MAHATMA PHULE KRISHI VIDYAPEETH

COLLEGE OF HORTICULTURE, PUNE

PRACTICAL MANUAL

B.Sc. (Hons) Horticulture

Semester: VI (New)

Course No.: H/PHT 363

Credits: 3 (1+2)

PROCESSING OF HORTICULTURAL CROPS

Prepared by

Dr. S.K. Marbhal
Dr. S.G. Bhalekar
College of Horticulture, Pune

Name : .....

Regd. No. : .....

Batch No. : .....

Semester : .....

Academic year : 2020-21

INDEX

Course No.: H/PHT 363 **Credits : 3 (1+2)**
Title : Processing of Horticultural Crops **Semester: VI (New)**

Ex. No.	Title of Exercise	Page No.	Date	Sign
1	Equipments used in food processing units			
2	Canning of fruits- mango, pineapple, guava etc			
3	Canning of vegetables- peas, tomato etc.			
4	Preparation of RTS			
5	Preparation of squash			
6	Preparation of syrup			
7	Preparation of cordial			
8	Preparation of jam			
9	Preparation of jelly			
10	Preparation of marmalade			
11	Preparation of preserves			
12	Preparation of candies			
13	Preparation of chutneys			
14	Preparation of tomato ketchup			
15	Preparation of hot pickles			
16	Preparation of sweet pickles			
17	Dehydration of fruits			
18	Dehydration of vegetables			
19	Refrigeration and freezing			
20	Dehydrofreezing of fruits and vegetables			

Ex. No.	Title of Exercise	Page No.	Date	Sign
21	Cut out analysis of processed food/ canned products			
22	Processing of plantation crops- Nut crops			
23	Processing of plantation crops- Beverage crops			
24	Processing of plantation crops- Rubber, Oil Palm			
25	Spoilage of processed products			
26	Types of containers used for processing of fruits and vegetables			
27	Visit to processing units			

CERTIFICATE

Certified that Mr./Miss.----------

Registration No. ---------- has completed all practical exercises for the course H/PHT 363 (Processing of Horticultural Crops) during academic session 2019-20.

Date:

Place: COH, Pune Course Teacher

Practical No. 1

EQUIPMENTS USED IN FOOD PROCESSING UNITS

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

The students will visit the processing unit/pilot plant and familiarize with different machineries and equipment used in fruit processing units. The students will observe the layout and the details of the machinery for different unit operations *viz.,* raw material receiving, washing, sorting/grading, peeling, slicing, pulping, heating, filling, exhausting, sealing, sterilization/processing, labelling and storage for different products. The list of the machineries and equipments and important chemicals used in fruit preservation is as under

Apparatus/machineries/equipments used in food industries

A. Basic equipment/ accessories

1. Weighing balance (1-10kg) and electronic balance (for chemical weighing)
2. Cutting Knife (SS), coring knife, pitting knife, peeling knife
3. Abrassive peeler
4. Working table
5. Buckets, Tubs, Jugs
6. Belt conveyors
7. Fruit /vegetable washer
8. Fruit /vegetable blancher
9. Bottle washer

B. Heating equipment

1. Hot plate
2. Diesel bhatti
3. LPG bhatti/gas stove
4. Boiler

C. Juice extraction/pulping

Hand operated /motor driven

1. Fruit grater/ Fruit mill
2. Basket press
3. Hydraulic press
4. Rosing machine/burring machine
5. 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

J. Common chemicals

1. Citric acid
2. NaOH (Sodium hydroxide)
3. Sodium Benzoate
4. Alcohol (Rectified spirit)
5. Pectin
6. Salt
7. KMS (Potassium meta-bi-sulphite)
8. Acetic acid
9. Coal tar dyes (carmosine, Tatartrazine)
10. Flavour/Essences, (apple, peach, mixed fruit, strawberry essence, raspberry essence, orange and alphonso essence etc.)

Brief detail and operation of different machineries

1. Belt Conveyor

The conveyers are suitable for feeding, inspection and initial preparation of fresh fruits and vegetables. It can handle 1-10 tonnes of material per hour.

2. Fruit and vegetable washers

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.

3. Halving and burring Machine

The halving and burring machine is used to extract juice from citrus fruits like orange, mosambi, grapefruit, lemon, lime etc. Fruit in a cup of machine is cut into two halves by a stationary or revolving knife. The burrs (roses) are made of stainless steel, aluminium or non-odorous wood. They are conical shape and are ribbed. The fruit half is held against the revolving burr and the reamed juice is collected in a vessel. By regulating the speed of burr and the pressure on the fruit held against it, optimum juice recovery can be obtained besides avoiding extraction of oil, which may otherwise cause bitterness in juice.

4. Fruit grater

The fruit grater is used for grating/crushing 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, carrots, aonla after removal of seeds etc can also be crushed in the grater.

5. 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.

6. 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. Capacity of the machine is 30 -50 kg/h.

7. Basket/hydraulic press

The basket press (Fig. 1.1) 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 alongwith 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 is useful in extracting juice from the apple, pear, grape, jamun, pomegranates, phalsa etc.

8. 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 (Fig. 1.2) 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 the hopper and after pulping action, the extracted pulp and separated seeds/peel are collected from different ends.

9. 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 jacket 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) (Fig 1.3), Steam jacketed kettle (fixed type) and fixed type kettle with stirrers.

10. Fruit and vegetable blancher/Hot water blancher

Hot water blanchers (Fig 1.4) 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.

11. Crown corking machine

Crown corking machine (Fig 1.5) is hand operated and can cork 20-25 bottles per minute. It is suitable for sealing the juice bottles with crown corks.

12. 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.

13. Bottle washers

Bottle washers are provided with revolving brushes to which bottle/jar is placed for automatic washing action. The time consuming part of bottle washing is rinsing out the detergent and bottle washers are used to reduce this time. They are made by soldering vertical pipes onto a larger base pipe and connecting the

base pipe to a water supply. For rinsing, the bottles or jars are inverted over the vertical pipes and rinsed until free of detergent.

14. Laboratory glassware/equipment

The laboratory equipment used for testing fruit and vegetable products includes glass beakers, pipettes, flasks and a burette (Fig 1.6). Pipettes are used to suck a known volume of a chemical and drop it into a sample of juice. 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.

15. Refractometer

Hand refractometer (Fig 1.7) measures total soluble solids (TSS) as °Brix, which corresponds to % sugar. It is available in three ranges 0-32^{0}Brix, 28-62^{0}Brix and 58-92^{0}Brix 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 0-100^{o}B. Abbe refractometer is expensive instrument but it gives an accurate measurement of TSS and can also be used for standardization of hand refractometer.

16. Double seamer

It is suitable for high speed air tight seaming of the open top sanitary (OTS) cans (Fig 1.11). The seaming of the cans is done for getting hermitic seal of cans. Double seaming is a two step operation. In the first operation, the can lid is inserted on to the can body hook by holding and rotating the lid-in-position can between two rollers. This operation is called as clinching; during which first operation roller gently guides the lid in the body hook. The next step is to press the seam using the second operation roller, which results in an appropriate overlap of the body hook and cover hook to provide appropriate countersink. Between the cover hook and body hook lies a layer of sealing compound which ensures the sealing process.

17. Can sterilizer/Autoclave

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 (Fig. 1.13) can also be used for sterilization of sealed cans of vegetables and mushroom which are processed under steam pressure.

18. Weighing balance/scales

Small scales (0-2kg), medium portable scales (up to 10kg) and large scales (upto 100kg) are used to weigh small amounts of ingredients or laboratory chemicals, weighing of ingredients and products and weighing 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.

Practical No. 2

CANNING OF FRUITS - MANGO, PINEAPPLE, GUAVA ETC

Canning

Canning refers to a method of preserving food by first sealing it in air-tight jars, cans or pouches & then heating it to a temperature that destroys contaminating microorganisms. 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 of A1 tall or A2½ size.
3. Fruits *viz*., mango, pineapple, guava etc suitable for canning
4. Peeling and coring knives
5. Sugar
6. Sodium hydroxide

Canning process for fruits:

1. Raw material selection:
   Select ripe but firm, evenly matured fruits, free from blemishes, insect damage and malformation.
2. Washing:
   Wash the fruits with running water to remove dust, dirt, debris & 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:
   Lye peel peaches, apricot, sand pear by placing in boiling 2% sodium hydroxide solution followed by dipping in 1-2% citric acid or 0.5% HCl solution to neutralize lye then wash in running tap water.
   - Peel apple manually and slice. Keep in 2% salt solution to avoid browning.
   - Cut peeled peaches and apricot into halves and remove the pit/stone. Keep dipped in 2% salt solution to check browning.

- Cut whole pineapple into 5mm thick slices, remove peel and core by using pineapple corers.

5. Preparation of cans:
   - Reform the flattened cans using reforming machine.
   - Flange in a Flanger.
   - Place lid on one side of can using double seaming machine.
   - Sterilize can in can sterilizer or place in boiling water.

6. Filling into cans:
   Place uniform sized peaches/apricot/pear/halves, pineapple slice into lacquered cans to its declared drained weight (not less than 50%). (Generally from one kg of peach fruit, one can of A 2 ½ size is obtained).

7. Syruping:
   Prepare syrup by boiling sugar and water, followed by straining. Keep concentration of sugar as 35-55%.
   - Use 40% sugar syrup containing 0.3% acidity for peach canning. Fill the cans with boiling hot syrup.
   - Add the syrup in the can at a temperature of 79-82°C, leaving 0.32-0.47cm head space.

8. Exhausting:
   Immediately after filling of syrup, place loose lid/ end cover on the can or clinch the can using first operation roll of the double seamer. (The lid/ end cover should be embossed with a coding machine). Place in a hot water tank or in a exhaust box for exhausting. Exhaust the cans till a temperature at the centre of can reaches 79^{o}C.

10. Double seaming:
    Immediately after exhausting, seal the cans using double seamer.

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.

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 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.

Specific requirement for canning of fruit crops

Fruit	Preparation	Strength of syrup (°B)	Exhaust	Processing time (min) in boiling water for various size containers			Type of can
				A2 (tin)	A2 ½ (tin)	Pint jar (glass)	
Mango	Peel, cut into slices	40	Exhaust can at 82-100°C for 6-10 min or until temp. in centre of can reaches about 79°C	25	30	-	Plain
Pineapple	Peel, cut into 1 cm slices, remove core and eyes	40	-do-	20	30	25	Plain
Guava	Peel, cut into pieces, remove seedy portion, treat with 2% brine and wash	40	-do-	20	20	25	Plain

FPO specification for canned fruits

Specifications	Canned fruits
Drained weight	Not less than 50% Exception: berry fruits 40%
Appearance	Free from blemishes, stalks, leaves, etc.
Texture	Free from disintegration and damage from bruises.
Added colour	No colour except strawberry and cherry

Practical No. 3

CANNING OF VEGETABLES - PEAS, TOMATO ETC

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 of A1 tall or A2½ size.
3. Vegetables eg. Peas, beans, tomato, potato, cabbage, carrot, okra etc. suitable for canning
4. Peeling and coring knives
5. Salt
6. Sodium hydroxide

Canning process for vegetables:

1. Raw material selection:
   Select vegetables when tender except tomatoes. Vegetables free from blemishes, insect damage and malformation.
2. Washing:
   Wash the 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, shelling:
   - Peas and beans: shelling
   - Peel potatoes manually or using abrasive peeler and cut into slices. Keep slices in 2% salt solution to check browning.
5. Blanching:
   Place vegetables and mushroom in boiling water or in blanching tank for 2-5 minutes followed by dipping in cold water for blanching.
6. Preparation of cans:
   - Reform the flattened cans using reforming machine.
   - Flange in a Flanger.
   - Place lid/ end cover on one side of can using double seaming machine.
   - Sterilize can in can sterilizer or place in boiling water.
7. Filling into cans:
   Fill mushrooms and vegetables (peas, tomato, okra, potato) in cans of not less than 55% of the total capacity of the can.

8. Brining:
   Prepare hot brine by boiling salt and water (2-10%) along with citric acid (0.3%) and sugar (1%) followed by straining and pour in the can containing vegetable while still hot.

9. Exhausting:
   Immediately after filling of brine, place loose lid/ end cover on the can or clinch the can using first operation roll of the double seamer. (The lid/ end cover should be embossed with a coding machine). Place in a hot water tank or in a exhaust box for exhausting. Exhaust the cans till a temperature at the centre of can reaches 79^{o}C.

10. Double seaming:
    Immediately after exhausting, seal the cans using double seamer.

11. Heat processing/sterilization:
    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 the cans one above other to allow 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.

Specific requirement for canning of vegetables

Vegetable	Preparation	Strength of syrup (°B)	Exhaust	Processing time (min) in boiling water for various size containers			Type of can
				A2 (tin)	A2 ½ (tin)	Pint jar (glass)	
Peas	Shell, grade, boil for 3-5 min	2+2.5% sugar solution	Exhaust can at 82-100°C for 6-10 min or until temp. in centre of can reaches about 79°C	40	45	40	Lacquered
Tomato	Place in loose musclin bag, dip in boiling water for a min. then dip quickly in cold water to loosen skin, remove green portions and stem, if present	Tomato juice is used instead of syrup	-do-	25	30	-	Plain

FPO specification for canned vegetables

Specifications	Canned vegetables
Drained weight	Not less than 55% Exception: canned tomato 50%
Appearance	Free from pods, stalks, roots and blemishes *etc*.
Texture	Free from disintegration and damage from bruises.
Added colour	Not permitted, except for peas

Practical No. 4

PREPARATION OF RTS

Ready to serve (RTS) drink is a type of fruit beverage which contains at least 10% of fruit juice and 10°Brix TSS with 0.3% acidity. It is not diluted before serving, hence it is known as ready to serve beverage. Mango drink, guava drink, pineapple drink are the commercial products available in the market.

Raw material, ingredients, machinery required

1. Mango, orange, lemon, lime, litchi, pear, kiwi & apricot are used for making RTS.
2. Stainless steel knives, juicer/screw type juice extractor, utensils for cooking and mixing, glass bottles, sterilization tank, gas bhatti etc.
3. Recipe for preparation of RTS from different fruits:

Pulp/juice	1.5 litre
Sugar	685 g
Citric acid	3.5g
Water	7.8 litre
Potassium meta-bisulphite (KMS)	1.5g

***Note:** RTS drink can also be preserved by adding not more than 70 ppm SO_2 or 120 ppm benzoic acid.

Procedure for preparation of ready to serve (RTS) drinks

1. Take fruit pulp/juice and mix with syrup which is prepared by mixing sugar with water and citric acid.
2. Homogenize the mixture for proper mixing.
3. Heat the drink to boil for pasteurization.
4. Fill in the glass bottles (200ml capacity) while still hot.
5. Crown cork the bottles and process in boiling water for 20-25 minutes.
6. On cooling, label the bottles and store in cool and dry place.
7. Potassium meta-bisulphite (KMS) or benzoic acid can be added to the RTS drink as preservative.
8. Synthetic and approved artificial colour and flavour can be added when declared on the label.

FPO specifications for Ready to serve drinks

Juice/pulp content	Lime - Not less than 5% Other fruits - Not less than 10%
TSS	Not less than 10%
Preservatives	Sulphur dioxide - Not more than 70 ppm Benzoic acid - Not more than 150 ppm
Acidity	Not more than 3.5%

Practical No. 5
PREPARATION OF SQUASH

Squash is a type of fruit beverage containing at least 25% fruit juice or pulp and 40% total soluble solids (TSS). Squash is diluted before serving (1:3). According to FPO specifications, class II preservative in fruit squash shall not exceed 350 ppm sulphur dioxide or 600 ppm sodium benzoate. Artificial colour and flavours can be added when declared on the label.

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, ladle and utensils for cooking and mixing, glass bottles, sterilization tank, LPG stove/diesel bhatti etc.
4. Recipe for preparation of squash from different fruits is given in Table 5.1

Table 5.1 Recipe/ingredients required for preparation of squashes from different fruits

SN	Fruit pulp/juice	Fruit pulp/juice (1kg)			
		Sugar (kg)	Water (lts)	Citric acid (g)	Preservative (g)
1	Lemon, Lime	1.80	1.2	-	1.5 KMS
2	Orange	1.75	1.2	20	2.5 KMS
3	Pineapple	1.75	1.2	20	2.0-2.5 KMS
4	Mango	1.80	1.2	35	2.0 KMS
5	Papaya	1.80	1	25	2.5 KMS
6	Jamun	1.80	1	15	3.0 Sod. benzoate

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.

Procedure for preparation of fruit squash

1. 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. (Rosing machine can also be used for juice extraction).
   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) Jamun: Wash the fruits, boil with small quantity of water, pass through pulper to extract the pulp and separate the seeds.
   v) Papaya/watermelon: Peel fruits, separate seeds, pass through pulper to extract the pulp.
   vi) Pineapple: Remove the crown of fruits by giving twist, remove peel and eyes. Cut the sound portion into small pieces, pass them through a mincer. Wrap the pieces in muslin cloth and press out the juice through basket press. Strain the juice through coarse muslin cloth.
2. Preparation of syrup
   Prepare sugar syrup by mixing sugar, citric acid with water. Heat to boil, strain through muslin cloth and allow to cool.
3. Mix fruit pulp or juice with the required quantity of sugar syrup.
4. Add required quantity of KMS or sodium benzoate along with permitted edible food colour and flavour and mix thoroughly.
5. Fill in per-sterilized glass or plastic bottles leaving a small head space (2.5 cm).
6. Cap and seal bottles using PP cap sealing machine.
7. Label and store in cool and dry place.

FPO Specifications for Squash

Juice content	Not less than 25%
Total soluble solids	Not less than 40%
Acidity	Not more than 3.5%
Preservatives	Sulphur dioxide (Not more than 350 ppm) Benzoic acid (Not more than 600 ppm)

Practical No. 6

PREPARATION OF SYRUP

Syrup is prepared by using minimum of 25% fruit juice or pulp and sweetened by using cane sugar. It shall contain not less than 65% total soluble solids and not exceeding 350ppm SO_2 or 600ppm benzoic acid as class II preservative. Syrups of rose, sandal, almond, strawberry, pineapple, rasp berry, orange, mulberry, etc. are very popular as summer drinks.

1. Synthetic syrup

Heavy sugar syrup of 70-75 percent strength is used as the base of all synthetic syrups, which are flavoured and coloured with artificial flavour and colours. They may or may not contain fruit pulp or juice.

2. Natural syrup

In this type, only colour or essence is added in fruit juice. The natural syrups are more nutritious than synthetic syrups.

Raw material, ingredients, machinery and equipments required

Juice of natural material flavour, citric acid sugar, water, glass bottles.

Procedure of preparation of fruit syrup

1. Select fruits free from diseases and bruises
2. Wash the fruits thoroughly in cold water.
3. Extract the juice.
4. Strain the juice.
5. Preparation of syrup: For 1 kg of juice prepare 3 kg sugar syrup of 70°Brix by dissolving 2 kg sugar in 900 ml of water. Strain it and 50 gm of citric acid.
6. Mix the juice to hot syrup.
7. Fill the product in previously sterilized bottles.
8. Keep the bottles in boiling water for half an hour and seal them when hot.
9. Allow the bottles to cool, label them and store in cool dry place.

Important hints for preparation of fruit syrup

a. Final product should have minimum of 65 °Brix and 25% of juice.
b. It can be synthetically prepared by adding artificial flavours.
c. Above procedure can be used for preparation of syrup of lemon fruit. There is no need of adding citric acid.
d. Syrups are consumed after dilution with sufficient quantity of water.

Practical No. 7

PREPARATION OF CORDIAL

Aim: To prepare cordial from lemon and lime

Cordial is a sparkling, clear, sweetened fruit beverage from which pulp has been removed completely. It contains at least 25% fruit juice, 30% total soluble solids (TSS), 1.5% acid and 350 ppm sulphur dioxide. Lemon and lime juice cordials are the commercial products.

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

Ingredients	Quantity
Lime/lemon juice	1 litre
Sugar	1.4 kg
Water	1.6 litre
Potassium meta-bisulphite (KMS)	1.5 g

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
Organoleptic quality	Free from objectionable taste and flavour

Practical No. 8

PREPARATION OF 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. For preparation of jam not less than 45 parts of fruits are used for every 55 parts of sugar. According to FPO specifications, minimum TSS in the prepared jam shall not be less than 68% (w/w). The jam prepared by using two or more fruit pulps, is called as mixed fruit jam. Approved fruit colour and flavour can also be added into the jam when declared on the label.

Raw material, ingredients and utensils required

1. Fruits like papaya, mango, strawberry, guava, pineapple, 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.
3. The recipe (for 1kg fruit pulp) for different fruits is given in Table 8.1

Table 8.1 Recipe for preparation of jam from different fruits

(basis 1 kg fruit pulp)

Fruit	Sugar (g)	Citric acid (g)	Water (ml)
Papaya	700	3.0	100
Mango	750	1.5	50
Strawberry	750	2.0	100
Mixed jam (equal amount of fruit pulp)	800	2.5	100

Procedure for jam preparation

1. Select fully ripe fruits and wash thoroughly to remove any adhering dust and dirt.
2. Peel the washed fruits slice and cook till softening and extract the pulp. Preserved pulp can also be used for jam making.
   - Mangoes are peeled, stones separated and then sliced. The slices are then passed through a pulper.
   - Pineapples are peeled, sliced and the cores punched.
   - Apple, guava and pear after washing are cut into halves or quarter, boiled till softening and pulp extracted in a pulper.
3. Addition of sugar: Add continue cooking with stirring. Generally 55 parts of cane sugar (sucrose) is used for every 45 parts of fruit for preparation of jam.

4. Citric acid is used to supplement the acidity of the fruit for jam making. (Generally 5 g citric acid for each kg of sugar used is added to the jam). Flavours are added at the end of cooking process and just before packing.
5. Only permitted colours are added not exceeding 100 ppm limit as per the Indian Food Laws.
6. Cook the mixture slowly with occasional stirring with a small quantity of water to facilitate pulping. After addition of sugar, the mixture is boiled rapidly to concentrate the soluble solids to about 68.5% in a pan made of stainless steel or aluminium.
7. Add pectin (5 g for each kg of sugar used) in powdered or liquid form just before the end point if jam is made from preserved pulp.
8. Determine the end point of jam by using a jelmeter test, ladle test or sheet test or weight test.
9. Fill the prepared jam while hot in glass jars.
10. Allow the product to cool and seal the jar air-tight. A layer of molten paraffin wax can be placed at the top of cooled jam which helps in preservation. When paraffin wax solidifies, place the lid on the jar.
11. Label and store 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.

OR

A drop of prepared jam if poured gently in glass tumbler full of water settles down at the bottom of tumbler also indicates the end point. In case of shattering in water further cooking is needed.

Weight Test

Generally from one kg sugar and one kg pulp approximately one and half kg jam is obtained.

FPO specifications for Jam

Fruit contents	Not less than 45% Except strawberry jam where it shall be not less than 25%
TSS	Not less than 68% (w/w)
Preservatives	Sulphur dioxide (Not more than 40 ppm) Benzoic acid (Not more than 200 ppm)
Crystallization	Absent

Practical No. 9

PREPARATION OF JELLY

A jelly is a semi-solid product prepared by boiling a clear, strained solution of pectin-containing fruit extract, free from pulp, after the addition of sugar and acid. 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 jelly should be transparent, well set, but not too stiff and having original flavour of the fruit. It should be attractive in colour and should keep its shape. In the preparation of jellies, pectin is the most essential constituent.

As per FPO specifications, the quantity of fruit and TSS in the final product shall not be less than 45 and 65 % (w/w), respectively. Guava jelly is the commercial product available in the market however jelly can be prepared from sour apple, karonda, jamun, etc.

Raw material, ingredients, machinery required

1. Guava, sour apples, karonda, loquat etc are used for making jelly.
2. Stainless steel knives, ladle utensils for cooking and mixing, glass bottles, sterilization tank, juicer/basket press, bhatti/LPG stove/boiler, Refractometer etc.

Table 9.1 Recipe for preparation of jelly from different fruits

Fruit	Quantity	Sugar (g)	Citric acid (g)
Guava	1kg	750	3.0
Sour Apple	1kg	750-1000	3.0
Karonda	1kg	750	-
Jamun	1kg	750	1.0

Procedure for guava jelly preparation

1. Select sound, mature fruits, wash thoroughly and cut them in small pieces along with peel (peel contains maximum pectin).
2. Cover the pieces with water and add citric acid 1.5 to 2 g/kg fruits.
3. Boil the mass gently to enable release of pectin.
4. Repeat the process 2-3 times for complete extraction of pectin.
5. Strain the mass through a muslin cloth to separate the extract.

