit/vegetable or its pieces impregnated with cane sugar or glucose syrup, subsequently drained off and fruit pieces are further dried is known as candied fruit/vegetable. The most suitable fruits for candying are aonla, karonda, pineapple, cherry, papaya, apple, peach, and peels of orange, lemon, grapefruit and citron, ginger, etc. Candies are also prepared similarly to preserve but the TSS maintained is slightly higher (75-80%). For candy preparation, the fruit pieces are dipped initially in 55-60% sugar solution and the TSS of the syrup is increased by 5% everyday up to 4-5 days till a TSS of 70^{o}Brix is reached.

Procedure for preserve and candy making

1. Select healthy, mature fruits and wash in running water to remove dirt and residues.
2. Peeling, coring and cutting the fruits into pieces.
3. Pricking should be done with stainless steel forks. In case of petha, after pricking place them in lime water. (If slices are substantially thin, pricking may not be necessary).
4. Blanch the fruits and place in alternate layers of fruit and sugar.
5. The sugar spreaded in the layers on fruits starts to dissolve in juice which comes out of the fruits.
6. In case of syrup, the strength of the syrup is increased by 5% on each alternate day up to the TSS of 70^{0}B and 75^{0}B for preserve and candy respectively.
7. When the fruit pieces of prepared preserve settle at the bottom of the syrup, it indicates the end point.

Flow sheet for preparation of fruits preserve or candy



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Fruit	Step-1	Step-2	Step-3	Step-4
Aonla	Wash and prick the fruits with stainless steel fork (avoid using iron needle)	Steep in 2% salt solution for 24 hours to remove astringency	Wash and dip in 2% alum solution for 24 hours and wash	Blanch until soft but segments should remain attached
Bael	Remove shell, slice peeled fruit crosswise into 2.5 cm thick pieces, wash & prick	Steep in cold water for 24 hours	-	Blanch in boiling water
Mango	Peel and remove green portion, cut fruit lengthwise	-	-	Blanch until soft and then prick the pieces or use thin slices
Karonda	Cut into two pieces and remove seeds	Steep in 2% salt solution for 24 hours, wash and prick with fork	-	Blanch in boiling water containing 0.25% citric acid to soften
Papaya	Peel, cut into rectangular pieces, remove seed & prick	Steep in 2% salt solution for 24 hours	Wash thoroughly	Blanch in boiling water until soft
Petha/ (ashgourd)	Cut lengthwise, remove fluffy portion, peel, cut into pieces of suitable size & prick	Soak in diluted lime water for 24 hours to harden texture	Wash and soak in 2% alum solution for 24 hours	Blanch until tender, in boiling water containing little KMS.
Ginger	Scrape off peel with peeler from tender ginger, cut into thin slices	-	-	Boil for an hour with 0.5% citric acid, prick and wash
Citrus peel	Remove the rags from thick rind of orange, citron, pummelo, lime, lemon peel	Dip in 2% hot sodium bicarbonate solution for 30 minutes then wash and prick	-	Blanch in boiling water until tender and to remove bitterness

In case of candy, the process is similar to preserve making except the concentration of sugar is increased till it attains 75^0B TSS.

- The syrup is then drained off and the pieces of fruits are dried in the drier.
- The prepared candy after draining from the syrup can be rolled in powdered sugar and then dried.
- Pack the pieces in pouches or airtight containers/glass jars.

FPO specifications for preserve and candies:

Fruit contents	Not less than 45%
Total soluble solids	Not less than 68% (w/w) for preserve Not less than 75% in candies
Fermentation test	Negative
Organoleptic test	Retain flavour of original fruit and free from burnt or other objectionable flavour
Crystallization	Absent

Practical- 16

Processing of Plantation Crops

Objective: To conduct practical on processing of **Plantation Crops**.

Theory:

Processing of Tea *(Camellia sinensis*)

Plucking in tea: Best plucking is two leaves and a bud.

Two major manufacturing methods commonly used are:

i) **Orthodox** which employs non-cutting rollers. The orthodox tea has superior flavour but poor in colour.

ii) **Crushing, tearing and curling (CTC)** which employs rotoravanes and cutting rollers. CTC tea is more economical with red colour and popular in India.

Steps involved in the processing of tea:

1. Withering
2. Rolling
3. Fermentation
4. Drying
5. Grading

1. **Withering:** The first step in processing of black tea is withering. The main objective of withering is to reduce moisture content of tea leaves. It lowers moisture content to about 55 per cent (by removing 15 to 20 % moisture). During this the leaves undergo physical and chemical withering. Leaves are withered in troughs for about 12-18 hr. When leaves have been withered correctly, it becomes flaccid and suitable for rolling.

Withering may be of

1) Natural or Chung withering: 18 to 20 hours
2) Artificial withering: 3 to 4 hours.

Judging the end point of withering:

- No cracking sound: Well withered leaves will not produce any cracking sound when squeezed i.e., it must not be too dry.

- Compact ball: Withered leaves when pressed by hand should form compact ball.

- The stalk of the withered leaves should not be brittle.

- Feel test: Withered leaves will have silk kerchief feel to touch.

9. **Rolling:** The withered leaf is passed on to rollers where it is twisted so as to cause sufficient damage to the individual leaf cells and to initiate enzymic oxidation. During rolling, cells in the leaves are broken to liberate the sap contain polyphenols (catechins) in the presence of oxygen and enzyme polyphenol oxidase (PPO) oxidizes the polyphenols to produce **theaflavins** and **thearubigens**. These are responsible for colouring of the tea. Rolling is usually done for 30 minutes.

