JHARKHAND
Rai University

POST HARVEST AND VALUE ADDITION OF FRUITS & VEGETABLES

Practical Manual

Prepared by

Neha Nishchal

M.Sc.(Agri.) in Hort.

COLLEGE OF AGRICULTURE, NAMKUM

INDEX

<u>**Exercise No.1**</u>

Objective: Practice in judging the maturity of various fruits and vegetables

Theory: Maturity standards have been determined for many fruit, vegetable and floral crops. Harvesting crops at the proper maturity allows handlers to begin their work with the best possible quality produce. Produce harvested too early may lack flavor and may not ripen properly, while produce harvested too late may be fibrous or overripe. Pickers can be trained in methods of identifying produce that is ready for harvest. The following table provides some examples of maturity indices.

- **Elapsed days from full bloom to harvest:** Apples, pears
- **Mean heat units during development:** Peas, apples, sweet corn
- **Development of abscission layer:** Some melons, apples, feijoas
- **Surface morphology and structure:** Cuticle formation on grapes, tomatoes, Netting of some melons, Gloss of some fruits (development of wax)
- **Size:** All fruits and many vegetables
- **Specific gravity:** Cherries, watermelons, potatoes
- **Shape:** Angularity of banana fingers, Full cheeks of mangos, Compactness of broccoli and cauliflower
- **Solidity:** Lettuce, cabbage, brussels sprouts
- **Textural properties**
- **Firmness:** Apples, pears, stone fruits
- **Tenderness:** Peas
- **Color external:** All fruits and most vegetables
- **Internal color and structure:** Formation of jelly-like material in tomato fruits, Flesh color of some fruits
- **Compositional factors**
- **Starch content:** Apples, pears
- **Sugar content:** Apples, pears, stone fruits, grapes
- **Acid content, sugar/acid ratio:** Pomegranates, citrus, papaya, melons, kiwifruit
- **Juice content:** Citrus fruits
- **Oil content:** Avocados
- **Astringency (tannin content):** Persimmons, dates
- **Internal ethylene concentration:** Apples, pears

Vegetables are harvested over a wide range of maturities, depending upon the part of the plant used as food. The following table provides some examples of maturity indices of vegetable crops.

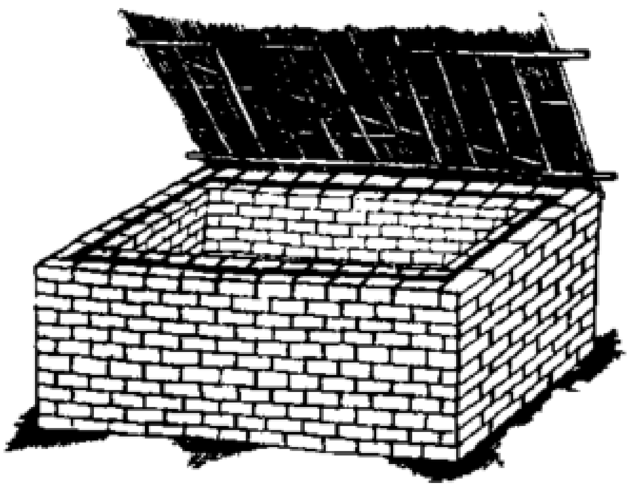
- **Root, bulb and tuber crops**
- **Radish and carrot**: Large enough and crispy (over-mature if pithy)

- **Potato, onion, and garlic**: Tops beginning to dry out and topple down
- **Yam bean and ginger:** Large enough (over-mature if tough and fibrous)
- **Green onion:** Leaves at their broadest and longest
- **Fruit vegetables**
- **Cowpea, yard-long bean, snap bean,batao, sweet pea, and winged bean:** Well-filled pods that snap readily
- **Lima bean and pigeon pea:** Well-filled pods that are beginning to lose their greenness
- **Okra:** Desirable size reached and the tips of which can be snapped readily
- **Snake gourd, and dishrag gourd:** Desirable size reached and thumbnail can still penetrate flesh readily (over-mature if thumbnail cannot penetrate flesh readily)
- **Eggplant, bitter gourd, chayote or slicing cucumber:** Desirable size reached but still tender (over-mature if color dulls or changes and seeds are tough)
- **Sweet corn:** Exudes milky sap from kernel if cut
- **Tomato:** Seeds slipping when fruit is cut, or green color turning pink
- **Sweet pepper:** Deep green color turning dull or red
- **Muskmelon:** Easily separated from vine with a slight twist leaving clean cavity
- **Honeydew melon:** Change in fruit color from a slight greenish white to cream; aroma noticeable
- **Watermelon:** Color of lower part turning creamy yellow, dull hollow sound when thumped
- **Flower vegetables**
- **Cauliflower:** Curd compact (over-mature if flower cluster elongates and become loose)
- **Broccoli:** Bud cluster compact (over-mature if loose)
- **Leafy vegetables**
- **Lettuce:** Big enough before flowering
- **Cabbage:** Head compact (over-mature if head cracks)
- **Celery:** Big enough before it becomes pithy

Exercise No. 2

Objective: Conservation of zero energy cool chambers for on farm storage

Theory: In India quality deterioration of horticultural produce takes place immediately after harvest due to lack of on-farm storage. Maintenance of low temperature is a great problem in a tropical country. Refrigeration is energy intensive, expensive, not so easy to install and run in remote areas and not always environment friendly. Due to lack of cold/cool storage space a substantial amount of fruits and vegetables are lost after production. Considering acute energy



crisis and lack of cool storage facility efforts made to develop low cost/low energy cool chambers.