6. Do not squeeze, only strain all the extracts and allow it to stand for settling.
7. Collect only the supernatant.
8. Perform pectin test by adding two teaspoonful of rectified spirit to a teaspoonful of extract. Formation of one big clot indicates high pectin in the extract, formation of many clots indicates medium pectin and thin gelatinous precipitates indicates poor pectin.
9. If the pectin contents are poor, concentrate the extract till it gives test of high pectin or add the pectin externally.
10. To prepare jelly from the extract cook till end point reaches. The end-point of a jelly can be judged by using any of the following methods:
    - Cold plate test: A drop of the boiling liquid from the pan is taken and placed on a plate and allowed to cool quickly. If the jelly is about to set, the mixture on the plate will crinkle when pushed with a finger.
    - Sheet or flake test: This test is more reliable than the plate test. A small portion of jelly is taken with a large spoon or wooden ladle, cooled slightly and then allowed to drop off. If the jelly drops like syrup, it requires further concentration, but if it falls in the form of flakes or sheet, the end point has been reached.
    - Temperature of boiling mixture: The temperature of boiling jelly during end point generally corresponds to 105.5^0C.
11. Pour the finished jelly into clean, dry, pre-sterilized jars kept on a wooden board to prevent breakage.
12. Allow the product to cool and seal the jar air-tight.
13. A layer of molten paraffin wax can be placed at the top of cooled jelly which helps in preservation.
14. Label and store in a cool and dry place.

FPO specifications for jelly

Fruit contents	Not less than 45%
Total soluble solids (TSS)	Not less than 65% (w/w)
Preservatives	Sulphur dioxide (Not more than 40 ppm) Benzoic acid (Not more than 200 ppm)
Organoleptic test	Retain flavour of original fruit and free from burnt or other objectionable flavour
Crystallization	Absent

Practical No. 10

PREPARATION OF 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. It shall contain minimum of 45% fruit and 65% TSS.

Raw material, ingredients, machinery required

1. Orange and lemon like citrus fruits are used for making marmalade.
2. Stainless steel knives, utensils for cooking and mixing, muslin cloth, glass jars, sterilization tank, gas bhatti etc.
3. Sugar (1:1), Citric acid 1g, shredded peel of orange 62g and flavour.

Procedure for preparation of marmalade

1. Wash orange and lemon fruits in water and remove the thin peel.
2. Cut peel into thin fine shreds using knife or shredding machine.
3. Cut the peeled fruit into slices (0.3-0.45 cm thick) or crush into rough pulp.
4. Boil slices gently for 30-45 minutes by simmering with 2-3 times its weight of water to extract the pectin.
5. Test the extract for pectin by using alcohol test.
6. Clarify or strain the extract by passing through muslin cloth or use filter aid like wood pulp or flo-supercel or use filter press to get clean extract.
7. Cut peel into 1.9-2.5cm long and 0.8-0.12cm thick shreds using knife or shredding machine.
8. Soften these shreds by boiling in water for 10-15 minutes or in 0.25% sodium carbonate solution or by autoclaving at 10-15 psi steam pressure (116-121^{o}C).
9. Boil the extract along with sugar (1:1) to about 103^{o}C temperature.
10. Add prepared shreds to the boiling mixture.
11. Continue boiling to jellying end point (check by using sheet test, drop test, weight or temperature test), total boiling time shall not exceed 20 minutes.
12. Cool marmalade in a shallow pan with gentle straining to keep the shreds uniformly distributed in the marmalade. During cooling, orange peel oil can be added as an essence.

13. Fill cooled marmalade in pre-sterilized glass jars.
14. Place the layer of molten paraffin wax on the top surface of the jar.
15. Cover the jars with lug type lids and store in a cool and dry place.

FPO specifications for marmalade

Fruit content	Not less than 45%
Total soluble solids	Not less than 65% w/w
Preservatives	Sulphur dioxide - Not more than 40 ppm Benzoic acid - Not more than 200 ppm
Organoleptic test	Retain flavour of original fruit and free from burnt or other objectionable flavour
Crystallization	Absent

*** Sheet test:** This test is more reliable than the plate test. A small portion of jelly is taken with a large spoon or wooden ladle, cooled slightly and then allowed to drop off. If the jelly drops like syrup, it requires further concentration. Falling of the drop in the form of flakes or sheet indicates the end point.

Practical No. 11 & 12
PREPARATION OF PRESERVES AND CANDIES

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

Preserve

Preserves (murraba) are made by cooking the entire fruit or its slices/pieces in sugar syrup of higher concentration (65-70°Brix). Usually for 1kg fruit around 1.75 kg sugar is used and the cooking is continued till the TSS reaches 68%. Fruits like aonla, bael, apple, pear, karonda, pineapple and papaya etc can be used for making preserves. Aonla, bael and apple preserves are commercially available in the market.

Candies are also prepared similarly to preserve but the TSS maintained is slightly higher (75-80%). In preserve, the fruit is kept immersed in syrup and packed while in candies, the syrup is drained off and fruit pieces are further dried and packed.

Candy

A whole fruit / vegetable or its pieces impregnated with cane sugar or glucose syrup, and subsequently drained free of syrup and dried, is known as candied fruit / vegetable. In candies, the syrup is drained off and fruit pieces are further dried and packed. 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. The fruit pieces are then separated from syrup, rolled in powdered sugar, dried and packed.

Aonla, petha (ash gourd), ginger, papaya, karonda, apple, peels of orange, etc are used for candy preparation.

Glazed candy

Covering of candied fruits / vegetables with a thin transparent coating of sugar, which imparts them a glossy appearance, is known as glazing. Cane sugar and water (2:1 by weight) are boiled in a steam pan at 113-114°C and the scum is removed as it comes up. Thereafter the syrup is cooled to 93°C and rubbed with a wooden ladle on the side of the pan when granulated sugar is obtained. Dried candied fruits are passed through this granulated portion of the sugar solution, one by one, by means of a fork, and then placed on trays in a warm dry room. They may also be dried in a drier at 49°C for 2-3 hours. When they become crisp, they are packed in airtight containers for storage.

Crystallized candy

Candied fruits/ vegetables when covered or coated with crystals of sugar, either by rolling in finely powdered sugar or by allowing sugar crystals to deposit on them from dense syrup are called crystallized fruits. The candied fruits are placed on a wire mesh tray which is placed in a deep vessel. Cooled syrup (70 % TSS) is gently poured over the fruit so as to cover it entirely.

The whole mass is left undisturbed for 12 to 18 hours during which a thin coating of crystallized sugar is formed. Tray is then taken out carefully from the vessel and the surplus syrup drained off. Fruits are then placed in a single layer on wire mesh trays and dried at room temperature or at about 49°C in driers.

Procedure for preserve and candy making

1. Select healthy, mature fruits and wash in running water to remove dirt and residues.
2. Peel, core and cut 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. Prepare fruits for preserve and candy making by following steps as shown in Table 11.1.
5. Blanch the fruits and place in alternate layers of fruit and sugar.
6. Fruits can be dipped directly into syrup without blanching.
7. The sugar spreaded in the layers on fruits starts to dissolve in juice which comes out of the fruits.
8. In case of syrup, the strength of the syrup is increased by 5% on each alternate day up to the TSS of 70^0B and 75^0B respectively for preserve and candy respectively.
9. When the fruit pieces of prepared preserve settle at the bottom of the syrup, it indicates the end point.

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.

Table 11.1: Preparation of fruits for making preserve or candy

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 hrs to remove astringency	Wash and dip in 2% alum solution for 24 hrs and wash	Blanch until soft but segments should remain attached
Apple/ pear	Peel, prick with fork (remove core). keep peeled fruits submersed in 2% salt solution to check browning	Steep in 2% salt solution for 24 hours to prevent browning	Wash and dip in 2% alum solution or 24 hrs and wash	Blanch in boiling water containing KMS to bleach
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 & 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

Alternate method for preserve making

1. Cook the fruit pieces in syrup of low sugar contents and gently heat the mass to boil.
2. Continue boiling till the syrup thickens to 68^0B.
3. Cool the preserve after boiling.
4. Fill hot into clean and pre-sterilized bottles by using freshly prepared sugar syrup.
5. Seal the bottles and store in a cool and dry place.

FPO specifications for preserve and candies

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

Practical No. 13
PREPARATION OF CHUTNEYS

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

Fruit chutney is made in the same way as that of jam except that spices, salt and vinegar or acetic acid is also added. In comparison to jam, chutney contains less total soluble solids than jam. The product shall be of good quality with palatable and appetizing taste. As per FPO specifications, the chutney shall contain minimum of 40% fruit (w/w) in the final product with total soluble solids not less than 50%. The acidity in the final product shall not be more than 2% with ash content not exceeding 5 %. Mixed fruit chutney is commercially made by using different fruits in appropriate combinations.

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
3. Mango, apple, plum, papaya and apricot etc are most common.
4. The recipe (for 1kg fruit pulp) for preparation of chutney from different fruits is given in Table 13.1

Table 13.1: Recipe for preparation of chutney from different fruits (for 1kg fruit pulp)

Ingredients	Mango	Apple	Plum	Papaya
Sugar (g)	500	500	500	500
Cumin & black pepper (g) (each)	10	10	10	10
Cardamom, Red chillies (g) (each)	10	10	10	10
Salt (g)	40	40	40	40
Onion chopped (g)	50	250	50	100
Garlic & ginger chopped (g)	15	15	15	15
Vinegar (ml)	170	200	150	200
Clove (headless), No's	4-5	5	5	5
Sodium Benzoate, ppm	250	1250	250	250

Procedure for chutney preparation

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°C 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 contents	Not less than 40%
Total soluble solids	Not less than 50% (w/w)
Total acidity	Not more than 2.1%
Preservatives	Sulphur dioxide – Not more than 100 ppm Benzoic acid – Not more than 250 ppm

Practical No. 14

PREPARATION OF TOMATO KETCHUP

Tomato ketchup/sauce

Tomato ketchup/sauce is the commercial product made either from fresh tomato by converting them into juice/pulp or by using tomato puree or tomato paste. It is made by concentrating tomato juice or pulp without seeds and skin. Spices, salt, sugar, vinegar, onion, garlic etc are added to the extent that the ketchup contains minimum of 25 % total soluble solids (w/w). The juice or puree prepared earlier can be used for preparation of tomato ketchup/sauce.

Raw material, ingredients and utensils required

1. Tomatoes, sugar, salt, sodium benzoate etc.
2. SS knives, utensils, juicer, pulper, sterilization tank, glass bottles, corking machine, crown corks, muslin cloth, boiler/gas bhatti, etc.
3. Recipe for tomato ketchup/sauce (1kg pulp) given in Table 14.1

Processing of tomato ketchup/sauce

1. Selection of raw material

Select the fully ripe fruits free from blemishes and defects. Ripe deep red coloured tomatoes with higher TSS and pulp provide a better quality product. Pectin content and pigmentation are two important parameters determined the finished product quality. All green and yellow coloured portions should be removed.

2. Extraction of pulp or juice

The pulp or juice could be extracted by using hot or cold pulping method. However, hot pulping method yields pulp with higher proportion of total solids, lycopene; pectin content and of good microbiological quality. The freshly extracted pulp or juice as well as preserved pulp or puree or paste may be used as starting material. Use of puree or paste of suitable total solid level produces ketchup/sauce of uniform quality.

3. Juice standardization

Freshly squeezed juice is a thin, watery fluid and its specific gravity varies with the kind of tomato and duration of boiling. Its T.S.S. should not be below 5.66 °Brix. In case of tomato puree or paste these are diluted to desired total solid level before ketchup preparation. After standardization of juice or pulp total solid the ketchup or sauce is prepared.

4. Addition of ingredients

a. Spices

The spices should be of good quality and they should be added in the proper proportions to give an agreeable taste and flavour to ketchup or sauce. The spices include red chili, black pepper, nutmeg, clove, cinnamon, cardamom, mace and cumin. Beside these spices seasonings like onion, ginger and garlic may also be used in ketchup. While adding spice certain precautions are recommended to produce excellent quality ketchup or sauce.

- Red chili powder, spices, onion and ginger should be tied loosely in bag for better diffusion of flavoring principles in ketchup.
- The head portion of clove should always be removed before its grinding as it may lead to black neck defect in ketchup.
- Normally garlic is not preferred seasoning in ketchup or sauce manufacture as its flavour may predominate over other spices.
- Essence of clove, cinnamon and cardamom is preferred in place of using coarsely ground powder because of the convenience of use and better flavour note in finished product.

Spices bag is used during manufacture of ketchup/sauce.

Bag method

The coarsely ground spices are tied loosely in a muslin cloth bag and the bag placed in the tomato juice during boiling. The bag is pressed intermittently to release the flavouring component during processing. The proportion these spices should be standardized in such a way that they should not affect the colour of the resultant product and does not impart bitterness. Bag method yield ketchup of superior quality and it is most preferred for ketchup/sauce preparation.

b. Sugar

Sugar is mainly used to adjust the sugar-to-acid ratio of the ketchup/sauce. About $1/3^{rd}$ of sugar is added in the initial stage of boiling. This help in preserving the natural colour of the product. Rest of the sugar is added minute before final concentration is reached. Initial addition of sugar will adversely affect the colour of the product as cooking of the product with higher amount of sugar under acidic conditions flavour brown coloured.

c. Common salt

Salt bleaches the colour of the tomato and also dissolve to some extent copper from the processing equipment. It is, therefore, desirable to add towards the end point of the process. Range of common salt varies between 1.5 - 3.5%, salt is added to enhance flavour of the product and exert preservative action to a lesser extent.

d. Vinegar

Well matured salt-vinegar, cider vinegar or malt vinegar may be used as acidulant in the product. However, these vinegars are not colourless; hence they may affect the colour of the finished product. Vinegar contains not less

than 5% acetic acid. Vinegar is always added towards the end of the process in ketchup manufacture. Since it is a volatile product most of the acid will lose during cooking. Ketchup contains 1.25-1.50 % acetic acid. Vinegar contributes towards flavour as well as microbial stability of ketchup.

5. Cooking & concentration

The tomatoes juice/pulp along with other ingredients is cooked and concentrated to get the desirable flavour, uniform taste and fine thickness or body. The cooking of ingredients may be carried out in open jacketed kettle or vacuum concentrator. The cooking continues till the concentration reached 25 % TSS. However, concentration of 28-30 % TSS is ideal as further increase may adversely affect the flavour of the product.

6. Bottling & Packaging

Ketchup after cooking should be bottled hot at 85-88°C to prevent browning and loss of vitamin during subsequent storage and distribution. However, nowadays ketchup/sauce is also packed in laminated flexible packaging materials consisted of polyethylene (PE), polyester (PET) and aluminum. Bottled and packaged products are stored under ambient temperature (30-35°C) under dry places.

7. Pasteurization

The hot filled bottles are pasteurized in hot water (85-88°C) for 30-35 minutes. Care must be taken to cool the bottle immediately after pasteurization to avoid the degradation of nutrients and over-processing. Shelf-life is also enhanced by using preservatives.

Table 14.1 Recipe for tomato ketchup/sauce (for 1kg pulp)

Ingredients	Quantity
Onion (chopped) (g)	50
Garlic (chopped) (g)	5
Ginger (chopped) (g)	10
Red chili powder (g)	5
Spices (Cloves, Cardamom, Black Pepper, Cinnamon), g each	5
Vinegar (ml)	25
Sugar (g)	75
Salt (g)	10
Benzoic acid (g) per kg of final product	0.25

FPO specifications tomato ketchup/sauce

- It shall have good flavour characteristics of the tomato and free from any other objectionable flavour.
- It shall contain minimum of 25 % TSS excluding salt.
- Minimum acidity should be 1% as acetic acid

Practical No. 15
PREPARATION OF HOT PICKLES

Aim: To prepare hot pickle from different fruits.

The preservation of food 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 or 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.

Brining: For pickling, unripe fruits (like mango) after preparation (peeling, slicing) are mixed with salt or brine for its later use in pickle preparation.

Raw material, ingredients and utensils required

1. Mango, lime, lemon, aonla, karonda etc pickles are most common.
2. Stainless steel peeling/cutting knives.
3. Utensils for cooking and mixing, ladle, glass jars, LPG/bhatti etc
4. The recipe (for 1kg fruit) for preparation of pickle from different fruits is given in Table 15.1

Table 15.1 Recipe for preparation of pickle from different fruits (basis 1 kg prepared fruit)

Ingredients	Mango in oil	Lime in salt	Aonla in oil	Mushroom
Salt, g	150	200	150	100
Cardamom, Turmeric, Red chillies, g (each)	10-15	15	10	5
Clove, No's	8	5	5	5
Vinegar, ml	-	-	-	100
Aniseed powder, cumin, fenugreek, black pepper, g (each)	25	10	30	5
Mustard oil, ml	350	350	350	350

Procedure for preparation of hot mango pickle

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.

FPO specifications for hot pickles

a) Pickles in vinegar

- Drained liquid (vinegar) - not more than one third of total content
- Acidity of vinegar as acetic acid - Not less than 2%

b) Oil pickles

- Drained weight - Not more than 60.0%
- Preservatives - Sulphur dioxide - Not more than 100 ppm
- Benzoic acid - Not more than 250 ppm
- Oil - Mustard, ground nut, sesame oil
- Salt content - Should not be less than 12%.

Practical No. 16

PREPARATION OF SWEET PICKLES

Aim: To prepare sweet pickle from jackfruit.

Raw material, ingredients and utensils required

1. Jackfruit
2. Stainless steel peeling/cutting knives.
3. Utensils for cooking and mixing, ladle, glass jars, LPG/bhatti etc
4. The recipe (for 1kg fruit) for preparation of sweet pickle from jackfruit given in Table 16.1

Table 16.1 Recipe for preparation of sweet pickle from jackfruit
(basis 1 kg prepared fruit)

Ingredients	Quantity
Salt, g	100
Red chilli powder, g	15
Ginger (chopped)	20
Turmeric, black pepper, cardamom, cinnamon, cumin, aniseed powder, g (each)	10
Mustard, g	20
Vinegar, ml	150
Jaggary, g	250
Mustard oil, ml	350

Procedure for preparation of sweet pickle from jackfruit

1. Select small mature jackfruits.
2. Wash and peel it
3. Then cut the fruit into equal suitable sized slices.
4. Steeping in 10% salt solution is done for a week.
5. Drain off the brine and wash the slices with plain water.
6. Fry all the spices in oil except vinegar, jaggery or sugar.
7. Mix spices with jackfruit slices and fry for 5 minutes, allow to cool and fill in the glass jars.
8. Keep the jar in sunlight for a week.
9. Make paste of sugar/jaggery with vinegar and mix the paste to the prepared slices.
10. Store the pickle in cool and dry place.

Practical No. 17

DEHYDRATION OF FRUITS

Aim: To conduct practical on dehydration / drying of fruits

Drying generally refers to the method of removal of moisture from the food under natural condition such as sunlight and wind for example open sun drying, shade drying etc. Whereas, dehydration refers to a process of removal of moisture by application of artificial heat under controlled conditions of temperatures humidity and air flow. It also represents drying of agricultural commodity to dry state. 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.

Raw material, ingredients and utensils required

1. Fruits like mango, grapes, papaya, apple, apricot, date, aonla & fig etc.
2. Stainless steel knives, utensils for blanching and dipping in KMS, dehydrator, drying trays , solar drier, sulpher fumigation chamber.

Procedure for drying / dehydration of fruits

Drying generally involves three stages: pre-drying treatments or pre-treatments (Table 17.1), drying and post drying handling, packaging & storage.

1. Select mature and firm fruits for drying.
2. Sort, wash and peel (where required),
3. Follow schedule for preparation as given in Table 17.1
4. Slice apple and Papaya into thin slices.
5. Cut small bunches of grapes along with rachis.
6. **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.
7. **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

8. **Sulphiting**: Place the prepared fruits/ in a solution of potassium meta-bisulphite (1-2% KMS) and keep for 30-45 minutes. After the treatment, the fruits are drained and are placed on the trays for drying.
9. **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.
10. **Sweating**: Keep the dried product in boxes/cloth bag or bins to equalize the moisture contents within the product.
11. **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.
12. **Yield of dried products**: The yield of dried product generally depends upon the total solid content including TSS of the fresh product. Drying yield of different products vary between 20-25% grapes, 18-20% apricot, 10-12% apple, 14-20% banana and 3-5% onion etc.
13. **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°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.

Table 17.1 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 for 6-7 hours or sun dry
Apricot	Dip in 0.5% boiling caustic soda solution for 7-10 seconds and rinse	1 hour (3g sulphur/ kg fruits)	57-68 for 10-12 hours or sun dry
Aonla	Wash, grate or cut into halves, destone	Salt treatment @ 40g/kg fruits	Sun dry
Banana	Wash, peel, cut lengthwise/ round shape 12 mm thick	30 minutes (1-2% KMS)	55-71 for 10-12 hours or sun dry
Date	Wash, dip in boiling 0.5 % caustic soda solution then rinse	-	45-50 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 or sun dry
Mango	Wash, peel, cut into 12 mm thick slices	2 hours (1-2% KMS)	50-60 or sun dry
Papaya	Wash, peel, cut into 6 mm pieces/slices, remove seed	2 hours 1-2 %KMS)	60-65 or sun dry

FPO specifications for dried and dehydrated fruits

Moisture	Dehydrated fruits- Not more than 20% w/w
	Sun dried fruits- Not more than 24% w/w
Preservatives	Sulphur dioxide: Raisins- Not more than 750 ppm
	Apricots, peaches, pears, apple and other fruits - Not more than 2000 ppm

Practical No. 18

DEHYDRATION OF VEGETABLES

Aim: To perform practical on drying/dehydration of different vegetables.

Drying refers to the method of removal of moisture content from the food to a level at which the activities of food spoilage and food poisoning micro-organism are inhibited. Therefore, reduction in water activity of the food is the main principal of preservation by drying. In the dehydrator initial temperature is generally kept at 43^{o}C which is then gradually increased to 60-66^{o}C for vegetables. The product shall be prepared from wholesome vegetables free from blight, insect infestation and fungal discoloration. Only edible portion of the vegetables shall be used and it shall be free from stalks, peels, stems, and extraneous matter. The dried/dehydrated vegetable may contain permitted preservative. The finished product shall be of good edible quality and shall reasonably reconstitute to its original shape and quality on boiling for 15 minutes to an hour. Kind of dry vegetable shall be declared on the label.

Raw material, ingredients and utensils required

1. Vegetables like cauliflower, cabbage, spinach, coriander, potato, carrot, radish red chillies, onion, garlic, methi, etc. are most commonly dried.
2. Stainless steel knives, utensils for blanching and dipping in KMS, dehydrator, sulphur fumigation chamber, drying trays, solar drier etc.

Procedure for drying/dehydration of vegetables

1. Selection of vegetables
2. Sorting, washing, peeling (hand peeling, steam, hot water, lye peeling or abrasive peeling and slicing).
3. **Blanching**: Blanching of vegetables is carried out to inactivate enzymes. The vegetables are kept in boiling water or under steam for a pre-determined period followed by immediate cooling.
4. Use either sulphuring or sulphiting for treating vegetables with sulpher dioxide before drying.
   a) **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 prepared vegetable for sulphuring. Generally 3g sulphur for each kg of prepared vegetables 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.
   b) **Sulphiting**: Place the prepared vegetables in a solution of potassium meta-bisulphite (0.5-2% KMS) and keep for 30-45 minutes.

5. **Drying**: Place the treated vegetables in thin layers on the trays and keep either in sun light, solar drier or in mechanical dehydrator. Allow the drying process to continue till a constant weight loss. Turn the material frequently on the trays to achieve uniform drying. Drying time depends upon the tray load and drying temperature.

6. **Sweating**: Keep dried product in cloth bags for 10-15 days for moisture equalization. Pack the sorted and graded product in air tight containers.

7. **Yield of dried products**: The yield of dried product generally depends upon the total solid content of the fresh product. Percent drying yield for some vegetables is given in Table 18.1.