10. **Fermenting (enzymatic oxidation):** Actually fermentation starts at the time of rolling and continues till the entry into the driers. The main operation in the manufacture of black tea is enzymatic oxidation, which was originally termed **fermentation**. In tea processing, fermentation is the term employed to denote enzymatic oxidation by which the polyphenols in the leaf get oxidized with the help of PPO (Polyphenol oxidase) enzyme.

Method:

The coarse and fine fractions of the rolled leaf are spread on clean cement floors or other suitable platforms to a thickness of 2.5- 10.0 cm depending upon the season and condition of the leaf and allowed to ferment for 2-4 hours depending upon the type of roller used.

Colouring compounds formed during fermentation process: The quantity of TR and TF formed will be related to the period of fermentation and the temperature of fermenting leaves.

1) **Theaflavins** (TF): Responsible for orange red colour of tea.
2) **Thearubigens** (TR): Responsible for red- brown pigments found in black tea.

11. **Drying:** The main objective of drying is to arrest/stop the fermentation process and slowly removing the moisture content without a burnt smell but preserving the inherent quality. This is achieved by passing the fermented tea in thin layers through conveyers into a drier in which the inlet temperature is maintained around 250-280^{o}F and outlet temperature is a round 150-200 ^{o}F. Proper drying takes 30-40 minutes. The dried product contains 3-4 percent moisture can withstand long storage and transit.

12. **Sorting and Grading:** The black tea is sold loose or in packets, under different brand names. Stalk is removed during sorting. **There are four main sizes,** viz. Whole leaf, Broken, Fannings and Dusts. The bulk tea is passed through different sized meshes, which aid in separation into different grades. The highest grades are referred to as "orange pekoe" and the lowest as "fannings" or "dust".

Processing of Coffee (*Coffea arabica* L. and *C. canephora* Linden)

Coffee is processed by two methods:

1) **Wet method** – to prepare parchment coffee.
2) **Dry method –** to obtain cherry coffee.

Wet Processing in coffee: Parchment coffee which is preferred in the market.

Steps involved in the preparation of **parchment coffee** are:
1. Pulping
2. Fermentation
3. Drying

1. **Collection of ripe berries:** For both types of processing picking of fruits at correct stage of ripening (on gentle squeezing the fruit, beans inside pop up easily and the colour of berries changes to red) is essential. Just ripe berries are ideal for pulping, to prepare parchment coffee. Over ripe or under ripe berries results in poor cup quality on processing. If harvesting could not be done in time the over ripe, under ripe and green coffee should be sorted separately and processed for cherry coffee.

2. **Pulping**: This method requires pulping equipment and adequate supply of clean water. Removal of outer skin of ripe berries by soaking in water. Pulping the ripe berries on the same day to avoid fermentation before pulping. Fruits may be fed to the pulper through siphon arrangements to ensure uniform feeding and to separate light and floats from sound fruits. The pulped parchment should be sieved to eliminate any unpulped fruits and fruit skin. The skin separated by pulping should be let away from the vats into collection pits so that microbial decomposition of the skin will not affect the bean quality, when it get mixed up with the bean.

3. **Demucilaging and washing:** The mucilage on the parchment skin can be removed by

a) Natural fermentation: The mucilage breaks down in the process of fermentation and its takes 24 to 36 hours for arabica coffee and 72 hours for robusta, because of thicker mucilage. When correctly fermented the mucilage comes out easily from beans, when squeezed by hand.

b) **Enzymatic fermentation**: Enzymes used for demucilaging is pectinolytinc.

c) **Treatment with Alkali:** Removal of mucilage by treatment with alkali takes about one hour for Arabica and one and a half to two hours for robusta. A 10 percent solution of caustic soda (sodium hydroxide) is used. 10 liters of the alkali is sufficient to treat 1000 liters of parchment.

d) **Removal of mucilage by friction:** There are machines which pulp and demucilage the beans in one operation.

Washing: Washing in clean water after soaking for 24 hours (overnight), it improves quality and appearance.

4. **Drying:** Seeds spread on the mats in the open for sun drying until the moisture content is sufficiently reduced to permit storage of beans. Sun drying may takes about 7-10 days under bright weather conditions.

5. **Hulling**: Removal of outer core likes epicotyls and parchment along with testa. The brittle, dry husk like parchment (endocarp) is removed by machines and the sliver skin is removed by polishing.

6. **Polishing**: Removal of adhering testa.

7. **Sorting**: When coffee is being dried, all naked beans, bruised beans, black, green and other defective beans are sorted out and dispatched to curing work separately.

8. **Roasting:** The coffee beans are roasted at 500ºF or 270ºC for 5 minutes. The roasted coffee beans have 0.5 to 1.5 per cent caffeine.

9. **Grinding**: Grinding of roasted beans is the last step in the preparation of coffee powder. Optimum moisture content for safe storage is 10.5% in arabica and 11% in robusta cherry coffee.

Dry method of processing: To obtain **cherry coffee**.

1) **Harvesting of ripe berries:** For the preparation of cherry coffee fruits should be picked when ripe.

2) **Drying:** Ripe berries are spread out evenly to a thickness of about 8 cm on drying grounds. Preferably tiled or concrete floors. Green and under-ripe fruits should be sorted out and dried separately. This has to be heaped and covered with plastic in the evening and spread out in the morning. Drying of ripe berries for 12 to 15 days in bright sun weather until rattling sound is heard when shaken. Drying usually takes 12 to 15 days with intermittent stirring (hourly in the beginning).

3) **Bagging:** The **greenish grey seeds** are graded and are then usually packed for export purposes.

4) **Roasting:** The coffee beans are roasted at 500ºF or 270ºC for 5 minutes. The roasted coffee beans have 0.5 to 1.5 per cent caffeine.