Construction:

• Select an-upland having a nearby source of water supply.

• Make floor with brick 165 cm x 115 cm.

• Erect the double wall to a height of 67.5 cm leaving a cavity of 7.5 cm.

• Drench the chamber with water. Soak the fine river bed sand with water.

• Fill the 7.5 cm cavity between the double walls with this wet sand.

• Make top cover with bamboo (165 cm x115 cm) frame and 'sirki' straw or dry grass.

• A thatch/ tin shed made over chamber to protect from direct sun or rain or snow.

Exercise No. 3

Objective: Determination of Total Soluble Solids (TSS).

Theory: The average moisture content in fresh fruits and vegetables varies from 60 to 96 percent. Among the various constituents present in fresh fruits and vegetables, some of them are soluble in water. The water soluble substances are minerals, acids, sugars, few proteins and some vitamins. The estimation of total soluble constituents gives the approximate amount of water soluble substance present in the sample. Among the various soluble substances the amount of sugars is 80-85 percent. The TSS value is roughly considered to be the amount of sugars and soluble content can be determined (1) Gravimetrically (2) Hand Refractometer and (3) Brix Hydrometer.

1. Gravimetric Method

Materials Required: Shallow flat-bottomed dish, made of stainless steel or aluminium or porcelain or silica of 7-8 cm diameter and about 2.5 cm deep, desiccator and water bath.

Procedure:

1. Take clean, dry, empty dish and heat it for one hour at 100 °C in a hot air oven, cool it in a desiccator weigh on a chemical balance. This gives the tare weight of the dish.
2. Transfer 10 ml of filtered juice by means of a pipette and weigh it on a chemical balance.
3. Place the dish on a boiling water bath and heat until dried.
4. Remove the dish from the water bath, wipe the bottom and keep the dish in the electric hot air oven and dry for half an hour at 95-105 ºC.
5. Cool the dish in a desiccator.
6. Weigh the content and record the observations as outlined below.

Observation:

1. Wt. of the dish = W g
2. Wt. of the dish + Juice = W_1 g
3. Wt. of the dish + residue = W_2 g

Calculation:

Wt. of juice = (W_1 – W) g

Wt. of TSS of juice = $(W_2 - W)$g

Percentage of TSS in juice = $(W_2 - W)$g / $(W_1 - W)$ g × 100

2. By Hand Refractometer

Materials Required: Hand Refractometer of 0-20 range (works on the principle of total refraction of the plant product), juice, muslin cloth or tissue paper and glass rod.

Procedure:

1. For calibrating the refractometer use clean distilled water.
2. Once the instrument is calibrated the juice of the test material is to be put on prism for determining the TSS.
3. For calibrating the instrument put few drops of distilled water on the specimen chamber of refractometer with the help of a clean glass rod.
4. Fold back the cover of refractometer lightly. Look through eye-piece with projection inlet facing towards light.
5. Read and record the point where the boundary where the boundary line of shaded area intersects with the unshaded area on the scale.
6. If necessary rotate eye piece either for clear reading. The reading should be zero. If the reading is not zero, set it to zero with scale correction knob.
7. Now place three to four drops of test solution on dry clean surface of the prism. Record the reading in the same manner as that of distilled water.
8. Clean the specimen chamber with muslin cloth.
9. Record the observation.

No. of readings/ Variety	1 2 3 4 5 6	Total	Mean	Correction Factor	Corrected reading (Mean-correction factor)
A					

B					
C					
D					

Exercise No. 4

Objective: Determination of Acidity in Juice

Theory: The organic acids present in fruits and vegetables influence the flavor, colour, keeping quality and maturity. They also influence texture and metabolic reaction. In certain fruits the maturity standards is determined by titrating the juice against standard alkali solution.

Materials Required: 10 ml pipette, 25 ml burette, small glass funnel, dropper, juice extractor, distilled water, 100 ml volumetric flask, burette stand, beaker, N/10 sodium hydroxide, filter paper, phenolphthalein indicator (one gram of phenolphthalein in 100 ml of 95% ethyl alcohol).

Procedure:

1. Extract the juice from fruit or vegetable.
2. Use sufficient quantity fruit to give at least 50 ml of juice.
3. Filter the juice with the help of funnel and filter paper.
4. Take 10 ml of juice by means of a pipette and transfer it into a 100 ml.
5. Volumetric flask and add distilled water to make up the volume (100 ml).
6. Shake well.
7. Draw 25 ml aliquat of distilled juice with a pipette and transfer into a 250 ml beaker.
8. Add 3 drops of phenolphthalein indicator to the solution.
9. Fill the burette with N/10 sodium hydroxide solution and adjust to zero mark.
10. Titrate the juice of beaker with alkali solution.
11. The alkali is added drop by drop to the beaker with constant stirring until the pink end point is reached and persists for about 30 seconds.
12. Read the quantity of alkali consumed.
13. Take 3 to 4 readings and record the data.

Sl. No.	Initial burette reading	Final burette reading	Volume of alkali consumed (ml)
1			
2			
3			
Mean			

Calculation:

$$\text{Percent acidity} = \frac{\text{Titre value} \times 0.1 \times 64 \times 10}{\text{Aliquot} \times 10}$$

Or,

(Percentage of acidity (as anhydrous citric acid) can also be calculated from the relationship that 1 ml of 0.1 N sodium hydroxide is equivalent to 0.0064 gm citric acid).