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

Table 18.1 Schedule for preparation of vegetables for drying & dehydration

Vegetables	Preparation/ pretreatments	Treatment before drying	Drying temp. (^{0}C)	Drying yield
Cauliflower	Wash, remove stalk, stems, break flowers florets into pieces of uniform size	Blanch in boiling water for 4-5 minutes, immerse in 1% KMS solution for one hour and drain	55-60^{0}C or sun dry or use solar drier	3-4
Cabbage	Wash, remove stalk, outer leaves and cut into fine shreds	Blanch for 5-6 min., immerse in 0.5% KMS solution for 10 minutes & drain	55-60 or sun dry or use solar drier	5-7
Onion	Remove the outer peel and cut into round thin pieces	Dip for 10 minutes in 5% salt solution	60-65 or sun dry or use solar drier	10.0
Green leafy vegetables	Wash, sort, trim off rough stems and stalk, shreds	Blanch for 2-3 minutes in boiling water	60-65 or sun dry or use solar drier	-
Potato	Wash, peel, cut into 10 mm thick slices.	Blanch for 4-5 minutes and immerse in 0.5% KMS	60-65 or sun dry or use solar drier	14.0
Tomato	Wash, cut in to pieces	Blanch for 30-50 seconds, peel and cut into round slices 10 mm thick	60-65 or sun dry or use solar drier	3-4
Okra	Use whole, halves or discs	Blanch in boiling water for 4-8 minutes	63-68	8-10

FPO specifications

- Preservative – Sulphur dioxide - Not more than 2000 ppm
- Rehydration ratio - Reconstitute to original shape and quality by boiling for 15- 60 minutes
- The dried product shall be free from visible mould, insect or larvae.

Practical No. 19

REFRIGERATION AND FREEZING

Aim: To conduct practical on refrigeration and freezing of fruit and vegetables

Refrigeration or chilling (0-5°C):

Chilling temperature are obtained and maintained by means of ice or mechanical refrigeration. Fruits and vegetables and their products can be preserved for a few days to many days when kept at this temperature. The best storage temperature for many foods is slightly above 0°C but this varies with the product and is fairly specific to it. Besides temperature, the relative humidity and the composition of the air can affect the preservation of the food. Commercial cold storages with proper ventilation and automatic control of temperature are now used throughout the country (mostly in cities) for the storage of semi-perishable foods such as potatoes and apples. This has made such foods available throughout the year and has also stabilized their prices.

Freezing (-18 to -40°C):

Freezing method is the most harmless method of food preservation. Microbial growth is inhibited and the rate of chemical reactions is slowed down at low temperatures. In commercial frozen storage the activity of meat enzymes is stopped while plant food have to be blanched before freezing to avoid undesirable quality changes. At temperatures below the freezing point of water (-18 to -40°C) growth of microorganisms and enzyme activity are reduced to a minimum. Most perishable foods can be preserved for several months if the temperature is brought down quickly (quick freezing) and the food kept at these temperatures. Foods can be quick frozen in about 90 minutes or less by i) placing them in contact with the coil through which the refrigerant flows, ii) blast freezing in which cold air is blown across the food, and iii) dipping in liquid nitrogen.

The storage life of fresh perishable foods such as vegetables and fruits can be extended by several days by storing them at temperatures just above freezing, usually between 1 and 4°C. The storage life of foods can be extended by several months by freezing and storing them at subfreezing temperatures, usually between -18 and -35°C, depending on the particular food.

Refrigeration slows down the chemical and biological processes in foods, and the accompanying deterioration and loss of quality and nutrients. Sweet corn, for example, may lose half of its initial sugar content in one day at 21°C, but only 5% of it at 0°C. Fresh asparagus may lose 50% of its vitamin C content in one day at 20°C, but in 12 days at 0°C. Refrigeration also extends the shelf

life of products. The first appearance of unsightly yellowing of broccoli, for example, may be delayed by three or more days by refrigeration.

Early attempts to freeze food items resulted in poor-quality products because of the large ice crystals that formed. It was determined that the rate of freezing has a major effect on the size of ice crystals and the quality, texture, and nutritional and sensory properties of many foods. During slow freezing, ice crystals can grow to a large size, whereas during fast freezing a large number of ice crystals start forming at once and are much smaller in size. Large ice crystals are not desirable since they can puncture the walls the cells, causing a degradation of texture and a loss of natural juices during thawing. A crust forms rapidly on the outer layer of the product and seals in the juices, aromatics, and flavoring agents. The product quality is also affected adversely by temperature fluctuations of the storage room.

The ordinary refrigeration of foods involves cooling only without any phase change. The freezing of foods, on the other hand, involves three stages: cooling to the freezing point (removing the sensible heat), freezing (removing the latent heat), and further cooling to the desired subfreezing temperature (removing the sensible heat of frozen food). Fresh fruits and vegetables are live products, and thus they continue giving off heat that adds to the refrigeration load of the cold storage room. The storage life of fruits and vegetables can be extended greatly by removing the field heat and cooling as soon after harvesting as possible. The optimum storage temperature of most fruits and vegetables is about 0.5 to 1°C above their freezing point. But this is not the case for some fruits and vegetables such as bananas and cucumbers that experience undesirable physiological changes, when exposed to low (but still above-freezing) temperatures, usually between 0 and 10°C. The resulting tissue damage is called the chilling injury and is characterized by internal discoloration, soft scald, skin blemishes, soggy breakdown, and failure to ripen. The severeness of the chilling injury depends on both the temperature and the length of storage at that temperature. The lower the temperature, the greater the damage in a given time. Therefore, products susceptible to chilling injury must be stored at higher temperatures. A list of vegetables susceptible to chilling injury and the lowest safe storage temperature are given in Table 19.1.

Chilling injury differs from freezing injury, which is caused by prolonged exposure of the fruits and vegetables to subfreezing temperatures and thus the actual freezing at the affected areas. The freezing injury is characterized by rubbery texture, browning, bruising, and drying due to rapid moisture loss. The freezing points of fruits and vegetables do not differ by much, but their susceptibility to freezing injury differs greatly. Some vegetables are frozen and thawed several times with no significant damage, but others such as tomatoes suffer severe tissue injury and are ruined after one freezing. Products near the refrigerator coils or at the bottom layers of refrigerator cars and trucks are most

susceptible to freezing injury. To avoid freezing injury, the rail cars or trucks should be heated during transportation in sub-freezing weather, and adequate air circulation must be provided in cold storage rooms. Damage also occurs during thawing if it is done too fast. It is recommended that thawing be done at 4°C.

Table 19.1 Some vegetables susceptible to chilling injury and the lowest safe storage temperature

Vegetables	Lowest safe temperature, °C
Cucumbers	10
Eggplants	7
Watermelons	4
Okra	7
Sweet peppers	7
Potatoes	3 to 4
Pumpkins	10
Sweet potatoes	13
Ripe tomatoes	7 to 10
Mature green tomatoes	13

FREEZING OF FRUITS

Freezing is a method of preservation in which the food temperature is reduced below freezing point and a proportion of water changes in to ice-crystals. Immobilisation 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. The process variables for freezing of different fruits and flow chart are shown in Table 19.2. 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

A. Pre-process handling

1. Follow different steps for preparation of fruits for freezing (Table 19.2)

2. 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.

3. 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.

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.

B. 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.

C. 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 upto 10% of their volume, the package in which food is frozen should be strong and flexible.

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

Table 19.2 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.
Berries	Select firm, fully ripe berries. Sort, wash/ and drain.	Use 30% syrup or dry unsweetened pack, dry sugar pack or tray pack.
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.
Melons (cantaloupe, watermelon)	Select firm-fleshed, well-coloured, ripe melons. Wash rind well. Slice or cut into chunks.	Pack in 30% syrup or pack dry using no sugar. Freeze in recipe-size containers.

FREEZING OF VEGETABLES

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 products, since freezing does not improve product quality. Pre-process handling, from the time vegetables are picked until ready to eat, is the important factor affecting quality of finished product. The process variables for freezing of different vegetables and flow chart are shown in Table 19.3. Generally fruits after preliminary treatments are packed in sugar syrup and frozen in freezer.

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 of vegeables

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.
4. **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.
5. **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. Temperature regime covering the freezing process, the cold-store temperatures (-18°C), distribution temperatures (-15°C) and retail (-12°C) are generally recommended.
6. **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 (with or without oxygen removal) are common packages.

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

Table 19.3 Process variables for preparation of vegetables for 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)
Beet	Wash and remove the tops leaving 2.5 cm of stem and root.	Cook for 25-30 min. until tender. Cool promptly, peel, trim. Cut into slices or cubes and pack.	
Broccoli	Wash and cut to desired size pieces.	Water blanch	3 min.
		Steam blanch	3 min.
Cabbage	Wash and cut into wedges	Water blanch	3 min.
		Steam blanch	4 min.
Carrot	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)
Pea	Depodding/shelling of peas	Water blanch	1-1/2 min.
		Steam blanch	1-1/2 min.
Potato	Peel, cut or grate as desired	Water blanch	5 min. (Whole), 2-3 min. (pieces)

Practical No. 20

DEHYDROFREEZING OF FRUITS AND VEGETABLES

Dehydrofreezing is an adjunct to freezing in which a food is first dehydrated to a desirable moisture content and then frozen.

Vegetables dried at home normally have had 90 percent of their moisture removed; fruits 80 percent. By removing only 70 percent of the moisture and storing the fruit or vegetable in the freezer, the low temperature of the freezer inhibits microbial growth, food takes up less room in the freezer, vegetables and fruits are much tastier, have good color and they reconstitute in about one half the time it takes for traditionally dried foods.

Freezing is a very well established food preservation process that produces high-quality nutritious foods that offer the advantage of a long storage life. However, freezing is not suitable for all foods, and freezing does cause physical and chemical changes in many foods that are perceived as reducing the quality of the thawed material. Many innovative freezing processes are currently being researched and developed throughout the world to overcome these problems. One of these is dehydrofreezing. It is particularly suited to fruits and vegetables. Since fresh fruits and vegetables contain more water than meat, and their cellular structure is less elastic, they are prone to more damage during freezing than meat. Removing some of the water prior to freezing theoretically allows the ice crystals to form and expand without damaging the cellular structure. Reducing the water content prior to freezing also has the potential to reduce the freezing time, the initial freezing point, and the amount of ice formed within the product. Despite being often cited as a new, novel or emerging technology, the concept of dehydrofreezing was developed in the 1940s. However, it has remained a niche process being commercially applied to products such as potatoes, carrots, and onions. In recent years there has been renewed interest in dehydrofreezing, and this review looks at the most recent innovations in dehydrofreezing research. (James *et. al*., 2014)

Dehydrofrozen apples may be prepared by a new continuous process in less than one quarter of the time required for the presently used batch process. Key to the new process is a continuous vacuum sulfiting step which accomplishes complete sulfur dioxide (SO_2) penetration in 20 minutes vs. 2–4 hours for the batch SO_2 dip procedure. Dehydrofrozen slices prepared by the new process have 15–25% less volume than SO_2 dipped dehydrofrozen slices, however, when rehydrated, they absorb an average of 6.4% more water. Taste panel scores of pies made with apples prepared by the new method rated equal

to or better than those made with conventional dehydrofrozen or frozen slices on all scoring factors. The new system's main advantages to processors, in addition to improved quality, are reduction of labour costs, minimum space requirements, simple control, and high product density. (Kitson J.A., 1970)

Note: Dehydrofreezing is not technique of freeze-drying. Freeze drying is a method that forms a vacuum while the food is freezing and it is costly commercial process which can't be done in the home.

James Christian, Purnell Graham & James Stephen J. (2014). A Critical review of dehydrofreezing of fruits and vegetables. *Food and Bioprocess Technology*, 7:1219–1234

Kitson J.A. (1970). A continuous process for dehydrofreezing apples. *Canadian Institute of Food Technology Journal*, 3(4):136-138

Practical No. 21

CUT OUT ANALYSIS OF PROCESSED FOOD / CANNED PRODUCTS

Aim: To conduct cut out analysis of canned fruits and vegetables products.

Cut out examination of canned products is conducted to evaluate the product whether conforming to FPO standards or not. Canned fruit and vegetables are evaluated for presence of vacuum or pressure in the can, drained weight, total soluble solids, presence or absence of preservative, internal condition of can product contents and presence or absence of fermentation for ensuring microbiological safety.

Reagents/glassware/apparatus required

1. Can opener
2. Balance for estimating drained weight
3. Head space gauge
4. Vacuum cum pressure gauge
5. Thermometer
6. Refractometer, hydrometer or salometer
7. Sieve of 20.3 cm having 8 meshes per 2.5cm.

Procedure for cut out analysis

A. External/physical examination of unopened can

1. Note the gross weight of the can.
2. Note the label information from the label of the can. Compare the label with requirement as per FPO.
3. Note the external condition of can like dents, rusty spots, scratches, leakage around seams and condition of ends as per following classification.
   - **Flat:** A can where both ends are concave. The vacuum is high enough to maintain the ends concave. (Flat can is considered optimum condition of can).
   - Flipper: A can where vacuum is so low that mechanical shock will produce distortion of one or both ends. (Not desirable)
   - **Springer:** A can in which one end is distorted and the other end is flat and pressure on the convex end will cause the flat end to spring out when pressed. (Not desirable)
   - **Swell:** A can in which both ends are convex i.e. in which there is a sufficient pressure to cause permanent distortion of both ends. (Not desirable and should be discarded)
4. Note vacuum/pressure in the can by inserting vacuum/pressure gauge. (Can with good vacuum is desirable, can showing pressure is not desirable).

B. Internal examination of can

1. Open the can with a can opener
2. Note the appearance on the surface.
   - See for under filling and over filling of cans.
   - Cloudiness in syrup: Note colour, clarity and flavour of syrup or brine.
   - Use refractometer for measuring °B and salometer for percent salt
   - Note appearance of the material filled, record as satisfactory or unsatisfactory
3. Gross head space: Measure with seam checking gauge or head space gauge.

C. General examination of canned products: Record the following and compare with the requirements.

- Net weight or volume of contents
- Net volume of contents in relation to capacity of can
- Vacuum/ pressure: No positive pressure at sea level
- Head space: Not more than 1.6 cm (0.63 inch)
- Internal appearance of can Examine the internal surface of can after emptying and washing. See for evidence of corrosion, blistering, defects in lacquer, scratching, discoloration, leaks etc.)
- Tin content: Not more than 250ppm (Determine using standard method)
- Examination of spoilage: No sign of swelling when cans are incubated at 37ºC for fruits and 55ºC for vegetables for 7 days.
- Fruit/ vegetable contents: Evaluate the sensory parameters like colour, firmness, flavour and overall acceptability.

Vacuum/pressure determination

- Use gauge which indicates both vacuum and pressure.
- Pierce the hollow pointed end of the gauge through the lid so that rubber gasket makes a gas tight seal and prevents the loss of vacuum.
- Moisten the rubber before applying the gauge and pierce the can with the gauge towards one edge.
- The vacuum or pressure is indicated by a needle on the dial of the gauge.
- Note the vacuum in (inches of Hg) and pressure (lb/in^2) or kg/cm^2.
- Do not measure pressure of swollen cans.
- Vacuum varies with altitude, storage temperature and head space volume.
- Generally cans should not show any positive pressure at sea level.

Drained weight: The sample is drained on a standard mesh size sieve and weighed. The drained weight is the weight of the sieve and the contents after draining minus the weight of the dry sieve.

Net weight of contents: Wash the inside of the can with water, dry and note the

tare weight of the empty can. Subtract the tare weight from gross weight to get the net weight of contents.

Procedure for determining drained weight

1. Weigh the unopened can; open and pour the entire contents on a circular sieve without disturbing the product, incline the sieve to facilitate draining of syrup/brine.

2. In case of products with a cavity such as peach, apricot, guava, pear halves, invert the cups /halves down on the screen so that the liquid can drain out but the product should not be disturbed. (Use circular sieve containing 8 meshes to 2.5 cm i.e. 0.097 inch openings. For A 2 ½ (401×411) size can use sieve of 8 inches in diameter. For A 10 can use sieve of 12 inch in diameter. For tomatoes, use sieve containing 12 meshes to an inch i.e. 0.446 inch opening.

3. Drain for five minutes.

4. Weigh the drained product from the sieve.

5. Empty the can and take the tare weight of can including ends.

6. Calculate net weight and % drained weight as under:

$$\textbf{Drained weight (\%)} = \frac{\text{Drained weight}}{\text{Net weight of content}} \times 100$$

Net weight of contents = Gross weight of can - Tare weight of empty can

Estimation of vegetable contents in sauce

- Empty the contents of the can on the sieve
- Wash the contents with water to make free of sauce
- Note the weight of the sieve and washed vegetable
- Subtract the weight of the dry sieve and calculate the vegetable content as percentage of the net weight of the contents of can.

Estimation of foreign matter in cans

- Note for presence of foreign matter such as flies, ants, maggots, leaves, straw, hair etc. in the can. Their presence indicates gross carelessness and working under un-hygienic conditions.

- The micro-organisms growing at 37°C usually cause spoilage accompanied by the production of gas (CO_2) which causes the cans to become 'springers' or 'hard swell'.
- A can which swells at 37^0C indicates presence of living mesophilic organism usually caused by leakage.
- At 55°C, cans do not generally swell. Spoilage causing micro-organisms are flat sour type and they do not grow at low temperature.

Observations

Record the observations in a cut out proforma as mentioned below:

Cut-out Performa

A) Product Details
   i) Name of the product
   ii) Date of manufacture
   iii) Date of inspection
   iv) Description of the product

B) Inspection of the can conditions
   i) Size of the can
   ii) External appearance
   iii) Condition of ends of can
   iv) Vacuum
   v) Gross weight
   vi) Headspace
   vii) Drain weight
   viii) Weight of empty can
   ix) Net weight
   x) Weight of syrup
   xi) No. of pieces
   xii) Internal can corrosion

C) Inspection of cans content-organoleptic evaluation
   i) Slices Appearance, Colour, Texture, Taste, Foreign matter
   ii) Syrup Appearance, Color, °Brix

D) Microbiological examination

Results

FPO specifies standards for canned products. Compare the results obtained with the following FPO standards for canned products, tabulate as per the table given below and conclude whether the given canned product complies the FPO standards.

SN	Parameter	FPO standard	Results for given canned product	Comments
	CANNED FRUITS			
1	Drained weight	Not less than 50%, Exception Berry fruits-40%		
2	Drained solids			
a	Appearance	Free from blemished, stalks, leaves etc		
b	Texture	Free from disintegration, damage from bruises and uniformly prepared		
c	Organoleptic quality	Characteristic taste		
3	On whole product			
a	Preservatives	Not permitted		
b	Added colour	Permitted only in cherry & strawberry		
	CANNED VEGETABLES			
1	Drained weight	Not less than 55%, Exception canned tomatoes50%		
2	On Solids			
a	Appearance	Free from pods, stalks, detached skins, woody fibres, roots and blemishes.		
b	Texture	Free from disintegration, damage from bruises		
3	On Brine			
a	Added colour	Not permitted except for processed peas		
b	Preservatives	Not permitted		

Practical No. 22

PROCESSING OF PLANTATION CROPS- NUT CROPS

COCONUT

Coconut (*Cocos nucifera* L.) is most useful palm belonging to family Palmae. In India, coconut tree is called as kalpvriksha the tree of life, coconut is grown in a wide range of agro-climatic conditions. Productivity of coconut in India in terms of nuts/hectare is highest among major coconut growing area. Coconut is mainly consumed as raw nuts, copra and oil, whereas other products are coir and nuts. Coconut oil is the main commercial product. Copra obtained after drying kernel of coconut contains 65-70 % oil. Copra is used to extract coconut oil and coconut meal in the ratio of 3:2. The products like hair oil, soaps, shampoos and medicine use coconut oil as a main ingredient. In India, only 10% of the production is used for tender nut water. Traditionally, coconut industry in India is centered on copra making, coconut oil extraction and coir manufacture. The industrial products are desiccated coconut, cream milk powder, vinegar, nata-de-coco etc.

Coconut Products: following products are made from coconut on a commercial scale.

1. Copra
2. Coconut oil
3. Raw kernel
4. Coconut cake
5. Tender coconut water
6. Coconut toddy
7. Coconut shell based products
8. Coconut wood based products
9. Coconut leaves
10. Core pith

1. Copra

The dried coconut endosperm is called copra with oil content of 65% to 70% copra is the richest source of fat. The focus of copra are made in our country namely milling copra and edible copra, milky copra is made in the form of cups used for oil extraction. It is also used as a dry fruit for consumption. Whole, edible copra is shredded and used as garnish in various dishes. Drying of copra can be carried out in open sun or in hot air driers. Even electrical and solar driers can also be used. Sun drying takes 6-8 days while hot air driers involve 20-24 hours for drying. During drying the moisture content from 50-55

% is reduced to 5-6 %. Dried copra should be packed in polyethylene lined gunny bags and stored ion cool and dry place.

- copra: it is made in the form of cups and balls.
- Ball copra: fully ripe nuts of 12-14 months are stored in upper floor of specially made store (two storied brick and mortar building). The floor and four sides of upper story and smoked by a slow fire set under the platform using coconut palm waste. During this period, the water inside the nut dries up and kernel gets detached from shell and raffles on shaking. The process completes in 8-12 months. Small sized nuts are preferred over large sized one.
- Edible cup copra: nuts stored as above for shorter period are used for making edible cup copra. The copra balls are cut into halves and then they are sun dried for a few days.

2. Coconut oil

Coconut oil is extracted from milling copra. The pulped copra is fed continuously to the expeller from which oil and cake are expressed. Hydraulic pressing of cake also results in extraction of copra oil. Coconut oil is very low in unsaturated and polyunsaturated fatty acids, particularly linoleic acid as compared to other vegetable oils (Kumar et al. 2000). It is more resistant to oxidation than many other types of oils. It is obtained from mature meet which when dried contain 65% oil and the oil obtained from coconut milk is called as virgin coconut oil. Coconut oil is used for culinary, edible purposes and for industrial use like toiletries and soap making etc. Coconut oil processing methods are classified into two major types: dry and wet processes. When the oil is extracted from copra as raw material is termed as dry process, while use of fresh coconut as starting material is called wet process.

3. Coconut water

Water from tender coconut (7-8 month old) is a refreshing drink, effective in cases of gastroenteritis, diarrhea, vomiting and in preventing dehydration. The nut water is less nutritious from mature coconut as compared to tender coconut water. Nata-de-coco, soft drink, vinegar, food yeast etc are the products in which coconut water is main source. Coconut water can also be used to produce carbonated and non-carbonated beverages as refreshing and more nutritious drinks than other similar products.

4. Coconut meat

The kernel of seven to eight month old nut is very soft with maximum contents of protein and sugar. Kernel is as such consumed or with sweet nut water. Fresh kernel is consumed in the grated form and in the form of milk or cream obtained by squeezing the grating with or without addition of water. As

the nuts turn more mature the quality decreases gradually. Fresh coconut meat contains 50-55% moisture which is to be brought down to 5-6% during drying.

5. Coconut milk or cream

Coconut milk or cream is the oil-protein-water emulsion obtained by freezing grated fresh coconut kernel. It is the processed milk extracted from fresh matured coconuts. It is the processed milk extracted from fresh matured coconuts. It is used either directly or diluted with water to make various preparations like curries, sweets, puddings and many bakery preparations. Processed and packed coconut cream has a shelf life up to three months.

6. Instant coconut milk powder

It is a spray dried product similar to dairy milk powder. The spray dried coconut milk powder if dissolved in water, results in coconut milk which can be used in place of fresh coconut milk for food preparation.

7. Desiccated coconut (DC)

Desiccated coconut is the white kernel of fresh coconuts, shelled and dried to about 2.5% moisture content with high nutritional value. The common grade of desiccated coconut has particle size less than 5 mm. It is an important commercial product with a wide demand in confectionary and other industries, like chocolate and liquorice. The desiccated coconut contains moisture 2.5%, oil 67.5%, protein 5.9%, carbohydrates 5.9%, ash 9.3% and fibre 2.4 percent.

8. Coconut husk products

The coconut husk usually forms 35-45% of the whole nut weight at ripening. About 30% of husk is fibre and 70% is the coir dust. Coir pith is used as manure, as mulch or in making briquettes with good export potential. Coconut husk is the basic raw material for coir industry. The fibres extracted from coir is used for spinning into yarn for making mats, ropes, rugs, carpets, bleaching, dyeing, printing, poly coir, coir matting decorated boards, husk particle boards etc.

9. Coconut shell powder

It is made from matured coconut shells and is used in plywood and laminated board industry as a phenolic extruder and as filler in synthetic resin ghees, mosquito coils and agarbatis.

10. Other products:

Coconut sap, coconut syrup and sugar, fermented coconut sap, coconut vinegar, coconut shell powder, coir fibre and pith are some of the important coconut products.

ARECANUT

Arecanut (*Areca catechu* L.) is one of the most important commercial crops in South East Asia and is cultivated primarily for its kernels chewed in tender, ripe or processed form. Arecanut palm belongs to family Palmae. India is the leading country in production contributing to 51% of world's total production followed by China (25%). The arecanut is used as raw or in processed form as it is an essential component of gutka and pan masala, whereas, chali supari or kalipak are some of the value added products. Kalipak is prepared from immature green nuts and chali is prepared from ripe nuts.