5) **Grinding**: Grinding of roasted beans is the last step in the preparation of coffee powder. Optimum moisture content for safe storage is 10.5% in arabica and 11% in robusta cherry coffee.

Processing of cocoa (*Theobroma cacao* L.)

Processing of cocoa involves following steps.

1. Fermentation
    a. Box method
    b. Tray method
2. Drying
3. Grading
4. Storage
5. Packing

1. Fermentation: Fermentation is done immediately after collecting the bean from the pods. The beans should be fermented to:

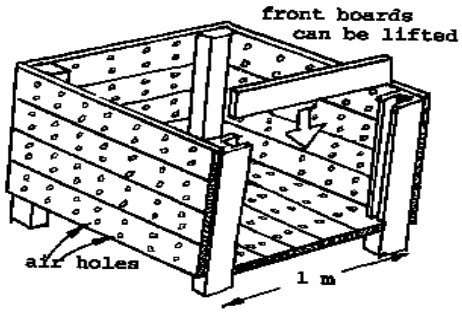
- ✓ **Develop chocolate flavour**
- ✓ Reduce bitterness
- ✓ Loose its viability
- ✓ Remove the mucilage coating
- ✓ Enable the cotyledons to expand

There are two popular methods of fermentation using either in trays or boxes.

A. Box method:-

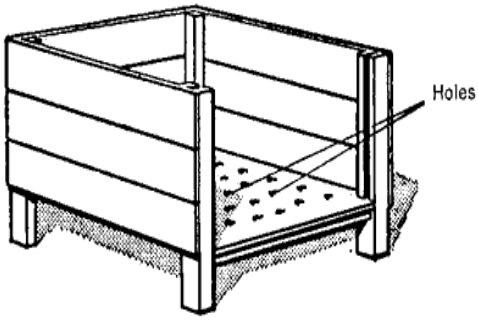
- ✓ In this traditional method, boxes of various shapes and sizes are used.
- ✓ The measurement of smallest box is 60 x 60c.m. and will hold about 150 kg wet beans.
- ✓ The bottom of box has a number of holes of 1cm diameter spaced at about 10cm apart.
- ✓ Three such boxes are arranged in a row so that beans can be transferred from one box to the other.
- ✓ The beans are placed in the top most and covered with banana leaves or gunny bags.
- ✓ After 2 days, the bean should be uncovered and transferred into the second box and then to the third box after another 2 days.
- ✓ On the 6^{th} day, fermentation is completed and beans can be taken out for drying.

55.21 Fermenting box



B. Tray method:

- ✓ This method is used only for fermenting forestero cocoa beans.
- ✓ The normal size of the tray is 90 x 60 x 12cm with a capacity to hold about 40 kg wet beans.
- ✓ The bottom of the tray is either slotted or drilled to make 1cm holes on a 4 cm square pattern.
- ✓ A minimum of 4 trays are needed for successful fermentation.
- ✓ All the trays are filled with beans.
- ✓ The top most trays are covered with banana leaves.
- ✓ The fermentation is faster here and is completed in about 4-5 days.
- ✓ This method is more convenient for large growers as the trays can be easily handled and no mixing is required and the period of fermentation is less.



13. **Drying:** After the fermentation, the beans can be dried by sun drying or artificial drying as the fermented cocoa beans have considerable moisture (55%).
- ✓ Sun drying is good as it gives superior quality produce, when compared to artificial drying.

- ✓ The fermented beans are spread in a thin layer over a bamboo mat or cement floor and dried for 5-6 days.
- ✓ Moisture content of well dried beans is around 6-7 per cent.
- ✓ Duration of artificial drying varies from 48-72 hours at 60-70^{o}C.
- ✓ Well dried beans when shaken should give a metallic sound.

3. Grading: Grading of cocoa beans is done by removing flat, slaty, shrivelled, broken and other extraneous materials.

4. Packing: Cleaned beans are packed in fresh polythene lined (150-200 guage) gunny bags.

5. Storage: The beans should not be stored in rooms where spices, pesticides and fertilizers are stored as they may absorb the odour from these materials.

Processing of palmyrah palm (*Borassus flabellifer* L.)

Tapping: The extraction of sap from the inflorescence is called **tapping**, which is the most important use of this palm. There are different kinds of tapping which vary according to the sex of the palm and the age of the inflorescence.

Male Inflorescence:

- In the male palm the sheath covering the **young inflorescence** (two week old) is removed and allowed to dry for 3 days . The end is cut every time and the pot is tied to the inflorescence. This method is called **Aripanai**.
- Other method known as **Vallupanai**, one month old male inflorescence is selected and each male spike bearing **sessile flowers** is pretreated by pressing and stroking of the inflorescence, 3-6 such spikes are brought together and wrapped with palmyrah leaves and fitted to a pot.

Female Inflorescence:

- In the case of female palm, the young female inflorescence is tapped by a method called **thattupalai.**
- The tapper soften the tissues by hitting the inflorescence main axis with the iron rod and fork is used to press the region from which the fruits develop.
- The other method **Kaivetty** is employed when the inflorescence is about 2-3 months old.
- The inflorescence at this stage is matured and bear fruits and the fruits are sliced as the tapping progress.

Normally, female palm is tapped for a longer period (April to December) compared to the male palm (December-February). The sap is collected twice a day, in the early morning and in the evening. Each time, at the end of the collection of the sap, a new surface is made by cutting a thin slice of the inflorescence. Evening time when the sap is collected, the bottom sediment which contains the yeast and bacteria are left behind. On every fifteenth day, the entire sediment is completely removed but not washed.