Exercise No. 5

Objective: Estimation of Ascorbic acid

Theory: Several fruits and vegetables are good and natural source of vitamin C. Vitamin C is anti-scourbutic vitamin. The amount of vitamin C in fruits and vegetables varies with variety and the age of fruit and vegetable.

Materials Required: Volumetric flask 250 ml, conical flask 250 ml, beaker 150 ml, water bath, burette 250 ml and pipette.

Procedure:

1. Weigh 30 gm (W_1) of fruit or vegetable and blend it with equal weight (W_2) of 6% metaphosphoric acid for 3 to 4 minutes.
2. Take 15 gm (W_3) of this slurry in a 100 ml (V_1) volumetric flask and make up volume by adding 3% metaphosphoric acid.
3. Filter it through a fast filter paper (Whatman No. 42).
4. Fill the burette with standardized 2,6-dichlorophenol indophenol dye.
5. Take 10 ml (V_2) of filtered solution in a conical flask and titrate immediately against the standard dye solution (V), till faint pink colour appears and persists for 15 seconds.

Calculation: $\frac{W_1 \times W_2}{W_1 \times W_2} \times \frac{V_1}{V_2} \times 100\ (V \times T)$ = Vitamin C mg / 100 of fruit.

Exercise No. 6

Objective: Packing methods and types of packaging

Theory: The main objective of packaging is to keep the fruits, vegetable and root crops in good condition until it is sold and consumed.

- **Plastic film bags –** widely used for consumer size packs in fruit and vegetables marketing. Retain water vapour so as to reduce H2O loss from the content.
- **Plastic boxes –** they are rigid containers most suited for packaging soft and delicate commodities.
- **Net / mesh bags –** widely used for packing fruits like apple, citrus, guava, sapota etc.
- **Sleeve packs –** Immobilization of packed fruits, superior visibility that gives a good sales appeal.
- **Cling film –** Ideal packaging for low water vapour transmission rate, high gas permeability.
- **Shrink film or stretch film –** Stretching the film under controlled temperature and tension, the film which is wrapped over the produce, stretches and then contract by cooling.
- **Active packaging –** Also called as smart packaging. It is actively involved with food products or interacts with internal atmosphere to extend shelf life by maintaining quality and safety.
- **Antimicrobial packaging –** Incorporating antimicrobial agents into polymer surface coating sand surface attachments.
- **Wooden packaging –** used for packing fruits and vegetable. Similar to plastic crates.
- **Modified atmosphere packaging –** It is the packaging of a perishable products. The modified atmosphere surrounding the produce beings about the beneficial effects and extends shelf life a products.
- **Vacuum packaging –** packaging the products in film of low oxygen permeability and sealing it after evacuating the air.
- **Teltrapackaging-** It is used to store the fruit beverages and RTS beverages
- **Bamboo mat holed boxes**- Suitable for transportation of apple
- **Polypropelene boxes-**Highly suitable for long markets it can be reused
- **Corrugated fibre board-** Suitable for fruit and vegetable and most economical.

- **For processed fruit and vegetable products:**

- Aluminium cans, Tin containers, collapsible tubes, glass containers, plastic containers – low density polyethylene (LDPE) HDPE, PP (Polypropylene), PVC (Polyviny), chloride, polytysrons (PS), biodegradable plastics, Phetodegradable plastics, laminate, coextruded films, retortable pouch, bulk packaging, aseptic packaging, etc.

Exercise No. 7

Objective: Pre cooling packing methods for export or international trade

Theory: Precooling is the rapid reduction of field temperature prior to processing,storage, or refrigerated transport. Generally it is a separate operation requiringspecial facilities, but complementary to cold storage. As deterioration isproportional to the time produce is exposed to high temperatures, precooling is beneficial even when produce is later returned to ambient conditions. It iscritical in maintaining the quality of fruits and vegetables and forms part ofthe "cold chain" to maximize postharvest life.

1. **Room cooling -** Room cooling is the **most widely used system** and is based on the product's exposure to **cold air inside a refrigerated room**. It is simple to operate as the product is cooled and stored in the same room. However, the slow removal of heat makes this system unsuitable for highly perishable commodities because at least 24 h is needed to reach the required storage temperature. Almost all other crops are suitable for this type of cooling; however, it is mainly used for **potatoes, onions, garlic, citrus,** etc.
2. **Forced-air cooling -** Cold air is forced to pass through produce by means of **a pressure gradientacross packages.** Cooling is four to ten times more rapid than room coolingand its rate depends on airflow and the individual volume of produce.
3. **Hydrocooling -** The refrigerating medium for hydrocooling is **cold water.** Because of its higher capacity to absorb heat, it is faster than forced-air cooling. Hydrocooling can be achieved by immersion or through means of a chilled water shower. In the latter case produce must be arranged in thin layers for uniform cooling. This system cannot be used for crops that do not **tolerate wetting, chlorine and water infiltration**. Tomatoes, asparagus and many other vegetables are hydrocooled commercially. **Chlorination of water (150–200 ppm) is important** to prevent the accumulation of pathogens.
4. **Ice cooling -** Ice cooling is probably one of the **oldest methods** used to reduce field temperature. It is most commonly used for individual packages – crushed ice is placed on top of the produce before the package is closed. Ice layers may also be interspersed with produce. As it melts, cold water cools the lower layers of produce. Liquid icing is another system where a mix of water and crushed ice **(40 % water + 60 % ice + 0.1 % salt)** is injected into open containers so that a big ice block is formed. The main disadvantage of ice cooling is that it is limited to ice-tolerant crops. It also increases costs because of the heavier weight for transportation and the need for oversized packages. Another disadvantage is that as water melts, storage areas, containers and shelves become wet.