Preservation of arecanut

In Assam, fresh fruits are preserved in thick layer of mud and this product is known as 'Bura Tamul'. In Kerala, fresh fruits are stored by steeping in water and the product is called 'Neettadakka'. The inner core is well preserved by this method but discolouration of outer husk and foul smell due to bacterial attack are some drawbacks. Preservation of ripe nuts after initial heat blanching in a solution containing sodium benzoate (0.1%) and potassium meta-bisulphite (0.2%), acidified to a pH of 3.5 to 4.0 with HCl helps in eliminating the foul smell and improves the quality of nuts.

Processing of arecanut

1. Dried ripe nuts (Chali or kottapak)

The dried whole nuts of arecanut are known as Chali or kottapak. The ripe nuts are dried in open sun for 35-40 days up to 12% moisture content and the marketing of whole nuts is done after dehusking. Dehusking can be done with manually operated dehusker developed by CPCRI, Kasargod. Depending upon the size, different grades of arecanut in decreasing order are moti, srivardhan, jamnagar and jini. Sometimes the fruits are cut longitudinally into 2 halves and are sun dried for 10 days. The kernels are scooped out and are given a final drying. The product is known as Parcha, which is popular in Kerala and Karnataka. Drying in mechanical drier takes 60-70 hours at 45-75°C.

2. Kalipak

This product is famous in Kerala and Karnataka. Tender nuts are dehusked, cut in to pieces, boiled with water or a diluted extract from previous boiling, coated with kali and dried. Kali is a concentrated extract obtained after 3-4 batches of boiling of arecanut. The kalipak is known by different names depending on number, shape and size of the cuts. Api or Unde (without any cuts), batlu (transverse cut into halves), choor (several longitudinal cuts), podi (both longitudinal and transverse cuts) and erazel (transverse thin slices). Lylon is another product made from green nuts which are cut transversely into 5-6 discs without kali coatings. A well dried product with dark brown colour, glossy appearance, chewing feel and absence of over-mature nuts are rated superior.

3. Scented supari

It is made both from chali and kalipak. Chali supari is more popular. The dried nuts are broken into bits and blended with spices for flavour and packed in butter paper. Saccharin is occasionally used for sweetening. Rose essence is commonly used for flavouring of supari. The scented supari is packed in aluminum or butter paper pouches for marketing.

CASHEWNUT

Cashewnut (*Anacardium occidentale* L.) is a tropical evergreen fruit tree belonging to Anacardiaceae family. It is widely cultivated in tropics for its nut and is a native of Brazil. In India it was introduced in Goa from where its cultivation spreaded to other parts of country. Cashew is a versatile tree nut and its kernel contains fats, proteins, carbohydrates, minerals and vitamins. Cashew has become number one crop in the world over almond. India provides around 55% supply of cashew kernels in world. The important commercial products of this crop are nuts and apple. The cashew kernels are used in confectionary and deserts. Cashew apple is eaten fresh or mixed in salads and even a drink is prepared from its juice. Cashew can be distilled to produce alcoholic drink called as Fenny. The cashew shell contains oil known as cashew nut shell liquid (CNSL) which has wide industrial uses. In India, the cashew processing is done manually, which consists of moisture conditioning, roasting, shelling, kernel drying, peeling, grading and packing.

Processing of cashewnut

I. Processing at orchard level

The cashew processing in the orchard is mainly confined to removal of raw nuts from cashew apple and drying. The fully matured nuts are harvested and the apples are removed. The nuts are dried for 2-3 days to reduce moisture from 25% to below 9%. Drying helps the kernels to retain their quality particularly flavour.

II. Processing of raw nuts

The nuts used for processing are dried again to reduce moisture level to 7-8%. The steps involved in processing of raw nuts are as under:

1. Cleaning and grading of nuts

The nuts are cleaned and graded into three sizes, *viz.*, small, medium and large. The grading of nuts is done on basis of nut thickness and not on the basis of its length. It helps in reducing the kernel breakage.

2. Roasting of nuts

Roasting of raw nuts is done to separate the adhering shell from kernel. There are three types of roasting *viz*., drum roasting, oil bath roasting and steam roasting.

a) Drum roasting

This is one of the oldest and more widely used methods. The nuts are fed into red hot rotating drum which will ignite the shell by maintaining its temperature because of burning of shell liquid. The drum is kept in rotation for 3-4 minutes and roasted nuts are discharged from lower end of drum and immediately covered by ash after sprayed with a little water, to absorb oil on surface. This facilitates removal of remaining oil on shell.

b) Oil bath roasting

The conditioned nuts are passed through CNSL (cashew nut shell liquid) bath heated to 170-200°C by conveyer buckets for 1-2 minutes. During this period the shells gets heated thus rupturing the wall and releasing oil into bath. The roasted nuts are then centrifuged to remove adhering oil, cooled and shelled by hand or leg operated shelling machines. The kernel with adhering testa is scooped out using a sharp needle. The method is followed traditionally in Kerala and Karnataka

c) Steam roasting (autoclaving)

The raw nuts are steam cooked at about 120-140 psi pressure to loosen the kernels from shells. Shell oil can be extracted in later stages by crushing. The nuts are shelled by hand or leg operated shelling machines. The steamed nuts are spread on floor under natural air for 12-24 hrs for cooling.

3. Shelling of nuts (decortications)

Cashew nut after roasting and cooling are shelled to remove kernels. Care should be taken to protect hands from Cashew Nut Shell Liquid (CNSL) which is highly corrosive. Hand gloves can be used while shelling. Nuts are knocked 2-3 times on long edge of wooden mallet or light hammer to release the whole kernels without any damage. Foot operated shell cutter can be used for shelling. This device consists of a pair of blade (knives) shaped in counter of half a nut. The blade cut through the shell all around the nut, leaving the kernel untouched. A hand lever is pressed to open shell into two parts. The kernel is then scooped out manually.

4. Separation of kernels

After shelling, the kernel and shell pieces are separated manually and the separated kernels are collected into containers.

5. Pre-grading

Pre-grading can be done before and after drying kernels. It can be done mechanically for large scale processing, whole kernels are separated from the

broken. Sometimes the whole kernels are also separated and graded according to the kernel size.

6. Drying of kernels

After removal from the shell, the kernels are dried at about 70-80°C imperforated trays for about 6-8 hrs for reducing the moisture level to 4-5 percent. Drying of these kernels is necessary to prevent fungus. In order to ensure uniform drying, the position of tray may be changed frequently. Excessive drying may result in scorched kernel. After drying kernels are kept in the moist chamber for 24 hours which facilitates easy removal of testa and minimizes broken kernels.

7. Peeling

It is done by using a sharp knife or bamboo piece to remove testa (seed coat) from the kernels

8. Grading of kernels

Kernels are graded according to the size manually. 25 different grades of cashewnut kernels are approved by Government of India. Standard specification for Indian cashew kernels are:

- **Wholes:** White wholes(WW)/scorched wholes(SW)/dessert wholes (SWS)
- **Broken :** White broken/scorched broken/dessert broken
- **Lower grades:** Rejection etc.

Further, the classification refers to broken kernels, splits, pieces, small pieces and whether kernels are white or scorched. The cashew kernels are sold as WW 180, WW210, WW240, WW450 and WW500 which means white whole with number of kernel per pound weight. Thus WW210 means white whole with 210 kernels/ lb weight. Similarly scorched wholes are numbered as SW180-SW500. Dessert wholes (DW), white pieces as B (Butts), S (Splits), LWP (Large white pieces), SWP (Small white pieces), BB (Baby bits), Scorched pieces as SB (Scorched butts), SS (Scorched splits), Dessert pieces as SPS (Scorched pieces seconds), DP (Dessert pieces).

9. Packaging of kernels

The import trade requires packaging of kernels in 11.34 kg capacity (25 lbs) tins/airtight cans in which the kernels are kept. After filling and weighing, the tins are evacuated and filled with CO_2 with help of vita pack process. This consists of removing all air from can and substituting it with CO_2 and the holes in the cans are then sealed. Cashew should be packed in impermeable packages, as they become rancid and go stale quickly.

III. By-Products from cashew

1. Cashew apple

Cashew apple is a swollen peduncle to which nut is attached. It is very juicy and sweet, it is not eaten raw because of its astringent and acidic taste. It is very rich in vitamin C and can be used for juice extraction.

2. Cashew juice

The juice can be extracted with screw press, basket press or hand press. Straining of extracted juice is done through muslin cloth which is then clarified by adding 1.4g of PVP (Poly vinyl pyrolidine) per litre juice; the mixture is stirred and again strains through muslin cloth. Add sugar to improve the taste, and boil the juice. Fill hot in pre-sterilized bottles, crown cork and process on boiling water for 20-25 minutes. On cooling, keep in cool and dry place. Sodium benzoate can be used as preservative.

3. Cashew apple jam and candy

Immerse the cashew apples in 3% salt solution for 3 days to remove astringency (tannins), followed by steaming for 15-20 minutes. Extract the pulp and prepare jam as per standard practice. In case of candy the sugar strength is kept 45°Brix and is increased @ 5°Brix for 4 days and then @ 10°Brix for 6^{th} and 7^{th} day so that the final strength of syrup reaches to 70°Brix. Keep in this solution for 8-10 days for complete absorption of sugar. Remove the pieces from syrup and dry.

4. Cashew kernels peel tannin

Kernel peel are a rich source of tannin (25%), which is in great demand by leather industry.

5. Cashew Nut Shell Liquor (CNSL)

It is a byproduct obtained during separation of cashew kernel. It is viscous dark liquid and is extremely corrosive. It is used as raw material for phenolic resins and friction powder in automobile industry. It is also used as moulding acid resistant paints, found in any resins, varnishes and as insecticide/ fungicides etc.

6. Cashew kernels oil

Low grade kernels are processed in to kernel oil (30-40%) which is of high quality.

7. Cashew kernel butter

Kernel residue after extraction of kernel oil used to produce cashew kernel butter which is similar to peanut butter.

Practical No. 23

PROCESSING OF PLANTATION CROPS - BEVERAGE CROPS

Aim: To conduct practical on processing of beverage crops *viz*., tea, coffee

TEA

Tea is an evergreen woody perennial grown in many Asian countries including China, Japan, Java, Sumatra and India. The plant produces dark green, small shiny leaves with white blossom. In post harvest and manufacturing practices for tea, only mechanical and physical processes are allowed with natural fermentation. It can be manufactured by orthodox, CTC (crush, tear and curl) processing.

Processing of tea

Tea processing is the method in which the leaves from the tea plant (*Camellia sinensis* L) are transformed into dried leaves for brewing. Processing steps are as follow:

1. The tea leaves should be harvested at proper time i.e., 2 leaves and bud. Plucking is done at an interval of 8-10 days (high crop period), 12-15 days (low crop period) and about 32-36 leaves can be plucked from single bush.
   - Light plucking: plucking done above mother leaf and is also known as step up plucking. It also helps to increase height of bushes.
   - Hand plucking: When the plucking is done below mother leaf.
   - Level plucking: When plucking is done to the level, irrespective whether mother leaf or fresh leaf.
2. Withering is done to remove excess water from the leaves and by the end of this process, the leaves become pliable enough for rolling.
3. After withering, the leaves are twisted and rolled with rolling machine or by hand to allow breaking of leaf cells. During rolling process, some of leaf juices and oils are released, that gives the tea its distinctive aroma and may aid in oxidation.
4. Processing is done either by CTC processing or orthodox method.
   - The CTC processing is done in machine consists of two cylindrical rollers (61 or 91 cm long and 20 cm in diameter) with stainless steel segment with fine tooth like sharp ridges (3-4 ridges/cm in lengthwise and 50-60 ridges over circumference). The speed of 70:700 and 100:1000 rpm have good effects. The crush, tear and curl (CTC) maceration takes only few minutes.

- In orthodox processing, the rolling is done normally in 36" or 46" diameter rollers. The roller may be table or jacket moving, normally rotates at 45 rpm speed. Battens help in cutting the leaves in roller. With each turn of roller, the leaf caught between cone and roller jacket subjects to heavy pressure and this result in greater extraction of sap. The withered leaf is then charged into the jacket.

5. Oxidation/fermentation begins once the leaf membranes are broken down enzymatically during the rolling process. It is an important stage in black tea processing. It is a chemical process where oxygen is absorbed and the leaves turn progressively darker. The tannins are released/transformed during this process. During this stage, the most important properties of tea are produced.

6. After oxidation, the leaves are dried evenly and thoroughly without burning by using conventional drying, fluidized bed drying, air drying or baking. Drying of leaves stop the oxidation process. The main objective of drying is to arrest fermentation and to remove moisture and produce good quality tea.

7. Curing/ageing: Curing is not required for all types of teas. Additional aging, secondary-fermentation or baking are curing processes to rich their drinking potential.

* For different types of teas the extent of oxidation is 5-40% for light oolong tea, 60-70% for darker oolong tea and 100% for black tea. During fermentation, low temperature (20^0C) and high humidity (95%) are desirable.

Characteristics of tea

Appearance and colour	Dried tea should be black.
Strength	Proper twist, green in appearance, All desired characteristics should be there.
Briskness	Tickling sensation in salivery glands.
Flavour	Tea produced in high elevations is having good flavour.
Infusion	Infused leaves should also be twisted

Grading of tea

Leaf grade	T,G,F,B,O,P
Broken grade	BOP
Dust grade	Special dust

TGFBOP: Tippy Golden, Flowering, Broken, Orange, Pikoe
Flowering Pikoe, Pikoe, Broken Pikoe Orange, Broken Pikoe, Pikoe Dust, Red Dust, Super Fine Dust are the important grades of tea.

COFFEE

Coffee is an important beverage used all over the world. Brazil and Columbia are the largest coffee producers in the world. Coffee is harvested in one of two ways; strip picking (entire crop is harvested at one time either by machine or by hand); selective picking (only the ripe berries are picked individually by hand) during dry season when cherries are bright red, glossy and firm. After picking, the coffee can be prepared either by dry method which produces natural coffee or by wet method which produces washed coffee.

Processing of Coffee

Coffee processing is the most critical activity in its production. Processing of coffee deals with the conversion of raw coffee fruit into coffee. The quality of the final product depends upon the manner of processing. The methods employed for curing of coffee includes; dry method and wet method to produce unwashed and washed coffee respectively. In the dry method, the beans are sun dried to 12-13% moisture. While, in the wet method, the fruit covering the seeds/beans is removed before they are dried. The manufacture of coffee powder involves roasting, grinding, blending and packing.

1. Raw green coffee does not have any flavour or aroma and has an unpleasant taste. Roasting is a heat treatment which transforms the green beans into aromatic brown nuggets.
2. Roasted beans are ground to three sizes namely fine, medium and coarse. Coarse ground powder retains aroma and flavour better.
3. Chicory strength, flavour, aroma and acidity are the chief criteria in judging the quality of coffee.
4. The packaging of coffee powder is done in various flexible films like polyethylene (PE), cellulose films are suitable for short storage and for long storage high density polyethylene (HDPE) is effective.

Dry method: The harvested cherries are spread over a concrete, brick or matting surface in suitably at good raked at regular intervals to prevent fermentation. In about 7-10 days the cherries dry to about 11% moisture. The outer shells become dark brown and brittle. The dried cherries are then stored in silos, where beans continue to loose moisture.

Wet method: In wet method, the beans are separated from the skin and pulp using a pulping machine. The beans are stored in a fermentation tank for 12-48 hours, during which time enzymes work to naturally separate the slimy layer (parenchyma) from the parchment like covering (endocarp). When the process is complete, the endocarp has pebbly feel. Coffee processed by the wet method

is called wet processed or washed coffee and is found superior in quality as compared to dry processed coffee.

Drying: The endocarp is dried in open sun or in mechanical drier to moisture content of about 11% so that beans can be stored in stable condition. In open sun drying, it takes 7-15 days for drying. The coffee is called as parchment coffee.

Hulling: In wet processed coffee, hulling is used to remove the hull or dried parchment layer surrounding the beans. In dry processed coffee, hulling refers to removal of husk or whole of dried outer covering of original cherries.

Roasting: Raw green coffee does not have any flavour or aroma and has an unpleasant taste. Roasting is a heat treatment which transforms the green beans into aromatic brown nuggets. Roasting is done at air temperature of 287.8°C and in this process the beans are kept moving to avoid burning. When the bean temperature reaches 209°C they start turning dark brown and oil (called coffee oil or caffeol or coffee essence) start to emerge. The cooling must be quick in order to preserve the flavour, aroma and keeping quality.

Grinding: The bulk of roasted beans is ground to powder and sold as ground coffee. Roasted beans are ground to three sizes namely fine, medium and coarse. Coarse ground powder retains aroma and flavour better and longer than fine ground powder. Coarse ground powder is more suitable for preparing coffee decoction by percolation. On the other hand, fine ground coffee gives a decoction with high body.

Blending: Two types of coffee powder are marketed namely pure coffee prepared from coffee seeds only and French coffee. Chicory strength, flavour, aroma and acidity are the chief criteria in judging the quality of coffee.

Packaging: For larger packs of roasted and ground coffee, gas packing under carbon dioxide or under vacuum is effective. Various flexible films like polyethylene (PE), cellulose films etc are used for packing coffee.

Different types of Coffee

1. **Decaffeinated Coffee:** The coffee from which caffeine is artificially removed is known as decaffeinated coffee.

2. **Estate Coffee:** Production of good quality coffee by highlighting special features of estate can be classified as estate branded coffee.

3. **Monsooned Coffee:** These are prepared by the special natural process which possesses a special monsooned flavour, mellow taste and golden look.

4. **High Grown Coffee:** The coffee grown at higher elevations more then 1250 m above mean sea level possessing distinct flavour and acidity in cup (tasting). The coffee is of high quality with dense beans.

5. **Mysore Nuggets Extra Bold:** The beans are large, uniform blush green in colour with a clean polished appearance. In cup, coffee exhibits full aroma, medium to good body, good acidity and fine flavour with a tint of spice.

6. **Robusta Kaapi Royale:** it is made from Robusta Parchment AB from the regions of Mysore, Coorag, Wynad, Shivaroys, Pulneys and Barbabudans. The beans are bold, round with pointed ends and gray to bluish gray in colour. This cup ensures full body, soft, smooth and mellow flavour.

Practical No. 24

PROCESSING OF PLANTATION CROPS - RUBBER, OIL PALM

RUBBER

Rubber **(***Hevea brasiliensis***)** tree is the most important source of natural rubber and meets around 98% of the global requirement. The rubber belongs to family Euphorbiaceae and its economic product rubber is a cis-poly-isoprenic molecule found in latex. Latex is found in all the plant parts like bark of trunk, roots, branches, leaves, flower, fruits and seeds. Commercially the latex present in the bark of trunk of mature tree is exploited. The latex consuming industry is virtually separate from the remainder of the rubber consuming industry. Natural rubber is a high molecular weight polymer and is used for the manufacture of medical gloves. Other products manufactured from latex include catheters and condoms (prophylactics), garment threads (used in garment manufacture) and foam (in pillows and mattresses) etc. The latex consists of 30-40% rubber, 1-2% resins, 55-65% water, 2-2.5% proteins, 1-1.5% sugars and 0.7-0.9% ash. Latex obtained from rubber tree is the basic raw material for extraction of rubber and its processing into different forms.

Methods used commercially are discussed here under:

Latex is obtained from the bark of rubber tree by tapping. Tapping is a process of controlled wounding during which thin shaving of bark is done. The purpose of tapping is to cut open latex vessels from the trees (used for first time) or to remove coagulum which otherwise block cut ends of latex vessels in case of trees under regular tapping. Tapping is done early in the morning when turger pressure for exudation of latex is maximum. For tapping and collection of latex knives, spout, cup hauzers, collection cups. Collection buckets and scrap buckets are used. Michie Golledge Knife and Jebong Knife are used for tapping however, for controlled upward tapping modified gauge knife is used. Different types of tapping include intensive tapping, high level tapping. Controlled upward tapping, puncture tapping, slaughter tapping etc.

Crop collection

The main crop from rubber plantation is latex, which is harvested by tapping process. 2-3 hours after tapping, latex collected in the crop is transferred to a clean bucket. About 70-80% of the crop from a rubber plantation is in the form of latex. The latex which gets solidified in tapping panel and collection cups or overflowed to the ground and gets dried up is also collected. This is collectively called as field coagulum.

Processing of latex

For long term storage and marketing the latex and field coagulum are processed in different forms such as preserved field latex, latex concentrate, sheet rubber, block rubber and crepe rubber. Field coagulum is generally processed only in the form of Crepe rubber or black rubber.

Latex can be processed into any of following forms

1. Preserved field latex

Field latex is preserved by using ammonia (1%), LATZ (low ammonia 0.2-0.3%) as preservative for long term storage. The processing of preserved latex consists of adding preservative to the sieved latex, bulking, settling, blending and packing.

2. Latex concentrate

Latex is concentrated by using either creaming or centrifugation method.

a) Concentration by creaming: In this method, creaming agents like ammonium alginate or tamarind seed powder is mixed with preserved latex and allowed to settle for some time. This treatment separates the mixture in to two layers. The upper layer contains concentrated latex while, lower layer of serum containing very little rubber. The lower layer of serum is removed, whereas, upper layer containing latex concentrate having 50-55% dry rubber contents is collected, packed and marketed.

b) Concentration by centrifugation: Centrifugation separates preserved field latex into two fractions, one containing concentrated latex (having more than 60% dry rubber) and other containing about 4-8% dry rubber. Skim latex is generally coagulated with H_2SO_4, made into crepe, dried and marketed as skim rubber, which is low grade rubber.

3. Sheet rubber

Latex is coagulated in container into thin slabs of coagulum and rolled with rollers followed by drying to get sheet rubber. On the basis of method of drying, sheet rubber is classified in to two types i.e., ribbed smoked sheets and air dried sheets.

Preparation of Sheet rubber

a) Straining and dilution of latex

For preparation of sheet rubber, the latex is processed immediately before precoagulation sets in. Anti-coagulation can also be added to prevent pre-coagulation of latex. The latex is strained through 40 and 60 mesh stainless steel sieves and diluted in bulking tanks to a standard consistency of 0.5kg dry rubber for every 4 litre of diluted latex (12.5% dry rubber contents). It is then allowed to stand in bulking tank for 15-20 minutes for sedimentation of heavy dirt particles. The clear diluted latex is decanted in coagulation pans.

b) Coagulation

For coagulation, diluted formic acid or acetic acid is mixed with latex. To prevent surface darkening small quantity of sodium bisulphate (1.2 kg/kg dry rubber content) dissolved in water is added to the diluted latex before coagulation. After coagulation, the coagulum is removed from the pan and washed thoroughly in running water. It is then rolled either in sheeting battery or smooth rollers to a thickness of 3mm and finally passed through grooved rollers. While sheeting, the coagulum is continuously washed in running water in a tank. To prevent mould growth on rubber sheet the freshly machined sheet is treated with dilute solution (0.05-0.1%) of para-nutrophenol (PNP). About 100 litres of 0.05-0.1% PNP solution is sufficient for treating 100 sheets. The wet sheets are then allowed to drip on reapers arranged in a well ventilated dripping shed.

c) Smoking/drying

The sheets after 2-3 hours of dripping in shade are placed in smoke house, where the temperature in maintained between 40-60°C. In the smoke house, sheets are dried gradually to avoid blisters. Besides, the creostatic substances present in the smoke also prevent mould growth on smoked sheets. 4-6 days of smoking is sufficient for drying of sheets.

The smoke house is a chamber in which sheets are placed on the reapers for drying. Smoke houses are of two types, those in which furnace is inside drying chamber and those in which furnace is outside the chamber. Rubber sheets can also dried by using any of the drying system such as solar cum smoke drying, sun drying or air drying.

d) Storage

Sheets after grading are packed in 50kg bales. There are six International grade descriptions for sheet rubber i.e., RSS IX, RSS 1 to RSS 5.

4. Crepe rubber

These are processed from fresh latex coagulum, field coagulum or cutting of rubber sheets (ribbed smoked sheets). The material is passed through a set of crepe making machines and a lace like rubber is obtained. This rubber on drying results in crepe rubber. Latex crepe and field coagulum crepe are two types of crepe rubber depends upon which the raw material used.