Products of palmyrah palm:

The sap tapped is called Neera or padaneer, which is transparent, pleasant smelling and sweet. It contains sugar 12-16 per cent, essential amino acids, vitamins like ascorbic acid and vitamin B complex. This neera is drunk as such or used to prepare various value added products:

1. Toddy: Toddy is obtained as a result of natural uncontrolled fermentation of the sugary sap by the wild yeast and bacteria, which come in contact with the sap. The alcohol content in a fully fermented toddy is about 5 per cent.

2. Jaggery: Jaggery is a solid mixture of reducing and non-reducing sugars prepared by concentration of the strained palmyra sap through gradual boiling.

3. Palm sugar: Palm sugar is obtained by boiling the strained and clarified sap to 108-110 ^{0}C to attain a saturation stage of 85^{0} Brix and allowing it to crystallize.

4. Palm cola: Palm cola is the aerated soft drink containing 11 per cent palm sugar having cola concentrate, citric acid and food colours as other ingredients.

Besides the above from neera, nungu and palmyrah tubers are also used. The tender palmyrah fruit is called **nungu**, it is delicious and rich in carbohydrates, phosphorous, iron, vitamin C and riboflavin and niacin.

Practical- 17

Preparation of Tomato Sauces and Ketchups

Objective: To conduct practical on preparation of sauces and ketchups from tomato.

Theory: The key difference between tomato sauce and ketchup too is the thickness or consistency. However, sauces are generally thinner and has a TSS of 24–25%, while ketchup has a consistency of 28-30%. Tomato ketchup and sauce can be made from freshly extracted juice or pulp. Strained tomato juice or pulp along with spices, salt, sugar and vinegar is cooked or concentrated to the extent that ketchup and sauce contains not less than 12 percent tomato solids, 25 percent total soluble solids and minimum acidity as 1% acetic acid. Sauces/ketchups are prepared from more or less the same ingredients and in the same manner as chutney, except that the fruit or vegetable pulp or juice used is sieved after cooking to remove the skin, seeds and stalks of fruits, vegetables and spices and to give a smooth consistency to the final product. However, cooking takes longer because fine pulp or juice is used.

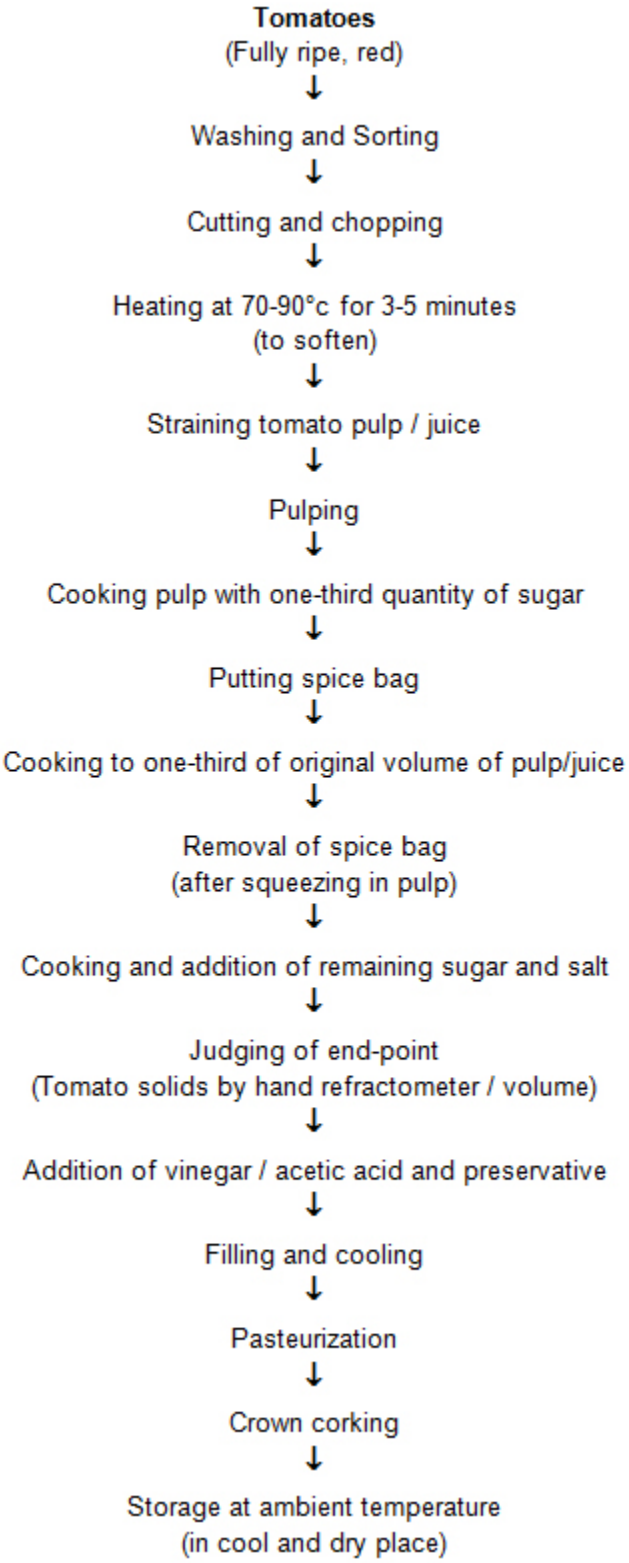
Raw material, ingredients and utensils required

1. Fruits like Apple, tomato, papaya, etc are used for making sauce.
2. Stainless steel knives, de-corers, ladle and utensils for cooking and mixing, glass bottles, sterilization tank, Bhatti/LPG stove etc.