5. **Evaporative -** This is one of the **simplest** cooling systems. It involves forcing **dry air through wet products.** Heat is absorbed from the product as water evaporates. This method has a low energy cost but cooling efficiency is limited by the capacity of air to absorb humidity.
6. **Vacuum cooling - Vacuum** cooling is one of the more rapid cooling systems; however, coolingis accomplished at **very low pressures**. At a normal pressure of 760 mmHg,water evaporates at 100 °C, but it evaporates at 1 °C if pressure is reducedto 5 mmHg. Produce is placed in sealed containers where vacuum coolingis performed. This system produces about 1 % product weight loss for each5 °C of temperature reduction. Modern vacuum coolers add water as a fi nespray in the form of pressure drops. Similar to the evaporation method, thissystem is in general appropriate for leafy vegetables because of their high

Exercise No. 8

Objective: Principles for prolonging storage life

Theory: The main method used to prolong the storage life of fruit is through reducing the fruit temperature to slow metabolism. Refrigerated storage slows the rate of ripening and senescence of the fruit, and also slows the development of any rots. The way in which temperature management is implemented after harvest can significantly affect the quality of the fruit at the end of storage, both in the amount of ripening retardation and also the presence or absence of disorders. The basic effect of refrigerated storage on fruit can be supplemented by modification of the atmosphere in the cool store, by reducing oxygen and increasing carbon dioxide concentrations. More recently, the application of the inhibitor of ethylene action 1-methylcyclopropene (1-MCP) has become common to slow the ripening of a range of fruit, and in particular certain cultivars of apple. The way in which all these technologies impact on the fruit is dependent on the physiological state, or maturity, of the fruit at harvest. What may be described as a 'correct' physiological state at harvest is not fixed, but may differ dependent on the commercial requirements of the fruit, i.e. a short or long storage period. Ultimately, the target for good storage is for the fruit to remain in good condition, to ripen properly, have an acceptable flavour and not have any disorders at the end of storage and when it reaches the consumer.

1. **Temperature**
   To obtain the maximum benefit from cold temperatures, the temperature must be as low as possible without causing damage to the fruit; this is termed the lowest safe temperature. Below the lowest safe temperature, but at non-freezing temperatures, the fruit may develop symptoms of chilling injury. At even lower temperatures, generally in the range –0.5°C to –1.5°C, freezing occurs which irreversibly damages a living product. Because of this, –0.5°C is usually the lowest temperature used for storage of fruit, including some apple cultivars, berries or 'Hayward' kiwifruit. Temperatures at which chilling symptoms occur are around $8^{o}C$ for subtropical species and may be anything up to 14°C for some tropical fruit: for example unripe banana and mango need to be shipped at 13–14°C. However, it is not only tropical and sub-tropical fruit that are susceptible to chilling injury; even 'Hayward' kiwifruit, which is stored at 0°C or just below, may develop chilling injury.

2. **Relative humidity**
   Once harvested, fruit will continuously lose water to a point where quality will be affected. In some species, a small amount of water loss may accelerate ripening (e.g. avocado), but in all fruit there eventually comes a point at which loss of water, usually

first seen as shrivelling, results in the fruit becoming unacceptable. Water loss from the fruit is driven by the vapour pressure gradient between the fruit and the surrounding environment. While the capacity for air to hold water is reduced at low temperatures, there is always a gradient driving water from the fruit into the coolstore atmosphere. The less fruit there is in a coolstore, the greater the water loss from each fruit before an equilibrium relative humidity is reached. Water may be lost from the coolstore atmosphere by condensation on the refrigeration coils that are colder than the room atmosphere, and the greater the temperature differential between the coils and atmosphere the greater the loss of water. When storage is at about 0°C, this can be seen by ice developing on the coils that must be removed by defrosting.In preventing quality loss of harvested fruit, the relative humidity of the storage environment is one of the first aspects considered, since fruit will lose water more rapidly at lower relative humidity. This is mostly an issue where fruit are held unpacked or in bulk in a coolstore, and water loss is exacerbated where there is only a small volume of fruit in the store, air flow is high and there is a large temperature differential on the refrigeration coil. In other circumstances, such as for kiwifruit that may be stored for months, the fruit is packed into fibreboard packs with a polyethylene liner or bag. In these circumstances, it is the bag that creates a high humidity environment for the fruit and limits the fruit's water loss. A very high relative humidity in the store environment where packed fruit are held may be detrimental to the integrity of the fibreboard packaging, which would soften and lose its strength.

3. **Controlled and modified atmospheres**
   The storage life achievable by refrigerated storage can be extended by modifying the store atmosphere by reducing the oxygen and increasing the carbon dioxide concentrations. Elevated CO_2 and reduced O_2, used either separately or together, can delay ripening and slow the onset of senescence. When both high CO_2 and low O_2 concentrations are combined then the beneficial effects may be additive. These methods were originally developed on a commercial scale for apple, but have been progressively applied to many other fruit. Container shipping helped their introduction because a sealed container made it easier to maintain the required temperature and atmosphere regimes.