- **a) Latex crepe:** Latex crepe rubber is of two types i.e., Pale latex crepe (PLC) and sole crepe. The latex used for these two types shall be free from yellow pigments and enzymic discolouration.
- **b) Field coagulum crepe:** The unit operations used in making field coagulum is soaking of coagulum in water, crepe making, drying, grading and packing. The crepe prepared from field coagulum materials falls into five types.
  - **i) Estate brown crepe:** It is made from the cup lumps and other higher grades of field coagulum.

ii) **Thin brown crepe:** It is made from wet slab coagulum as starting material.
iii) **Thick blanket crepe:** it is made from wet slabs, unsmoked sheets or other high grade scraps.
iv) **Smoked blanket crepe:** It is derived from ribbed smoked sheets or cuttings
v) **Flat bark crepe:** In this all types of low grade scrap including earth scrap is used.

5. Technically specified rubber (TSR)

TSR is marketed with quality certification from Bureau of Indian Standards, under the name of Indian Standard Natural Rubber (ISNR). It is produced from both latex and field coagulum and available in six grades of BIS specifications. Basic unit operation involved in manufacture of TSR includes size reduction, dewatering, dirt removal, drying, blending, grading and packing. Slab cutter, coagulum crusher, prebreaker, macerator/crepe roller, hammer mill/shredder drier and baking press are important machineries used in performing these unit operations. TSR bales are generally packed in low-density polyethylene (LDPE) bags.

OILPALM

Oil palm (*Elaeis guinensis*) is monoecious, cross pollinated plant placed in the Arecaceae family along with coconut and date palms. It is native to West Africa. Oil palm is the highest oil producer among all perennial oil yielding crops. Fruit of oil palm is drupe. It consists of exocarp, mesocarp and endocarp surrounding the kernel. The kernel has a testa, a solid endosperm and an embryo. It produces two distinct oils *viz*., palm oil (extracted from mesocarp of fresh fruits) and palm kernel oil extracted from kernels. The yield of palm oil ranges between 20-30%.

Processing of oil palm

The palm oil processing consist of threshing of bunches, heating of fruit, digestion, pressing, clarification/ drying and storage. The unit operation used in processing of oil palm for extraction of oil given in is explained as under:

1. Threshing

The fruit bunches consist of fruit embedded in spikelets growing on a main stem. For extraction of oil heating of fruit or bunches is necessary as it performs many functions. At small scale operation, bunches are threshed manually to separate the part from the spikelets and threshed fruits are cooked.

While at large scale operation, bunches are heated using high pressure sterilization system which helps in loosening of fruits.

2. Sterilization of bunches

Sterilization of bunches either by using hot water or steam under pressure serves the following operations:

- To destroy oil splitting enzymes and to arrest hydrolysis and autoxidation.
- To weaken fruit stem to help in removal of fruit from bunches on shaking or tumbling in threshing machine.
- To solidify proteins to allow oil bearing cells to come together and flow more easily on application of pressure.
- To weaken pulp structure in fruit to help in easy detachment of fibrous material and its contents during digestion process.
- Steaming breakdown gums and resins which are removed during oil clarification.
- High pressure steam cause separation of moisture in nuts. When pressure is reduced, contraction of nuts leads to detachment of kernel from shell wall, thus loosening kernels within their cells. Detachment of kernel from the shell wall facilitates nut cracking.

3. Digestion of fruit

It refers to the process of releasing palm oil in the fruit through rupture of oil bearing cells. Digestion consists of steam heated cylindrical vessel fitted with central shaft carrying better arms for stirring. Through action of rotating beater arms, the fruit is pounded. Pounding or digesting fruit at high temperature, helps to reduce viscosity of oil, destroys out covering (exocarp) of fruit and cause disruption of oil cells.

4. Pressing/extraction of oil

Oil can be extracted either by dry method or wet method. In dry method oil is extracted by using mechanical press while in wet method hot water is used for leaching out the oil from the digested material. Either batch press or screw press can be used for oil; extraction.

5. Clarification and drying of oil

Clarification is done to separate oil from impurities. The fluid coming out of press is a mixture of palm oil, water cell debris, fibrous material and non oily solids. Presence of non-oily solid make the mixture very viscous (thick). The mixture is therefore, diluted by adding hot water in 3:1 proportion. The diluted mixture is passed through a screen to remove coarse fibre. The screened mixture is boiled for 1-2 hours and then allowed to settle in large tanks. The clear oil is decanted and reheated in a cooking pot to reduce moisture content to 0.15-0.25%. Continuous clarifier consisting of three components heat the crude

mixture, dry the decanted oil and hold the finished oil in an outer shell as a heat exchanger.

6. Storage of oil

The purified and dried oil is stored in plastic drums or in other suitable containers and stored at ambient temperature.

7. Palm kernel oil extraction

The residue left after extraction of palm oil from fruits contain mixture of fibre and palm nuts. The nuts are separated manually or in depreciation. The nuts are then dried and cracked in centrifugal crackers to release the kernels. Breaking of kernels should be avoided as it increases the free fatty acids in the oil. The kernels are then separated from the shells using a combination of winnowing and hydro-cyclones. The kernels are dried in silos to a moisture content of 7% before packing and use for kernel oil extraction. The palm kernel oil is extracted by using following three unit operations

i) Kernel pretreatment
ii) Screw pressing
iii) Oil clarification

i) Kernel pre-treatment

The kernels after cleaning are broken into small fragments by using either hammer grinder or breaker rolls or combination of both. The kernel fragments are flaked (0.25-0.4 mm thick) in a roller mill. The kernel flakes are then placed in stack cooker for steam conditioning which adjust the moisture content to optimum level, rupture cell wall, reduce viscosity of the oil and coagulates the protein in the meal to facilitate release of oil from pertinacious material. In palm kernel, the meal is cooked to a moisture content of 3% at 104-110°C.

ii) Screw-pressing

Properly cooked meal is fed to screw-press, which consists of an interrupted helical thread (worm) which revolves within stationary perforated cylinder called cage or barrel. The meal is forced through the barrel by action of revolving worms. The expelled oil flows through the lining bars of barrel while de-oiled cake is discharged through annular orifice.

iii) Oil clarification

The expelled oil sometimes contains solid impurities thus the oil is drained to a reservoir. The oil is pumped to a decanter or revolving coarse screen to remove large part of impurities. After this, the oil is pumped to a filter press to remove remaining solids and fines to get clear oil. The cake from the press is collected separately.

Palm oil, olein and stearin are used worldwide in making margarine, in shortening and confectionery and in snack foods frying. Palm oil is also used in the manufacturing of soaps, detergents and other surfactants. It is good raw material for production of oleo-chemicals, fatty acids, fatty alcohols, glycerol and other formulations for cosmetics, household and industrial products.

Practical No. 25

SPOILAGE OF PROCESSED PRODUCTS

Aim: To study different types of spoilages occurred in processed & canned products.

Spoiled food is defined as the food that has been damaged or has undergone changes so as to render it undesirable/ unacceptable/ unfit for human consumption. Spoilage of processed products is mainly caused by the action of micro-organisms and due to the physical or chemical changes. The reasons for microbial spoilage include under - processing, inadequate cooling, contamination from leakage through can seams and pre-process spoilage. In under-processed cans (receiving low heat treatment) large number of micro-organisms is expected to be involved in spoilage.

Causes of food spoilage

Food spoilage or deterioration may be described as loss of weight, softening, souring, rotting, wilting, moulding or a combination of one or more forms. The major causes of food deterioration are: biotic and abiotic factors.

A. Biotic factors

- Microbial spoilage (yeast, mould, bacteria)
- Enzyme action (activation of enzymes present in foods)
- Insect and rodent damage (attack of insects, rodents and parasites)

B. Abiotic factors

- Factors like temperature, moisture, light, oxygen etc.

A. Biotic factors

1) Microbial spoilage

Micro-organisms like yeast, mould and bacteria spoil food after harvesting, during handling, processing and storage. Some of these micro-organisms can be used to produce desirable changes in foods under controlled conditions such as lactic acid producing bacteria in making cheese and fermented dairy products, yeast as leavening agent and for production of beer and wine, citric acid production by using Aspergillus sp etc.

a) Yeast

Yeasts are those fungi which are not filamentous but unicellular, ovoid or spheroid in shape and reproduce by budding or fusion. Yeasts are both useful as well as harmful in foods. Yeast fermentations are involved in the manufacture of foods such as bread, beer, wines and surface ripened cheese as well as for production of enzymes. Foods are often contaminated by yeasts as they cause

spoilage by converting sugar to alcohol and carbon dioxide. Common foods spoiled by yeasts include fruit juices, syrups, molasses, honey, jam, jellies, sauerkraut, wine etc. Most common yeasts grow in high to low available moisture, but generally require less moisture than majority of bacteria and comparatively more moisture than moulds. The optimum temperature for growth of yeasts is 25-30^{o}C with maximum limit up to 35-47^{o}C. Many types of yeast grow best in acidic (pH 4.0-4.5) but not in alkaline medium.

b) Moulds

Moulds are multi-cellular, filamentous fungi whose growth on foods is recognized by its fuzzy appearance. The growth may appear to be white, coloured, dark or smoky. They are strictly aerobes and require oxygen for their growth and multiplication. Moulds grow on almost all kinds of foods ranging from simple to complex. They require less free moisture than yeasts and bacteria. They grow over a wide range of pH (2.0 to 8.5) but majority of them favour acidic pH. Most moulds are able to grow at ordinary temperatures i.e. mesophilic. The optimal temperature for most moulds is 25-30^{o}C but some can grow at 37^{o}C or above like Aspergillus sp., while few moulds are psychotropic as they grow well at refrigeration temperature or even below freezing temperature. Most moulds are not harmful. Some moulds in foods are capable of producing toxic materials called mycotoxins. Examples of mycotoxins are aflatoxins produced by moulds growing on groundnut, patulin from Penicillium expansum on apple and other agricultural products such as wheat, millet and rye if they are not dried properly.

c) Bacteria

Bacteria are unicellular micro-organisms and are much smaller in size than yeasts or moulds. They occur in different sizes and shapes and are classified as coccus (spheroidal), bacilli (rod shape or cylindrical) or spirillae and vibrios (spiral shape). They can penetrate the smallest opening, as many can pass through the natural pores of an egg shell. Bacterial growth on the food make it unattractive in appearance, cause discolouration on the food surface, make surfaces slimy or results in undesirable cloudiness or sedimentation. In contrast to yeast and moulds, most bacteria cannot grow in acidic media (pH <4.5). Some bacteria require oxygen for their growth (aerobes) and some cannot tolerate oxygen (anaerobes) while some can grow in an atmosphere devoid of oxygen but can also manage in air (facultative anaerobes). Bacteria can grow and develop rapidly between 20-53^{o}C. On the basis of temperature requirement, bacteria are categorized as thermophiles (requiring temperature higher than 45^{o}C), mesophiles (requiring temperature between 20-25^{o}C) and psychrophiles (requiring temperature less than 20^{o}C). Bacteria usually cause spoilage in foods which are neutral or low acidic such as vegetables, milk, eggs, meat and fish. Thus micro-organisms like bacteria, yeast and moulds are the main causes of food spoilage.

2) Enzyme action

Enzymes are the polypeptides that catalyze a reaction with certain degree of specificity. Many reactions in plant and animal tissues are activated by enzymes. The changes in food during storage can be produced by the enzymes present in the food or by the micro-organisms that contaminate the food. They are responsible for bringing many changes during storage like change in colour, texture and flavour in fresh produce after harvest. Through some of these changes are desirable like ripening of fruits but these changes can also result in food deterioration if they are not halted at appropriate time. Thus, enzymes responsible for deteriorative changes should be inactivated by using a suitable method to prevent food deterioration. The enzymes are proteinaceous in nature and can be denatured by heat. Enzymes can act from 0oC to 60oC, however, 37oC is optimum temperature and the rate of reaction varies directly with temperature. Generally, most enzymes are inactivated by temperature above 80oC. Important enzymes involved in food deterioration include polyphenol oxidase, lipoxygenase, amylase, pectin methyl esterase and poly galacturonase.

3) Insects, parasites and rodents

Insects like worms, bugs, weevils, fruit flies and moths damage the food and reduce its nutrient content and render it unfit for human consumption. Insect eggs may persist in foods even after processing as in flour. Insects in grains, dried fruits and spices are generally controlled by fumigation with fumigants like methyl bromide, ethylene oxide, propylene oxide etc besides eating loss; the insects cause greater damage by making bruises and cuts in the fruits thus exposing the food to microbial attack and resulting in total decay.

Parasitic spoilage occurs in some foods. Parasitic nematode penetrates the hog's intestine when uncooked food is eaten by the hog's and finds its way into pork. Rodents like rats cause extensive damage of food grains. Urine and droppings of rodents harbour several kinds of disease producing bacteria and rats spread many human diseases like typhus fever, plague, typhoid fever etc.

B. Abiotic factors

1) Temperature

Low or high temperature apart from its role in food preservation also brings deterioration of foods. The rate of chemical reaction doubles with every 10oC rise in temperature. Excessive heat causes protein denaturation, destroys vitamins, breaks emulsions and dries out food by removing moisture. Similarly, low temperature cause deterioration like freezing and thawing of fruit and vegetables destroy their structure. Many fruits and vegetables are damaged even at refrigeration temperatures (4°C). The deterioration includes off-colour development, surface biting and various forms of decay. Thus banana, tomato, lemons etc are stored above 10°C to avoid chilling injury.

2) Moisture

The presence of water is the most important factor controlling the rate of deterioration of food either by micro-organisms, enzymes or other chemical reactions. Moisture is required for chemical and enzymic reactions and for microbial growth. Foods with high moisture contents deteriorate fast. Perishable foods with high water content like leafy vegetables, juicy fruits, meats and milk deteriorate rapidly. Changes in surface moisture with change in relative humidity cause caking, surface defects, crystallization and stickiness in foods. Condensation of moisture results in multiplication of bacteria and yeasts. Fruit and vegetables give off moisture from respiration and transpiration even when packaged in moisture free packages. Thus control of moisture in foods is necessary to ensure preservation.

The shelf-life of a food can also be measured by the water activity of food. Water activity (aw) is defined as the ratio of the vapour pressure of water in food to the saturated vapour pressure of pure water at the same temperature.

aw = p where, p = vapour pressure of water in food, Pa
p0 p0 = vapour pressure of pure water, Pa

Water activity can also be defined according to Raoult's law of mole fractions, which refers water activity as the ratio of number of moles of water in a solution to the total number of moles of water and solute in the solution as under:
This equation can be used to get desired water activity in the food by increasing the number of moles of solute and reducing the mole of solvent either by using drying, concentration, addition of sugar, salt, freezing etc. Thus most of the methods of preservation like drying, concentration, salting, sugar preservation etc are based on management of water activity. Most of micro-organisms fail to grow at reduced water activity and hence aids in preservation. The interaction of aw with temperature, pH, oxygen and carbon dioxide or chemical preservatives influence the microbial growth. Thus, water activity can be used as an important tool in food preservation.

3) Oxygen and Light

Air and oxygen bring about a number of destructive changes in food components such as destruction of food colour, flavour, vitamin A, C and E and other food constituents. As oxygen is required for growth of moulds, its removal from the food by deaeration, vacuum packing or flushing containers with nitrogen or carbon dioxide or by using oxygen absorbing chemicals like antioxidants helps in food preservation.

Vitamins like B_2, A, C and food colours in the food are deteriorated in the presence of light. Foods can be protected from light by using impervious packing or keeping them in containers that screen out specific wavelengths. Further, all the food deteriorative factors are time dependent. The longer the

time, the greater the destructive influences. Therefore, optimum time of storage for food commodities need to be worked out.

Spoilage of canned food products

Spoilage of canned products during storage may be due to two main reasons:

- Chemical reaction on the can producing hydrogen swells or perforations, &
- Chemical action on the fruit or vegetable resulting in discolouration or loss of flavour etc.

The appearance and smell (odour) of the spoiled can is different from that of normal unspoiled can and such cans should never be tasted. It is therefore, essential to identify the can from the external appearance and diagnose the cause of the spoilage.

I. Identification of spoilage on the basis of external appearance of cans

The extent of spoilage of heat processed product can be identified by observing the external appearance of the unopened can. The ends of a normal can of food after processing are flat or slightly concave having partial vacuum inside. With the development of pressure inside the can, the can goes through a series of distortions due to increasing pressures. The conditions of such cans are designated by following terms:

1. **Flipper**
   A can with a mild positive pressure having both ends flat. One end of this can will become convex when the side of the can is struck sharply or when the temperature of the contents is increased.
2. **Springer**
   It is the can with both ends bulged, but one or both ends will stay concave. If swollen end of can is pushed in, an opposite flat end will pop out. Both Flipper and Springer indicates the initial stage of hydrogen swell but may also be caused by insufficient exhausting or over filling of the can. Later on it results in denting of can with change in temperature.
3. **Soft swell**
   It refers to a can with both ends bulged, but the gas pressure is low enough to permit the ends to be dented by manual pressure.
4. **Hard swell**
   The can with hard swell has both ends bulged. It contains such a high gas pressure that neither end could be dented by hand. Oftenly, the high gas pressure distorts the ends or side seam of the cans and finally the can bursts from side seam or through the seal at ends. The decomposed food in the can has an offensive and sour odour and the product is generally

discoloured. It is not fit for consumption and may contain toxins produced by Clostridium botulinum.

5. **Breather**
   A breather is a can with a minute leakage that permits air to move in or out but does not necessarily allow micro-organisms to enter. In these cans, there is no vacuum and the pressure inside the can is equal to that of the atmosphere. The food remains fit for consumption.

6. **Leaker**
   A very small leakage in the can may be due to faulty seam, or pin hole as a result of corrosion inside the can or rusting of can from outside.

7. **Flat sour**
   It may be caused by under-sterilization. The product has a sour odour and its acidity is much greater than that of the normal product.

8. **Bursting of can**
   Bursting of cans is due to excess of pressure caused by the gases inside, produced by decomposition of food by micro-organisms, or by hydrogen gas formed by chemical action of acids of the food on the tinplate. The canned product becomes a total loss.

II. Identification of spoilage on the basis of appearance of glass containers

The glass containers like bottle, jar, carboys etc of food under gas pressure may have its closure bulged or popped off or may show leakage of food through the broken seal. The microbial growth can also be seen through the glass container in the form of gas bubbles, cloudiness and films of growth.

Practical No. 26

TYPES OF CONTAINERS USED FOR PROCESSING OF FRUITS AND VEGETABLES

Requirements and functions of food containers

The following are among the more important general requirements and functions of food packaging materials/ containers:

1. Non-toxic & compatible with specific foods
2. Sanitary protection
3. Moisture and fat protection
4. Gas and odour protection
5. Light protection
6. Resistance to impact
7. Transparency
8. Tamperproofness
9. Ease of opening
10. Pouring features
11. Reseal features
12. Ease of disposal
13. Size, shape, weight limitations
14. Appearance, printability
15. Low cost
16. Special features

Hermetic closure

Two conditions of the greatest significance in packaging are hermetic and non-hermetic closure. The term hermetic means a container which is absolutely impermeable to gases and vapours throughout its entirety, including its seams. Such a container, as long as it remains intact, will automatically be resistant to bacteria, yeasts, moulds, and dirt from dust and other sources since all of these agents are considerably larger than gas or water vapour molecules.

The most common hermetic containers are rigid metal cans and glass bottles, although faulty closures can make them non-hermetic.

Hermetic rigid aluminium containers can be readily formed without side seams or bottom end seams. The only seam then to make hermetic is the top end double seam, which may be closed on regular tin can sealing equipment.

Glass containers are hermetic provided the lids are tight. Lids will have inside rings of plastic or cork. Many glass containers are vacuum packed and the tightness of the cover will be augmented by the differential of atmospheric pressure pushing down the cover.

Films and foils; plastics

Films and foils have different values for moisture and gas permeability, strength, elasticity, inflammability and resistance to insect penetration and many of these characteristics depend upon the film's thickness.

Important characteristics of the types of films and foils commonly used in food packaging are given in Table 26.1. For the most part such films are used in the construction of inner containers. Since they are non-rigid, their main functions are to contain the product and protect it from contact with air or water

vapour. Their capacity to protect against mechanical damage is limited, particularly when thin films are considered.

Table 26.1 Properties of packaging films

Material	Properties
Paper	Strength; rigidity; opacity; printability.
Aluminium foil	Negligible permeability to water-vapour, gases and odours; grease proof, opacity and brilliant appearance; dimensional stability; dead folding characteristics.
Cellulose film (coated)	Strength; attractive appearance; low permeability to water vapour (depending on the type of coating used), gases, odours and greases; printability.
Polythene	Durability; heat-sealability; low permeability to water-vapour; good chemical resistance; good low-temperature performance.
Rubber hydrochloride	Heat-sealability; low permeability to water vapour, gases, odours and greases; chemical resistance.
Cellulose acetate	Strength; rigidity; glossy appearance; printability; dimensional stability.
Vinylidene chloride	Low permeability to water vapour, gases, copolymer odours and greases; chemical resistance; heat-sealability.
Polyvinyl chloride	Resistance to chemicals, oils and greases; heat-sealability.
Polyethylene terephtalate	Strength; durability; dimensional stability; low permeability to gases, odours and greases.

Source: FAD/WFP, (1970)

One of the newer classes of plastic materials referred to as copolymers illustrate what can be done with mixtures of the basic units from which plastics are built. The term copolymer refers to a mixture of chemical species in the resin from which films and other forms can be made. The many variations possible make copolymers an important class of plastics to extend the range of useful food packaging applications.

Plastic sheets

- Cellophane paper can be used for packing of dried products, mainly for dried fruit leathers.
- Polyethylene sheets have a variety of uses. They are flexible, transparent and have a perfect resistance to low temperatures and impermeability to water vapour. An important advantage is that these sheets can be easily heat-sealed. Utilisation is in forms of sheets and bags. It is a good packing material for primary protection of dehydrated products. If a good protection

is needed to prevent flavour and gas losses, it will be necessary to combine polyethylene with other materials.

Laminates

Various flexible materials such as papers, plastic films, and thin metal foils have different properties with respect to water vapour transmission, oxygen permeability, light transmission, burst strength, pin holes and crease hole sensitivity, etc. and so multi-layers or laminates of these materials which combine the best features of each are used. Commercial laminates containing up to as many as eight different layers are commonly custom designed for a particular product.

Laminations of different materials may be formed by various processes including bonding with a wet adhesive, dry bonding of layers with a thermoplastic adhesive, hot melt laminating where one or both layers exhibit thermoplastic properties, and special extrusion techniques. Such structured plastic films may be complete in themselves or be further bonded to papers or metal foils to produce more complex laminates.

Glass containers

As far as food packaging is concerned, glass is chemically inert, although the usual problems of corrosion and reactivity of metal closures will of course apply. The principal limitation of glass is its susceptibility to breakage, which may be from internal pressure, impact, or thermal shock, all of which can be greatly minimised by proper matching of the container to its intended use and intelligent handling practices.

Glass used for receptacles in fruit and vegetable processing is a carefully controlled mixture of sand, soda ash, limestone and other materials made molten by heating to about 1500°C.

Main classes of glass receptacles are:

a. jars which are resistant to heat treatments,
b. jars, glasses, etc. for products not submitted to heat treatment (marmalades, acidified vegetables, etc.);
c. glass bottles for pasteurized products (tomato juice, fruit juices, etc.) or not pasteurized (syrups) and
d. receptacles with higher capacity (flasks, etc.)

1. Jars for sterilised/pasteurized canned products

   These receptacles may replace metal cans, taking into considering both the advantages and disadvantages they present. Advantages are: they do not react to food content; they are transparent and can be manufactured in various shapes; they use cheap raw materials and are

reusable. Disadvantages: heavier than metal can of same capacity; fragile; lower thermal conductance and a limited resistance to thermal shocks.

Receptacles in this category must assure a perfect hermeticity after their pasteurization/sterilisation and cooling and this has to be achieved by the use of metallic (or glass) caps and specific materials for tightness. Taking into account the receptacles' closure method, there are two categories of receptacles:

a. glass jars with mechanical closure
b. glass jars with pneumatic closure

2. Jars for products without heat treatment

For marmalades, jellies and jams glass jars with non hermetic closures using metal, glass or rigid plastic caps are used; however for these products the receptacles mentioned above may also be used. The use of jars with pneumatic closure presents the advantage that some products (e.g. marmalades, jams) can be filled hot and therefore sterile in receptacles. Pneumatic closing generally protects against negative air action which is in this case eliminated from receptacles.

3. Glass bottles

These receptacles are widely used both for

a) Finished products which need pasteurization (eg. tomato juice, Knit juices, etc.) are stored in glass bottles hermetically with metallic caps, provided with special materials for tightness.
b) The products which are preserved as such (ea. fruit syrups) are stored in glass bottles closed with various corks, and aluminium caps with tightness materials.