Recipe for preparation of sauces and ketchups from different fruits

Ingredients	Tomato	Apple	Plum	Papaya
Fruit pulp, kg	1	1	1	1
Sugar, g	75	50	150	50
Salt, g	10	10	20	14
Cardamom, Red chillies, g (each)	5	15	10	5
Ginger chopped, g	10	100	25	10
Onion chopped, g	50	200	50	50
Garlic chopped, g	5	50	10	5
Vinegar, ml (Acetic acid), ml	50	50	40	50
Aniseed powder, cumin, g (each)	10	15	10	10
Sodium benzoate, ppm	750	750	750	750

Flow Chart for Tomato Sauce/Ketchup:



Practical-18

Preparation of vinegar

Objective: To prepare vinegar from different fruits.

Theory: The word vinegar is derived from French *vinaigre* meaning sour wine (*vin* means wine and *aigre* means sour). Vinegar is a liquid obtained by alcoholic and acetic fermentation of sugar and starch. Vinegar contains 5 percent acetic acid has germicidal and antiseptic properties, inhibits bacterial growth. FPO specification for fruit vinegar the minimum percent of acidity as acetic acid in final products should be 3.75. Jamun vinegar is very popular in Indian market.

Types of vinegar

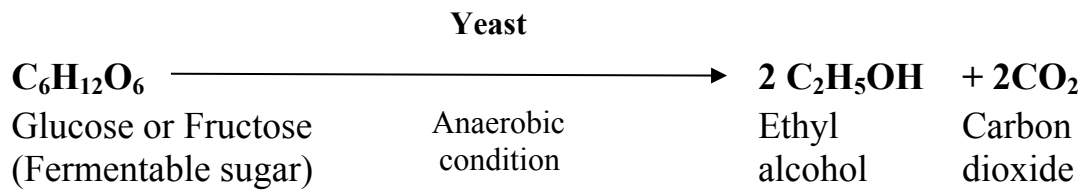
Vinegars are of two types:

1. **Brewed vinegars:** Brewed vinegars are made from various starchy materials i.e. potato starch, molasses, honey by alcoholic and subsequent acetic fermentation.
2. **Fruit vinegar:** The vinegar made from fruits is called fruit vinegar. The fruit vinegar has unique flavor of produced stuffs.

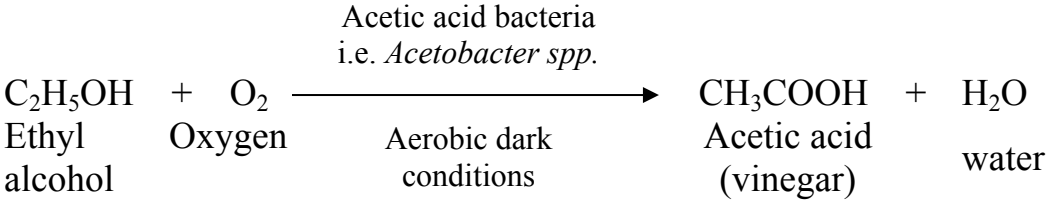
Steps involved in vinegar production

The vinegar process is essentially a two stage process, where yeasts convert sugars into alcohol, followed by *Acetobacter*, which oxidise alcohol into acetic acid (vinegar).

1. **Conversion of fruit sugar into alcohol by yeast (alcoholic fermentation):** The most common yeasts for fermentation of fruit sugar into alcohol are *Saccharomyces cerevisiae* (best for starchy substances) and *Saccharomyces ellipsoideus*. The most favourable temperature for the growth of yeast is 25-27^{o}C. The chemical reaction involve in alcoholic fermentation is as under:



2. **Conversion of alcohol into vinegar by acetic acid bacteria (acetification):** *Acetobacter* convert alcohols into acetic acid in the presence of oxygen. *Acetobacters* are strongly aerobic bacteria but whose activity is greatly reduced by light. The most desirable action of *Acetobacter spp.* (acetic acid bacteria) is in the production of vinegar (acetic acid).



Practical- 19

Preparation of Fruit Pickles

Objective: To prepare pickle from different fruits.

Theory: The preservation of fruit in common salt (NaCl) or in vinegar or edible oil with the addition of spices and condiments is known as pickling. It is one of the most ancient/oldest methods for preservation of fruits and vegetables. Salt, vinegar, edible oil and lactic acid act as preservative in pickle making. Several kinds of pickles are sold in the Indian market. Mango pickle ranks first followed by lime, lemon, mushroom, aonla, jackfruit and karonda pickles. The growth of a majority of spoilage organisms is inhibited by brine containing 12 per cent salt. Pickling is the result of fermentation by "lactic acid-forming bacteria" which are generally present in large numbers on the surface of fresh vegetables and fruits. Class I preservatives (salt) improves the taste, flavour and hardness of the tissue of vegetables and controls fermentations.

Brining: Mixed vegetable pickle from cauliflower, carrot and turnip is most common. Cucumber and olive pickles are examples of fermented pickles. The process of steeping vegetables/fruits in salt or brine solution is also a common method used for preservation of mango and vegetable slices for long duration storage for its later use in pickling.

Raw material, ingredients and utensils required

1. Mango, lime, lemon, aonla, jackfruit, karonda, cauliflower, red chilli, carrot and mixed vegetable etc pickles are most common.
2. Stainless steel peeling/cutting knives.
3. Utensils for cooking and mixing, ladle, glass jars, diesel or LPG/bhatti etc.