4. **Blocking ethylene action**
   With ethylene having a pivotal role in the ripening of many (but not all) fruit, the use of the ethylene action inhibitor 1-MCP has been investigated for prolonging the storage life of a wide range of species through retarding fruit ripening and softening (Watkins 2008). 1-MCP is usually applied after harvest as a gas treatment in a sealed store, container or tent, with the active ingredient released from a powder by dissolving in water. Successful use of 1-MCP to delay ripening depends on the physiology of the fruit, most likely on the natural rate of replacement of the ethylene receptors that are blocked by 1-MCP. Since binding of 1-MCP to existing ethylene receptors is irreversible, a single period of exposure can delay ripening for several to many days, depending on the rate of synthesis of new receptors. For all cultivars, careful optimisation of maturity stage, 1-MCP concentration, exposure frequency and duration and storage temperature is required.

Exercise No. 9

Objective: Effect of ethylene on ripening process

Theory:

- Ethylene is a small hydrocarbon gas. It is naturally occurring, but it can also occur as a result of combustion and other processes. You can't see or smell it. Some fruit will produce ethylene as ripening begins. Apples and pears are examples of fruit that produce ethylene with ripening. Ethylene is responsible for the changes in texture, softening, color, and other processes involved in ripening. Fruits such as cherries and blueberries do not produce much ethylene and it doesn't influence their ripening.

- Ethylene is thought of as the aging hormone in plants. In addition to causing fruit to ripen, it can cause plants to die. It can be produced when plants are injured, either mechanically or by disease. Ethylene will cause a wide range of effects in plants, depending on the age of the plant and how sensitive the plant is to ethylene. Ethylene effects include fruit ripening, loss of chlorophyll, abortion of plant parts, stem shortening, abscission of plant parts, and epinasty (bending of stems). Ethylene can be either good or bad, depending on what commodity you work with. It is used in a positive manner in fruit ripening, for example. It can also cause damage in crops. Examples of damage might include yellowing of vegetables, bud damage in dormant nursery stock, or abscission in ornamentals (leaves, flowers drop off). Often two of the important items to know are 1) if a crop naturally produces a lot of ethylene and 2) if it is responsive to ethylene. Responsiveness will depend on 1) the crop, 2) the stage of plant development, 3) the temperature, 4) the concentration of ethylene, and 5) the duration of exposure.

- Ethylene gas is used commercially to ripen tomatoes, bananas, pears, and a few other fruits postharvest. Ethylene can be explosive if it reaches high concentrations, so it has to be used cautiously. Several commercial liquid products release ethylene (ethephon, trade name Ethrel). These are only used preharvest.

- There are three main ways to produce ethylene:
- gas from a cylinder,
- catalytic generator, and
- ethephon. Other sources of ethylene include ripening fruit, exhaust from internal combustion engines/heaters, smoke (including cigarettes), welding, rotting vegetation, natural gas leaks, and manufacturing plants of some kinds.

- There are several anti-ethylene chemicals. Silver thiosulfate (STS) is used on flowers. Aminoethoxyvinyl-glycine (AVG, trade name ReTain) blocks ethylene synthesis. It is applied preharvest. The fruit (plant) will not produce much ethylene, so there is not an ethylene response. The ethylene blocker 1-methylcyclopropene (1-MCP, trade name EthylBloc) blocks ethylene by binding to its receptor. It is applied postharvest. The fruit (plant) may still produce some ethylene, but there is no response to the ethylene.

- There are several ways to measure ethylene:
- gas chromatography (best but expensive);
- kitagawa tubes, or equivalent;
- other types of chemical sensors; or
- another plant that is sensitive to ethylene.

Exercise No. 10

Objective: Identification of equipment and machinery used is preservation of fruits and vegetables.

Theory:

Following are the list of tools, machines or equipmentsand their purposes/uses

- **Autoclave:** For sterilizing / heating the food.
- **Blenders:** For mixing of the ingredients.
- **Blanchers:** For blanching of fruits and vegetables to inactivate enzymes that cause deterioration in colour and flavour during drying and subsequent storage. Blanching may be carried out using water or steam.
- **Bottle filling machine:** For filling the bottles automatically.
- **Bottle sterilizers:** For sterilizing the bottles.
- **Bottle washing machine:** For cleaning and washing of bottles.
- **Bottle washers:** may be of bristle, hydro or soaker type or a combination of these.
- **Brew equipment / Fermentors:** For brewing of beverages.
- **Butter churns:** Use for butter production.
- **Butyrometers:** For measuring the fat content in milk
- **Butter pats:** Used to knead and form butter. It also removes excess moisture and produces a uniform texture.
- **Cabinet drier:** For drying of food items.
- **Canning equipment:** Aid in canning process which involves filling the food into can, fitting the lid and heating the can in a retort to sterilizer the food.
- **Cap sealing machine:** For sealing the bottles
- **Can opener:** For opening of cans
- **Carbonating equipment:** Makes carbonated drinks using high-pressure carbon dioxide.
- **Centrifuges:** Separation of substances like cream, honey and juices using the principle of centrifugal force.
- **Cheese moulds, presses and kits:** For making cheese.