Paper packaging

As primary containers few paper products are not treated, coated or laminated to improve their protective properties. Paper from wood pulp and reprocessed waste paper will be bleached and coated or impregnated with such materials as waxes, resins, lacquers, plastics, and laminations of aluminium to improve water vapour and gas impermeability, flexibility, tear resistance, burst strength, wet strength, grease resistance, sealability, appearance, printability, etc.

1. Paper sheets
   - Kraft paper is the brown unbleached heavy duty paper commonly used for bags and for wrapping; it is seldom used as a primary container;
   - parchment paper: acid treatment of paper pulp modifies the cellulose and gives water and oil resistance and considerable wet strength to this type of packaging material;

- glassine-type papers are characterised by long wood pulp fibres which impart increased physical strength;
- paper with plastic material sheets.

2. Receptacles from paper or cardboard
   (paper = 8 to 150 g/m²; cardboard = 150 to 450 g/m²).

Tin can/ tinplate

The "tin can" is a container made of tinplate. Tinplate, a rigid and impervious material, consists of a thin sheet of low carbon steel coated on both sides with a very thin layer of tin. It can be produced by dipping sheets of mild steel in molten tin (hot-dipped tinplate) or by the electro-deposition of tin on the steel sheet (electrolytic tinplate). With the latter process it is possible to produce tinplate with a heavier coating of tin on one surface than the other (differentially coated).

Tin is not completely resistant to corrosion but its rate of reaction with many food materials is considerably slower than that of steel. The effectiveness of a tin coating depends on:

a. its thickness which may vary from 0.5 to 2.0 μm (20 to 80 x 10(-6) in.);
b. the uniformity of this thickness;
c. the method of applying the tin which today primarily involves electrolytic plating;
d. the composition of the underlying steel base plate;
e. the type of food, and
f. other factors

Tinplate sheets may be lacquered after fabrication to provide an internal or external coating to protect the metal surface from corrosion by the atmosphere or through reaction with the can contents. They may also be printed by lithography to provide suitable instructions or information on containers fabricated from tinplate sheets (otherwise paper labels can be attached to the outer tinplate surface).

Under normal conditions the presence of the tin coating provides a considerable degree of electrochemical protection against corrosion, despite the fact that in both types of tinplate the tin coating is discontinuous and minute areas of steel base plate are exposed. With prolonged exposure to humid conditions, however, corrosion may become a serious problem. Common organic coatings of FDA approved materials and their uses are indicated in Table 26.2.

The coatings not only protect the metal from corrosion by food constituents but also protect the foods from metal contamination, which can produce a host colour and flavour reactions depending upon the specific food. Particularly common are dark coloured sulphides of iron and tin produced in low acid foods that liberate sulphur compounds when heat processed, and

bleaching of red plant pigments in contact with unprotected steel, tin, and aluminium.

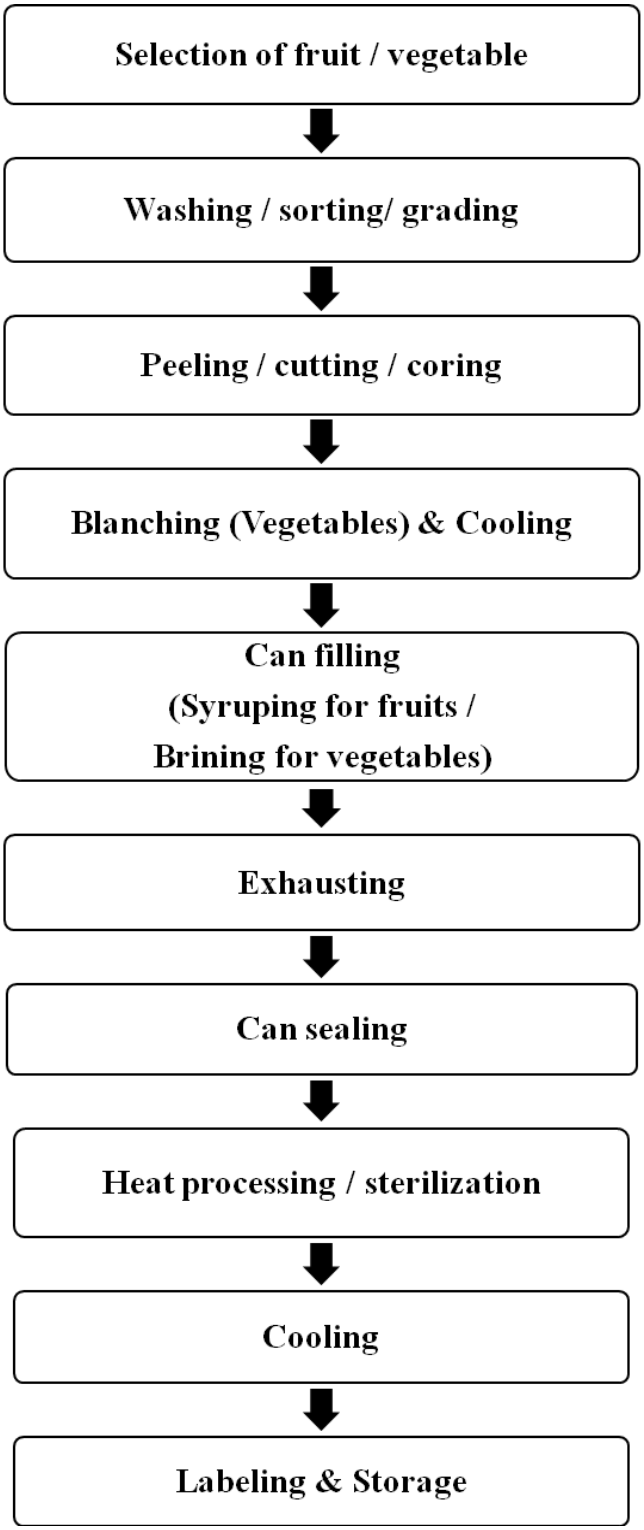
Table 26.2 General types of can coatings

Coating	Typical uses	Type
Fruit enamel	Dark coloured berries, cherries and other fruits requiring protection from metallic salts	Oleoresinous
C-enamel	Corn, peas and other sulphur-bearing products	Oleoresinous w. suspended zinc oxide
Citrus enamel	Citrus products and concentrates	Modified oleoresinous
Beverage can enamel	Vegetable juices; red fruit juices; highly corrosive fruits; non-carbonated beverages	Two-coated w. resinous base coat and vinyl top coat

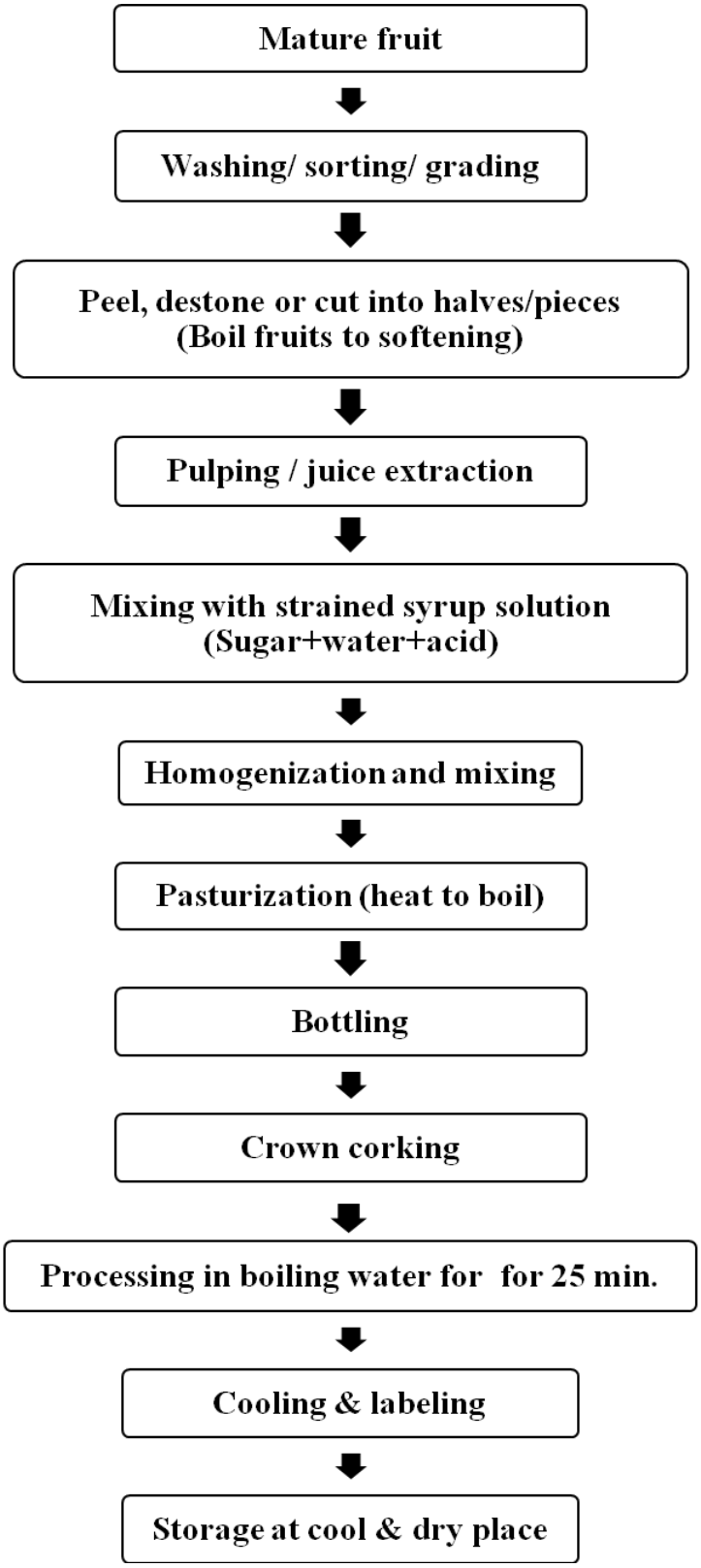
Source: Ellis (1963)

Practical No. 27
VISIT TO PROCESSING UNITS

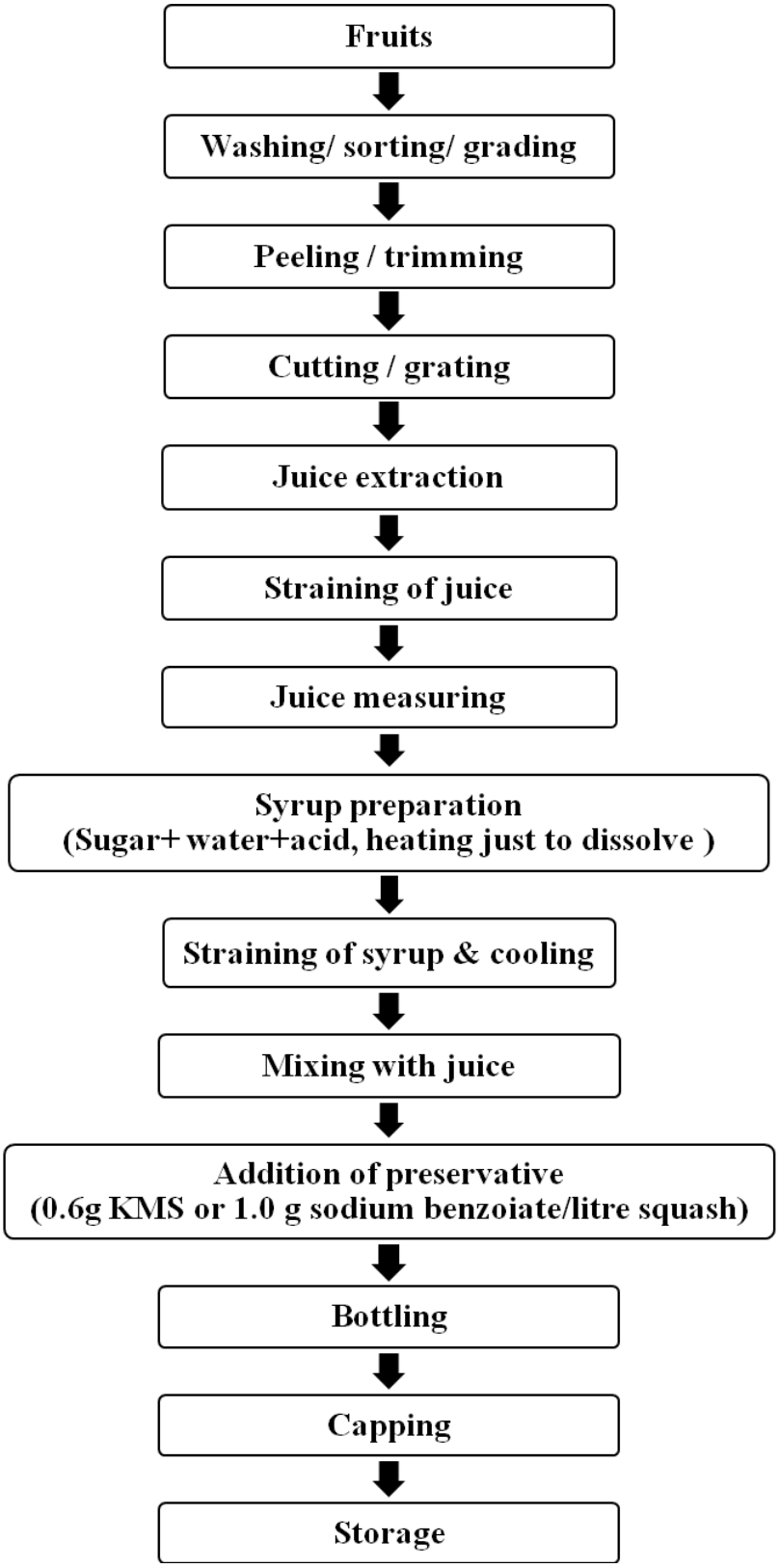
FLOW-SHEET FOR CANNING PROCESS



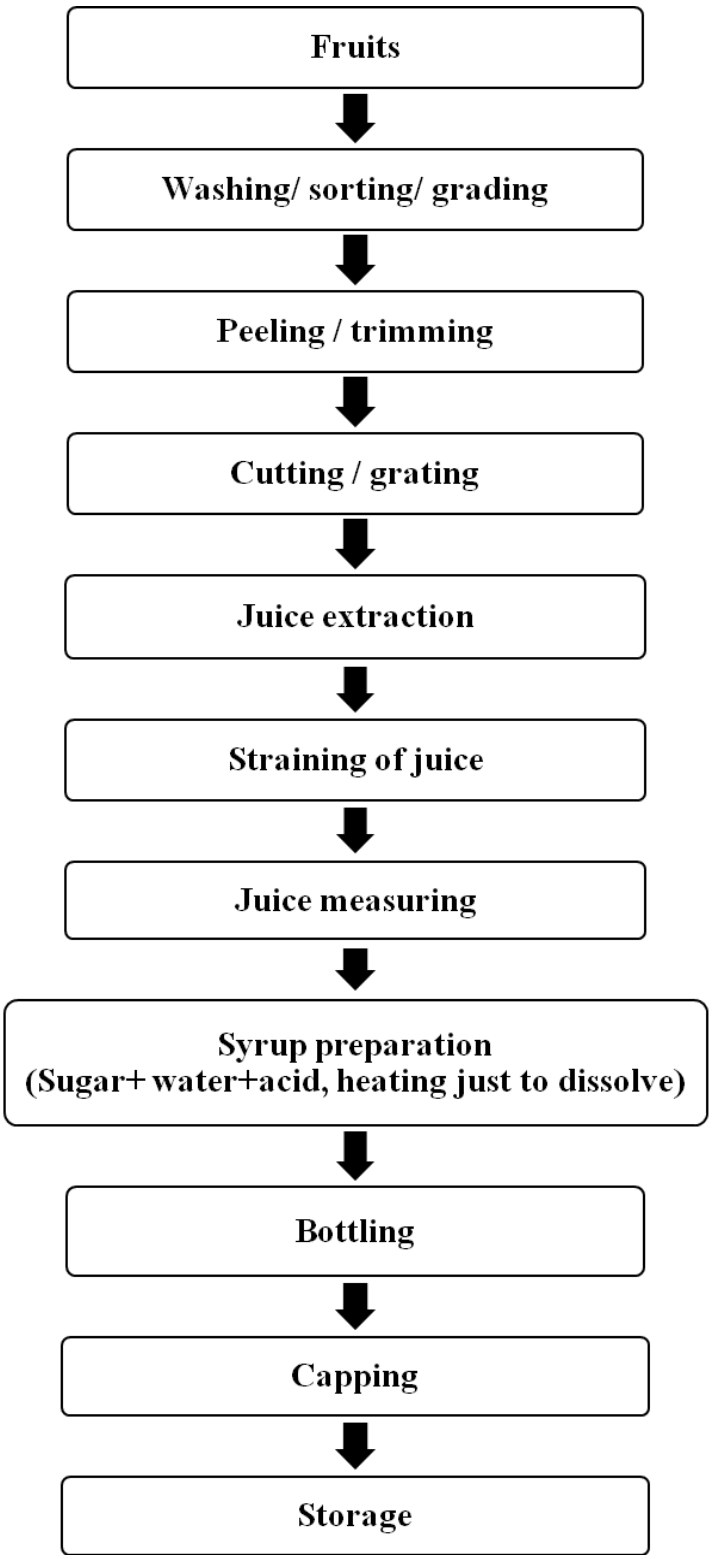
FLOW-SHEET FOR PROCESSING OF RTS



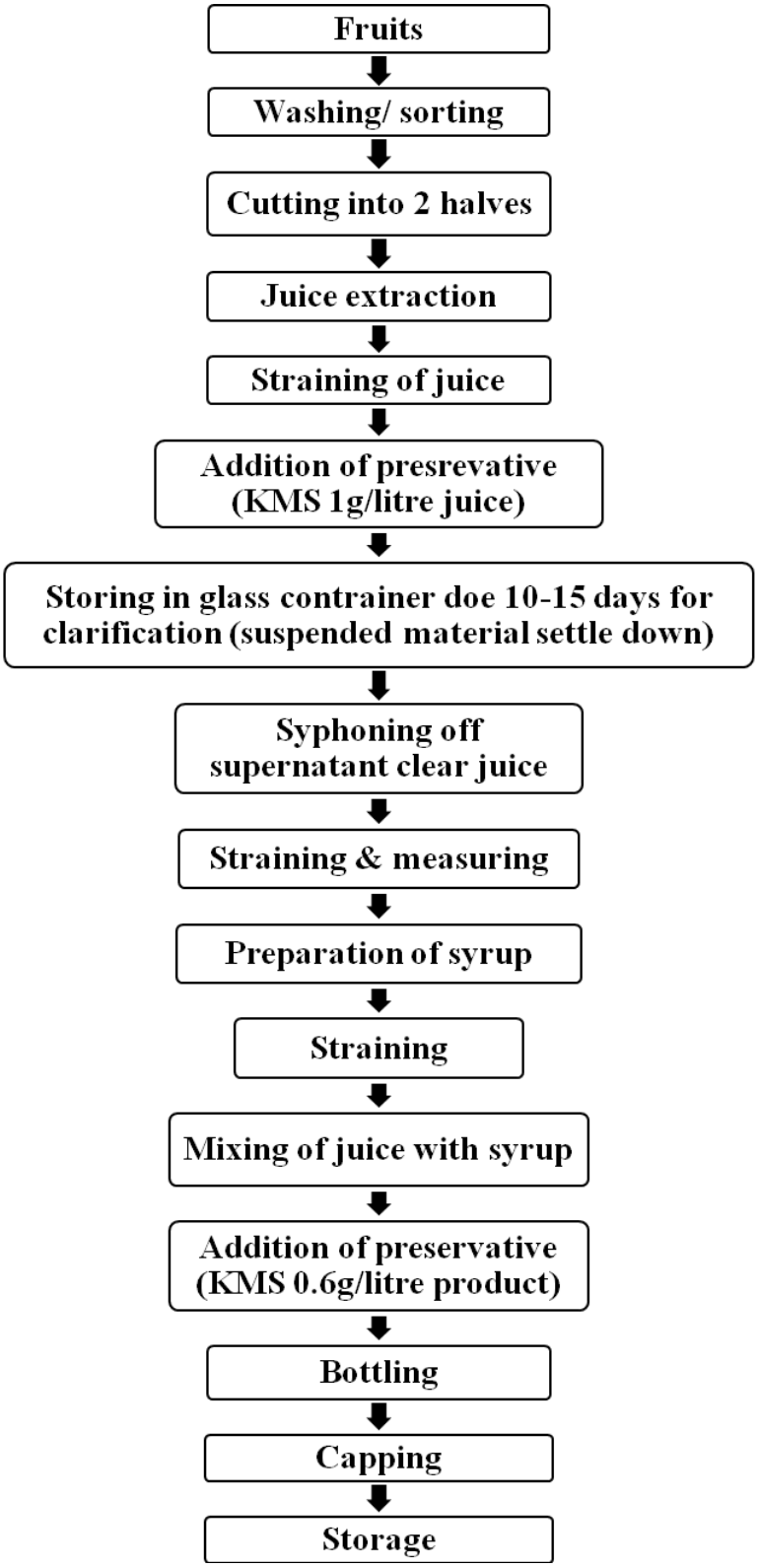
FLOW-SHEET FOR PROCESSING OF SQUASH



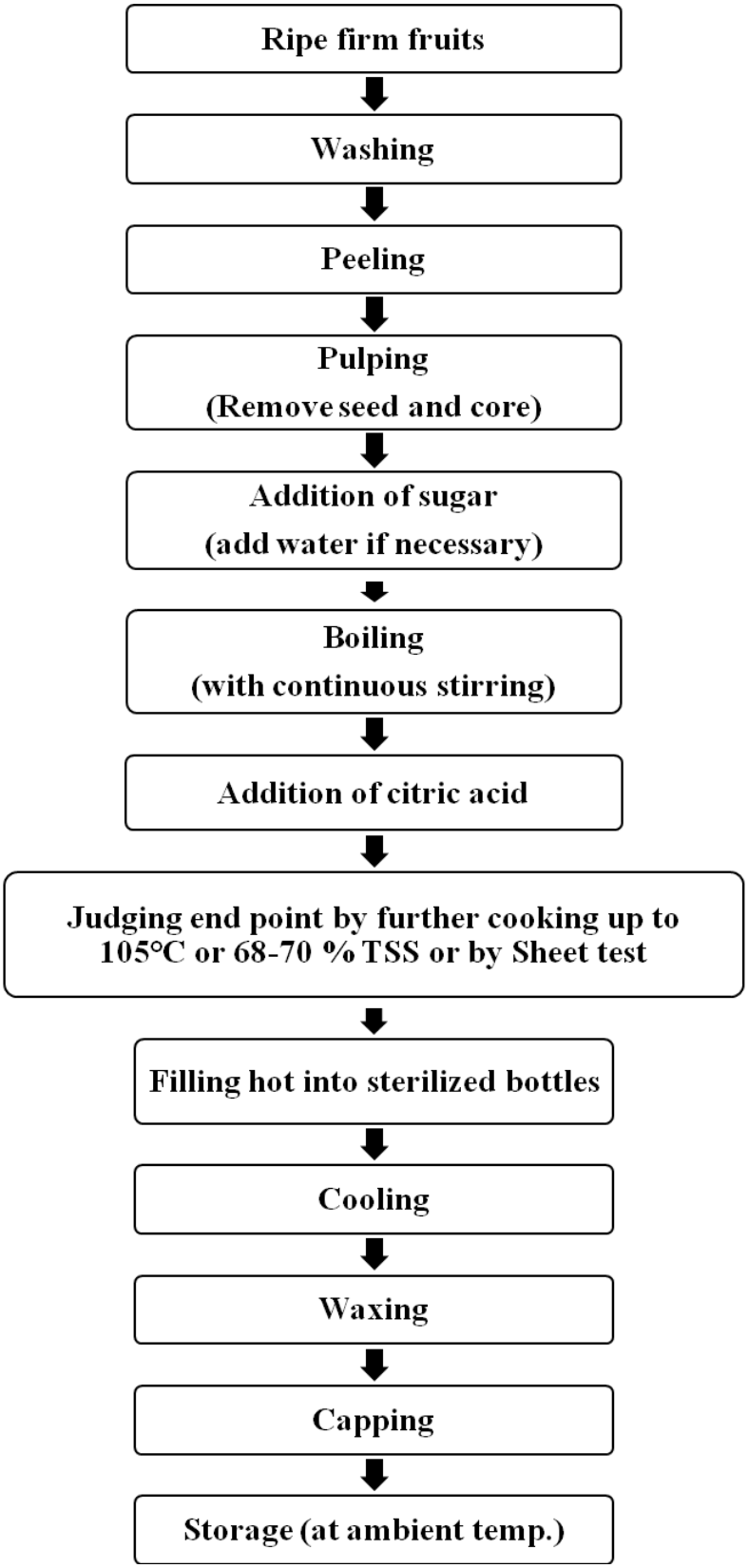
FLOW-SHEET FOR PROCESSING OF SYRUP



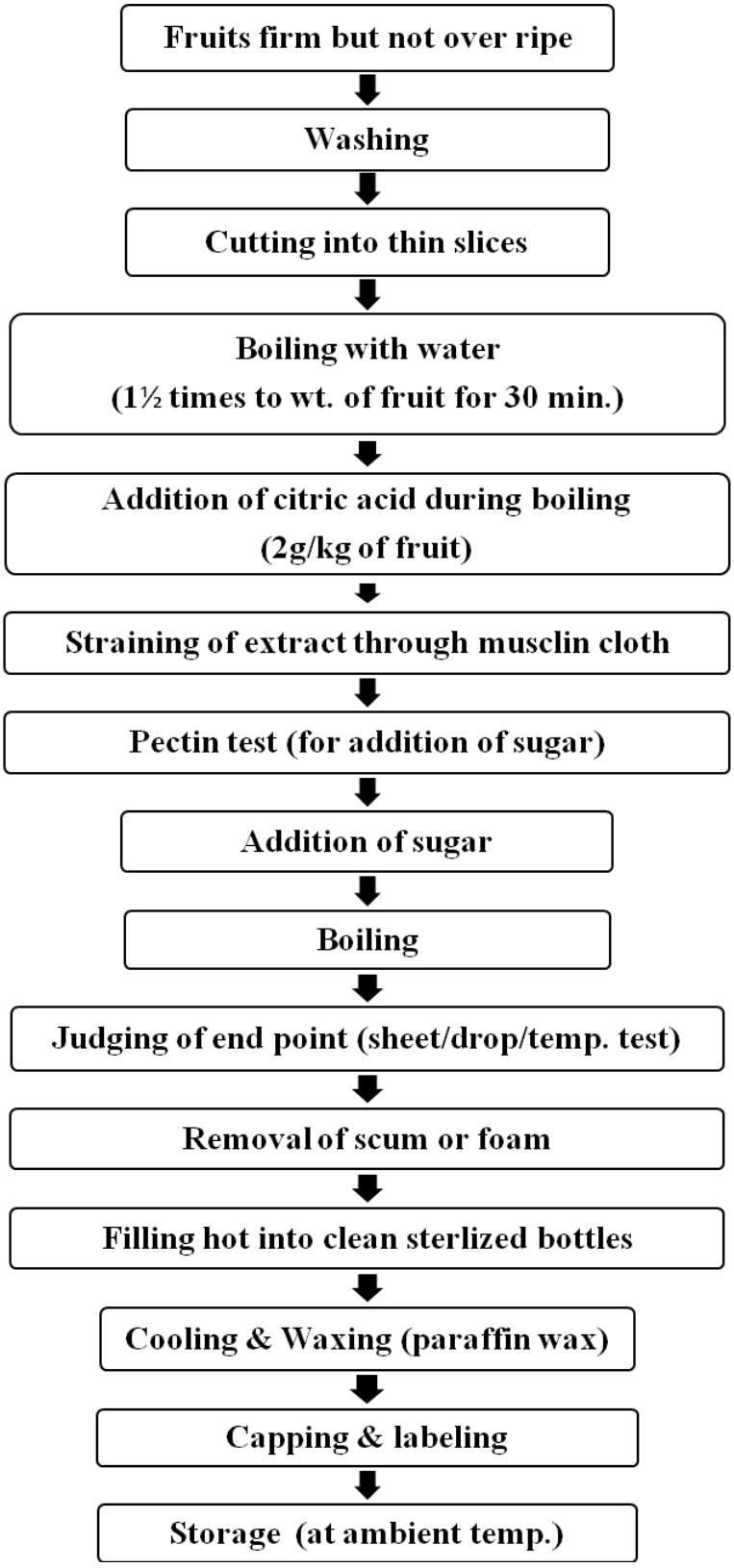
FLOW-SHEET FOR PROCESSING OF CORDIAL



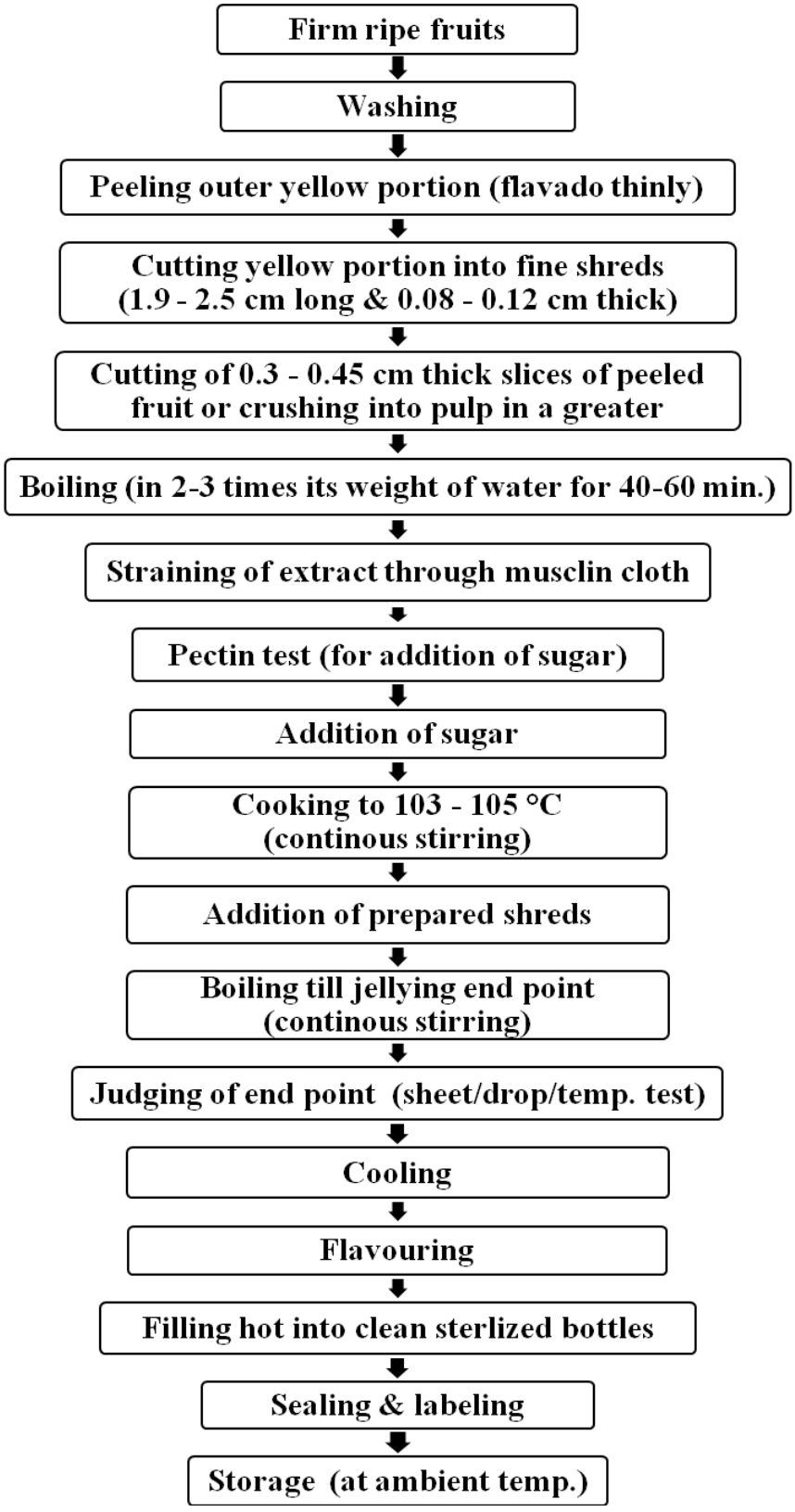
FLOW-SHEET FOR PROCESSING OF JAM



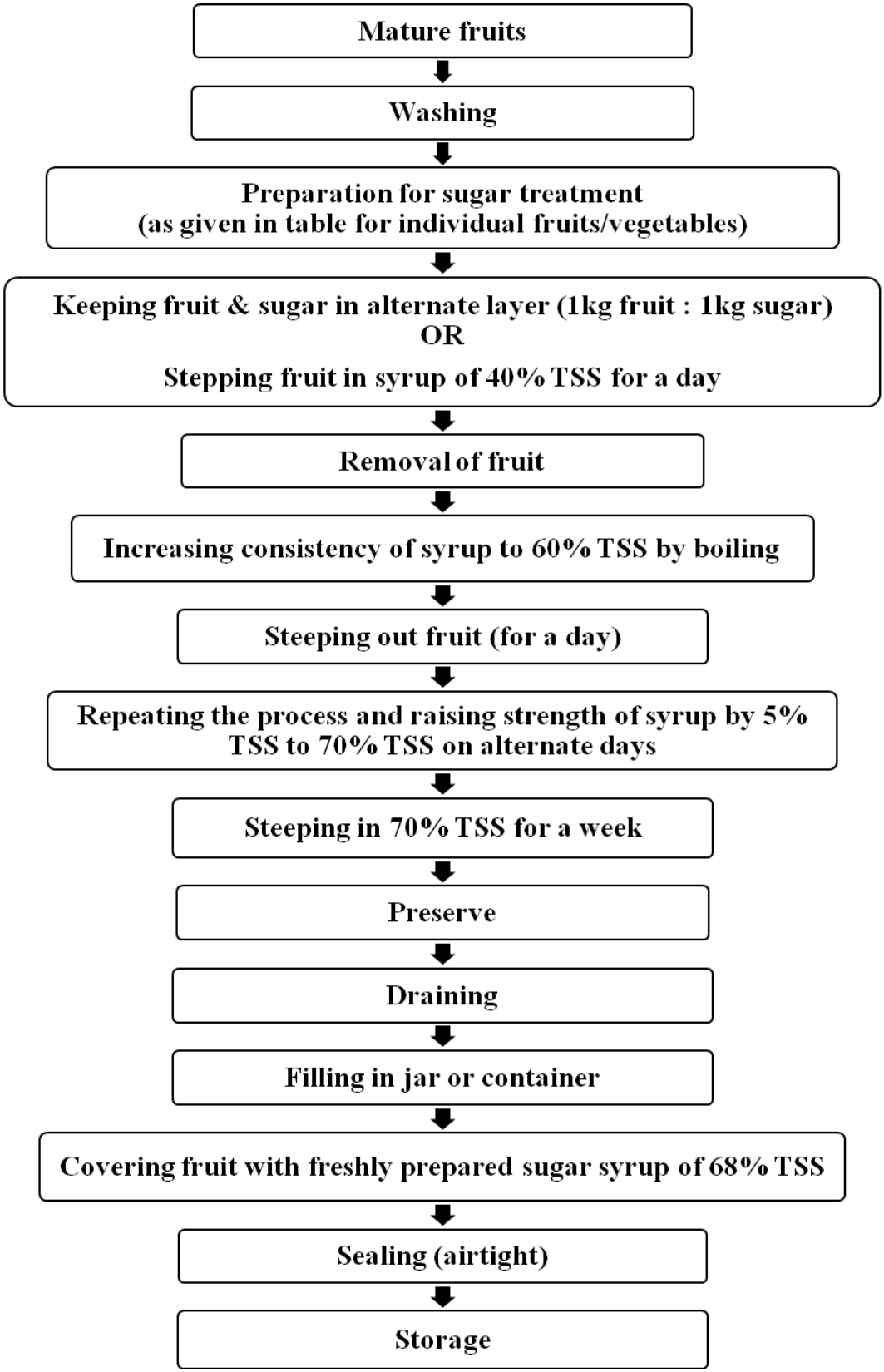
FLOW-SHEET FOR PROCESSING OF JELLY



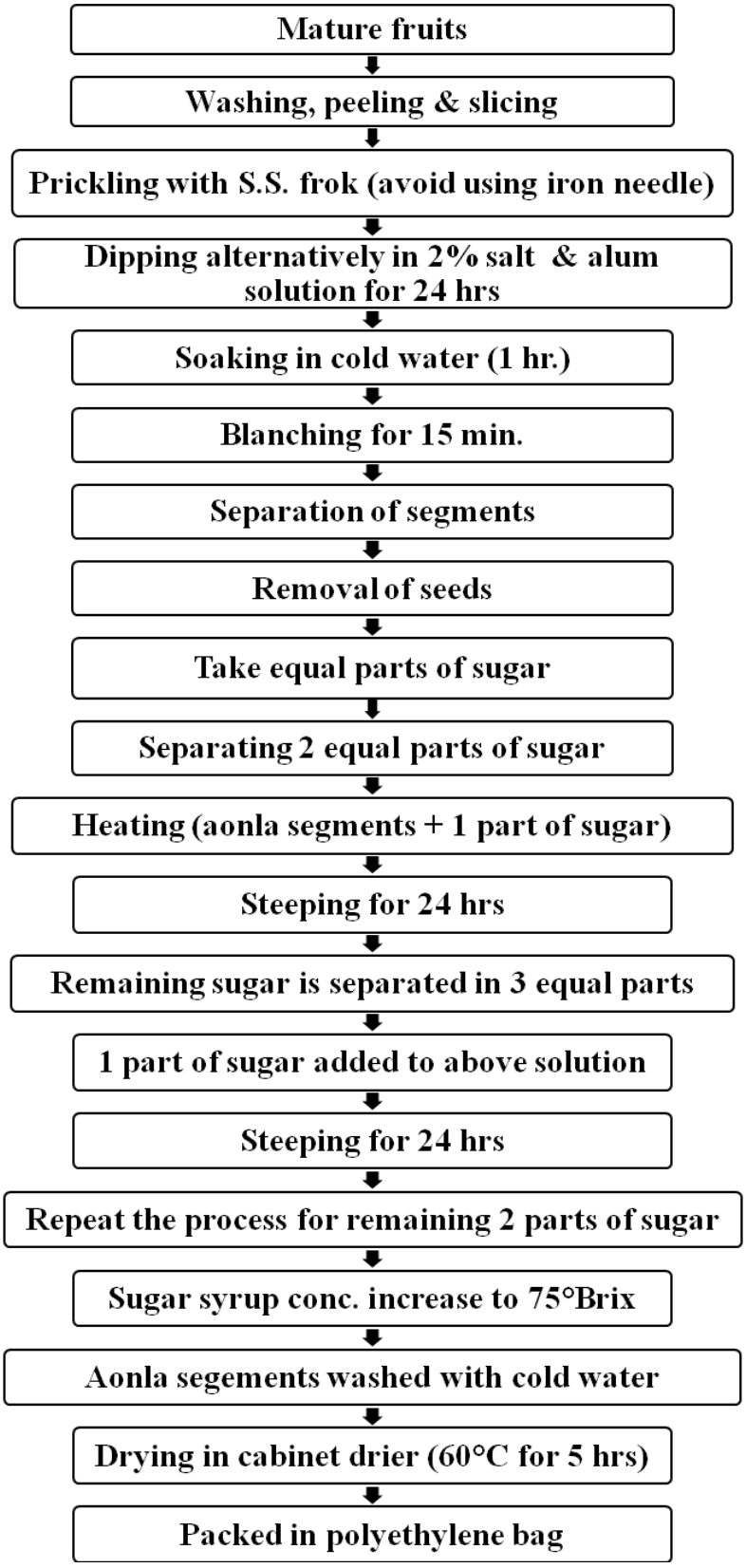
FLOW-SHEET FOR PROCESSING OF MARMALADE



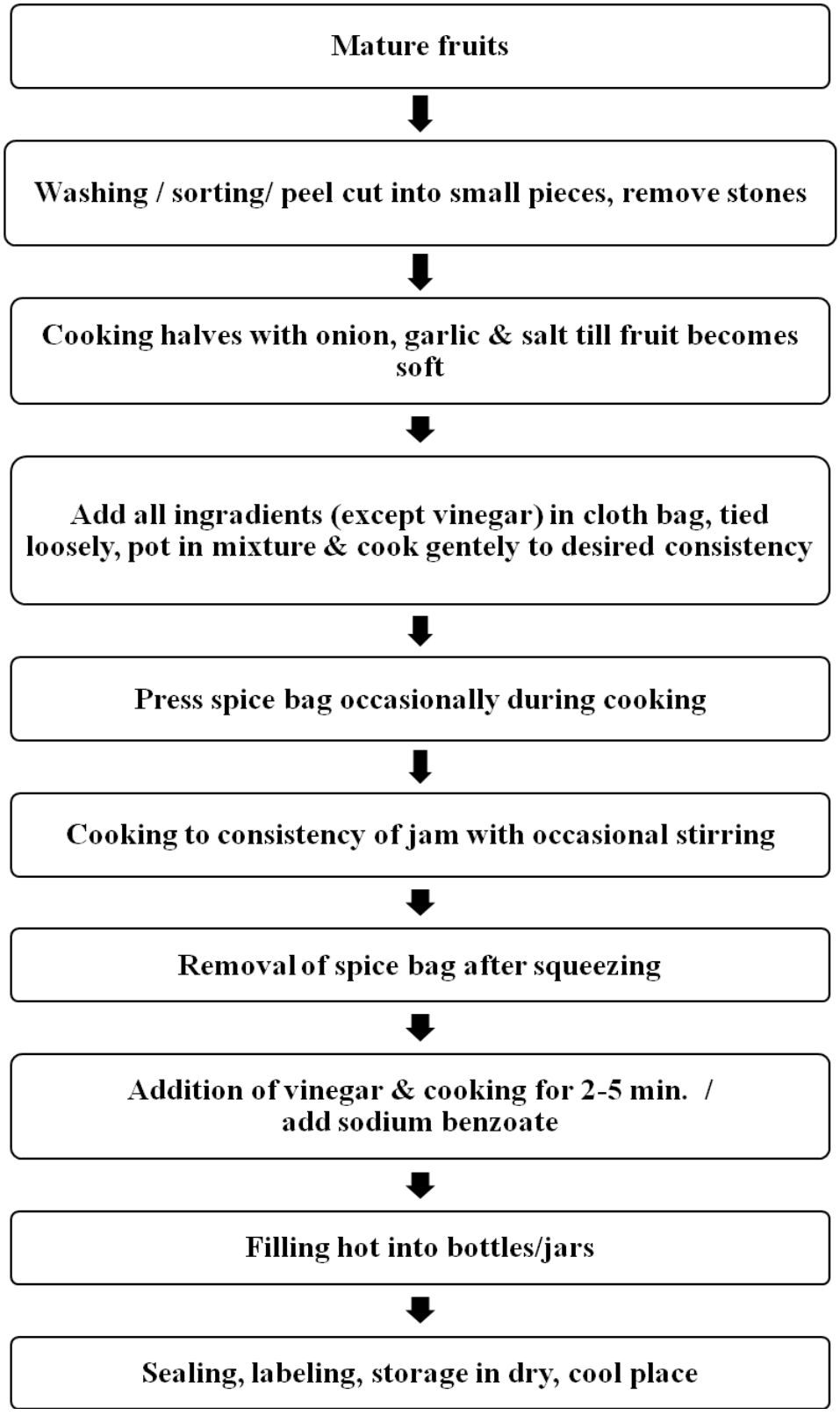
FLOW-SHEET FOR PROCESSING OF PRESERVE



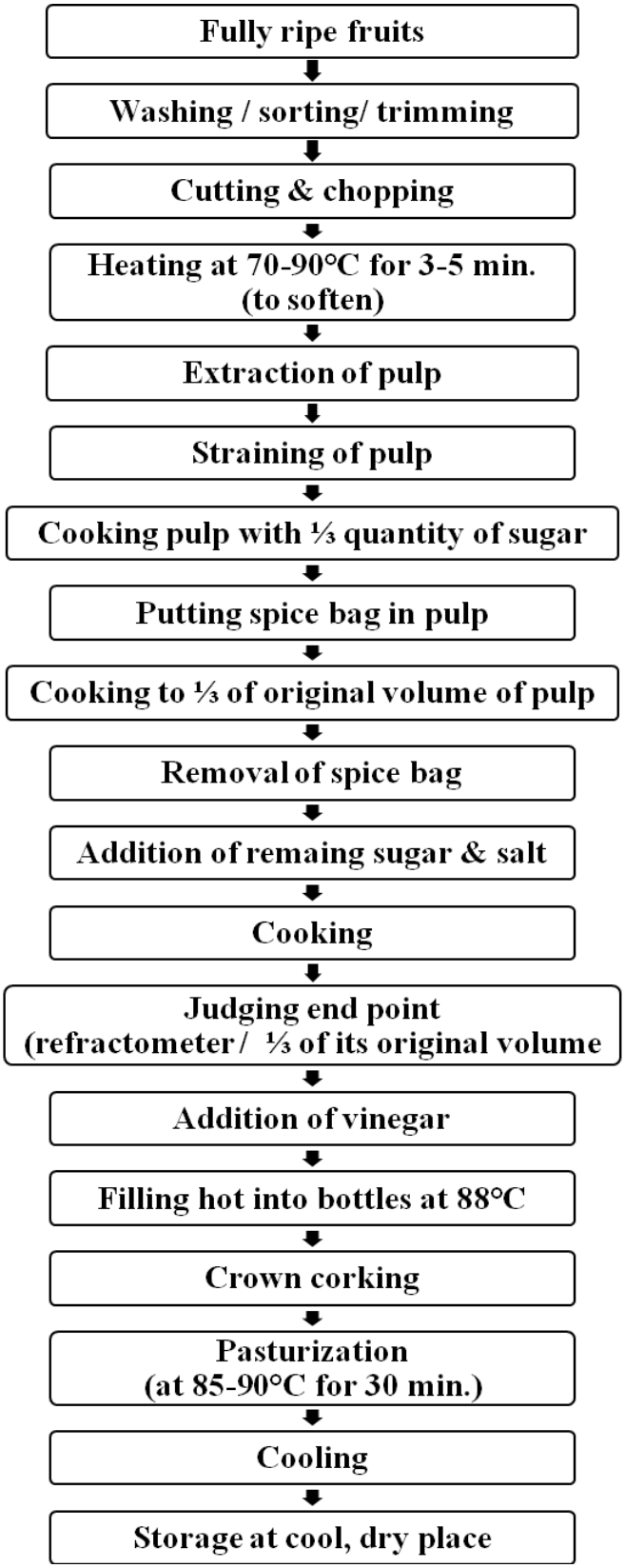
FLOW-SHEET FOR PROCESSING OF AONLA CANDY