Recipe for preparation of pickles from different fruits (1 kg prepared fruit)

Ingredients	Mango in oil	Lime in salt	Mushroom	Aonla in oil
Salt, g	150	200	100	150
Cardamom, Turmeric, Red Chillies, g (each)	30	15	5	10
Clove, No's	8	5	5	5
Vinegar or Acetic acid, ml	-	-	100	-
Aniseed powder, cumin, fenugreek, black pepper, g (each)	25	10	5	30
Mustard oil, ml	250	250	250	250

Procedure for preparation of mango pickles

1. Wash the mature green mango fruits.
2. Cut into 4 equal pieces length wise (depending upon fruit size) and remove the kernel.
3. Dip the mango slices in 2% salt solution to prevent browning.
4. Drain off the water and dry the slices in shade for 4-5 hours (Mango slices preserved in brine can also be used).
5. Heat the oil, cool and mix spices in a little quantity of oil.
6. Mix the fruit slices with spices thoroughly.
7. Fill mango slices in glass jars and keep the covered jars in sun for a week.
8. Shake the jar at least 2-3 times during drying.
9. Press the mango slices to remove the air, add remaining oil to cover the mango slices.
10. Store the pickle in cool and dry place at ambient temperature.

Mango Pickle : Mango (peeled and sliced) -1 kg, salt - 200 g, red chilli powder 10 g, asafetida -5 g, fenugreek, black pepper, cardamom (large), cumin and cinnamon (powdered) each 10 g, clove (headless) 6 numbers.

Flow chart for Mango Pickles

Mangoes

(Mature, green)

↓

Washing

↓

Peeling

↓

Slicing

↓

Putting slices in jar

Sprinkling salt

↓

Putting in sun for one week

(Shaking jar at least twice a day to mix the salt)

↓

Mixing spices

↓

Storage at ambient temperature

(in cool and dry place)

FPO specifications for pickles

Acidity as citric acid	Not less than 1.2%
Salt	Not less than 12%
Preservatives	Sulphur dioxide - Not more than 100 ppm
	Benzoic acid - Not more than 250 ppm
Acidity of vinegar as acetic acid	Not less than 2%

Practical- 20

Drying and Dehydration of Fruits and Vegetables

Objective: To conduct practical on drying and dehydration of fruits

Theory: Drying generally refers to the method of removal of moisture from the fruits under natural condition such as sunlight and wind for example open sun drying, shade drying.

Dehydration refers to a process of removal of moisture by application of artificial heat under controlled conditions of temperatures humidity and air flow. For drying, single thin layer of fruit and vegetables, either whole or sliced after primary pretreatments is spread on the trays which are then placed inside the dehydrator or in the open sun for drying. In the dehydrator initial temperature is generally kept at 43^{o}C which is then gradually increased to 66-71^{o}C for fruits and 60-66^{o}C for vegetables.

Ingredients and utensils required: Stainless steel knives, utensils for blanching and dipping in KMS, dehydrator, drying trays, solar drier, sulpher fumigation chamber.

Common driers used for drying / dehydration

a. **Air Convection Driers**

- Kiln drier
- Cabinet, tray and pan driers
- Tunnel and continuous belt driers
- Belt trough drier
- Air lift drier
- Spray driers

b. **Drum or Roller Driers**

c. **Vacuum Driers**

- Vacuum shelf driers
- Continuous vacuum belt drier
- Freeze-drying

Procedure for drying: Drying generally involves three stages: pre-drying treatments, drying and post drying handling, packaging and storage.

Pre-drying treatments: Select mature and firm fruits for drying. Sort, wash and peel (where required), Slice apple and Papaya into thin slices. Cut small bunches of grapes along with rachis.

Blanching: Fruits like grapes, plum and apricot are dipped in boiling 0.5% NaOH solution for 7-10 seconds followed by cooling to remove the bloom (waxy layer from grapes and plum) or to remove pubescence (hairy growth from apricots) which otherwise interfere in moisture removal.

Sulphuring: The sulphuring is done in sulphur fumigation box which is airtight wooden box of 90×60×90 cm size in which the trays are arranged to place the fruit for sulphuring. Generally 3g sulphur for each kg of prepared fruits and is burnt inside the chamber. Sulphur fumigation is carried out for 45-60 minutes to allow the fumes of sulphur dioxide to be absorbed by the commodity.

OR

Sulphiting: Place the prepared fruits in a solution of potassium metabisulphite (1-2% KMS) and keep for 30-45 minutes. After the treatment, the fruits are drained and are placed on the trays for drying.

Drying: Place the prepared fruits/after sulphuring or sulphiting in thin layers on the trays and keep either in sun light, solar drier or mechanical dehydrator. Allow the drying process to continue till a constant weight loss. Frequently turn the fruits upside down for uniform drying. Mechanical dehydrator takes few hours to dry while sun or solar drier takes longer time for drying. The drying time depends upon temperature used for drying and quantity of material loaded in the drier.

Sweating: Keep the dried product in boxes/cloth bag or bins to equalize the moisture contents within the product.

Sorting, grading and packing: After moisture equalization for 10-15 days, sort the dried product (remove rachis from grape bunches) and grade on the basis of colour, size, and pack in polythene bags or aluminium laminated bags.

Schedule for drying and dehydration of fruits (Preparation and Pretreatments)

Fruits	Preparation/ pretreatments	Sulphuring/Sulphiting time	Drying Temp. (^{0}C)
Apple	Wash, peel, core, trim and cut into 3-5mm thick slices	30 minutes (1-2% KMS)	60-71 ^{0}C for 6-7 hours or Sun dry
Aonla	Wash, grate or cut into halves, de-stone	Salt treatment @ 40g/kg fruits	Sun dry
Banana	Wash, peel, cut lengthwise/round shape 12 mm thick	30 minutes (1-2% KMS)	55-71^{0}C for 10-12 hours or Sun dry
Date	Wash, dip in boiling 0.5 % caustic soda solution then rinse	-	45-50 ^{0}C or Sun dry
Grapes	Dip in boiling 0.5% caustic soda for 7-10 sec and rinse or dip in 1-2%. ethyl oleate solution	1 hour (3g Sulphur/kg fruits)	55-60 ^{0}C or Sun dry
Mango	Wash, peel, cut into 12 mm thick slices	2 hours (1-2%KMS)	50-60 ^{0}C or Sun dry
Papaya	Wash, peel, cut into 6 mm pieces/slices, remove seed	2 hours (1-2 %KMS)	60-65 ^{0}C or Sun dry

Yield of dried products: The yield of dried product generally depends upon the total solid content including TSS of the fresh product. Moisture content in dehydrated fruits not more than 20% and sun dried fruits not more than 24%.