- **Chopper:** For chopping fruits and vegetables.
- **Cleaners:** To wash and clean fruits and vegetables, remove chaff and other impurities from grain.
- **Cooling tank:** For cooling food materials
- **Crown corking machine:** For sealing the bottles
- **Curd making equipment:** For making and storing curds. Specially designed for curd to avoid whey corrosion.
- **Cutting, slicing and dicing equipment**: For cutting, slicing and dicing various food products.
- **Deaerators:** For removal of air present in fruit juices
- **Decorticators (shellers):** For decortications/shelling of maize, groundnuts, cashew nuts, peas, walnuts, cocoa, coffee, sunflower, etc.
- **Destoner:** Separates grain mass
- **Dryers:** For drying and dehydration.
- **Enrobers:** Used to coat foods in chocolate, butter or other coating materials.
- **Evaporators:** For evaporation of water.
- **Exhaust box:** For removal of air in cans
- **Expellers:** For expression of oil from oilseed sand nuts.
- **Extruding machines:** Used for making extruded products such as snack foods from cereals.
- **Filling machines:** Filling of liquid and solid materials into containers and pouches.
- **Fillers, sieves and strainers:** Used for filtration, sieving and straining of oils, juices, powders/flours etc.
- **Flaking and splitting machine:** For making rice flakes and dhal splits.
- **Formfill and seal machine:** For packaging of the liquid and semi solid foods
- **Freezer:** for freezing of food materials
- **Fryers:** For frying.
- **Grating equipment:** For grating various food materials.
- **Grills:** For grilling of meat, fish and other products.
- **Heater and hotplates:** For heating water and other items.
- **Homogenizers:** To form a stable emulsion form two immiscible liquids.
- **Ice-cream making equipment:** For ice-cream making.
- **Incubators:** To hold food items at a preset temperature.
- **Jelmeter:** For testing the pectin content in fruits/food.
- **Lactometers:** For measuring the lactose content in milk
- **Kneaders:** For mixing the ingredients.
- **Measuring cylinders/jugs:** For measuring of raw and finished food products.
- **Mills and grinders:** For grinding cereals, pulses, spices, sugar etc. Will also reduce liquid suspensions to a finer particle size.
- **Mincers:** For grinding met for sausages and patties.
- **Mixers:** For mixing various ingredients into a homogeneous mixture.

- **Moulds and baking units:** Used in bakery production.
- **Ovens:** For cooking, roasting and baking.
- **Packaging equipment:** Packaging of different food materials.
- **Pans and kettles:** For cooking, coating, etc. of food items.
- **Pasta machines:** For making pasta foods.
- **Peeling equipment:** Used for peeling and coring of fruits and vegetables.
- **Presses:** For extraction of oil, juices, pulp, etc.
- **Pressure cookers:** For cooking of food.
- **Puffing machines:** For puffing grains like cereals and pulses.
- **Pulpers and juicers:** Used for the extraction of pulp and juices especially fruits and vegetables.
- **Pulverizer:** simple machine that grinds without stone.
- **Refractometer**: For checking the TSS (Bx) in fruits and its product
- **Refrigerator:** For cooling and preservation of food.
- **Roasting equipment:** For roasting coffee, cocoa, cashew nut, peanut, soybean, etc.
- **Rolling equipment:** To roll pastry and pasta. Papad is also made.
- **Salometer:** For testing the salt content in food.
- **Sealing machine:** For sealing the polyethylene bags.
- **Shrink film packaging machine:** For packing the food materials.
- **Steam boiler:** To produce steam with high temperature
- **Steam jacketed kettles:** To concentrate the raw extracted pulp and for cooking of food items
- **Sorting equipment:** Used for grading food items on the basis of size, density or shape, colour sorters are also available.
- **Spray drier:** For drying the liquid food items
- **Squeezer:** For squeezing the juice.
- **Threshers:** For threshing grain and oilseed crops.
- **Thermometers:** For checking the temperature during processing
- **Tin containers:** For canning of food in containers.
- **Vacuum packaging machine:** For packing the food materials under vacuum condition.
- **Water softener:** For removal of hardness of water
- **Weighing machine:** For weighing the food ingredients. Wooden laddles For stirring

Exercise No. 11

Objective: Preservation by drying and dehydration

Theory: The terms Drying and dehydration means the removal of water.

Drying - is done by using non-conventional energy sources like sun and wind.

Dehydration – means the process of removal of moisture by application of artificial heat under controlled conditions of temperature humidity and air flow.

Several types of driers and drying methods, each method better suited for a particular situation, are commonly used to remove moisture from a wide variety of food products including fruit and vegetables. Sun drying is followed in certain crops such as prunes, figs, apricots, grapes and dates.

There are three basic types of drying process

• Sun drying / solar drying

• Atmospheric drying including batch (Kiln, tower and cabinet driers) and continuous (tunnel, belt, belt-through, fluidized bed, explosion puff, foam mat, spray, drum and microwave).

• Sub atmospheric dehydration (Vacuum shelf / belt and freeze driers)

Drying techniques / methods

A) **Fruit and vegetable natural drying –**

1) **Sun or solar drying:** Surplus production and specially grown crops may be preserved by natural drying for use until the next crop can be grown and harvested. These can be cheaply distributed t areas where there are permanent shortages of fruit and vegetables.

2) **Shade drying:** It is done for products which can lose their colour and or turn brown if put in direct sunlight. Eg: Herbs, Green and red sweet peppers, chillies, green beans and okra.

3) **Osmotic dehydration:** Here the prepared fresh material is soaked in a heavy or thick liquid sugar solution or strong salt solution and then the material is solar dried.

B) **Common driers used for drying / dehydration**

a) **Air convection driers:** All air convection driers have some root of insulated enclosure, a means of circulating air through the enclosure and a means of heating this air –

1. **Kiln drier:** It is the simplest kinds of air convection drier. These are generally used to for large pieces of material. Eg: apple and Potatoes.