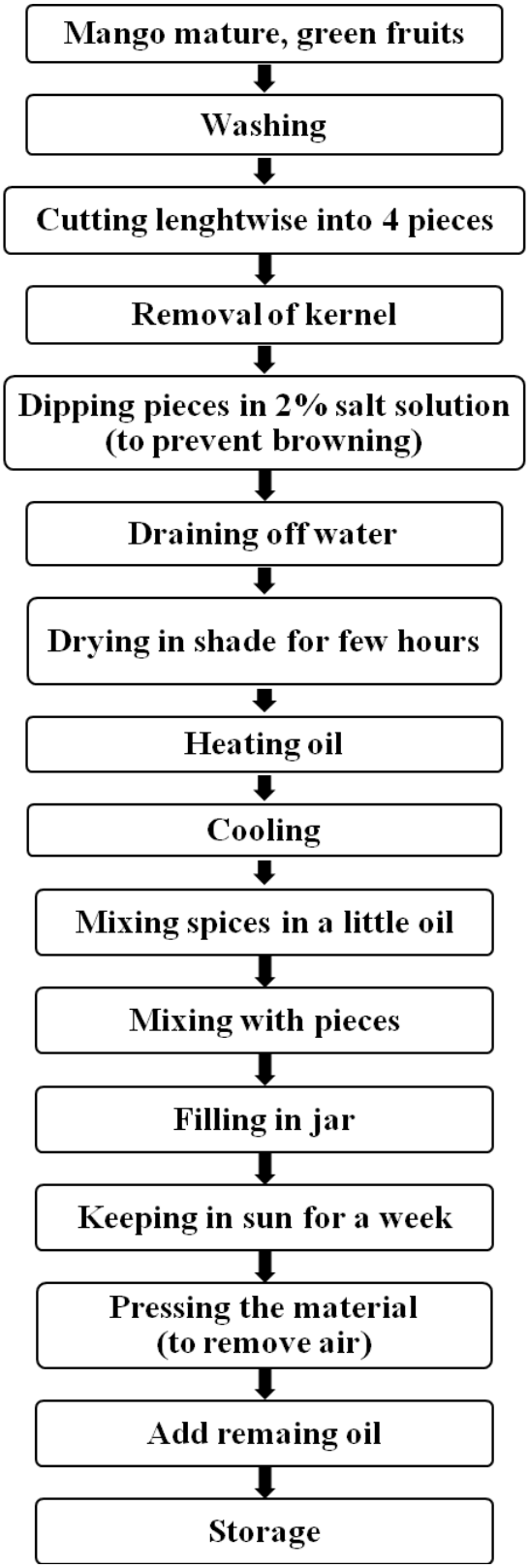
FLOW-SHEET FOR PROCESSING OF CHUTNEY



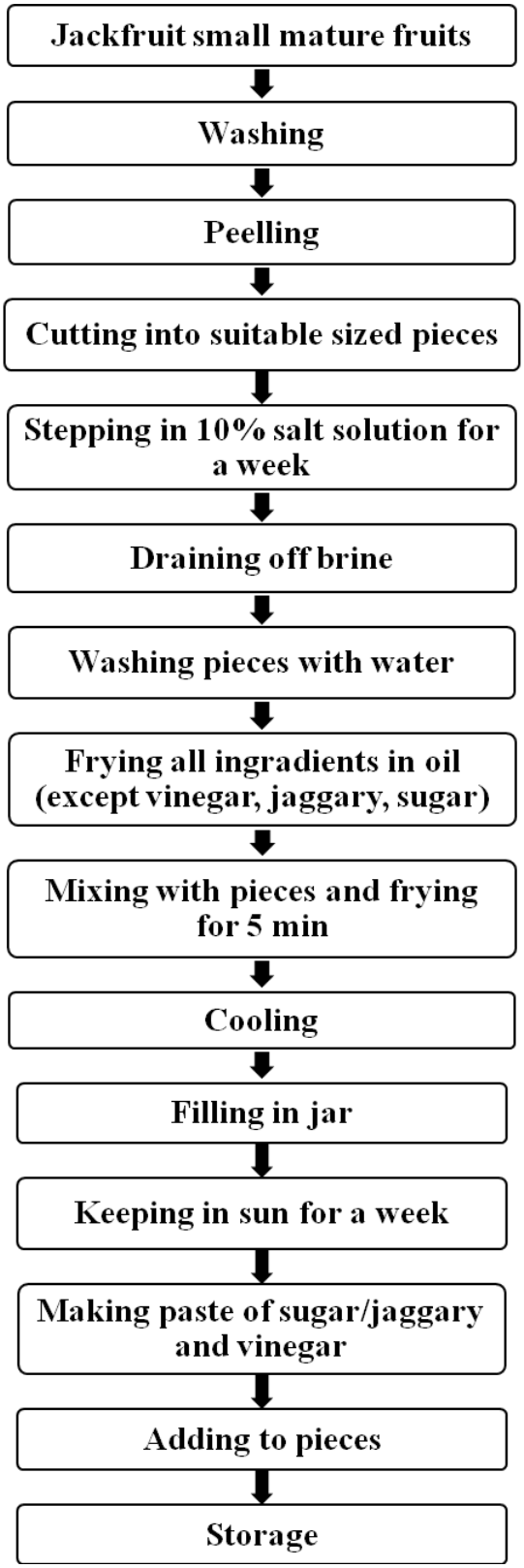
FLOW-SHEET FOR PROCESSING OF TOMATO KETCHUP



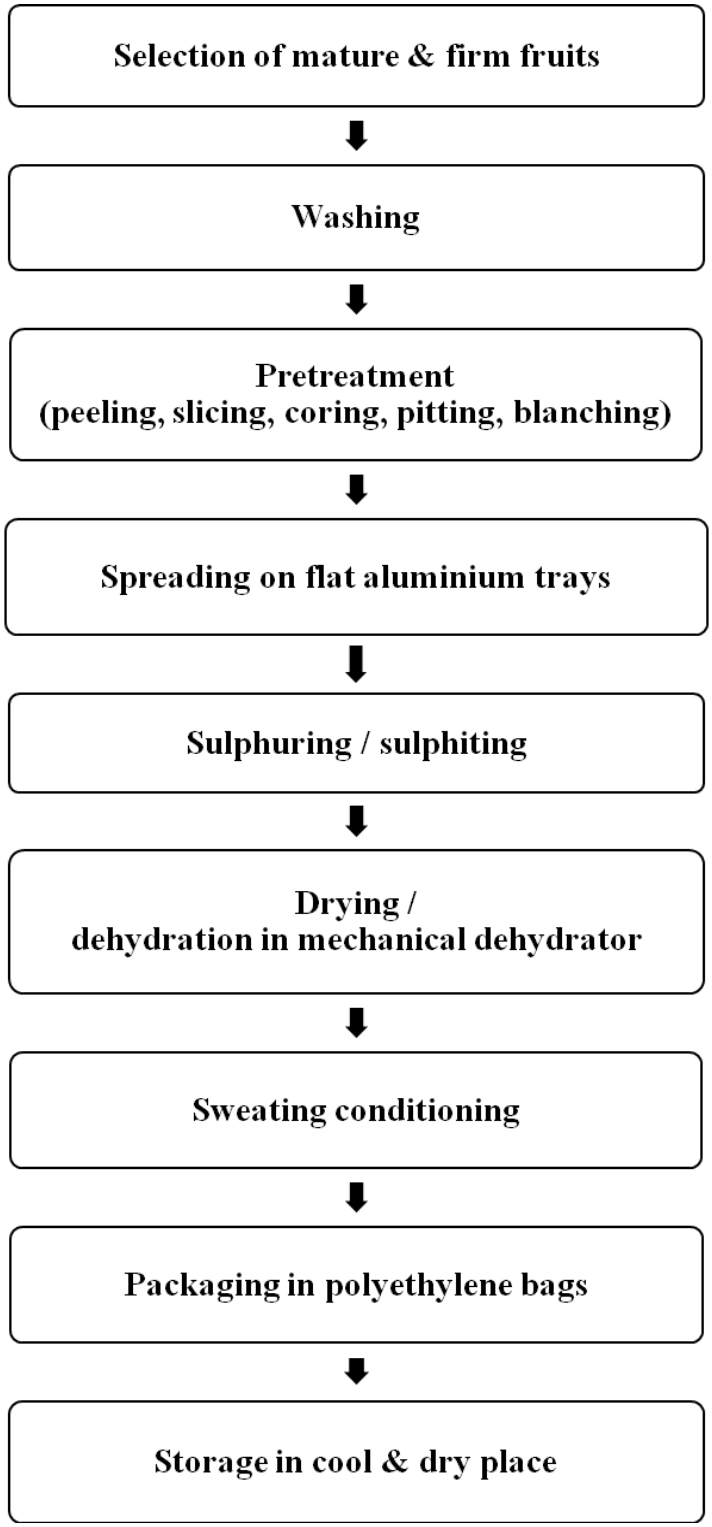
FLOW-SHEET FOR MANGO PICKLE (HOT)



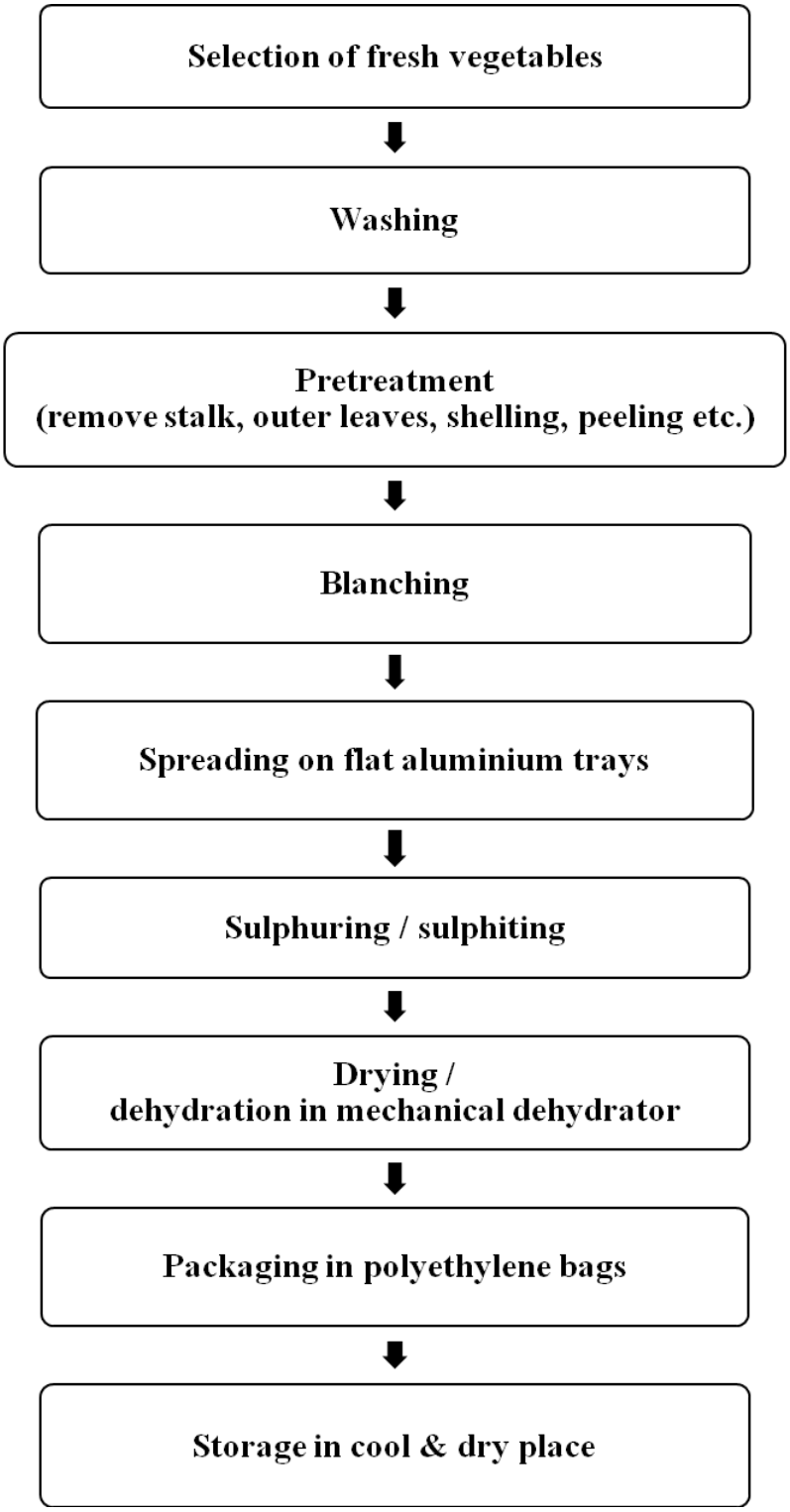
FLOW-SHEET FOR JACKFRUIT PICKLE (SWEET)



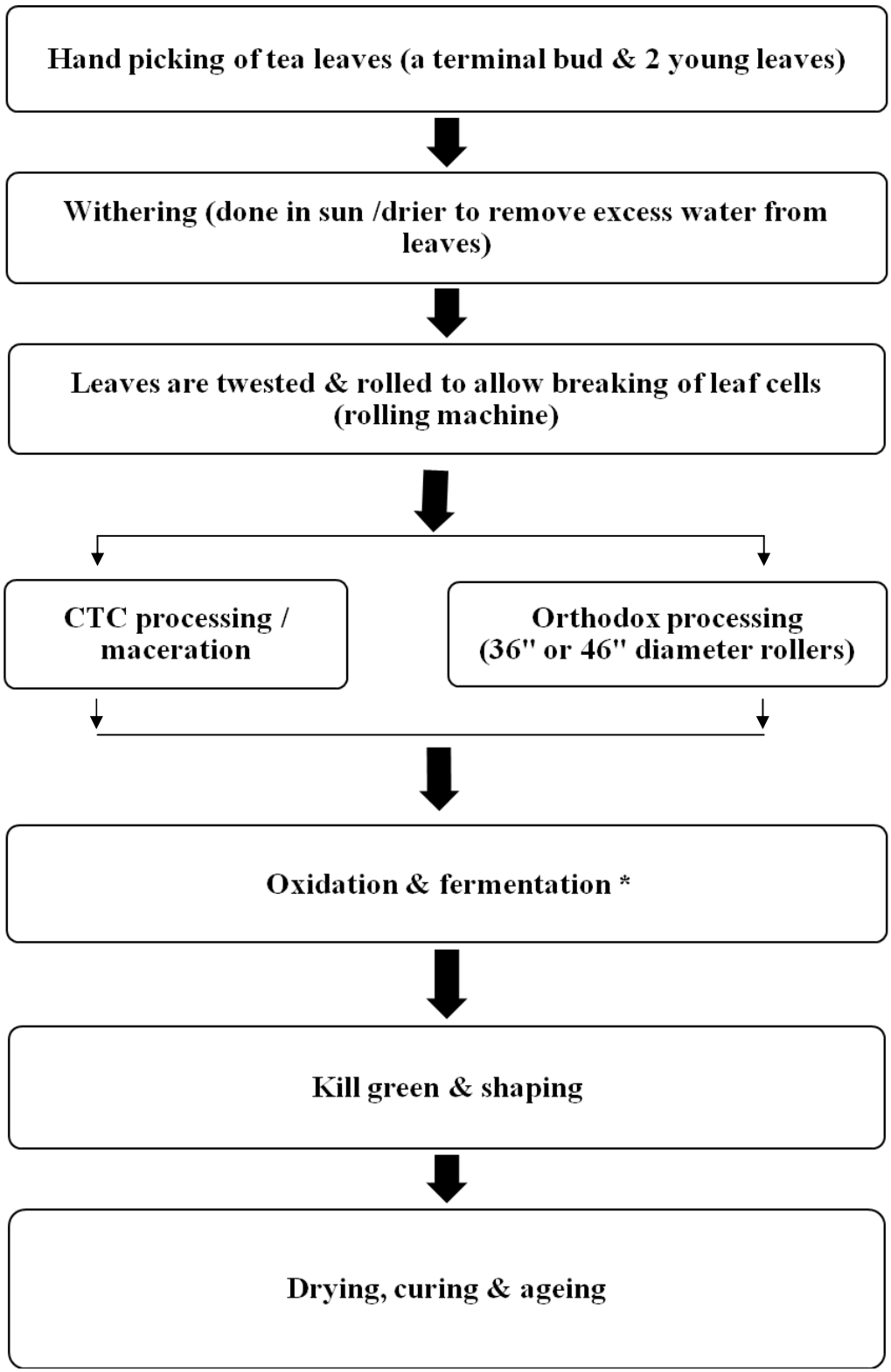
DEHYDRATION / DRYING OF FRUITS



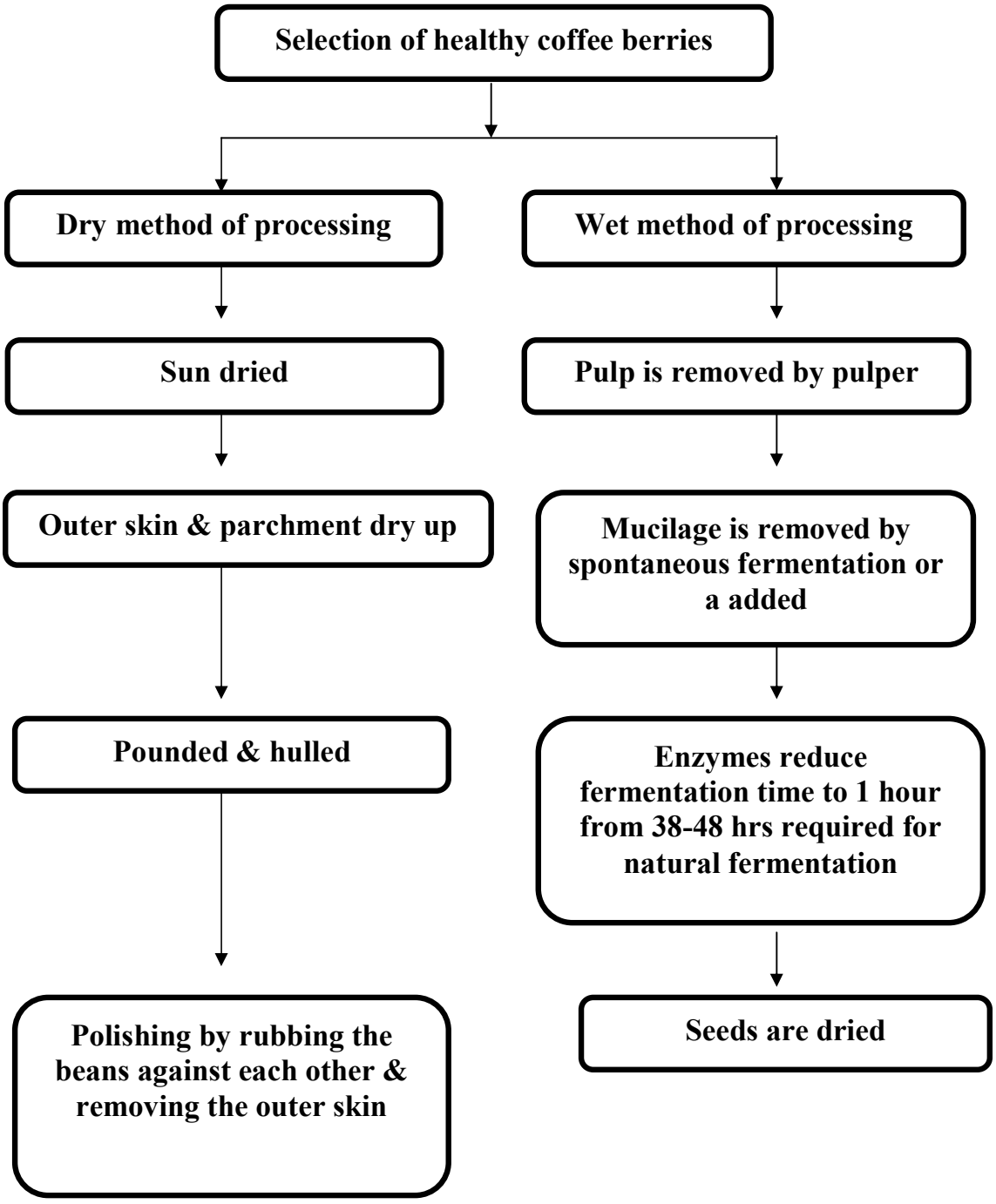
DEHYDRATION / DRYING OF VEGETABLES



STEPS INVOLVED IN PROCESSING OF TEA



COFFEE CURING PROCESS



OIL PALM PROCESSING OPERATIONS

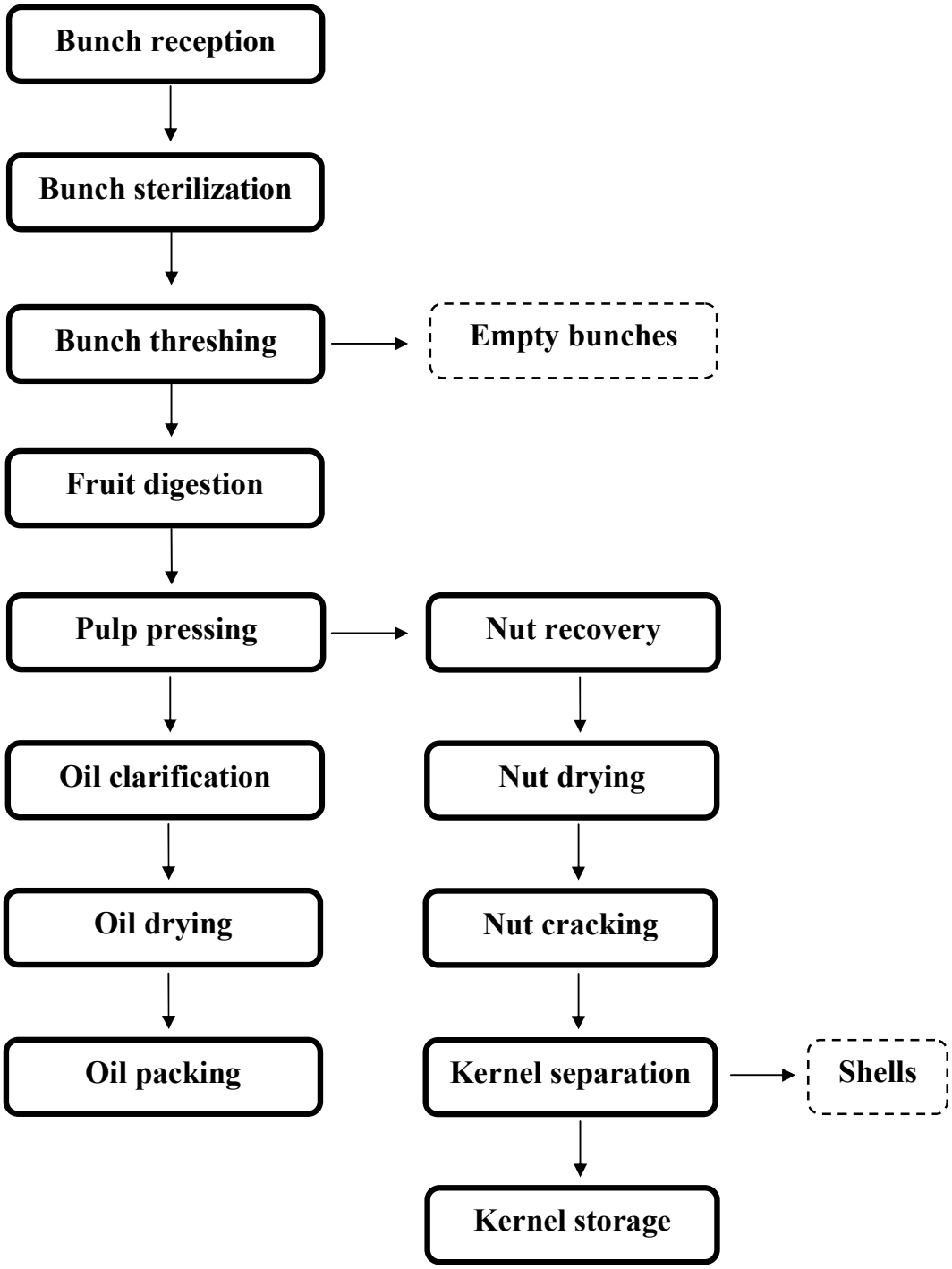


Fig. 1.1: Fruit Press

Fig. 1.2: Fruit Pulper

Fig. 1.3: Steam Jacketed Kettle

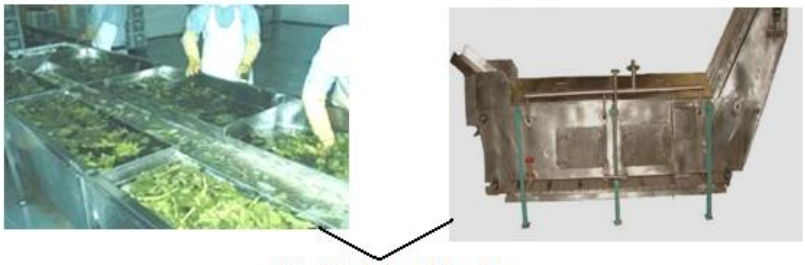


Fig. 1.4: Steam Blancher

Fig. 1.5: Crown corking machine

Fig. 1.6: Laboratory Glassware and plasticware

Fig. 1.7: Hand Refract meter

Lug type sealing machine

Fig. 1.8: Can body reformer

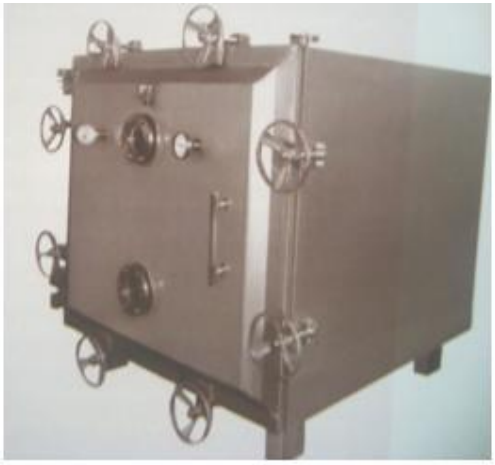
Fig. 1.9: Flanger

Fig. 1.10: Lid Embossing (Batch no, manufacture date etc)

Fig. 1.11: Double seamer

Fig. 1.12: Exhaust box

Fig. 1.13: Can retort/autoclave



Vacuum Dehydrator

Fruit Mill