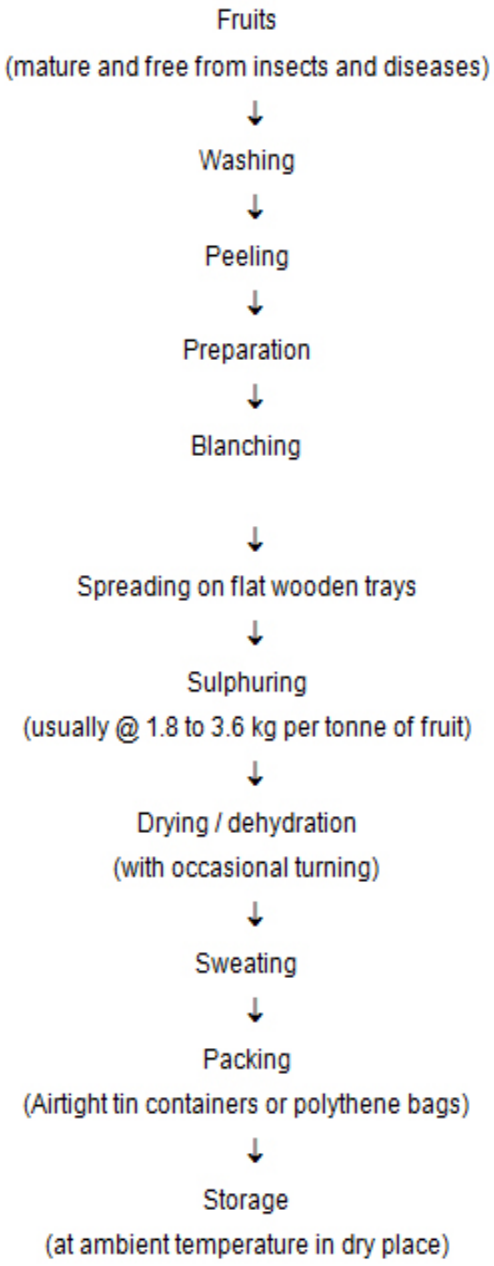
Storage: Store the dried products in a cool and dry place.

Osmotic dehydration

1. Place the prepared fruits (apple slices, apricot and plum) in 70^{o}Brix syrup at room temperature for overnight.
2. Drain the fruits and rinse in water to remove the excess syrup from the fruit surface.
3. Place on the drying trays and dry in mechanical drier to a constant weight.

4. After drying, keep in the cloth bags for moisture equalization.
5. Pack in airtight bags and store in cool and dry place.
6. The yield of osmotically dried fruits is more than that of fruits dried without osmosis.

Flow sheet for drying / dehydration of fruits:



Practical- 21

Freezing of Fruits

Objectives: To conduct practical on freezing of fruits.

Theory: Freezing is a method of preservation in which the fruit temperature is reduced below freezing point and a proportion of water changes in to ice-crystals. Immobilization of water to ice and the resulting concentration of dissolved solutes in unfrozen water cause lowering of water activity in the food. Thus, reduction in water activity and use of low temperature coupled with some pre-treatments is the basis for food preservation by freezing. The method for freezing of fruits depends upon the intended use. Generally fruits after preliminary treatments are packed in sugar syrup and frozen in freezer. The fruits are frozen to an internal temperature of -18^{o}C or lower and kept at -18^{o}C or lower throughout transport and storage.

Raw material, ingredients and utensils required

1. Fruits like pineapple, mango, guava, orange segments, peaches, strawberries, and cherries etc.
2. Stainless steel knives, peelers, blanchers, heating equipment, Freezer, utensils, packages, sugar, citric acid, ascorbic acid etc.

Procedure for freezing of fruits

Pre-process handling

1. Follow different steps for preparation of fruits for freezing. Blanching: Blanching of fruits is carried out to inactivate enzymes. The prepared fruits are kept in boiling water or under steam to pre-determined period followed by immediate cooling.
2. Addition of sugar syrup (syrup pack, sugar pack, sugar replacement and unsweetened pack).

a) **Syrup pack:** Use 40 percent sugar syrup for most fruits for freezing. For mild flavoured fruits, use lighter syrup to prevent masking of flavour while for sour fruits use heavier syrup.

Process variables for freezing of different fruits

Fruit	Preparation	Type of Pack followed by freezing
Apples	Wash, peel, slice, and immerse in solution containing citric acid/salt/ ascorbic acid to check browning.	Pack in 30-40% syrup containing 0.02% ascorbic acid.
Apricots	Wash, halve and remove pit, peel, and slice if desired. If apricots are not peeled, heat in boiling water for half minute, cool and drain.	Pack in 40% syrup containing 0.02% ascorbic acid.
Avocados	Peel soft and ripe avocados. Cut in half, remove pit and mash pulp (puree).	Add 0.05% ascorbic acid to puree. Package in recipe-size amounts.
Berries	Select firm, fully ripe berries. Sort, wash/ and drain.	Use 30% syrup or dry unsweetened pack, dry sugar pack or tray pack.
Cherries (sour or sweet)	Select well-coloured, tree-ripened cherries. Sort and wash thoroughly.	Pack in 30-40% syrup or in dry sugar.
Citrus fruits	Select firm fruit, free of soft spots. Wash and peel, use segments.	Pack in 40% syrup or in fruit juice. Use 0.02% ascorbic acid in syrup.
Grapes	Select firm, ripe grapes. Wash and remove stems. Slice or use whole.	Pack in 20% syrup or pack without sugar. Use dry pack for halved grapes and tray pack for whole grapes.

b) **Sugar packs:** Sprinkle sugar over the fruits or fruit slices and gently agitate the container to allow drying out the juice and dissolve the sugar. This sugar pack is generally used for soft sliced fruits such as peaches, strawberries, plums, and cherries, by using sufficient syrup to cover the fruit. Some whole fruits may also be coated with sugar prior to freezing.

c) **Tray packs:** Unsweetened packs are generally prepared by using tray packs. Spread prepared fruits in single layer on shallow trays and freeze promptly in freezer bags. In tray packs, the fruit sections remain loose without clumping together, which offers the advantage of using frozen fruit piece by piece.

d) **Sugar replacement packs:** Use artificial sweeteners like saccharine, sorbitol instead of sugar in the form of sugar substitutes. In sugar replacement packs, the sweet taste of sugar is replaced by using artificial sweeteners. Fruits frozen with sugar substitutes will freeze harder and thaw more slowly than fruits preserved with sugar.

Freezing: Carry out freezing of fruits either in chest freezer (-20^{o}C to -30^{o}C), air blast freezer (-18^{0}C to -40^{0}C) or in tunnel freezer.

Packaging: Packaging of frozen fruits is done to exclude air from the fruit tissue. Replacement of oxygen with sugar solution or inert gas or use of vacuum and oxygen-impermeable films is used for packaging frozen fruits. Plastic bags, plastic pots, paper bags and cans (with or without oxygen removal) are common packages. As most foods expand on freezing up to 10% of their volume, the package in which food is frozen should be strong and flexible.

Storage: Store the frozen products in a cool and dry place (in refrigerator).

Practical-22

Freezing of Vegetables

Objective: To conduct practical on freezing of vegetables.

Theory: Freezing is often considered the simplest and most natural way of preservation for vegetables. Frozen vegetables and potatoes form a significant proportion of the market in terms of frozen food consumption. The quality of frozen vegetables depends on the quality of fresh vegetables, since freezing does not improve product quality.

Raw material, ingredients and utensils required

1. Vegetables like beans, peas, carrot, cauliflower etc. are most commonly frozen.
2. Stainless steel knives, peelers, blanchers, heating equipment, Freezer, utensils, salt, sugar, citric acid, ascorbic acid etc.

Procedure for freezing

1. **Selection of raw material:** Vegetables at peak flavour and texture are used for freezing. Post harvest delays in handling vegetables are known to produce deterioration in flavour, texture, colour, and nutrients. Therefore, the delays between harvest and processing should be reduced to retain fresh quality prior to freezing.

2. **Blanching:** Blanching of vegetables is carried out to inactivate enzymes. The vegetables are kept in boiling water or under steam to pre-determined period followed by immediate cooling.

3. **Cooling:** Cooling vegetables by cold water, air blasting or ice will often reduce the rate of post-harvest losses sufficiently, providing extra hours of high quality retention for transporting raw material to considerable distances from the field to the processing plant.

4. **Freezing:** Carry out freezing either in chest freezer (-20^{o}C to -30^{o}C), air blast freezer (-18^{0}C to -40^{0}C) or in tunnel freezer. The temperature regime covering the freezing process, the cold-store temperatures (-18°C),

distribution temperatures (-15°C) and retail (-12°C) are generally recommended.

5. **Packaging:** Packaging of frozen vegetables is done to exclude air from the fruit tissue. Replacement of oxygen with brine or use of vacuum and oxygen-impermeable films is used for packaging frozen vegetables. Plastic bags, paper bags and cans are common packages.

6. **Storage:** Store the frozen products in a cool and dry place (in refrigerator).

Process variables for preparation of vegetables for freezing

Vegetable	Preparation	Blanch time followed by Freezing	
Asparagus	Wash and sort by size. Remove tough ends. Cut stalks into 5-cm lengths.	Water blanch	2 min.
		Steam blanch	3 min.
Beans	Wash and trim the ends. Cut to desired size pieces.	Water blanch	3 min. (whole), 2min. (cut)
		Steam blanch	4 min. (whole), 3min. (cut)
Broccoli	Wash and cut to desire size pieces.	Water blanch	3 min.
		Steam blanch	3 min.
Cabbage	Wash and cut into wedges	Water blanch	3 min.
		Steam blanch	4 min.
Carrots	Wash, peel and trim. Cut to desired size.	Water blanch	5 min.
Cauliflower	Discard leaves, stem and wash. Break into florets	Water blanch	5 min. (whole)
		Steam blanch	7 min. (whole)
Corn	Remove husks, trim ends and wash	Water blanch	5 min.
		Steam blanch	7 min.
Mushrooms	Wipe mushrooms with paper towel, Sort, trim and cut large sized mushrooms	Frozen without heat treatment	
Peas	De-podding/shelling of peas	Water blanch	1-1/2 min.
		Steam blanch	1-1/2 min.
Potatoes	Peel, cut or grate as desired	Water blanch	5 min. (Whole), 2-3 min. (pieces)

Freeze Drying – How does it work?

1. Fresh or cooked foods are flash frozen then placed in a vacuum chamber

2. About 90% of the food's moisture is drawn off by evaporating the ice at temperatures as low as -50°C

3. The freeze – dried food is sealed in moisture-and-oxygen proof packaging to ensure freshness until opened.

4. When the water is replaced the food regains it's original fresh flavour, aroma, texture and appearance.