2. **Cabinet, tray and Pan driers:** Advanced method, the food is loaded on trays or pans in a thin layer. Hot air is blown across the food trays. It is used for small scale operations.

3**. Tunnel and continuous belt driers:** These driers are most commonly used for dehydrating fruit and vegetable. Here also hot air is blown across the trays.

4. **Belt through driers:** the belt is usually of metal mesh and heated air is blown up through the mesh. The belt moves continuously keeping the food pieces in through. All products can not be dried by this method.

5. **Air lift driers:** These are generally used to finished dry materials that have been partially dried by other methods.

6. **Fluidized bed drier:** In fluidized bed drying, heated air is blown up through the food particles with just enough force to suspend the particles in a gentle boiling motion. Eg: grains and peas.

7. **Spray driers:** Are used for liquids and low riscority pastes and purees. Atomization in to minutes droplets results in drying in a matter of seconds with common inlet air temperature of about 2000C.

b) **Drum or roller driers:** In drum or roller drying, liquid foods, purees, pastes and mashes are applied in a thin layer on to the surface of revolving heated drum. While revolving the dried product is scraped from the drum.

c) **Vacuum drier:** In this method highest quality product can be obtained. In vacuum drying thetemperature of the food and the rate of H2O removal are controlled by regulating the degree of vacuum and the intensity of heat input.

1. **Vacuum shelf driers:** Liquids like concentrated fruit juices are dried, the concentrated juice puffs as it loses water vapour.

2. **Continuous vacuum belt driers:** It is used commercially to dehydrate high quality citrus juice crystals, instant tea and other delicate liquid foods.

3. **Freeze drying:** It is highly advanced method. It can be used to dehydrate sensitive and high value liquid foods such as coffee and juices, but it is especially suited to drying solid foods of high value such as strawberries. Whole shrimp, chicken dice, mushroom slices etc.

Exercise No. 12

Objective: Preparation of Squash

Theory: This is a type of fruit beverage containing at least 25 per cent fruit juice or pulp and 40 to 50 per cent total soluble solids, commercially. It also contains about 1.0per cent acid and 350 ppm sulphur dioxide or 600 ppm sodium benzoate. It is diluted before serving. Mango, orange and pineapple are used for making squash commercially. It can also be prepared from lemon, bael, papaya, etc. using potassium metabisulphite (KMS) as preservative or from jamun, passion-fruit, peach, plum, raspberry, strawberry, grapefruit, etc. with sodium benzoate as preservative.

Flowchart for squash preparation:

Fruits

↓

Washing

↓

Trimming

↓

Cutting or grating

↓

Juice extraction

↓

Straining

↓

Juice measuring

↓

Preparation of syrup

(Sugar + water + acid, heating just to dissolve)

↓

Straining

↓

Mixing with juice

↓

Addition of preservative

(0.6 g KMS or 1.0 g sodium Benzoate / litre squash)

↓

Bottling

↓

Capping

↓

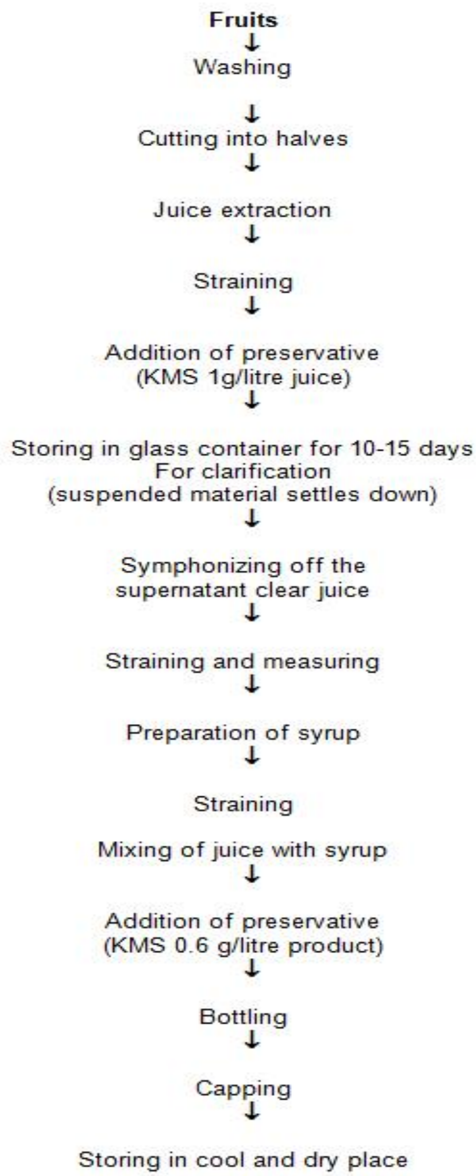
Storage

Exercise No. 13

Objective: Preparation of Cordial

Theory: It is a sparkling, clear, sweetened fruit juice from which pulp and other insoluble substances have been completely removed. It contains at least 25 per cent juice and 30 per cent TSS. It also contains about 1.5 per cent acid and 350 ppm of sulphur dioxide. This is very suitable for blending with wines. Lime and lemon are suitable for making cordial.

Flowchart of Cordial preparation:



Exercise No. 14

Objective: Preparation of Jam

Theory: Jam is a product made by boiling fruit pulp with sufficient amount of sugar to a reasonably thick consistency, firm enough to hold the fruit tissues in position. Apple, pear, sapota (chiku), peach, papaya, karonda, carrot, plum, straw-berry, raspberry, mango, tomato, grapes and muskmelon are used for preparation of jams. It can be prepared from one kind of fruit or from two or more kinds.

Flowchart of Jam preparation

Ripe firm fruits
↓
Washing
↓
Peeling
↓
Pulping
(remove seed and core)
↓
Addition of sugar (add water if necessary)
↓
Boiling
(with continuous stirring)
↓
Addition of citric acid
↓
Judging of end-point
↓
By further cooking
Up to 105°C or 68-70% TSS or
By sheet test
↓
Filling hot into sterilized bottles
↓
Cooking
↓
Waxing
↓
Capping
↓
Storage
(at ambient temperature)

<u>Exercise No. 15</u>

Objective: Preparation of Jelly

Theory: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. A perfect jelly should be transparent, well-set, but not too stiff, and should have the original flavour of the fruit. It should be of attractive colour and keep its shape when removed from the mould. It should be firm enough to retain a sharp edge but tender enough to quiver when pressed. Guava, sour apple, plum, karonda, wood apple, loquat, papaya and goose-berry are generally used for preparation of jelly. Apricot, pineapple, strawberry, raspberry, etc. can be used but only after addition of pectin powder, because these fruits have low pectin content.

Flowchart of Jelly preparation:

Fruit
(firm, not over-ripe)
↓
Washing
↓
Cutting into thin slices
↓
Boiling with water
(1 ½ times the weight of fruit for about 20-30 minutes)
↓
Addition of citric acid during boiling
(2 g per kg of fruit)
↓
Straining of extract
↓
Pectin test
(For addition of sugar)
↓
Addition of sugar
↓
Boiling
↓
Judging of end-point
(sheet/drop/temperature test)
↓
Removal of scum or foam
(one teaspoonful edible oil added for 45 kg sugar)
↓
Colour and remaining citric acid added
↓
Filling hot into clean sterilized bottles
↓
Waxing
(paraffin wax)
↓
Capping
↓
Storage at ambient temperature

Exercise No. 16

Objective: Preparation of Marmalade

Theory: This is a fruit jelly in which slices of the fruit or its peel are suspended. The term is generally used for products made from citrus fruits like oranges and lemons in which shredded peel is used as the suspended material. Citrus marmalades are classified into (i) jelly marmalade, and (ii) jam marmalade.

Flowchart of Marmalade Preparation:

Fruit
(firm, not over-ripe)
↓
Washing
↓
Cutting into thin slices
↓
Boiling with water
(1 ½ times the weight of fruit for about 20-30 minutes)
↓
Addition of citric acid during boiling
(2 g per kg of fruit)
↓
Straining of extract
↓
Pectin test
(For addition of sugar)
↓
Addition of sugar
↓
Boiling
↓
Judging of end-point
(sheet/drop/temperature test)
↓
Removal of scum or foam
(one teaspoonful edible oil added for 45 kg sugar)
↓
Colour and remaining citric acid added
↓
Filling hot into clean sterilized bottles
↓
Waxing
(paraffin wax)
↓
Capping
↓
Storage at ambient temperature

<u>Exercise No. 17</u>

Objective: Preparation of Candy and Preserves

Theory: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. The most suitable fruits for candying are aonla, karonda, pineapple, cherry, papaya, apple, peach, and peels of orange, lemon, grapefruit and citron, ginger, etc.

The process for making candied fruit is practically similar to that for preserves. The only difference is that the fruit is impregnated with syrup having a higher percentage of sugar or glucose. A certain amount (2530 per cent) of invert sugar or glucose, viz., confectioners glucose (corn syrup, crystal syrup or commercial glucose), dextrose or invert sugar is substituted for cane sugar. The total sugar content of the impregnated fruit is kept at about 75 per cent to prevent fermentation. The syrup left over from the candying process can be used for candying another batch of the same kind of fruit after suitable dilution for sweetening chutneys, sauces and pickles and in vinegar making.

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 a 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 per cent total soluble solids) 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.
- The tray is then taken out carefully from the vessel and the surplus syrup drained off.
- The fruits are then placed in a single layer on wire mesh trays and dried at room temperature or at about 49°C in driers.

PRESERVE

- A mature fruit / vegetable or its pieces impregnated with heavy sugar syrup till it becomes tender and transparent is known as a preserve. Aonla, bael, apple, pear, mango, cherry, karonda, strawberry, pineapple, papaya, etc. can be used for making preserves.
- Intermediate-moisture foods or semi moist foods, in one form or another, have been important items of diet for a very long time.

- Generally, they contain moderate levels of moisture, of the order of 20-50% by weight, which is less than is normally present in natural fruits and vegetables, but more than is left in conventionally dehydrated products.
- In addition, intermediate-moisture foods contain sufficient dissolved solutes to decrease water activity below that required to support microbial growth. As a consequence, intermediate-moisture foods do not require refrigeration to prevent microbial deterioration.
- There are various kinds of intermediate-moisture foods : natural products such as honey; manufactured confectionery product high in sugar, jellies, jams, and bakery items such as fruit cakes; and partially dried products including figs, dates, etc.
- In all of these products, preservation is partially from high osmotic pressure associated with the high concentration of solutes; in some, additional preservative effect is contributed by salt, acid and other specific solutes.

Exercise No. 18

Objective: Preparation of Ketchup

Theory: Ketchup is a sweet and tangy sauce typically made from tomatoes, sweetners, and vinegar with assorted seasonings.

Flowchart of ketchup preparation: