S.V.G.I COLLEGE OF HORTICULTURE JALGAON (JA)

SVGI College of Horticulture

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Course Title: Processing of Horticultural Crops 3 (1+2)

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Topic:- 1 IMPORTANCE AND SCOPE OF FRUIT AND VEGETABLE PRESERVATION IN INDIA

Fruits and vegetables are an important supplement to the human diet as they provide the essential minerals, vitamins and fibre required for maintaining health. In India, the total fruits and vegetable production is about 137 million tonnes per year i.e. 46 MT fruits and 92 MT vegetables. The varied agro climatic conditions available in our country make it possible for us to produce several types of tropical, subtropical and temperate fruits and vegetables. It has been variously estimated that 20 to 30% of the horticultural produce is lost before consumption which accounts for Rs. 5000 crores because of poor harvesting, handling, storage, transportation and marketing practices. The fruits and vegetables are highly perishable commodities and the ambient high temperature obtained in the tropical country like ours makes them more susceptible for rapid development of senescence, decay and rotting. Both respiratory and transpiratory rates are proportional to temperature, increases and so that the produce quickly dries, wilts and spoils unless properly preserved.

Two approaches are possible for solving this problem. One is the creation / expansion of cold storage facilities in the fruit and vegetable producing regions themselves, as also in the major urban consumption centres, to ensure supply of fresh fruits and vegetables throughout the year. Another approach is to process the fruits and vegetables into various products which could be preserved for a long time and add to the value of the product. With increasing urbanization rise in middle class purchasing power, change in food habits and the dyeing out of the practice of making preserves in individual homes, there is increasing demands for factory made jams, jellies, fruit beverages, dehydrated foods, pickles etc. in the domestic market. Moreover, there is considerable demand for some of these products in foreign markets e.g. mangoes both fresh and canned, fruit juices, salted cashew are good foreign exchange earners.

The production of fruit and vegetable products in India are canned, bottled fruits and vegetables, jams, jellies, marmalades, fruit juices, fruit pulps,

squashes, crashes, cordials, fruit syrups, fruit nectars, RTS fruit beverages, fruit juice concentrates, chutneys, pickles, mango slices in brine preserves, candied and crystallized fruits and peels, dehydrated fruits and vegetables, frozen fruits and vegetables, tomato products, sauces, soups etc.

In India there are 4000 processing industries are functioning. But a marginal quantity of1.0 to 2.0 % of the produce is processed and packaged in contrast with developed and developing countries i.e., 70 to 80%. The total annual consumption of processed fruits and vegetable products in the country is rockened at only 50,000 tonnes of which defence and star hotels account for 15,000 tonnes and the remaining 35,000 tonnes to the public, i.e. a percapita consumption of 40 gms / year. Thus, we can see on enormous scope and potential for the expansion of fruits and vegetable industries in India in the future.

Export of fruits and vegetables from India

In terms of global trade, India's share in agricultural export is insignificant. While India contributes 8.56% and 13.5% respectively to world's fruits and vegetables production, its share in global exports of these products is less than 1.0%. Delhi, Bombay and Trivandrum are the three main parts for air freighting of fruits and vegetables. These are mainly exported to Kuwait, Dubai and Saudi Arbia. Grapes are exported in large quantities from Bombay during January to March, while mango is exported during April to June. West Asia, the Far East and West Europe are the main export markets for Indian fruits and vegetables. Fruits juices, fruit pulp and pickles are mainly imported by the USSR, Yemen, Arab Republic. The other markets for processed fruits are UK, UAE, Saudi Arabia, Kuwait, Germany, USA, Holland and Switzerland. Nearly half of India's processed fruit exports are mango-based fruit juice, canned and bottled fruits.

Fresh onions and mangoes are the main commodities entering in export trade. The other important fruits exported are melon, sweet melon, grapes, pomegranate, sapota, custard apple, orange, papaya, pineapple. Among other vegetables the principal items are tomato, ladyfinger bitter gourd, chilies, fresh beans, cabbage, brinjal etc.

Topic:- 2 FOOD PIPE LINE, LOSSES IN POST HARVEST OPERATION

Food Pipe Line refers to a post-harvest system which deals with ensuring the delivery of a crop from the time and place of harvest to the time and place of consumption, with minimum loss, maximum efficiency and returns to all concerned including grower, processors and consumer. The term 'system' represents a dynamic, complex aggregate of locally interconnected functions or operations within a particular sphere of activity. While, the term pipeline refers to the functional succession of various operations but tends to ignore their complex interactions.

Stages of post-harvest system

The food commodities broadly undergo different stages/operations of post harvest systems right from harvest till consumption.

1. Harvesting
2. Threshing (food grains, pulses and oilseeds)
3. Drying (food grains, pulses and oilseeds)
4. Transportation and distribution
5. Storage
6. Processing

a) Primary processing (washing/cleaning, sorting, grading, dehulling, pounding, grinding, packaging, soaking, winnowing, drying, sieving, whitening and milling)

b) Secondary Processing (mixing, cooking, drying, frying, moulding, cutting, extrusion product preparation)

7. Product evaluation (quality control, product standardization, standard recipes)
8. Packaging (weighing, labeling, packing/sealing)
9. Marketing (publicity, selling, distribution)
10. Use (recipes elaboration, method of consumption, traditional dishes and new dishes)
11. Consumer preferences (Product-evaluation, consumer education)

Food Pipe line

While undergoing various unit operations of post-harvest systems, the quality of produce is affected by action of various biotic and abiotic factors

Post-harvest losses in horticulture crops

Post-harvest loss is one of the biggest problems which affects economic

growth globally. The FAO (Food and Agriculture Organization) estimates that 1/3rd of food products is lost every year. The loss depends upon the type of crop is grown. As the fruits and vegetables are perishable, so their chances are more to get spoiled or degraded. Post-harvest losses mainly occur in developed and developing countries.

Post-harvest loss can define as the loss from the stage of harvesting to the stage of consumption which occurs as a result of qualitative loss, quantitative loss and the food waste (by the consumers) altogether.

Quantitative

loss can define as the food loss which occurs as the result of weight loss, spillage of crops, attack of moulds and pests etc.

Qualitative

loss can define as the food loss which occurs as a result of nutrient loss, undesirable change in taste, texture etc., presence of excreta of birds, rodents etc. and contamination by mycotoxin.

Direct and indirect loss:

Direct losses occur when the disappearance of food stuff is caused by leakage, pilferage or consumption by pests (insects, rodents, birds), loss in weight whereas indirect losses occur when a reduction in quality leads to the consumer's refusal to purchase.

The level of post harvest loss in food grains and perishables are estimated as 10-15% and 25-33% respectively.

Losses in the value chain: weight loss, bruises, peeling and blanching losses, over ripening, spoilage due to micro-organisms, enzymes, insects and rodents.

Losses during processing: peeling, trimming, coring, pitting, washing, blanching and heat processing.

Pilferage during transportation, storage and marketing.

Losses in food grains: broken grains, excessive trimming, spillage, bruising and leakage.

Losses due to spoilage caused by moulds, bacteria, rodents, birds, sprouting.

Polishing and quality losses during marketing.

Factors Affecting Post-Harvest Losses

There are some primary and secondary factors which affect the post-harvest loss of food products.

Primary factors:

Mechanical loss: It is caused by poor handling from the stage of harvesting to storage.

Microbial action: It is caused by microorganisms like bacteria, fungi, yeasts which quickly affects the perishable food crops like fruits and vegetables.

Environmental factors: Temperature and humidity are the two important environmental factors which are mainly responsible for the post-harvest losses.

Secondary factors:

Inadequate harvesting methods

Incomplete drying before threshing

Inadequate storage facilities

Longer shipment

Longer distribution period

Lack of market access and policies

Topic:- 3 UNIT OPERATION IN FOOD PROCESSING, GUIDELINES FOR THE LOCATION OF PROCESSING UNIT

UNIT OPERATION IN FOOD PROCESSING

1.RAW MATERIAL HANDLING

Material handling include varied operations as hand or mechanical harvesting on the farm, transportation in trucks or refrigerated vehicles of perishable produce to the market or to the processing plant or to store/godowns. For conveying, wide variety of mechanical conveyors is used depending upon the type of material. Common conveyors used in the processing plant include screw conveyor, bucket conveyor, belt conveyor and vibratory conveyor. Throughout these operations care is taken to maintain sanitary conditions, minimizing bruises and product loss, maintaining raw material quality like physical appearance, vitamin contents, minimizing microbial growth and minimizing other detrimental changes to the product quality during handling etc. It also includes other unit operations like receiving, cleaning/washing, sorting, grading, peeling, halving, slicing, blanching etc for preparation of fruit and vegetables for processing.

Raw material selection/receiving

Fruits and vegetables should be ripe but firm, evenly matured, free from blemishes, insect damage and malformation.

Harvesting at proper maturity is an important step in selection of raw material.

Most of the fruits are harvested at soft ripe stage.

Vegetables except peas, beans etc are harvested at mature stage to enable them to withstand cooking during sterilization.

Some vegetables like green beans, greens peas, ladies finger should be tender and free from soil, dirt etc.

2. WASHING/CLEANING

Cleaning is the unit operation in which contaminating materials are removed from the food and separated to leave the surface of the food in a suitable condition for further processing. Cleaning can be performed by using:

Wet procedures: Soaking, spraying, floatation, washing and ultrasonic cleaning.

Dry procedures: Separation by air, magnetic attraction of metal contaminants or by physical methods depending upon the product and nature of the dirt.

Fruit and vegetables are generally washed with water to remove dust, dirt and adhering surface micro-flora.

Fruits like peach, apricot etc that are lye peeled are not washed before peeling.

Washing after peeling removes vitamins and minerals and should be discouraged.

Different methods of washing include soaking or agitating in water, washing with cold or hot water sprays etc.

Mechanical washers involve agitating or tumbling the commodity on moving belts or revolving screens while they are immersed in water or subjected to water sprays.

Washing by using high pressure sprays is most satisfactory.

Detergents are frequently used in the wash or rinse water.

Vegetables may be soaked in dilute solution of potassium permanganate or chlorine (25-50 ppm) for disinfection.

3. SEPARATING

It involve separating a solid from a solid like peeling of potatoes, separating a solid from a liquid as in filtration or a liquid from solid as in pressing of juice from a fruit. It might involve the separation of a liquid from a liquid as in centrifugation of oil from water. It might also involve removing gas from a solid or liquid as in vacuum removal or air from canned food during canning. Common separating methods used in fruit and vegetable processing are discussed as under:

Sorting: Sorting is the separation of foods into different categories on the basis of a measurable physical property. Sorting and grading ensures the removal of inferior or damaged commodity. For sorting, inspection belt can be used, in addition to trained personnel who detect poor quality produce unsuitable for canning. Automatic colour sorters can be used for sorting to reduce labour cost.

Grading: After preliminary sorting, the fruit and vegetables are graded to obtain uniform quality with respect to size, colour etc. Grading can be done either manually or with the help of mechanical graders. Different types of mechanical graders include screen grader, roller grader, rope or cable grader,

conveyor grader etc.

Peeling, coring and pitting: These are the primary unit operations for preparing fruit and vegetables for processing.

Peeling of fruit and vegetables is carried out to remove unwanted or inedible material and to improve the appearance of the final product.

The main consideration for peeling is to minimize cost by removing as little of the underlying food as possible and reducing energy, labour and material cost to a minimum.

The peeled surface should be clean and undamaged.

Depending upon the commodity, peeling and coring methods can be selected such as 1) hand or knife peeling 2) machine/abrasive peeling 3) flash steam peeling 4) lye (caustic) peeling 5) flame peeling.

Cores and pits in fruits like apple, peach, apricot etc are removed by hand or by machine (de-corer).

4. DISINTEGRATING

It covers wide range of operations that are used to sub-divide large masses of foods into smaller units or particles. It may involve cutting, slicing, chopping, grating, pressing to extract juice, pulping, homogenizing etc.

Slicing, chopping, cutting and dicing: Fruit and vegetables are sliced to a desirable size either manually or by using semi or automatic slicing/chopping or dicing machines. These unit operations are collectively called as size reduction. These unit operations increase the rate of drying, heating, cooling and improve the efficiency and rate of extraction of liquid components like fruit juices.

Juice extraction: For juice extraction, the fruits and vegetables like apple, pear, carrot, aonla etc are grated in fruit grater to reduce their particle size. The grated mass is then pressed through basket press/hydraulic press to extract juice.

Homogenization: Homogenization of milk causes disintegration of fat globules in milk or cream from large to minute globules. The smaller fat globules then remain evenly distributed throughout the milk or cream with less tendency to coalesce and separate from the water phase of the milk. Disintegration of fat globules is done by forcing the milk or cream under high pressure through a valve with very small openings. Similarly, fruit juices are homogenized to prevent sedimentation during storage.

Pulping: For extraction of pulp, the fruits like apple, pear, apricot, guava, plums, tomato etc after preliminary treatment (crushing with or without heating), are passed through the pulper. With the action of blades/flights in the pulper, the fine pulp is forced through the openings of the screen/sieve which is collected at one end, while, seeds, skin and core is forced through other end of the pulper. Depending upon the type of fruit, various types of pulper like baby pulper, tomato pulper, mango pulper etc can be used.

5. PUMPING

This unit operation is used for moving liquids from one processing step to another. Single screw type and gear type pump are used for this purpose.

6. MIXING

There are different types of mixers depending upon the type of material to be mixed. They may be used for mixing solids with solids, liquid with liquids, liquids with solids, gases with liquids etc.

For simple mixing of dry ingredients, a conical blender may be used.

A ribbon blender with rotating mixing elements is used to mix sugar with other dry components to produce fluffy dry mix.

Propeller type agitator mounted within stainless steel vat is used for mixing solids into liquids to dissolve them as in case of salt and sugar solution.

7. HEATING

Heating of foods is carried out to destroy the micro-organisms, to preserve the food as in case of pasteurized milk and canned peas and to make them more tender and palatable as in cooking operations. Foods are heated by conduction, convection, radiation or their combination. Most of the foods are sensitive to heat and prolonged heat may cause burnt flavour, dark colour or nutrition loss. It is therefore desirable to heat such foods rapidly and cool immediately. Foods may be heated or cooked by using hot water toasters, direct steam, direct contact to flame or microwave cookers.

a. Blanching: Treatment of fruit and vegetables by dipping in boiling water or steam for short periods followed by immediate cooling is called blanching. The basic objectives of blanching are:

Inactivation of enzymes, to cleanse the product initially to decrease the microbial load.

To preheat the product before processing.

To soften the tissue for facilitating compact packing in the cans.

To expel intercellular gases in the raw fruit.

To prevent excessive pressure built up in the container.

To allow improved heat transfer during heat processing.

To ensure development of vacuum in the can and

To reduce internal can corrosion.

b. Pasteurization: Pasteurization is a relatively mild heat treatment in which the food is heated below 1000C to destroy selected vegetative microbial pathogens or to inactivate enzymes.

The pasteurization of liquid foods (fruit juices, milk, milk products, liquid egg etc) is carried out in continuous heat exchanger. The product temperature is quickly raised to the pasteurization levels in the first heat exchanger, held for

the required length of time in the holding tubes, and quickly cooked in a second heat exchanger.

For viscous fluids, a swept surface heat exchanges (SSHE) is used to promote faster heat transfer and to prevent surface fouling problems.

In package pasteurization is similar to conventional thermal processing of foods, but is caused at lower temperatures.

The extent of heat treatment required to stabilize a food is determined by the D value of the most heat resistant micro-organism or enzyme present in the food.

Milk pasteurization is based on D60 and a12 logarithmic cycle reduction in the numbers of Coxiella burnetti while liquid whole egg is treated to produce a 9 D reduction in numbers of Salmonella seftenberg. Since colour, flavour and vitamins are also characterized by D values, therefore HTST (High temperature short time) process is used for retention of nutritional and sensory quality.

In milk processing, the low temperature long time (LTLT) process operating at 630C for 30 minutes (holder process) cause greater changes to flavour and loss to vitamins than HTST processing at 71.80C for 15 seconds.

Flash pasteurization uses higher temperature and shorter times (HTST) for example 880 C for 1 s, 94 0 C for 0.1 sec or 100 0 C for 0.01 sec. for milk and is known as Higher heat shorter time processing.

For milk pasteurization, inactivation of alkaline phosphatase is used as indicator of pasteurization.

Liquid egg pasteurization is based of measurement of a- amylase activity.

c. Processing: Heat processing consists of heating cans to a predetermined time and temperature combination of heating to eliminate all possibilities of microbial spoilage.

Over cooking should be avoided as it spoils the texture, flavour and appearance of the product.

In continuous non-agitating cookers, the cans travel in boiling water in crates carried by over-head conveyors on a continuous moving belt.

In continuous agitating cookers, the sealed cans moving on the belt are rotated by a special mechanical device to agitate the contents of the cans. This helps in reducing the processing time.

Generally all fruits and acid vegetables can be processed satisfactorily in boiling water (100oC) and non acidic vegetables (except tomato and rhubarb) are processed at higher temperatures of about 115-121oC under pressure.

d. Sterilization: Sterilization is a more severe heat treatment given to a food to destroy both spoilage and pathogenic micro-organisms, after packaging the food in a hermetically sealed container. The thermal processing criterion for acid and medium acid foods (pH<4.5) is the destruction of heat resistant

vegetative micro-organisms or enzymes.

The low acid foods such as mushrooms, potatoes, peas and other vegetables are processed at elevated temperatures (115-1210C).

Acid foods like peaches, pears, pineapple and other fruits are processed at 1000C or lower for adequate inactivation of enzymes.

8. COOLING

Cooling is the subtraction of heat energy which is added during processing. The cooling may be done to the degree where food is chilled to refrigerated temperature. The milk is cooled by passing them in thin layers through heat exchangers or through coolers (cold water or refrigerants are pumped). Fruits such as apple slice, berries, and cherries are frozen. Thawing will be done by the unit operations of heating or disintegrating.

Air blast freezers automatically freeze peas, beans and other vegetables, mushrooms individually.

Freezing of canned or packaged foods may be done by direct immersion in refrigerants.

9. EVAPORATION

Evaporation in the food industry is used principally to concentrate foods by removal of water. All liquids boil at lower temperature under reduced pressure and are the key to modern evaporation. Vacuum evaporators and multi stage evaporators can easily remove water.

10. DRYING

Drying involves the removal of water with minimum damage to the food. Evaporators will concentrate the food 2-3 folds or more while driers take the foods very close to total dryness that is to 97-98% solids. Driers are used to prepare well known products like milk powder and instant coffee. Subdivision of a liquid is the basic principle behind the widely used spray driers. The liquid is atomized by a spray nozzle and at the same time the hot air is passed, which results into drying. Sun and solar drying, atmospheric dehydration including stationary or batch processes (kiln, tower, and cabinet driers) and continuous processes (tunnel, continuous belt, belt-trough, fluidized-bed, explosion puffing, foam-mat, spray, drum, and microwave-heated driers) are used. Vacuum shelf, vacuum belt, vacuum drum and freeze driers are the type of driers that can be used for drying and dehydration of products. Prior to drying, the fruits are pretreated in sulphur fumigation chambers by burning sulphur or are dipped in a solution of potassium metabisulphite.

11. FORMING

It is an important unit operation in the breakfast cereals and snack food industries. The characteristic shapes of the popular breakfast cereals are the result of pressure extrusion through dies, together with adherence operating conditions like pressure, temperature, dough consistency and other variables. The special kind of forming is known as extrusion cooking. Further examples

of forming are shaping of butter, bars, pressing of cheese curd into various shapes, bread dough shapes and shaping of sausages.

12. PACKAGING

The packaging of food is necessarily required to protect the food from microbial contamination, dirt, dust, light, moisture and the losses. The foods are packaged in metal cans, glass, plastic bottles, paper and metallic films, pouches etc. Now a days the packaging of food products has emerged as an important industry and automatic packaging units are in great demand. The containers for packaging are automatically formed, filled and sealed by passing through machines. Such packages are easy to open and dispose off. The newer packaging systems have some advantages like saving of space in food plants, during transportation and marketing.

Thus, for preparation of any furnished product, different unit operations are used. Depending upon the availability of facilities, the processing can be carried out as a batch process, semi-continuous process or as an automatic continuous process.

GUIDELINES FOR THE LOCATION OF PROCESSING UNIT

1. Selection of Site for fruit processing unit

The location of unit is a dominant factor in viability (success or failure) of any processing industry. The following factors are considered in the selection of site for processing unit.

Easy availability of raw material: Fruit and vegetables should be available in adequate quantity in the locality as they are highly perishable and deteriorate in long distance transportation. Other raw material like fuel, sugar, salt, chemicals etc and miscellaneous hand tools such as nuts, bolts, minor machinery parts etc should also be easily available in the locality.

The site should be well connected with road.

Proper transport facilities for movement of raw material and finished products.

Area should have adequate supply of potable water and electricity (preferably three phase connection).

Environment should be clean and free from debris, dirt, dust etc.

The processing industry should preferably be well away from other industries to avoid soot, smoke and disagreeable odour.

Provision for disposal of processing waste.

Adequate availability of labour.

The selected site should have scope for future expansion.

2. Building for processing plant: Following points should be kept in mind for establishment of building for the processing plant.

It may be single storied or multi storied building. Single storeyed building is sufficient for small unit working for short periods during the year. However, for larger processing plants running throughout the year, multistoried construction is desired. It facilities the movement of raw material and finished products.

Firm flooring to withstand constant use of water and movement of heavy machinery.

Slope in flooring (2cm per meter) for proper drainage.

All doors, windows and ventilators should be provided with fine wire gauge to prevent entry of flies, wasps and other insects.

The roof of the building should be high and well ventilated to provide outlet for vapours and steam.

The windows should have large glass panels for sky light and artificial lighting.

Provision for dressing and toilet rooms separately for male and female workers.

3. Types of plant layout

The layout of a processing plant can be selected on the basis of either product layout or process layout (Fig 5.1). Product layout deals with either single fruit or single product such as apple processing in to juice or jam processing line in which only apple product can be handled.

In product layout, all types of jam, pickle, juice or ketchup can be handled irrespective of fruit.

In process layout, the machinery dealing with different unit operation is placed separately. For example for extraction of juice, the fruit is washed in washing line, grate in grating machine, pressed in hydraulic press and then juice is filled in filling line and processed in processing line.

Depending upon the size of the unit, the layout can be selected.

4. Water supply and drainage

Water of potable nature should be abundant in supply. If water is not of desired quality there is a need for installing water softening plant.

A large quantity of water is needed for cleaning of fruits and vegetables, making syrup and brine, washing floors and machinery etc.

Water system should work at sufficiently high pressure so that supplies can be made to different places without any break.

The water should not be alkaline or very hard, should be free of organic matter.

Presence of iron and sulphur make the water unsuitable for making syrups and brines.

Saline water affects the taste of the products and should be avoided.

5. Categories of fruit processing units

According to Fruit Products Order (1955) of the Govt. of India, the fruit processing units are categorized as under depending upon the installed capacity and requirement of minimum area for processing

Categorization of fruit processing units and requirement of area.

Sr.No	Category	Annual Production, tonnes	Minimum manufacturing area required, m^2
1.	Home scale(B)	25	25
2	Cottage scale	10-50	60
3.	Small Scale(A)	50-100	100
4.	Small Scale(B)	100-250	150
5.	Large Scale	>250	300

The area shown is excluding store and office space. Besides the area occupied by the machinery should not be more than 50% of the total area. The minimum daily availability of water in different units should be 4.5 kilo litres (large scale), 1.13 kilo litres (small scale) and 0.45 kilo litres (cottage scale)

6. Machinery and equipments: Requirement of machinery and equipments for a Fruit Processing unit depends upon the capacity of the unit and category to which it belongs. Depending upon the requirement of operation, the unit should have following machineries.

Machinery and equipment required for different categories of processing units on the basis of unit operations.

Sr.No	Unit Operation	Categories of Unit		
		Cottage scale	Small scale	Large scale
1.	Washing of Raw material and Bottles	· One rectangular tank with false bottom capacity 100 Lts. · One tank of 200 Lts capacity. · Bottle brush and buckets	· Rectangular tanks-2 · One tank with water taps capacity 200 Lts. · Bottle washing machine · Bottle sterilizing tank · Trolleys for holding and conveying bottle	· 3 rectangular tanks. · 2 tanks with water tap, 450-500 Lts capacity. · Bottle washing machine · Bottle sterilizing tank · Trolleys for holding and conveying bottle.

2.	Preparation of Fruit and Vegetables	· Tables with aluminium or stainless steel (SS) top area 1.86 m^2. · Stainless steel (SS) peeling, slicing, trimming and coring knives. · Stainless steel (SS) pricking forks for preserves. · Vessels for blanching. · Polythene barrels tank with covers for curing. · Stainless steel (SS) trays 5 No's.	· Tables with aluminum or stainless steel top area. 4.65 m^2 · Stainless steel peeling, slicing, trimming and coring knives. · Stainless steel (SS) pricking forks for preserves. · Vessels for blanching · Polythene barrels tanks for curing with covers. · Stainless steel (SS) trays 10 No's.	· Tables with aluminum or stainless steel top area 10 m^2 · Peeling, coring, cutting equipment/ machinery. · Stainless steel (SS) pricking forks, pricking machine for preserves. · Blanching tank with steam. · Polythene barrels/ tanks for curing with covers. · Stainless steel (SS) trays at least 20 (No's)
3	Juice/pulp extraction	· Juice extractor/ basket press/ fruit grater · Stainless steel/ aluminium sieve · Tanks/barrels (45-50 Lts capacity) · Buckets	· Juice extractor/ Rosing machine for citrus fruits · Basket/Hydraulic press, Pulper · Tanks/barrels (200 Lts capacity) · Buckets	· Power driven juice extractor, fruit mill/ grater heavy duty · Hydraulic press, pulper heavy duty · Storage tanks heavy duty 250 lts capacity · Buckets
4.	Heating/Boiling	· Diesel Bhatti/LPG · Heating pan/vessels. · Ladles (SS/wooden) · Thermometer · Refractometer · Sensitive Balance	· Boiler · Steam jacketed kettle · Ladles(SS/wooden) · Thermometer · Refractometer · Sensitive Balance	· Boiler heavy duty. · Steam jacketed kettle. · Ladles(SS/wooden) · Thermometer · Refractometer · Sensitive Balance
5.	Filling/ Bottle Sealing	· Mugs/funnel · Crown corking machine · Rolled on (RO)/ Pilfer Proof (PP) cap sealing machine · Weighing balance	· Mugs/Funnel · Bottle filling machine, automatic crown corking machine · Rolled on (RO)/ Pilfer Proof (PP) cap sealing (Heavy duty machine). · Weighing balance	· Bottle filling machine (vacuum operated) · Automatic crown corking(Heavy duty) · Rolled on (RO)/Pilfer Proof (PP) cap sealing (Heavy duty machine) · Weighing balance

6.	Exhausting, Sealing and Processing	· Can reformer · Flanger · Coding machine · Double seamer · Sterilization tanks · Cooling tank pressure cooker/ retort for vegetable processing.	· Can reformer · Flanger · Coding machine · Exhaust box · Double seamer · Semi-automatic retort · Cooling tank · Incubator · Can sterilizer	· Can reformer · Flanger · Coding machine · Exhaust box · Double seamer · Can sterilizer · Retort · Cooling tank · Incubator

7. Product selection: Selection of products to be prepared depends upon the market potential and capacity of the processing unit. For the small scale and cottage scale unit manufacturing of single item is not appropriate for viability of the unit. Efforts should be made to regulate the production in such a way that the processing unit runs throughout the year for minimum 200 days of working. While for large scale processing plant handling of single commodity can be practiced since they have assured supply of raw material and assured market for the products. The varieties of products which can be prepared keeping in new the availability of raw material in a processing unit are given in Table

List of different products prepared from fruits and vegetables.

Products	**Fruit and Vegetables**
Juice/Beverage/ready to serve drinks	Apple, mango, litchi, kinnow, guava pineapple, grapes, bael juice, based carbonated drink
Squash /Appetizer/cordial	Plum, apricot, litchi, mango, lemon, lime, ginger, pineapple, guava, bael.
Jam/chutney/jelly	Apple, mixed fruit jam, mango, guava, mixed fruit chutney, dry fruit chutney, ginger, pineapple.
Canned products	Peach, pear, pineapple, mango slices/orange segments, mushroom, potato, peas, okra.
Preserve and candies	Aonla, bael, apple, carrot, and petha (ash gourd), ginger, citrus peel candy.(Ash guard)
Pickle	Mango, mushroom, galgal, kagzi lime, mixed vegetable pickle, garlic/ginger.
Sauce/ketchup	Tomato ketchup mixed vegetable sauce and continental sauce.
Dried products	Raisin, dried apricot, triphala, dried date palm.
Instant powder	Instant chutney powder, potato powder, mushroom powder.
Products from medicinal herbs	Brahmi syrup, Rhododendron squash
Alcoholic products	Apple cider, plum wine, fruit wines, peach wine, jack fruit wine, peach wine, jackfruit wine

Consolidated list of fruit and vegetable products for year-round working of processing unit

S. No.	Period	Fruit/Vegetable	Products
1.	January-April	Citrus fruits like galgal (Hill lemon), kagji lime, oranges, kinnow, guava, papaya, anola, harar and bahera. Vegetables like carrot, cauliflower, turnip, tomato, peas *etc*	Squash, cordial, pickle, candy, marmalade, carbonated drinks. Jelly, toffee, dried products, canned products, Pickle, preserves (Murrabba), candy, candy, tuty-fruity jam drink ketchup, sauce, canned puree, paste, brined vegetable slices.
2.	May-August	Mango, stone fruit like peach, apricot, plum, pineapple, litchi. Tomato, green chilies, olive and brahmi leaves.	Squash, nectar, mango bars/leather (*papad),*canned peach, canned pear, jam, dried apricot, pickle, tomato puree, ketchup, brahmi syrup, apple juice, pickle in oil and brined raw mango slices.
3.	September - December	Galgal, kagzi lime, apple, guava Garlic, ginger, tomato and mushroom	Pickle, candy, squash, cordial, canned mushroom, dried mushroom, chutney, juice, paste, squash, puree, dried ginger (sonth) and ketchup.

8. Viability of a processing unit:

Following factors are taken into consideration for making the processing unit a viable enterprise.

Establishing unit at proper location

Start with a small capacity and venture into large scale production only after getting experience and good response for the product

Purchase raw material in bulk as possible

During harvesting season of fruit and vegetables prepare semi-finished products like pulps, raw juices and slices in bulk keeping in view the demand of finished products for the year

Explore the possibility of contract farming to get assured the supply of quality raw material

Working days of processing unit should be increased to atleast 200 in a year.

Utilize the unit to its maximum installed capacity

Efforts should be made to utilize each and every part of the fruit and vegetable

for minimizing the waste and utilizing it to prepare value added products

Use most appropriate technology to minimize the cost of production

Explore new markets for the products and maintain quality of products throughout the production

Keep in contact with research and development institutions and look for new technologies and products

9. Guidelines for the establishment of Fruit processing unit:

The objective for establishment of fruit processing unit in fruits and vegetable growing areas is to provide processing services to the local growers by utilizing the locally available raw material. The detail about different types of units, machineries & equipments required for the establishment of processing unit along with the approximate expenditure is given in Table 5.5 to 5.7 and discussed as under:

Approximate dimensions for a fruit processing unit:

Processing hall: 15×10 = 150 m2

In plant quality control (QC) laboratory: 5×4 = 20 m2

Raw material store: 4×4 = 16 m2

Finished products store: 4×4 = 16 m2

Office: 4×3= 12 m2

Managers room: 3×3= 9 m2

Boiler room: 3×3= 9 m2

Wash rooms: 3×3= 9 m2

Total area = 241 m2 or say 250 m2

Categories:

1. Large Scale: Factories with floor area of 279- 372 m2 with capacity to process products about 250 MT/annum or 2 MT/day. Minimum availability of potable water should be 4.5 kilolitres per day. The factory should have well equipped inplant quality control laboratory of 19 m2 area with adequate analysis facilities.

2. Small Scale: Factories with minimum manufacturing area of 186 m2 (excluding store & office) with capacity to process products 50- 250 MT/annum or up to 2 MT/day. Minimum availability of potable water should be 1.13 kilolitres per day. The factory should have well equipped laboratory with adequate analysis facilities.

3. Cottage Scale: Factories with minimum manufacturing area of 23 m2 to 93 m2 including store and office with capacity to process about 10-50 MT products/annum. Minimum availability of potable water should be 0.45 kilolitres per day. The factory should have well equipped laboratory with adequate analysis facilities.

4. Home Scale: Factories with capacity to process up to 10-50 MT products/annum.

Important points to manage a fruit and vegetable processing unit

Assure a raw material temporary storage (cold room for sensible raw material).

Plan the equipment to operate during working shifts (about 7-9 hours per day), for **5 working days per week.**

Plan to operate the processing centre for a maximum number of working days per year).

Proper investment on buildings and equipment for making unit able to process as many species of fruits and vegetables by using different preservation methods like dehydration, concentration, sugar preservation etc.

Utilize the available raw materials during crop season by additional manufacturing semi-processed products for later conversion into finished products during the off-season.

Raw material quality is a major element with positive impact on finished product quality.

Initial and continuous personnel training and motivation is also an important factor in the success or failure of a processing centre.

Topic:- 3 PRINCIPLES OF FOOD PRESERVATION, METHODS OF PRESERVATION-REFRIGERATION, FREEZING PRESERVATION, PASTEURIZATION, STERLIZATION

PRINCIPLES OF FOOD PRESERVATION,

1. Prevention or delay of microbial decomposition of food

By keeping out micro-organisms (asepsis)

By removal of micro-organisms (filtration)

By hindering the growth or activity of micro-organisms (use of low temperature, drying, creating anaerobic conditions or using chemicals).

By killing the micro-organisms (using heat or irradiation).

2. Prevention or delay of self decomposition of food

By destruction or inactivation of food enzymes (blanching or boiling)

By prevention or delay of purely chemical reactions (use of antioxidants to prevent oxidation).

3. Prevention of damage by insects, animals, mechanical causes etc (use of fumigants, cushioning, packaging etc).

1. Prevention or delay of microbial decomposition

i) By micro-organisms (Asepsis): keeping out Asepsis refers to keeping out

the micro-organisms from the food by making use of either natural covering or providing artificial covering around the food. Natural barrier in foods include outer shell of the nuts (almond, walnut, pecan nut) skin/peel of fruit and vegetables (banana, mango, citrus, ash gourd etc), shells on eggs, skin or fat in meat, husk of ear corn etc. Similarly packaging prevents entry of micro-organisms in the food.

For example peach or mushroom sealed in tin can, clean vessels under hygienic surroundings helps in preventing spoilage of milk during collection and processing by keeping out the micro-organisms.

ii) By removal of micro-organisms (Filtration): Filtration of liquid foods through bacteria proof filters is a common method for complete removal of micro-organisms from the foods. Liquid foods are passed through the filters made of suitable material like asbestos pad, diatomaceous earth, unglazed porcelain etc and allowed to percolate through either with or without nano-filtration etc works on this principle. Centrifugation, sedimentation, trimming and washing etc can also be used but are not very effective.

iii) By hindering the growth and activity of micro-organisms

a. By using low temperature: Microbial growth and enzyme activity is retarded in foods by storing them at low temperatures. The food commodities can be stored under cellar storage (15oC) like root crops, potato, onion refrigerator or chilling temperatures (0-50C) like most fruits and vegetables, meat, poultry, fresh milk and milk products and under freezing temperature (-18oC to -40oC) like frozen peas, mushrooms etc.

b. By drying of food commodity: Removal of water from the food to a level at which micro-organisms fails to grow is an important method of preservation. Moisture can be removed by the application of heat as in sun drying and in mechanical drying or by binding the moisture with addition of sugar (as in jams, jellies) or salt (high salt in raw mangoes) and making it unavailable to the micro-organisms. Examples include osmotic dehydration, dried grapes (raisins), apricots, onion, cauliflower etc.

c. By creating anaerobic conditions: Anaerobic condition can be created by removal or evacuation of air/oxygen from the package, replacement of air by carbon dioxide or inert gas like nitrogen.

Lack of oxygen prevents growth of any surviving bacteria and their spores under such conditions.

Production of carbon dioxide during fermentation and its accumulation at the surface makes the conditions anaerobic to prevent the growth of aerobes.

Carbonation of drinks and storing fresh food under controlled atmospheres serves the same purpose.

Canned food in which the food is sealed after removal of air (exhausting) illustrates this principle.

Anaerobic bacteria and their spores present however, need to be killed to

prevent the food from being spoiled.

A layer of oil on top of any food prevents growth of microbes like moulds and yeasts by preventing exposure to air.

d. By use of chemicals: Appropriate quantity of certain chemicals added to the food can hinder the undesirable spoilage in the food by

Interfering with the cell membrane of the micro-organisms, their enzyme activity or their genetic mechanism

e. By acting as an anti-oxidant.

The optimum quantity of preservative as per approved regulation need to be used as higher concentrations can be a health hazard.

Chemical preservatives are benzoic acid and its sodium salt, sorbic acid, potassium meta-bi-sulphite, calcium propionates etc.

Common antioxidants to check off flavour (rancidity) in edible oils include butyl hydroxy anisole (BHA), butyl hydroxy toluene (BHT), tertiary butyl hydroxy quinone (TBHQ), lecithin etc.

Addition of organic acids like citric, acetic and lactic acid in the food inhibits the growth of many organisms.

f. By killing the micro-organisms

a) Use of heat: Coagulation of proteins and inactivation of their metabolic enzymes by application of heat leads to destruction of micro-organisms present in foods. Exposure of food to high temperature also inactivates the enzymes present in the food. Foods can be heated either at temperature below 100oC (pasteurization) at 100oC (boiling) or at temperature above 1000C (sterilization).

i) Pasteurization (heating below 100°C): It is a mild heat treatment given to the food to kill most pathogenic micro-organisms and is used in the food where drastic heat treatment cause undesirable changes in the food. It is usually supplemented by other methods to prolong shelf life. Pasteurization is most commonly used in treatment of milk and other dairy products either as low temperature long time (LTLT) or high temperature short time (HTST) process.

Heat treatment of milk at 62.2oC for 30 minutes refers to LTLT process.

Heating at 72oC for 15 seconds is termed as HTST process.

Grape wine is pasteurized at 82-85oC for 1 minute and beer is pasteurized at 600C.

Pasteurization of juices depends upon their acidity and method of packing whether in bulk or in bottle or can.

Bottled grape juice is pasteurized at 76.70C for 30 minutes while in bulk the juice is heated to 80-85oC for few seconds by flash treatment.

Carbonated juice is heated at 65.6oC for 30 minutes in bottles and vinegar in

bulk is held at 60-65oC for 30 minutes.

ii) Boiling (heating at 100^{o}C): Cooking of food including vegetables, meat etc by boiling with water involves a temperature around 1000C. Boiling of food at 100oC kills all the vegetative cells and spores of yeast and moulds and vegetative cells of bacteria.

Many foods can be preserved by boiling (e.g. milk).

Canning of acid fruit and vegetables (tomatoes, pineapple, peaches cherries etc) is carried by boiling at about 100oC.

Various terms used for heating of food are baking (in bread), simmering (incipient or gentle boiling), roasting (in meat) frying (shallow or deep fat frying) and warming up (small increase in temperature up to 100^{o}C).

iii) Heating above 100^{0}C: Heating by steam under pressure is used to obtain temperature above 100^{0}C by using steam sterilizer or retort. The temperature in the retort increases with increase in steam pressure. The temperature in retort at mean sea level is 100^{o}C; with 5psi pressure at 109^{0}C; with 10psi pressure at 115.5^{o}C and with 1 kg/cm2 (100 Pa) pressure at 121.5oC.

For canning of mushrooms and other non-acid vegetables the processing temperature of 121.10C at 15 psi pressure are used.

For sterilization of milk and other liquid foods like juices, ultra high temperature (UHT) process is used.

In UHT process, the food is heated to very high temperature (1500C) for only few seconds by use of steam injection or steam infusion followed by flash evaporation of the condensed steam and rapid cooling. The process is also used for bulk processing of many foods.

b) Use of radiation: Irradiation consists of exposing the food to either electromagnetic or ionizing radiations to destroy the micro-organisms present in the food. Examples of irradiation include use of ultraviolet lamps in sterilizing slicing knives in bakeries. Gamma (?) radiation from cobalt -60 or cesium 137 source have been used for irradiation of many fruits like papaya, mango and onion, spices, fish etc. They are also used for inhibition of sprouting in onion and potatoes.

2. Prevention or delay of self decomposition of food

i) By destruction or inactivation of food enzymes (blanching or boiling): Blanching is a mild heat treatment given to vegetables before canning, freezing or drying to prevent self decomposition of food by destroying enzymes. Blanching is carried out by dipping the food commodity either in boiling water or by exposing than to steam for few minutes followed by immediate cooling.

ii) By prevention or delay of purely chemical reactions (use of antioxidants to prevent oxidation): Foods containing oils and fat turn rancid and become unfit for consumption due to oxidation. Addition of appropriate quantity of antioxidants like butyl hydroxy anisole (BHA), butyl hydroxyl toluene (BHT), tertiary butyl hydroxy quinone (TBHQ), lecithin etc

prevents oxidation and preserves the food.

iii) Prevention of damage by insects, animals, rodents and mechanical causes: Use of fumigants in dried fruits, cereals etc checks the damage caused by insects and rodents. Wrapping of fruits, providing cushioning trays, using light pack and good packaging material checks the damage to fresh food commodities during handling and transportation.

Methods of food preservation on the basis of food preservation principles.

Physical method	**Method**
a) By removal of heat (Preservation by low temperature)	Refrigeration, Freezing preservation, dehydro-freezing, carbonation
b. By addition of heat (preservation by high temperature	Pasteurization (LTLT, HTST), sterilization, UHT Processing, microwave.
c. By removal of water	Drying (open sun, solar/poly tunnel solar), Dehydration (mechanical drying), Evaporation/concentration, Freeze concentration, reverse osmosis, freeze drying, foam mat drying and puff drying
d. By Irradiation	UV rays and gamma radiations
e. By non-thermal methods	High pressure processing, pulsed electric fields
Chemical methods	
a. By addition of acid (acetic or lactic)	Pickling (vegetable, olive, cucumber, fish, meat)
b. By addition of salt/brine	Salted mango/vegetable slices, salted and cured fish and meat i. Dry salting ii. Brining
c. By addition of sugar along with heating	Confectionary products like jams, jellies, preserves, candies, marmalades *etc.*
d.By addition of chemical preservatives.	i) Use of class II preservatives like Potassium meta-bi- sulphite, sodium benzoate, sorbic acid in food products. ii) Use of permitted and harmless substances of microbial origin like tyrosine, resin, niacin as in dairy products.

iii.By fermentation	i. Alcoholic fermentation (wine, beer) ii. Acetic acid fermentation (vinegar) iii. Lactic acid fermentation (curd, cheese, pickling of vegetables).
iv.By combination method	i. Combination of one or more methods for synergistic preservation. ii. Pasteurization combined with low temperature preservation. iii. Canning: heating combined with packing in sealed container. iv. Hurdle technology like low pH, salting, addition of acid, use of sugar, humectant and heating.

METHODS PRESERVATION

PRESERVATION THROUGH CANNING

History of canning: Important historical developments in canning are as under:

The credit for invention of canning goes to **Nicholas Appert,** a French confectioner who was awarded a prize in 1809 by the French government for developing new method of heat preservation of food in sealed container and after whose name the process of canning is known as Appertization.

In year 1810, **Appert** published the first book on canning entitled "The Art of Preserving Animal and vegetable substances for many years" which is the first known work on canning.

The work of Appert consists of packing food in glass bottles, closing with corks and heating the container in boiling water for several minutes depending upon the type of the food.

In 1810, **Peter Durand** got first British Patent on canning of foods in tin or metal containers.

In 1813**, Doukin, Hall and Gamble** introduced the practice of post processing incubation of canned foods.

In 1825 **T Kensett and E Duggett** were granted US patent for preserving food in cans.

In 1825, **Thomas Kenett, an American** developed first kettle pan.

1837 **Winshow** was first to can corn from cob.

1839 Tin cans came into wide use in limited states.

1845 **S. Elliott** introduced canning in Australia.

Louis Pasteur (1864) discovered that food spoilage was caused by micro-organisms which were destroyed at elevated temperature and technique was known as Pasteurization. This understanding helped to form a scientific basis for establishing and revolutionizing the canning industry.

1873 **Andrew Shriver** developed first retort pressure cooker.

1890 **Max Ann** developed first double seaming machine.

1895 **Russel** made first bacteriological study of canning.

1916 **Bitting** gave the index of processing time and temperature relationships for food products.

1920 **Ball,** a mathematician developed mathematical calculation for heat sterilization.

1921 **Magoon and Culpepper**, horticulturist by trade, gave idea of exhausting and vacuumin processed products.

1928 Heat process calculations were completed for the canning industry.

The civil war in America and later the Boer war and the Great European war of 1914 with their enormous requirement of foods for the fighting forces gave a further impetus to the canning industry.

The process of sealing food stuffs hermetically in containers and sterilizing them by heat for long storage is known as canning.

1804, **Appert** in France invented a process of sealing foods hermetically in containers and sterilizing them by heat. In honour of the inventor, canning is also known as appertizing. Saddington in England was the first to describe a method of canning of foods in 1807. In 1810, Peter Durand, another Englishman, obtained the first British Patent on canning of foods in tin containers. In 1817, William Underwood introduced canning of fruits on a commercial scale in U.S.A.

Principles and Process of Canning

Principle

Destruction of spoilage organisms within the sealed container by means of heat.

PRESERVATION BY BOTTLING

Bottles have proved to be very good containers for home preservation of fruits. Although their initial cost is high, they can be used several times and last for many years if carefully handled.The fruits look attractive through glass and do not develop metallic flavour. Bottling does not need a sealing machine.

There are many types of glass containers of different shapes and sizes and with various types of hermetic seals. The products remain in a very hygienic condition and do not come into contact with rubber or metal.

Filling and syruping

The bottles are thoroughly washed and sterilized. The fruit slices are filled leaving about 3cm space at the top of the Jar or bottle. The sugar syrup recommended for different fruits is filled boiling hot leaving ahead space of 1-1.5cm.

Exhausting and sterilization

Separate exhausting of bottles is not required and it is done simultaneously with sterilization by putting a pad of cloth under the bottles. The bottles should not be abruptly immersed in hot water, otherwise they may break because of sudden rise in temperature. The temperature of the water should about the same as that of the same as that of the contents and should be raised gradually and the bottles kept i9n the boiling water for the required time. At the start of sterilization the lids are left loose and the level of boiling water should come up to the neck of the bottle, but when sterilization is over the mouths of bottles and jars should be immediately closed or corked tightly.

Cooling and storage

These are done as for canning of fruits and vegetables.

PRESERVATION BY FREEZING

At temperature below the freezing point of H2O, growth of microorganisms and enzyme activity are reduced to minimum. Most perishable foods can be preserved for several months. Fruits, vegetables, juices and fleshy foods (meat poultry fish and sea foods) can be preserved in this method.

Cold storage we generally means storage at temperature above freezing, and this covers a range of about 16oC (60oF) down to –2.2 oC (28oF). Commercial and household refrigerators are usually run at 4.4o – 7.2 oC (40-45 oF). While pure water will freeze at 0oC (32 oF)), most foods will not begin to freeze until about –2.2 oC) (28oF) or lower is reached.

Frozen storage (Freezing) as the name implies refers to storage at temperatures where the food is maintained in frozen condition. Good frozen storage generally means – 18oC (0 oF) or below.

Refrigerated or cold storage generally will preserve perishable foods for days or weeks depending upon the food. Frozen storage will preserve perishable foods for months or even years. Further distinctions between refrigeration and freezing temperatures are related to microorganisms activity. Most food spoilage microorganisms grow rapidly at temperatures above 10oC (50oF) .Some food poisoning organisms grow slowly down to 3.3oC (38 oF) psychrotropic organisms will grow slowly within the range of 4.4 oC to – 9.4 oC (40 oF to 15 oF), provided the food is not solidly frozen. These will not produce food poisoning or disease but even below – 3.9oC (25 oF) will cause the food to deteriorate. Below – 9.4oC (15 oF) there is no significant growth of microorganisms in food; instead there is a gradual decrease in the numbers of living organisms. But the destruction of microorganisms by cold is not complete when the food is thawed there can be rapid microorganisms multiplication and spoilage.

Characteristics of food systems being frozen

It is a basic property of aqueous solutions that increasing their concentrations of dissolved solids will lower their freezing points. Thus the more salt, sugar, minerals, or proteins in a solution the lower the freezing point and the longer it will take to freeze when put into a freezing chamber. If water and juice are placed in a freezer the water will freeze first. Further, unless the temperature is considerably below the freezing point of pure water the juice will never freeze completely but rather will become icy and slushy. What really is happening here is that the water component of the juice freezes first and leaves the dissolved solids in a more concentrated solution which requires a still lower temperature to freeze it.

Since different foods have quite different compositions with respect to their levels of water and the kinds and amounts of solids dissolved in the water, it is to be expected that these will have different freezing points and under a given freezing condition will require different times to reach a solidly frozen state.

Methods of freezing

There are various methods of freezing

1. Sharp Freezing (Slow freezing)

This technique, first used in 1861, involves freezing by circulation of air, either naturally or with the aid of fans. The temperature may vary from –15 to –29oC and freezing may take from 3 to 72 hours. The ice crystals formed one large and rupture the cells. The thawed tissue cannot regain its original water content. The first products to be sharp frozen were meat and butter. Now-a-days freezer rooms are maintained at –23 to –29oC or even lower, in contrast to the earlier temperature of –18oC.

2. Quick freezing

In this process the food attains the temperature of maximum ice crystal formation (0 to – 4oC) in 30 min or less. Such a speed results in formation of very small ice crystals and hence minimum disturbance of cell structure. Most foods are quick frozen by one of the following three methods:

a) By direct immersion

Since liquids are good heat conductors food can be frozen rapidly by direct immersion in a liquid such as brine or sugar solution at low temperature. Berries in sugar solution packed fruit juices and concentrates are frozen in this manner. The refrigeration medium must be edible and capable of remaining unfrozen at –18oC and slightly below. Direct immersion equipments such as ottenson Brine freezer, Zarotschenzeff 'Fog' freezer, T.V.A. freezer, Bartlett freezer etc. of commercial importance earlier are not used today.

Advantages

There is perfect contact between the refrigerating medium and the product, hence the rate of heat transfer is very high.

Fruits are frozen with a coating of syrup which preserves the colour and flavor during storage.

The frozen product is not a solid block because each piece is separate.

Disadvantages

Brine is a good refrigerating medium but it cannot be used for fruits.

It is difficult to make a syrup that will not become viscous at low temperature.

The refrigeration temperature must be carefully controlled, as at high temperature the medium will enter the product by osmosis and at low temperature the medium may freeze solid.

It is very difficult to maintain the medium at a definite concentration and also to keep it free from dirt and contamination.

b) By indirect contact with refrigerant

Indirect freeing may be defined as freezing by contact of the product with a metal surface which is itself cooled by freezing brine or other refrigerating media. This is an old method of freezing in which the food or package is kept in contact with the passage through the refrigerant at –18 to -46oC flows. Knowles Automatic Package feezer, Patterson continuous plate freezer, FMC continuous can freezer and Birds eye freezers are based on this principle.

c) By air blast

In this method, refrigerated air at –18 to –34oC is blown across the material to be frozen. The advantages claimed for quick freezing over slow freezing (sharp freezing) are (1) smaller (size) ice crystals are formed, hence there is less mechanical destruction of intact cells of the food (2) period for ice formation is shorter, therefore, there is less time for diffusion of soluble material and for separation of ice (3) more rapid preservation of microbial growth and (4) more rapid slowing down of enzyme action.

3) Cryogenic freezing

Although most foods retain their quality when quick frozen by the above methods, a few require ultrafast freezing. Such materials are subjected to cryogenic freezing which is defined as freezing at very low temperature (below –60oC). The refrigerant used at present in cryogenic freeing are liquid nitrogen and liquid CO2. In the former case, freezing may be achieved by immersion in the liquid, spraying of liquid or circulation of its vapour over the product to be frozen.

4. Dehydro-freezing

This is a process where freezing is proceded by partial dehydration. In case of some fruits and vegetables about 50% of the moisture is removed by

dehydration prior to freezing. This has been found to improve the quality of the food. Dehydration does not cause deterioration and dehydro frozen foods are relatively more stable.

5. Freeze drying

In this process food is first frozen at –18oC on trays in the lower chamber of a freeze drier and the frozen material dried (initially at 30oC for 24 hrs and then at 20oC). Under high vacuum (0.1 mm Hg) in the upper chamber. Direct sublimation of the ice takes place without passing through the intermediate liquid stage. The product is highly hygroscopic, excellent in taste and flavour and can be reconstituted readily. Mango pulp, orange juice concentrate, passion fruit juice and guava pulp are dehyderated by this method.

Changes during freezing and storage of frozen products

Quick freezing rapidly slow down chemical and enzymatic reactions in foods and stops microbial growth. A similar effect is produced by sharp freezing, but less rapidly. The physical effects of freezing are of great importance. This is an expansion in volume of the frozen food and ice crystals form and grow in size. These crystals are larger in slow freezing than in quick freezing and more ice accumulates between tissue cells and may crash the cells. Water is drawn from the cells to form ice. It is claimed that ice crystals rapture fruit and vegetable tissue cells and even microorganism. The increased concentration of solutes in the cells hastens their salting out, dehydration and denaturation of proteins and causes irreversible changes in colloidal systems, such as the syneresis of hydrophilic colloids. Further, freezing is considered to be responsible for killing microorganisms. The vegetative cells of yeasts and moulds and many gram negative bacteria are susceptible, while gram – positive bacteria including staphyloeocci and enterococci are moderately resistant, while spores bacilli and clostridia are insensitive to freezing.

During storage of food in the frozen condition, chemical and enzymatic reactions proceed slowly. Unfrozen concentrated solution of sugars, salts etc. May ooze out from fruits or concentrates during storage as a viscous material called ‘metacryotic liquid’. Fluctuation in storage temperature results in an increase in the size of ice crystals resulting in physical damage to the food. Desiccation of the food at its surface is likely to take place during storage. When ice crystals evaporate from the surface of fruit, “freezer burn” is produced which usually appears as dry, grainy and brownish spots where the chemical changes mentioned above takes place and the tissues become dry and tough. There is slow but continuous decrease in the number of viable microorganisms on storage.

Freezing – 18 to –40oC

Freezing process of fruits, vegetables and juices

Suitable vegetables: Beans, cauliflower, peas, carrot etc.

Suitable fruits: Pineapple slices, mango slices or pulp, guava slices and

orange. segments etc.

Topic:- 5 METHODS OF PRESERVATION SUN DRYING, DEHYDRATION

1.PRESERVATIO BY DEHYDRATION /DRYING

The practice of drying of food stuffs, specially fruits and vegetables, for preserving them is very old. The term 'drying' and 'dehydration' means the removal of water. The former term is generally used for drying under the influence of non-conventional energy sources like sun and wind. If fruits (or) vegetables are to be sun dried, they (or) their pieces should be evenly spread in single layer (on) trays or boards and exposed to the sun. In sun drying there is no possibility of temperature and humidity control. The hottest days in summer are, therefore, chosen so that the foods dry very fast, thus preventing them from getting spoiled due to souring. Souring (or) turning acidic is usually due to growth of microorganisms which convert the carbohydrates in the food to acid. Quick removal of moisture prevents the growth of the microorganisms.

Dehydration means the process of removal of moisture by the application of artificial heat under controlled conditions of temperature, humidity and air flow. In this process a single layer of fruits (or) vegetables, whole or cut into pieces (or) slices are spread on trays which are placed inside the dehydrator. The initial temperature of the dehydrator is usually 43oC which is gradually increased to 60-66oC in the case of vegetables and 50-71 oC for fruits.

Advantages of dried / dehydrated foods

Dried foods are in more concentrated form than foods preserved in other ways. They are less costly to produce than canned or preserved food, because of lower labour costs and because of no sugar is required.

Due to reduction in bulk of the product, it requires less storage space.

The weight of a product is reduced to 1/4th to 1/9th its original (or) fresh weight and thus the cost of its transport is reduced.

Sundrying

Sundrying of fruits and vegetables is practiced widely in tropical and subtropical regions where there is plenty of sun shine and practically little or no rain during the drying season. Sundrying in direct (or) diffused sunlight (shade drying), one of the earliest method of food preservation, is still used for the production of dried fruits, and also for drying nuts. It was originally limited to fruits high in sugar content, which when harvested, would dry naturally without hazard of loss from fermentation and molding.

Process for drying of fruits

Fruits (mature and free from insects and disease→ Washing → Peeling / removal of outer skin → Preparation → Pretreatments → Spreading on flat wooden trays → Sulphuring → Drying → Sweating → Packaging in air tight tin containers (or) polythene bags → Storage (at ambient temperature).

Pretreatments

Lye peeling

Dipping the fruits (grapes and dates) in 0.5% to 2.5% boiling caustic soda solution for 0.5 to 2.0 minutes depending on their nature and maturity. Hot lye loosens the skin from the flesh by dissolving the pectin. The peel is then removed easily by hand. Any trace of alkali is removed by washing the fruit thoroughly in running cold water (or) dipping it for a few seconds in 0.5% citric acid solution.

Sulphuring

Sulphuring is done only for fruits and not vegetables. So2 fumes act as a disinfectant and prevent the oxidation and darkening of fruits on exposure and thus improves their colour. This phenomenon is generally seen in sliced fruits which darken due to oxidation of the colouring matter. Sulphur fumes also act as a preservative, check the growth of molds etc. and prevent cut fruit pieces from fermenting while drying in the sun. Vitamins in sulphured fruits are protected but not in unsulphured ones.

The whole fruits, slices (or) pieces are exposed to the fumes of burning sulphur inside a closed chamber known as sulphur box for 30-60 min. or in small airtight rooms.

Sulphur box is a closed airtight chamber of galvanized iron sheet. It is fitted in a wooden frame work having runways on both sides to hold the trays. For small scale sulphuring, a box of size of 90 x 60 x 90 cm which can hold 11 trays, each of 80 x 60 x 5 cm size is suitable. A box holding 10 trays will require burning of about 3 g of sulphur in one charge.

Sweating

Keeping dried products in boxes or bins to equalize moisture content.

2.Spray drying

The most important kind of air convection drier is the spray drier. Spray driers turn out a greater tonnage of dehydrated food products than all other kinds of driers combined, and there are various types of spray driers designed for specific food products.

Spray driers are limited to foods that can be atomized, such as liquids and low viscosity pastes or purees. Atomization into minute droplets results in drying in a matter of seconds with common inset air temperatures of about 200oC. Since evaporative cooling seldom permits particles to reach above about 80oC (180oC) and properly designed systems quickly remove the dried particles from heated zones, this method of dehydration can produce exceptimally high quality with many highly heat sensitive materials, including milk, eggs and coffee.

In typical spray drying we introduce the liquid food as a fine spray or mist into a tower or chamber along with heated air. As the small droplets make intimate contact with the heated air they flash off their moisture, become

small particles and drop to the bottom of the tower from where they are removed. The heated air which has now become most is withdrawn from the tower by a blown or fan. The process is continuous in that liquid food continues to the pumped into the chamber and atomized, along with dry heated air to replace the moist air that is withdrawn, and the dried product is removed from the chamber as it descends.

Milk and coffee powder is usually dried in the spray drier. Thermoplastic materials / substances viz., fruit juices are spray dried in a specially developed BIRS spray drier.

3. Freeze drying

Freeze drying can be used to dehydrate sensitive high value liquid foods such as coffee and juices, but it is especially suited to dry solid foods of high value such as straw berries, whole shrimp, chicken dice, mushroom slices and sometimes food pieces as large as steaks and chops. These types of foods, in addition to having delicate flavours and colors, have textural and appearance attributes which cannot be well preserved by any current drying method except freeze drying. Any conventional drying method that employs heat would cause considerable shrinkage distortion and loss of natural strawberry structure (texture), upon reconstitution such as dried strawberry would not have the natural colour, flavour or turgor and would be more like a strawberry preserve or jam. This can be largely prevented by drying from the solidly frozen state, so that in addition to low temperature, the frozen food has no chance to shrink or distort while giving up its moisture.

The principle behind freeze drying is that under certain conditions of low vapor pressure, water can evaporate from ice without the ice melting. When a material can exist as a solid, a liquid and a gas but goes directly from a solid to a gas without passing through the liquid phase. The material is said to sublime. Dry ice sublimes at atmospheric pressure and room temperature. Frozen water will sublime if the temperature is 0oC or below and the frozen H2O is placed in a vacuum chamber at a pressure of 4.7 mm (or) less. Under such conditions the H2O will remain frozen and water molecules will leave the ice block at a faster rate than water molecules from the surrounding atmosphere reenter the frozen block.

Within the vacuum chamber heat is applied to the frozen food to speed sublimation and if the vacuum is maintained sufficiently high usually within a range of about 0.1 to 2 mm g and the heat is controlled just short of melting the ice, moisture vapour will sublime at a near maximum rate. Sublimation takes place from the surface of the ice, and so as it continues the ice front recedes towards the center of the food piece; i,e. the food dries from the surface inward. Finally, the last of the ice sublimed and the food is below 5% moisture. Since the frozen food remains rigid during sublimation, escaping H2O molecules leave voids behind them, resulting in porous sponge like dried structure. Thus freeze dried foods reconstitute rapidly but also must be protected from ready absorption of atmospheric moisture and O2 by proper packaging.

A heating plate is positioned above and below the food to increase heat transfer rate but an open space is left with expanded metal so as not to seal off escape of sublimed H2O molecules. Nevertheless, as drying progresses and the ice front recedes, drying rate drops off for several reasons. Thus the porous dried layer ahead of the reducing ice layer acts as an effective insulator against further heat transfer and the porous layer slows down the rate of escape of H2O molecules subliming from the ice surface.

4. Foam mat drying

The foam is deposited on a perforated tray or belt support as a uniform layer approximately 3 mm thick. Just before the perforated support enters the heated oven it is given a mild air blast from below. This forms small craters in the stiff foam which further expands foam surface and increases drying rate. At oven temperatures of about 82oC foam layers of many foods can be dried to about 2 to 3% moisture in approximately 12 min.

5. Preservation by Irradiation

Sterilization of food by ionizing radiations is a recently developed method of preservation which has not yet gained general acceptance. The unacceptable flavour of some irradiated foods and the fear that radioactivity might be induced in such food has come in the way of its greater use.

When gamma rays (or) electron beams pass through foods there are collisions between the ionizing radiation and food particles at atomic and molecular levels, resulting in the production of ion pairs and free radicals. The reactions of these products among themselves and with other molecules results in physical and chemical phenomena which inactivate microorganism in the food. Thus irradiation of food can be considered to be a method of 'Cold sterilization' i.e. food is free of microorganism without high temperature treatment. Radiation dose of upto 1 Mrad is not hazardous.

Ionizing radiations can be used for sterilization of foods in hermetically sealed packs, reduction of the spoilage organisms in the perishable foods, delays ripening of fruits, inhibits sprouting of root vegetables and controls infestation (insects) in stored cereals.

PRESERVATION BY LOW TEMPERATURE

Microbial growth and enzyme reactions are retarded in foods stored at low temperature. The lower the temperature, the greater the retardation. Low temperature can be produced by

(a)Cellar storage (about 15^{o}C)

The temperature in cellar (underground rooms) where surplus food is stored in many villages is usually not much below that of the outside air and is seldom lower than 15oC. It is not enough to prevent the action of many spoilage organisms or of plant enzymes. Root crops, potatoes, cabbage, apples, onions and similar foods can be stored for limited periods during the winter months.

(b)Refrigerated (or) chilling (0 to 5oC)

Chilling temperature are obtained and maintained by means of ice or mechanical refrigeration. It may be used as the main preservative method for foods or for temporary preservation until some other preservative process is applied. Most perishable foods, including eggs, dairy products, meats, sea foods, vegetables and fruits, may be held in chilling storage for a limited time with little change from their original condition. Enzymatic and microbial changes in the foods are not prevented but are slowed considerably.

Factors to be considered in connection with chilling storage include the temperature of chilling, the relative humidity, air velocity and composition of the atmosphere in the store room, and the possible use of ultra violet ray.

Topic 6 METHODS OF PRESERVATION BY SALT, VENEGAR, SHUGAR, CHEMICAL PRESERVATIVES

PRESERVATION BY CHEMICALS

A preservative is defined as only substance which is capable of inhibiting, retarding or arresting the growth of microorganisms.

Microbial spoilage of food products is also controlled by using chemical preservatives. The inhibitory action of preservatives is due to their interfering with the mechanism of cell division, permeability of cell membrane and activity of enzymes.

Pasteurized squashes, cordials and crushes have a cooked lavour. After the container is opened, they ferment and spoil within a short period, particularly in a tropical climate. To avoid this, it is necessary to use chemical preservatives. Chemically preserved squashes and crushes can be kept for a fairly long time even after opening the seal of the bottle. It is however, essential that the use of chemicals is properly controlled, as their indiscriminate use is likely to be harmful. The preservative used should not be injurious to health and should be non-irritant. It should be easy to detect and estimate.

Salts and edible oils are the common chemicals generally used to check the growth of microorganisms. Therefore, they are called preservatives. We add salt or acid preservatives to pickles to prevent the attack of microbes. Sodium benzoate and sodium metabisulphite are common preservatives. These are also used in the jams and squashes to check their spoilage.

Two important chemical preservatives are permitted to beverages according to the FPO (1955).

1. Sulphur dioxide and
2. Benzoic acid

Sulphur dioxide

It is widely used throughout the world in the preservation of juice, pulp, nectar, squash, crush, cordial and other products. It has good preserving

action against bacteria and moulds and inhibits enzymes, etc. In addition, it acts as an antioxidant and bleaching agent. These properties help in the retention of ascorbic acid, carotene and other oxidizable compounds. It also retards the development of nonenzymatic browning or discolouration of the product. It is generally used in the form of its salts such as sulphite, bisulphate and metabisulphite.

Potassium metabisulphite

(K_2O 2So2 (or) $K_2S_2O_5$) is commonly used as a stable source of So2. Being a solid, it is easier to use than liquid (or) gaseous So2.It is fairly stable in neutral (or) alkaline media but decomposed by weak acids like carbonic, citric, tartaric acid and malic acids. When added to fruit juice (or) squash it reacts with the acid in the juice forming the

potassium salt and So2, which is liberated and forms sulphurous acid with the water of the juice. The reactions involved are as follows

Potassium Potassium Sulphur

meta bisulphate + Citric acid → Citrate + dioxide + H_2O

$SO2 + H_2O \rightarrow H_2SO_3$ (Sulphurous acid)

SO2 has a better preservative action than sodium benzoate against bacteria and moulds. It also retards the development of yeasts in juice, but cannot arrest their multiplication, once their number has reached a high value.

It is well known that fruit juices with high acidity do not undergo fermentation readily. The preservative action of the fruit acid its due to is hydrogen ion concentration. The pH for the growth of moulds ranges from 1.5 to 8.5, that of yeasts from 2.5-8.0, and of bacteria from 4.0 to 7.5.As fruit beverage like citrus squashes and cordials have generally a pH of 2.5 to 3.5, the growth of moulds and yeasts in them cannot be prevented by acidity alone. Bacteria, however, cannot grow. The pH is therefore, of great importance in the preservation of food product and by regulating it, one or more kinds of microorganisms in the beverage can be eliminated.

The concentration of So2 required to prevent the growth of mirgroorganism at different pH levels are as under.

pH	S.ellipsoideus (yeasts)	Mucor (mold)	Penicillium (mold)	Mixed bacteria
2.5	200	200	300	100
3.5	800	600	600	300
7.0	Above 5000	Above 5000	Above 5000	Above 1000

The toxicity of So2 increases at high temperature. Hence its effectiveness depends on the acidity, pH, temperature and substances present in fruit juice.

According to FPO, the maximum amount of So2 allowed in fruit juice is 700 ppm, in squash, crush and cordial 350 ppm and in RTS and nectar 100 ppm.

Advantages

of using So2 are a) It has a better preserving action than sodium benzoate against bacterial fermentation b) it helps to retain the colour of the beverage for a longer time than sodium benzoate (c) being a gas, it helps in preserving the surface layer of juices also (d) being highly soluble in juices and squashes, it ensures better mixing and hence their preservation and (e) any excess of So2 present can be removed either by heating the juice to about 71^{o}C or bypassing air through it or by subjecting the juice to vacuum. This causes some loss of the flavouring materials due to volatilization, which can be compensated by adding flavours.

Disadvantages (or) limitations

a.It cannot be used in the case of some naturally coloured juices like those of jamun, pomegranate, strawberry, coloured grapes, plum etc. on account of its bleaching action.

b.It cannot also be used for juices which are to be packed in tin containers because it not only corrodes the tin causing pinholes, but also forms H2S which has a disagreeable smell and reacts with the iron of the tin container to form a black compound, both of which are highly undesirable and

c.So2 gives a slight taste and colour to freshly prepared beverages but these are not serious defects if the beverage is diluted before drinking.

II. Benzoic acid

It is only partially soluble in H2O hence its salt, sodium benzoate is used. One part of sodium benzoate is soluble in 1.8 parts of water at ordinary temperature, whereas only 0.34 parts of benzoic acid is soluble in 100 parts of water. Sodium benzoate is thus nearly 170 times as soluble as benzoic acid, pure sodium benzoate is tasteless and odourless.

The antibacterial action of benzoic acid is increased in the presence of Co2 and acid e.g. Bacillus subtilis cannot survive in benzoic acid solution in the presence of Co2. Benzoic acid is more effective against yeasts than against moulds. It does not stop lactic acid and acetic acid fermentation.

The quantity of benzoic acid required depends on the nature of the product to be preserved, particularly its acidityIn case of juices having a pH of 3.5-4.0, which is the range of a majority of fruit juices, addition of 0.06 to 0.10% of sodium benzoate has been found to be sufficient. In case of less acid juices such as grape juice atleast 0.3% is necessary. The action of benzoic acid is reduced considerably at pH 5.0. Sodium benzoate is excess of 0.1% may produce a disagreeable burning taste. According to FPO its permitted level in RTS and nectar is 100 ppm and in squash, crush and

cordial 600 ppm.

In the long run benzoic acid may darken the product. It is, therefore, mostly used in coloured products of tomato, jamun, pomegranate, plum, watermelon, strawberry, coloured grapes etc.

Preservation by Common Salt

Common salt has been used to preserve meat and fish for ages. Meat and fish are covered with dry salt to check the growth of bacteria. Salting is also used to preserve amla, raw mangoes, tamarind, etc.

The preservation by using common salt, spices and vinegar is a common method for preparation of pickles, sauce and chutneys. Salt is mostly used as preservative in pickles in combination with acid. Minimum concentration of salt to act as preservative is about 12%. It inhibits enzymatic browning/discoloration by acting as an anti-oxidant. It exerts its preservative action by:

Causing high osmotic pressure and thus suppress the microbial cells.

Dehydrating food by tying up the moisture thus making it unavailable for the growth of microorganisms.

Salt in the food affects the solubility of oxygen and thus growth of aerobic microorganisms is inhibited

Chlorine in sodium chloride being good oxidizing agent is toxic to microorganisms

Salt increases the permeability of the cell wall and thus cause changes in the permeability. Only the haloduric microorganisms can tolerate these effects while others are unable to survive.

Similarly addition of acid to the food lowers the pH of the food which inhibits the growth of spoilage causing microorganisms.

Addition of spices and edible oil in these products besides improving flavour and taste also help in preservation.

Thus preservation by using salt, spices and acid is one of the most ancient and effective methods of food preservation. Vegetable sauce, continental sauce, tomato sauce, mixed fruit chutney, mango pickle, lime/lemon pickle, mixed vegetable pickle etc are common products made in this category.

Preservation by Sugar

Jams, jellies and squashes are preserved by sugar. Sugar reduces the moisture content which inhibits the growth of bacteria which spoil food.

Preservation by Oil and Vinegar

Use of oil and vinegar prevents spoilage of pickles because bacteria cannot live in such an environment. Vegetables, fruits, fish and meat are often preserved by this method.

Topic: -7 PREPARATION OF JUICES, SQUSHES, SYRUP

Fruit juice and beverages generally comprise of naturally extracted juices, drinks, ready to serve (RTS) beverages, nectars, squashes, cordials and appetizers etc. These products are highly refreshing, thirst quenching, appetizing and nutritionally superior to many synthetic and aerated drinks. Fruit juice is the natural liquid expressed by pressure or other mechanical means from the edible portion of the fruit. Fruit juices are generally extracted from fruits in a number of ways, depending on their structure and composition.

`The composition of juice is unaltered during preparation and preservation while for fruit beverages like drinks, squashes, cordial etc the fruit juice or pulp, sugar, acid, colour, flavour etc are mixed in appropriate proportions to a desirable taste. Apple juice, orange juice, mango squash, guava drink, pineapple juice and squash, mixed fruit drink, mango nectar etc are the commercial products available in the market.

Types of fruit juice and beverages

a) Unfermented beverages

Fruit juices which do not undergo alcoholic fermentation are termed as unfermented beverages. They include natural fruit juices, sweetened, ready to serve drinks, nectar, cordial, squash, crush, syrup, fruit juice concentrate and fruit juice powder. They are prepared by following minimum standards as prescribed under Food Safety and Standards Regulation, 2011 and Fruit Products order and discussed as under:

Fruit Products Order (FPO) specifications for fruit beverages

Product	**Minimum % of total soluble solids in final product (w/w)**	**Minimum % of fruit juice in final product (w/w)**	**Maximum acidity expressed as citric acid (%)**
Unsweetened juice	Natural	100	3.5
Fruit syrup	65	25	3.5
Crush	55	25	3.5
Squash	40	25	1.5
Fruit nectar (excluding orange and pineapple)	15	20	1.5
Orange and pineapple nectars	15	40	1.5
Cordial	30	25	3.5
Sweetened juice	10	85	-

Lime/lemon Ready to serve beverage	10	5	-
Ready-to-serve beverage/drink	10	10	-
Fruit juice concentrate	32	100	-
Synthetic syrup/sherbet	65	-	-

Preservative SO2/BA ppm specified by Food Safety and Standards Regulation, 2011. SO2- sulphur dioxide; BA- benzoic acid

Fruit juice: It is a natural juice pressed out of the fruit and remains practically unaltered in its composition during processing and preservation. It is also called as unfermented fruit juice or pure fruit juice, for example apple juice.

Fruit juice beverage: It is fruit juice which is considerably altered in composition during preparation. It may or may not be diluted before consumption. Ready to serve (RTS) drinks, nectar, squash, cordial, appetizer are all fruit juice beverages.

Synthetic drinks: Synthetic drinks are prepared by using sugar, water, flavourants, acidulents, colour etc. These drinks do not contain any fruit juice or pulp.

Ready to serve (RTS) drink: This is a type of fruit beverage which contains atleast 10% fruit juice (for lime drink 5% juice) and not less than 10% total soluble solids. The acidity in these drinks shall not exceed 3.5% as citric acid. RTS beverages are preserved by using class II preservatives not exceeding 70 ppm SO2 or 120 ppm benzoic acid. It is not diluted before serving hence it is known as ready to serve drink for example mango drink, guava drink, pineapple drink etc.

Fruit nectar: This type of fruit beverage contains atleast 20% fruit juice or pulp and 15% total soluble solids and is preserved by heat processing. The acidity in fruit nectars shall not exceed 1.5% as citric acid. No class II preservative like SO2 or benzoic acid is permitted in fruit nectar as per Indian Food Laws. It is not diluted before serving.

Squash: Fruit squash consists of fruit juice or pulp to which cane sugar is added for sweetening. According to Indian Food Laws, the fruit squash shall contain atleast 25% fruit juice or pulp and not less than 40% TSS. It shall not contain class II preservative in excess of 350 ppm SO2 or 600 ppm benzoic acid. Acid content in squashes generally remain between 1-1.5% but shall not exceed 3.5% as citric acid. Squash is generally diluted with water in 1:3 ratio before serving. Lime, lemon, mango, orange, guava and pineapple squashes are commercially manufactured.

Fruit juice cordial: It is a sparkling, clear, sweetened fruit juice from which pulp and other suspended substances have been completely removed. It contains atleast 25% juice, 30% total soluble solids and not exceeding 350 ppm SO2 or 600 ppm benzoic acid as preservative. It is also used for mixing with alcoholic drinks for example lime juice cordial.

Fruit Appetizer: Fruit appetizer is similar to fruit squash but also contains spices, condiments and herb extract. Spices like black pepper, cumin, large cardamom, ginger along with mentha extract and salt are used for manufacture of appetizer. They are also called as spiced fruit squash. Plum and apricot appetizers are quite common.

Fruit crush: Fruit crush contains minimum of 25% fruit juice or pulp, 55% total soluble solids (TSS) and not exceeding 350 ppm of SO2 or 600 ppm of benzoic acid. It is diluted before serving.

Fruit syrup: It 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 350 ppm SO2 or 600 ppm benzoic acid as class II preservative.

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. Rose, sandal, almond, khuskhus, kewra sherbets/syrups are quite common.

Carbonated fruit beverages: It is a ready to serve fruit juice beverage which contains variable amount of fruit juice, sugar, acid etc and impregnated with carbon dioxide gas. Apple juice, lime, lemon and grape juice can be used for the preparation of carbonated fruit juice beverages. They are prepared either by pre mix or post mix method.

Fruit juice concentrate: It is a fruit juice, which has been concentrated by removal of water either by evaporation, freezing or reverse osmosis. Several products can be made from fruit juice concentrate. Apple juice concentrate, orange juice concentrate etc are commercially prepared in the industry.

Fruit juice powder: This is a fruit juice which has been converted into a free-flowing powder. They can be prepared either by freeze drying, foam mat drying or spray drying processes. They are readily reconstituted to yield full strength fruit juice drinks.

PREPARATION OF FRUIT JUICES

i.Selection of fruit:

All fruits are not suitable because of difficulties in extracting the juice or because the juice is of poor quality. The variety and maturity of the fruit and locality of cultivation influence the flavor and keeping quality of its juice. Only fully ripe fruits are selected. Over ripe and green fruits, if used, adversely affect the quality of the juice.

ii.Sorting and washing

Diseased, damaged (or) decayed fruits are rejected or trimmed. Dirt and spray residues of arsenic, lead etc., are removed by washing with water or dilute hydrochloric acid (1 part acid 20 parts water).

iii.Juice extraction

Generally juice is extracted from fresh fruit by crushing and pressing them. Screw type juice extractors, basket presses or fruit pulpers are mostly used.

The method of extraction differs from fruit to fruit because of differences in their structure and composition. Before pressing, most fruits are crushed to facilitate the extraction. Some require heat processing for breaking up the juice containing tissues. In case of citrus fruits, the fruit is cut into halves, and the juice extracted by light pressure in a juice extractor or by pressing the halves in a small wooden juice extraction. Care should be taken to remove the rind of citrus fruits completely otherwise it makes the juice bitter. Finally, the juice is strained through a thick cloth or a sieve to remove seeds. All equipments used in the preparation of fruit juices and squashes should be rust and acid proof. Copper and iron vessels should be strictly avoided as these metals react with fruit acids and cause blackening of the product. Machines and equipments made of aluminium, stainless steel etc. can be used. Extracted juices should not be unnecessarily exposed to air as it will spoil the colour, taste and aroma and also reduce the vitamin content.

IV.Deaeration

Fruit juices contain some air, most of which is present on the surface of the juice and some is dissolved in it. Most of the air as well as other gases are removed by subjecting the fresh juice to a high vacuum. This process is called deaeration and the equipment used for the purpose is called a deaerator. Being a very expensive method, it is not used in India at present.

V.Straining (or) Filtration

Fruit juices always contain varying amounts of suspended matter consisting of broken fruit tissue, seed, skin, gums, pectic substances and protein in colloidal suspension. Seeds and pieces of pulp and skin which adversely affect the quality of juice, are removed by straining through a thick cloth or sieve. Removal of all suspended matter improves the appearance but often results in disappearance of fruity character and flavour. The present practice is to let fruit juices and beverages retain a cloudy or pulpy appearance to some extent. In case of grape juice, apple juice and lime juice cordial however, a brilliantly clear appearance is preferred.

VI.Clarification

Complete removal of all suspended material from juice, as inlime juice cordial, is known as clarification which is closely related to the quality, appearance and flavour of the juice. The following methods of clarification are used (a) Settling (b) filtration (c) freezing (D) cold storage e) high temperature (f) chemicals such as gelatin, albumen, casein, mixture of tannin and gelatin

(g) enzymes such as pectinol and filtragol.

VII.Addition of sugar

All juices are sweetened by adding sugar, except those of grape and apple. Sugar also acts as preservative for the flavour and colour and prolongs the keeping quality. Sugar based products can be divided into 3 groups on the basis of sugar content.

a. Low sugar – 30 per cent sugar or below

b. Medium sugar – sugar above 30 and below 50%

c. High sugar – 50% sugar and above

Sugar can be added directly to the juice or as a syrup made by dissolving it in hot water, clarifying by addition of a small quantity of citric acid or a few drops of lime juice and filtering.

VIII. Fortification

Juices, squashes, syrups etc. are sometimes fortified with vitamins to enhance their nutritive value, to improve taste, texture or colour and to replace nutrients lost in processing. Usually ascorbic acid and Beta-carotene (water – soluble form) are added at the rate of 250-500 mg and 7-10 mg per litre, respectively. Ascorbic acid acts as an antioxidant and beta-carotene imparts an attractive orange colour. For a balanced taste some acids are added. Citric acid is often used for all types of beverages and phosphoric acid for cola type of drinks.

IX. Preservation

Fruit juices, RTS and nectars are preserved by pasteurization but sometimes chemical preservatives are used. Squashes, crushes and cordials are preserved only by adding chemicals. In the case of syrup, the sugar concentration is sufficient to prevent spoilage. Fruit juice concentrates are preserved by heating, freezing or adding chemicals.

X. Preservation by Bottling

Bottles are thoroughly washed with hot water and filled leaving 1.5-2.5 cm headspace. They are then sealed either with crown corks (by crown corking machine) or with caps (by capping machine).

Juices

Juices are of two types

a. Natural juice (pure juice): It is the juice, as extracted from ripe fruits, and contains only natural sugars.

b. Sweetened juice: It is a liquid product which contains at least 85% juice and 10% TSS.

Pure fruit juices such as apple juice and orange juice are commercially manufactured. Apple juice is generally bottled while other juices are canned.

Example for Natural juice

Citrus juice

Mandarin and sweet oranges → Washing → Peeling (By hand) → Separation and cleaning of segments → Juice extraction (Screw type extractor) → Straining → Heating at 80oC Bottling (or) canning (Baby food cans) → Crown corking (or) can sealing →Pasteurization → Cooling → Storage.

Example for sweetened juice Mango juice

Mangoes (ripe) → washing → peeling stone removal →s training of pulp – addition of water (1 lit pulp 0.5 lit H2O) → mixing with syrup → Homogenization → Heating at 85oC → Filling hot into cans → sealing → Processing at 100oC for 20 min → cooling → storage.

Ready-to-serve (RTS)

This is a type of fruit beverage which contains atleast 10% fruit juice and 10% total soluble solids besides about 0.3 per cent acid. It is not diluted before serving hence it is known as ready to serve.

Commercially RTS beverages (with 13% TSS and 0.3 % acid) can be prepared by using SO2 -70 ppm or benzoic acid 120 ppm.

example: Papaya RTS

Ripe fruits → Washing → Peeling → Cutting into halves → Seed removal → Passing through pulper → Pulp → Mixing with strained syrup solution (Sugar+Water acid, heated just to dissolve) Homogenisation → Bottling → crown corking → Crown corking → Pasteurization (about 90oC for 25 min) – Cooling → Storage.

PREPARATION OF SQUASH

This is a type of fruit beverage containing atleast 25 per cent fruit juice (or) pulp, 45% TSS, 1.0% acidity and 350 ppm of So2 (or) 600 ppm of sodium benzoate. It is diluted before serving (13). Lime, mango, orange and pineapple are used for makingsquas commercially using KMS as preservative or fruits viz. jamun, passion fruit, raspberry, strawberry, grapefruit etc. with sodium benzoate as preservative.

PREPARATION OF SYRUP

This type of fruit beverage contains 25% fruit juice (or) pulp, 65% TSS, 1.3 to 1.5% acidity and 350 ppm of So2 or 600 ppm of KMS. It is diluted before serving, Fruits like aonla,jamun, pomegrante, grape, lemon, orange and sometimes ginger can be used for the preparation of syrup. It is also prepared from extracts of rose, sandal almond etc.

Synthetic syrups

Heavy sugar syrup of 70-75 per cent strength is used as the base of all synthetic syrups and they are flavoured and coloured with artificial

essence/flavours and colours. They never contain fruit pulp/juice. A large proportion of these syrups can, however, be replaced by real fruit juices, squashes and syrups which are more nutritious.

Large quantities of synthetic syrups (orange, lemon, pineapple, strawberry) are manufactured and sold in varius countries. These can be prepared by using 1.5 kg of sugar, 500 ml of H2O and 15 g of citric acid. Different colours and flavours are added as required. Among colours, orange red, lemon yellow, green, raspberry red etc. are mostly used, while artificial essence/flavours of rose, orange, pineapple, strawberry, lemon etc. are added as flavouring substances.

Preservation of Juices:

Fruit juices, RTS and nectars are preserved by pasteurization or by using chemical preservatives. Squashes, crushes, syrups and cordials are preserved by adding chemical preservative like potassium metabisulphite or sodium benzoate.

1. Pasteurization: Preservation of fruit juices by application of heat is the most common method. Pasteurization is a process in which juice is heated to 1000C or slightly below for a sufficient time to inactivate/kill the micro-organisms, which cause spoilage. Usually the fruit juices are pasteurized between 75 and 880C with times ranging from 30 sec to 30 min depending on the type of heating system, the nature of the juice and the size of the container. Pasteurization can be performed either by heating at low temperature for a long time (LTLT) or heating at high temperature for short time (HTST). Commonly followed methods are:

a. Holding pasteurization: In this method, the prepared juice is filled into glass bottles with a proper head space and the bottles are sealed airtight. After sealing the bottles are pasteurized. However, this method is not followed for commercial scale products.

b. Pasteurization by overflow method: In this method, the juice is heated to a temperature about 2.5oC higher than the pasteurization temperature and filled into the hot sterilized bottles up to the brim. Care should be taken to maintain the temperature during filling and sealing operation. The sealed bottles are processed in boiling water for specified period. After processing the bottles are cooled. On cooling, the juice contracts to leave a small headspace in the bottle which does not contain any air. The method is commercially followed in preservation of all types of juices in the food industry.

c. Flash Pasteurization: In this process, the juice is heated only for short time at a temperature about -5.5oC than the pasteurization temperature, filled into the containers and sealed air tight under cover of a steam to sterilize the seal and then cooled. This process is also known as HTST (High temperature and short time) method and the juice is heated vary rapidly. Flash pasteurization helps to minimize the loss of flavour, better retention of vitamins, keep juice uniformly cloudy and minimize the cooked taste of the juice.

2. Aseptic processing and packaging of fruit juices: Aseptic processing and packaging is defined as the process in which a commercially sterile product is packed into pre-sterilized container in a sterile environment. The system make use of high temperature short time (HTST) sterilization in the temperature range of 90-110oC for acid products (pH<4.6) and ultra high temperature (UHT) sterilization 121oC and above for low acid foods (pH>4.6). The commercial aseptic sterilization process takes place in a continuous, closed system. Aseptic processing may produce products with better retention of nutrients and excellent sensory quality. Apple, mango, litchi, pineapple drinks etc. in tetra pack are processed commercially using aseptic processing and packaging system.

3 Preservation by sugar: Fruit juice containing 66% sugar generally does not ferment. Fruit syrup or sharbats with high total solids (65% and above) have a very low water activity hence micro-organism do not grow. The sugar acts as a preservative by osmosis and does not support the growth of micro-organism. However, the growth of mould and yeast can occur on the surface of jams or jellies which need to be protected by using airtight packing or covering the product with molten paraffin wax.

4. Preservation by freezing: The properly frozen juice retains its freshness, colour, taste and aroma for a long time. De-aerated juice is transferred into containers, which are hermetically sealed and frozen. Freezing does not sterilize fruit juices, it merely reduces the temperature to the point where micro-organisms do not multiply and chemical changes take place very slowly. The more rapidly a juice is frozen, the smaller the ice crystal formed and the less the amount of colloidal matter coagulates. When the juice is frozen to -18oC, practically all of the juice will be solid except for a little thick syrup in the centre of the containers. This method is particularly useful in the case of juices whose flavour is adversely affected by heating.

5. Preservation by drying: Micro-organisms need water for their growth and multiplication and as the water is removed, they are unable to grow. Fruit juices can be preserved in the form of powder by different methods viz., spray drying, drum drying, freeze-drying, foam-mat drying etc. Fruit juice powders are highly hygroscopic and require special care in packing. It should be packed in free flowing powder form in hermetically sealed containers with in package desiccant to prolong the shelf-life of the product. Lemon juice powder can also be prepared by using foam mat drying process.

6. Preservation by carbonation: Carbonation is a process of mixing carbon dioxide under pressure with water, juice or beverages so that the product when served; gives off gas in fine bubbles and has the characteristics taste. Carbonated beverages are generally bottled with carbon dioxide content ranging from 1 to 8 g/litre. Though this concentration is much lower than that required (14.6 g/litre) for complete inhibition of microbial growth, yet it is significant in supplementing the lethal effect of acidity on pathogenic bacteria. Carbonation also helps in removal of air which creates anaerobic condition and reduces the oxidation of ascorbic acid. Since moulds and yeasts

require oxygen for their growth and as such become inactive in the presence of carbon dioxide. Thus the absence of air and presence of carbon dioxide in fruit beverages help to prevent the growth of moulds and yeast. The keeping quality of carbonated beverages is enhanced by adding about 50ppm sodium benzoate. Carbon dioxide in beverages is measured in terms of gas volume. The gas volume is defined as the amount of gas in millilitres that a given volume of water will absorb at atmospheric pressure i.e. 760 mm of Hg at 15.50C temperature. Generally 1.3-4.0 gas volume CO2 is used for carbonation of fruit juice. Lime, lemon, grape, apple juice can be carbonated by using carbonation process.

7. Preservation by filtration: In this method, the clarified fruit juices (particularly apple and grapes) are passed through special filters, which are capable of retaining yeasts and bacteria. Various types of germ proof filters are used for this purpose and the method is used for soft drinks, fruit juices and wines.

FILLING and PROCESSING: Bottles are thoroughly washed with hot water and filled leaving 1.5-2.5 cm headspace. The bottles meant for heat processing are sealed by using crown corks whole those preserved by using chemical preservative can be sealed by using PP (pilfer proof) caps.

Topic: -8 PRIPARTION OF CORDIAL, FERMENTED BEVERAGES

PREPARATION OF CORDIAL

It is a sparkling, clear, sweetened fruit juice from which pulp and other insoluble substances have been completely removed. It contains atleast 25% juice, 30% TSS, 1.5% acid and 350 ppm of So2.This is very suitable for blending with wines. Lime and lemon are suitable for making cordial.

Process

Fruits → Washing → Cutting into halves →Juice extraction → Straining →Addition of preservative (kms/gm/litre juice) → Storing in glass container for 10-15 days for clarification (suspended material settles down) → Syphoning off the suspernatant clear juice → Straining and measuring → Preparation of Syrup → Straining → Mixing of juice with syrup → Addition of preservative → (KMS 0.6 g / lit product) → Bottling → Capping → Storing in cool and dry place

Fermented beverages

Fermented fruit beverage is a fruit juice which has undergone alcoholic fermentation by yeast like Saccharomyces cerevisae. When other fruits are used for preparation of Dry wines contain practically very little or no sugar, whereas sweet wines contain some sugar and taste sweet. The alcohol content of these wines ranges from 7 to 20 percent.

The wines are also categorized on the basis of alcohol contents as Light, medium or strong wines 'Light wine' contains alcohol contents of 7 to 9

percent.

'Medium wine' with alcohol 9 to 16 percent and, 'Strong wine' with alcohol of 16 to 20 percent.

Generally, wine with more than 12% alcohol are fortified with fruit brandy (alcohol) prepared by distilling grape wine.

Still wines are without any carbon-dioxide.

Sparkling wines contain carbon-dioxide.

Method for preparation of wine

Fruits suitable for wine making: Wine can be prepared from the apple, custard apple, pear, plum, jamun, muskmelon, coconut toddy, pomegranate, banana, guava, ber, strawberry, peach, kiwi fruit, raspberry, cherry, pineapple, date, apricot, litchi and mixed fruits (Table 8.3). Wine may be red or white depending on the grapes used. The red coloured grapes are crushed and fermented to give red wine, whereas white wine is prepared from fermentation of white grape juice.

Preparation of fruits for fermentation

Beauty Seedless, Arka Shyam, Concord etc. cultivars of grapes are generally used for wine making. In case of white grapes, the juice is taken whereas, in case of coloured grapes, crushed grapes without any stems (must) are taken for fermentation. Fruits are crushed to extract the juice or in pulpy fruits, the fruit pulp is used. The sugar content is maintained between 22-24 percent and an acidity of 0.6 to 0.8 percent should be maintained. In low sugar fruits, the cane sugar is added to raise the TSS to 22 percent. Sulphur dioxide is also added to the must at the rate of 50-70 ppm to check the growth of wild yeasts and bacteria, which are undesirable.wine then these are called by prefixing the name of fruits for example plum wine, peach wine etc. Wines are of two kinds viz. dry and sweet.

Different types of wines.

Type	**Characterization**
Champagne	It is made chiefly in France with certain varieties of grapes. Champagne is a sparkling clear wine and also made in several other countries. Generally the fermentation is allowed to proceed to completion in bottles. These bottles are specially made to withstand high pressure of gas produced during fermentation.
Port	This is fortified sweet red wine originally in Portugal, but now produced in other countries.
Muscat	It is prepared from Muscat variety of grapes in Australia, California, Italy and Spain

Tokay	It is famous fortified wine of Hungary
Sherry	Sherry is a Spanish wine, which is matured by placing the filled barrel in sunlight having a temperature of 54 to 60°C for 3 to 4 months
Perry	The wine prepared from pears is called as Perry. It can be prepared from the culled fruits and fruit trimmings of the canneries.
Orange wine	Sweetened orange juice is fermented to produce orange wine. The method of preparation is similar to that of grape wine. Orange peel oil should be minimum in the juice, otherwise its presence stop the fermentation completely.
Berry wine	The wine made from fruits like strawberry, blackberry and elderberry is known as berry wine.
Feni	Feni is a wine made from fermentation of cashew apple, in some places like Goa.
Nira	Nira is prepared from the juice of the palm tree

Inoculation and Fermentation

The grape juice (must) after addition of sugar syrup is fermented by addition of a culture of pure wine yeast Saccharomyces cerevisae var. ellipsoideus as a starter @ 2-5%. For proper fermentation temperature should be maintained between 27-29oC. A low temperature below 10oC and higher than 38oC, almost ceases the fermentation process. After three days the contents are filtered through muslin cloth and again allowed to ferment for another 10 days, so that yeast cells and other solids settle at the bottom. For other fruits the time taken for completion of fermentation varies between 15-20 days.

Aging and packaging:

When fermentation is complete, the clear wine is siphoned out and further clarified with the help of fining agent like bentonite. When all the colloidal materials settle down along with bentonites, the clear wine is siphoned off and filtered if necessary. The clear wine is filled into bottles or barrels completely and sealed airtight to exclude air and allowed to mature for 6-8 months. During this aging process, the wine loses its raw and harsh flavour to a smooth and characteristic aroma. Generally, oak wood barrels are used for aging as they impart a finer aroma to the wine. During maturation dissolved carbon dioxide escapes and spontaneous clarification occur. The extraction of oak flavours and limited oxidation also occur during this process. Astringent tannic substances precipitate and result in slow smoothing of the taste. Generally wines are pasteurized at 82-88oC for 1-2 minutes followed by bottling. To produce fortified wines, alcohol is added in the form of brandy or wine spirit. For improving the taste sugar may be added before final packing of the wine.

Cider:

Cider is fermented apple juice, which is made from apples. In India, dessert apples are employed for preparation of good quality of cider. The alcohol content ranges from 4 to 6 percent in cider. Apples with high tannin (0.1 to 0.3%) contents are generally used for the preparation of cider.

Apples are crushed and pressed to extract juice, then its sugar content is raised to 220 Brix by addition of cane sugar. It is preserved with 100 ppm SO2 and pure culture of wine yeast is added for fermentation. Sometimes di-ammonium hydrogen phosphate (DAHP) (0.02 to 0.05%) is added as a food supplement for the yeast. The method of fermentation is similar to that of other wines. The cider is aged in oak wood barrels after filtration. The matured cider is heated to 650C filled into bottles, crown corked and pasteurized at 600C for 30 minutes. Apple cider is also carbonated for better acceptability

Vermouth:

It is a fortified wine in which alcohol contents ranges from 15 to 21%, and flavoured with mixture of herbs & spices.

Brandy: Brandy is a distillate obtained from the distillation of wine and generally aged in small oak cooperage, example cognae and armagnae.

Vegetable juices:

Generally fruit juices are consumed either fresh or processed form. Certain vegetable juices are also consumed in fresh form but for mostly medicinal purpose. Tomato juice is consumed in processed form either canned or bottled. Tomato is also used as soup, a warm beverage prior to meal.

Fruit juice powders:

Fruit juice powder process includes the evaporation of water from fruit juices to bone dryness. These powders are highly hygroscopic in nature, therefore proper packaging is required. These powders are prepared from strained fruit juices by different drying techniques such as spray drying, double-drum drying, vacuum drying, freeze drying and foam-mat drying. The powder has a long shelf-life and is soluble in cold water. Reconstitution of the powder yields full strength fruit juice drinks.

During the drying process much of the characteristic fresh flavour is lost, which is compensated by adding natural fruit flavour in powder form. Mango, orange, lemon, guava, passion fruit and tomato juice etc can be dried into powder.

Fruit juice concentration and evaporation:

Concentration is a process of removal of water from juice to increase concentration of soluble solids in fruit juices. It is also used to pre-concentrate a juice for further use in processing such as spray drying or drum drying. Concentration has the significant advantages to the processing, to reduce

storage, packaging and transport costs, concentration of soluble solids aid in preservation by reduction in water activity. The juice concentrate can be used as base material for making various food and beverages formulation. Concentration of juice can be carried out by evaporation, freeze concentration by using reverse osmosis.

Evaporation is most commonly used for preparation of apple juice concentrate at commercial scale. The evaporator consists of a steam fed heat exchanger to heat the fruit juice to a desirable temperature for evaporation. There is a separator from which vapour is separated from the concentrated liquid phase, a condenser to effect condensation of the vapour and its removal from the system, and a fractionating still for aroma recovery. Generally, falling film evaporator is used to concentrate the apple juice. Final concentration is carried out in centritherm evaporator. Apple juice is concentrated to 6-7 folds from its initial total soluble solids. Apple juice concentrate is immediately cooled and stored in cold store in large barrels

Advantages of concentration and evaporation

Reduced weight and bulk compared to fresh juice result in economy in packaging, storage and transport.

The whole crop of fruit is fully utilized during peak season, helps in lowering the prices.

The product can be used as base material for making various beverages.

Concentrates of pure fruit juices particularly of orange, apple, pineapple and grape are highly popular.

Topic: -9PRIPARTION JAM, JELLY, MARMALADE

Jams, jellies and marmalades constitute an important class of preserved fruit products. Apple jam, pineapple jam, strawberry jam and mixed fruit jam prepared by using pulp of two or more fruits are quite common. Similarly, guava jelly and orange marmalade are also examples of such products.

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. The method for preparation of jam and jelly is the same except that pulp and pieces of fruit are used in jam while, for jelly making clear fruit extract is used. According to FPO specifications, minimum soluble solids in the final product shall not be less than 68 percent.

PREPARATION OF JAMS

Jam is a product made by boiling fruit pulp with sufficient quantity of sugar to a reasonably thick consistency, firm enough to hold the fruit tissues in position. Apply, sapota, papaya, plums, mango, grapes, jack, pineapple, banana, guava and pears are used for preparation of jam. It can be prepared from one kind of fruit or from two or more kinds.In its preparation about 45%

of fruit pulp should be used for every 55% of sugar.The FPO specification of jam is 68.5% TSS, 45% of fruit pulp and 0.5-0.6% of acid (citric acid) per 100 gm of the prepared product.

a). Selection and preparation of fruit

Select good quality ripe fruits. Wash the fruits well in cold water. Peel the fruits and remove the stones and corers present. Cut the peeled fruit into small pieces with a stainless steel knife. If the fruit is hard, it should be cut into very small pieces. Pulp the fruits by using pulper.

b). Addition of sugar and acid

Generally, 55 parts of cane sugar (sucrose) is used for every 45 parts of fruit for preparation of jam. The prepared jam should contain 30 to 50 percent invert sugar to avoid crystallization of sugar in the jam during storage. If the percentage of invert sugar (reducing sugar) is less than 30, then jam develops crystallization and if it is more than 50%, the jam will develop into a honey like mass due to the formation of small crystals of glucose. Sugar should not be added in excess as jam with higher total soluble solids becomes gummy and sticky.

Addition of acid, colour and flavour:

Citric, tartaric or malic acid are used to supplement the acidity of the fruit for jam making. Addition of acids to fruits which are deficient in acid is required to get appropriate combination of pectin, sugar and acid for proper setting of jam. The pH of the mixture of fruit juice and pectin should be 3.1 before sugar is added. Only permitted edible food colours should be used and these should be added towards the end of the boiling process. Flavours are added at the end of cooking process and just before packing.

c). Cooking

Cook the mixture slowly with occasional stirring. The fruit pulp should be crushed with a laddle during cooking. Continue cooking till the temperature of the mass reaches 105.5^{o}C. Sheet (or) Flake Test.

d). End point

The end point can be determined by carrying out a jelmeter test. Generally, fruits which are fairly rich in pectin, the weight of the finished jam is one and a half times (11/2 times) the weight of sugar used. Jam containing 68.5 percent of soluble solids boils at 1050C at sea level. It should yield a definite quantity of the finished jam.

A small portion of jam is taken out during boiling in a spoon or wooden laddle and cooled slightly. It is then allowed to drop. If the product falls off in the form of a sheet (or) flakes instead of flowing in a continuous stream (or) syrup, it means that the end point has been reached and the product is ready. Otherwise boiling is continued till the sheet test is positive.

e). Packaging and Storage

Fill the hot jam into clean dry sterilized jars. Allow the jam to cool and fix the sterilized lid to the jar. Store in a cool place. The jam is packed in sterilized glass jars. It should be noticed that unless the jars are stored in a fairly cool place, moisture will evaporate from the jam resulting in shrinkage of the jam. If jam is prepared from fresh, unsulphited fruit pulp then it is advisable to add about 40ppm of sulphur dioxide in the form of potassium meta-bi-sulphite to the jam, which is permitted by law. A layer of molten paraffin wax can be put on the top surface of the cooled jam in the glass jar, which on cooling sets. This acts as a safeguard against any possible moulding on the surface of the jam

Process

Selection of Ripe firm fruits → Washing → Peeling →Pulping (Remove seed and core) → Addition of sugar and acid → Boiling (with continuous stirring) → Judging of end point by further cooking upto 105oC (or) 68% TSS (or) by sheet test → Filling hot into sterilized bottles → cooling → Sterilized bootles → cooling → Waxing → Capping → Storage (at ambient temperature).

PREPARATION OF JELLY

Jelly is prepared by boiling the fruit with or without addition of water, straining the extract and mixing the clear extract with sugar and 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 of attractive colour and should keep its shape with a clean-cut surface. In the preparation of jellies, pectin is the most essential constituent. Pectin is present in the cell wall of fruits. In order to get a good quality jelly fruits rich in pectin, but deficient in acid should be preferred.

It shoul no b gummy, sticky or syrupy or have crystallized sugar. The product should be ree from dullness with little (or) no syneresis (weeping) and neither tough nor rubbery. The FPO specification for jelly is the final product should have 65% solids, 45% fruit extract and 0.5-0.75% acid.

Guava, sour apple, plum, karonda, wood apple, papaya and jack fruit are rich in pectin and generally used for preparation of jelly. Pineapple, strawberry grapes etc. can be used but only after addition of pectin powder, because these fruits have low pectin content.

Pectin requirement: Usually 0.5 to 1 percent of pectin in the extract is sufficient to produce a good jelly. If the pectin content is in excess, a firm and tough jelly is formed and if it is less, the jelly may fail to set. Pectin, sugar, acid and water are the four essential constituents of a jelly and must be present approximately in the following proportions:

Pectin 1 percent

Sugar 60 to 65 percent

Fruit acid 1 percent

Water 33 to 38 percent

However, the exact proportion of the sugar depends on the pectin grade.

Pectin grades: Grades of pectin means the weight of sugar required to set one gram of pectin under suitable conditions to form a satisfactory jelly. e.g. 100 grade pectin means 100g of sugar is required for setting of 1 g pectin.

Process

Selection of Fruit (Firm, not over ripe) → Washing → Cutting into thin slices → Boiling with water (1½ times the weight of fruits for about 20-30 min) → 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 / temp test) → Removal of scum (or) foam (one teaspoonful of edible oil added for 45 kg sugar) → Addition of colour and remaining citric acid → Filling hot into clean sterilized bottles → Waxing (paraffin wax) → Capping → Storage at ambient temperature.

Determination of end-point: The end-point in jelly can be judged by using 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. The main drawback in this method is that while the drop on the plate is cooling, the jelly mixture continues to boil in the pan and there is a risk of over-cooking the product or of missing the correct setting point.

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. Falling of the drop in the form of flakes or sheet indicates the end point.

Problems in Jellies

A). Failure of jellies to set: Sometimes the jellies do not set due to the following reasons:

i) Lack of acid or pectin: A jelly may fail to set due to lack of acid or pectin in the fruit from which it is made. It may also fail to set due to insufficient cooking of the fruit resulting in inadequate extraction of pectin and acid.

ii) Addition of too much sugar: If sugar is added in excess of the required quantity, a syrupy or highly soft jelly results. It can be corrected by adding fresh clarified juice rich in pectin.

iii) Cooking below the end point: If the cooking is stopped before the

concentration of sugar reaches 65 percent, the jelly may fail to set and may remain syrupy and highly soft.

iv) Cooking beyond the end point: If heating is continued beyond the end point, the jelly becomes tough due to over-concentration. This occurs when the juice is rich in both acid and pectin and enough sugar has not been added. If the acid is in excess, the pectin breaks down and forms syrup like jelly.

B). Synersis or weeping of jelly: The phenomenon of spontaneous exudation of fluid from a gel is called synersis or weeping of jelly. It is caused by following factors:

i) Excess of acid: Addition of excess of acid results in the breakdown of jelly structure due to the hydrolysis or decomposition of pectin.

ii) Too low concentration of sugar or soluble solids: This causes the network of pectin to hold more liquid than it possibly can do under normal conditions.

iii) Insufficient pectin: This results in the formation of a pectin network which is not sufficiently dense and rigid enough to hold the sugar syrup.

iv) Premature gelation: Gelation is caused due to breakdown of pectin during pouring of jelly into the containers. The jelly becomes weak and remains broken.

v) Fermented jellies: Fermentation usually takes place in those jellies in which synersis has taken place.

C). Cloudy or foggy jelly: It might be due to use of non-clarified extract, use of immature fruits (immature fruits contain starch which is insoluble in juice), Over cooking and cooling, non-removal of skum, faulty pouring (when jelly poured from a great height, air get trapped in bubbles form and jelly become opaque) and premature gelation is also a reason for cloudy or foggy jelly

D). Formation of crystals: Crystals in the jelly may be formed due to addition of excess sugar.

Preparation of MARMALADE:

It is similar to fruit jelly but the slices of the fruit or of the peel are suspended. Marmalades are generally made from citrus fruits like oranges and lemons in which peel shreds are added as a suspended material. Citrus marmalades are classified into (1) jelly marmalade (2) jam marmalade. As per FPO specifications, the quantity of fruit and soluble solids in the final product shall not be less than 45 and 65 per cent (w/w) respectively for jelly and marmalade.

Ingredients

Pectin extract 1 litre

Sugar 750 gm

Shredded peel 62 gm

Process

Selection of Ripe fruits → Washing → Peeling outer yellow portion (Flavedo) thinly → Cutting yellow portion into fine shreds (1.9 - 2.5 cm long and 0.8 – 0.12 cm thick) 0.4 Cutting of 0.3 thick slices of peeled fruit (or) crushing into pulp in a greater → Boiling (in 2-3 times its weight of H2O for 40-60 min.) Straining the extract →Testing pectin content of sugar (as required) Cooking to 103-105°C (Continuous stirring) Addition of shreds (shredded peel boiled for 10 to 15 min. in several changes of water for softening and removing bitterness and added @ about 62 g per kg of extract)oiling till (continuous stirring) -88° testing for end point with continuous stirring) Flavouring Storage at ambient temperature.

Preparation of peel shreds:

The peel is cut into shreds (1.9-2.5 cm long and 0.8-0.12 cm thick). The shreds are softened by boiling before they are added to the marmalade. If they are added directly without preliminary softening to the sugar solution and boiled, they become tough. Generally, three methods are employed for softening the shreds.

i) The shredded peel is boiled for 10-15 minutes in several changes of water. The bitter principles present in the peel are also removed in this process.

ii) The shreds are boiled in 0.25 percent solution of sodium carbonate or 0.1 percent ammonia solution.

iii) The shreds are then autoclaved at 1160C to 1210C (70-105 k Pa). The time required to soften shreds depends upon their size and shape.

Cooking:

The extract is boiled along with required quantity of sugar in a steam-jacketed kettle or stainless-steel vessel. Boiling is continued and the impurities rising to the surface are removed. When the temperature of the boiling mixture reaches 1030C at sea level, the prepared shreds are added to it at the rate of 62 g for each kg of the original extract. Boiling is continued till the jellying point is reached which is determined by using either sheet test, drop test or weight test.

Cooling:

The marmalade is cooled in a shallow pan or in a water-cooled pan by slow stirring to allow the uniform distribution of shreds in the marmalade. During cooling, when the temperature reaches 82 to 880C, a thin film begins to form on the surface of the marmalade which becomes sufficiently thick to prevent floating of the shreds onto the surface.

Addition of flavour:

Due to volatilization of natural flavour during cooking process, addition of artificial flavour is desirable to compensate the loss. It is desirable to add a

small amount of flavour to the product, because most of the natural flavour volatilizes during the boiling and cooking processes. Generally, a small quantity of orange oil is added to the marmalade at the time of filling into jars or cans as a flavourant.

Packing:

After cooling the marmalade is filled into jelly glasses or glass jars, which can be closed air-tight or is packed in cans which are hermetically sealed. In jelly glasses, the marmalade is allowed to set overnight and on cooling a thin layer of molten paraffin wax is poured on the top. When packed in A21/2 size cans, the cans are inverted upside down to sterilize the lids and stored in a cool dry place.

Jam Marmalade

The method of preparation is practically the same as that for jelly marmalade. In this case the pectin extract of fruit is not clarified and the whole pulp is used. Sugar is added according to the weight of fruit, generally in the proportion of 11. The pulp – sugar mixture is cooked till the TSS content reaches 65%.

Topic: -10 PRIPARTION OF PRESERVE, CANDIED, CRYSTALLIZED FRUITS

PRESERVE:

A fruit preserve is made from properly matured fruit, by cooking it whole or in the form of large pieces in heavy sugar syrup, till it becomes tender and transparent.

Procedure for preserve preparation: In preparation of preserve, at least 45 kg of the fruits are used for every 55 kg of sugar and cooking is continued till a concentration of at least 68 percent of soluble solid is reached.

Selection of fruit: Fruit should be fully developed, firm and slightly under-ripe. Unripe or over-ripe fruit with loose pulp should be rejected.

Preparation of fruit: Fruit are washed thoroughly and damaged portions are removed. Thin skinned fruits like berries are not peeled. Thick skinned fruits like mango, apple, bael, petha are peeled. The cores, seeds or stones are removed. Fruits are preserved either whole or in pieces.

Pricking/puncturing: The whole fruits or slices are uniformly punctured/pricked with stainless steel/wooden pickers to enable proper permeation of sugar syrup. Excessive pricking should be avoided to prevent softening of fruit/slices. Aonla and petha (ash gourd) can be pricked by using mechanical prickers.

Soaking: The fruits or their slices are soaked in water, brine or alum solution for few hours to few days before blanching and to enable proper permeation of syrup. Soaking make hard fruits porous, check browning, remove

astringency, minimize shrinkage and prevents stiffening of fruits.

Blanching: The soaked fruits or slices after thorough washing are placed in muslin cloth and blanched in boiling water for few minutes (5-10) according to their texture to soften the hard texture. Excessive blanching should however be avoided.Preparation of syrup: The quantity of sugar varies for various fruits, ranging from equal to double of the prepared fruits or slices. Syrup is prepared by boiling the sugar with 2-3 times of water and adding 0.3-0.4% citric or tartaric acid. Addition of acid also helps in removing the dirt from the sugar.

Cooking in syrup: The prepared fruits or slices are cooked in syrup in three different ways i.e

a) Open kettle one-period process

b) Open kettle slow process; and

c) Vacuum cooking proces

a) Open kettle one period process: The fruits are cooked in syrup containing low sugar contents. Boiling is continued with gentle heating until the syrup become sufficiently thick. The final concentration of sugar should not be less than 68oBrix corresponding to a boiling point of 106oC. Rapid boiling should be avoided, as it makes the fruit tough.

b) Open kettle slow process: In this process, the sugar equal to half the weight of fruit is added to the prepared fruit or slices in alternate layers in a vessel and allowed to stand for 24 hours. During this period, excess water from the fruit is leached out and sugar turn into a solution of 37-38oBrix. The concentration of syrup is raised to 60oBrix by adding more sugar. Citric or tartaric acid is added @ 0.06-0.12% to invert the portion of sugar. The whole mass is boiled for 3-4 minutes and kept for overnight. On the third day, concentration of syrup is raised to 68oBrix by adding more sugar and the whole mass is boiled again for 3-4 minutes and the fruit is then left in the syrup for another 3-4 days. Finally the strength of syrup is raised to 70oBrix and the preserve is packed in containers. However the stages may vary with the type of fruit.

c) Vacuum cooking: Vacuum cooking results in better retention of flavour and colour of the product. In this process, the fruit is initially softened by boiling and then placed in the syrup of 30-35oBrix concentration. The fruit syrup blend is then transferred to vacuum pan and concentrated under reduced pressure to 70oB. To facilitate sugar penetration, slow boiling is practiced for hard fruits.

Precaution during cooking: In both methods, deep pans should be used otherwise the syrup becomes concentrated within a short period in shallow pans and fails to permeate the fruit. While adding fruit slice in boiling syrup, the consistency should not be too thick. The thick coating of the juice prevents the sugar syrup to enter and the product becomes tough or shriveled. Fruits should always be covered in the syrup to prevent drying of top pieces and

improve the quality.

Cooling and packing: For storage in bulk, the preserve is cooled quickly after final boiling to avoid discoloration. For packing in A2½ size cans, the preserved fruits are drained and filled in to the cans. Freshly prepared boiling syrup (68oB) is then poured into the containers (A2½ size can), exhausted for 8-10 minutes at 100oC in steam, hermetically sealed, sterilized for 20-25 minutes at 100oC and cooled immediately.

Process

Selection of Mature fruits → Washing → Preparation of fruit for sugar treatment → Keeping fruit and sugar in alternate layers (1.0 kg Fruit: 1 kg Sugar) (or) steeping fruit in syrup of 40% TSS for a day → Removal of fruit → Increasing consistency of syrup to 60% TSS by boiling Steeping ofruit for a day →Repeating the process and raising strength of syrup by 5% TSS to 70% on alternate days – Steeping in 70% TSS for a week → Preserve – Draining Filling in jar (or) container → Covering fruit with freshly prepared sugar syrup of 68% TSS Sealing (airtight) –Storage.

CANDIED FRUITS:

The method for making candy is practically the same as that followed for preserves, with a minor variation that the fruit is impregnated with a higher concentration of sugar or glucose. The total sugar content of the impregnated fruit is kept at about 75 percent to prevent fermentation. The most suitable fruits for candying are those which possess pronounced flavour like peels of orange, lemon, grape fruit and ginger.

Procedure for preparing candied fruits

Preparation of fruit: Stored fruit or peel is taken out from barrels and washed thoroughly in running cold water to leach out as much of the brine as possible. The fruit or peel is then placed in a cooking pan and boiled for about 15 minutes to remove traces of salt and to soften its texture.

Cooking in syrup: The prepared fruit or peel is boiled in cane sugar syrup (30oB) containing 0.1% citric or tartaric acid for 10-15 minutes and then left in syrup for about 24 hours. Next day, the syrup concentration is raised to 40oB by adding more sugar. The whole mass is boiled for about 5 minutes and left for another 24 hours. The process is repeated until the syrup reaches 60oB. Beyond this concentration, the syrup strength is progressively raised to 75oB at the rate of 5oB and boiling the mass on every alternate day.

Draining and drying: After syrup treatment, the fruits or the slices are removed from syrup and drained for about half an hour and sorted out to separate any defective and unwanted pieces. After this, the fruit/slices are dipped for a moment in boiling water to remove the adhering syrup followed by slow drying in the shade or in a drier at 66oC for 8 to 10 hrs.

Glacing: For glacing process, the sugar syrup is prepared by boiling sugar and water in 2:1 ratio in a steam pan at 113-114oC followed by cooling to 93oC. Sugar granulation is achieved by rubbing the syrup with a wooden ladle

on the side of pan. Dried candied fruits are passed through this granulated portion of the syrup and then placed on the trays for drying in drier at 49oC for 2-3 hours. When the pieces become crisp, they are packed in air tight-containers.

Packaging: For retail trade, tin containers (15-20 kg capacity) and glass jars are used for storing preserves. Candied and crystallized fruits and peels are packed singly or in combination in layer in water proof paper or in polythene. Attractive china and porcelain jars are sometimes used for packing these products intended for exclusive export market. In addition to metal and glass containers, the newer flexible films can also be used, which are cheaper and highly effective.

PREPARATION OF CRYSTALLIZED FRUITS /VEGETABLES

Candied fruits /vegetables coated with crystals of sugar, either by rolling in finely powdered sugar or by allowing sugar crystals from dense syrup to deposit on them are called crystallized fruit / vegetable.

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 12-18 hrs during which a thin coating of crystallized sugar is formed. The tray is then taken out carefully from the vessel and the surplus syrup dried off. The fruits are then placed in a single layer on wire mesh trays and drained at room temperature or at about 49oC in driers.

Topic: -11 PRIPARTION OF PICKLE, CHUTNEY, TOMATO KRTCHUP

PICKLES:

The preservation of fruit and vegetables in salt and vinegar is called pickling. Pickles may prepare without fermentation or with partial or complete fermentation. Spices, edible oil, sugar/jaggery etc are added to improve taste and palatability of the product. Thus, pickles are good appetizer and help in digestion by stimulating the flow of gastric juices. The nutritive value of pickle varies with the kind of raw material used and method of preparation such as with or without fermentation. Manufacturing of pickle has developed as an industry in the country. Mango pickle, cauliflower, turnip, carrot (mixed vegetable), anola, lime/lemon pickle etc. are the commercial products available in the market.

Pickling process:

Pickling is the process of fermentation by lactic acid forming bacteria, present on the surface of commodities. Lactic acid bacteria (active at 30oC) convert fermentable sugar in the food to lactic acid and volatile acids. The acid and brine acts upon vegetable tissues to produce characteristic taste and aroma of pickle. The salt and lactic acid formed preserve the pickle by preventing the growth of putrefactive bacteria provided oxygen is excluded.

Fermented cucumber and olive pickles are quite common. Pickle is prepared by using either of following processes followed by finishing and packing:

Curing or fermentation with dry salting

Fermentation in brine

Salting without fermentation

A). Dry salting

The dry salt added to the prepared vegetables, extracts the juice from the vegetables and forms the brine. The brine is then fermented by lactic acid forming bacteria which serves the purpose of pickling. The method is known as dry salting.

Procedure for dry salting

Vegetables are washed, sliced and placed in barrel in layers to which salt is sprinkled followed by placing another vegetable layer and sprinkled with salt. Generally, 3 kg dry salt is used for each 100 kg of prepared vegetable. The salt is added in layers till the barrel is ¾ full. The vegetables are covered with a cloth and wooden board along with a weight to press the vegetable. Brine is formed in 24 hours.

The barrel is placed in warm and dry place to allow the fermentation to proceed within short period. Once brine is formed, fermentation and bubbles of CO2 begin to rise from the liquid. The fermentation temperature is 27-32^0 C and completes in 8-10 days.

When the gas bubbles cease to form, the fermentation is considered as complete. This may be confirmed by taping the barrel gently. The pickle is then pressured and packed by excluding the air.

If air is not removed from the pickle, pickle scum (a type of mould yeast) appears on the surface, which destroys the lactic acid formed by fermentation and spoils the pickle.

Methods to remove air /expel air from the pickle:

1. By making air seal on the surface of brine by pouring 0.6 cm thick layer of edible oil (rapeseed oil/mustard oil or cotton seed oil) on the top of it. The oil being lighter than brine floats on the surface and prevents the access of air in to the pickle.

2. After dry salting and fermentation, the barrel is filled with the prepared vegetables to its maximum capacity and covered with a lid. A 1.25 cm hole is bored in the lid (cover). The barrel is filled up to the brim with the brine so that very little air is left inside. It is allowed to stand for 48 hours till all gas bubbles ceases to rise. When the bubbling stops the vent hole is closed tightly and barrel kept in a cool dry place.

3. The barrel is kept undisturbed. The molten paraffin wax is poured over the surface of the brine. It imparts air tight-seal. The paraffin wax can be easily separated from the brine and the wax can be remelted and reused.

B). Fermentation in Brine (Brining)

Immersing vegetable or unripe fruits like mangoes in salt-solution of known concentration for a certain length of time is called brining. Brining is generally used for pickling of cucumber, olives, raw mangoes and similar other vegetables, which do not contain sufficient juice to form brine with dry salt.

Brine preparation:

Brine is prepared by dissolving common salt in water and filtered through a muslin cloth. The amount of brine required to cover the vegetable is approximately equal to about half the volume of the material to be fermented (for each barrel of 100 litres, about 50 litres of brine is required). Brine with 8 -10 % strength is considered optimum for the growth of salt tolerant lactic acid bacteria.

Thus vegetables are placed in 10 % brine to allow lactic acid fermentation to take place and then the proportion of salt is increased gradually, so that when pickle is ready, salt concentration would have reached 15 % level. The brine strength can also be maintained by adding dry salt. Brining takes about 4-5 weeks.

C). Salting without fermentation

In this method, vegetables raw mango slices are packed with a large quantity of salt to inhibit fermentation. Generally, 25 kg salt is mixed with 100 kg of prepared vegetable. The cured vegetables are drained and excess salt is removed by soaking in cold or warm water. After removal of salt, the vegetables are stored in plain vinegar 10% (100 grain) strength. This treatment reduces the tendency of the vegetable to shrivel when packed in sweetened and spiced vinegar and also helps in absorption of vinegar by the vegetable tissues.

Packing: After curing, the vegetables become semi translucent in appearance with their colour changing from green to dark olive green or yellowish green. During this process the raw flavour of the vegetables is lost and the texture becomes firm and crisp. For good keeping quality they are packed by using salt, vinegar and lactic acid in sufficient quantities which act as preservative either singly or in combination.

1. Salt: The concentration of 15-20% salt is used for pickling. Mould and lactic acid forming bacteria do not grow at this concentration. The fermentation of vegetables is inhibited when they are covered with strong brine or packed with fairly large quantity of salt. This method of preserving is applicable to those fruit and vegetables which contain very little sugar because sufficient lactic acid cannot be formed by fermentation to act as preservative.

2. Vinegar: Vinegar acts as preservative in vinegar pickles by lowering down the pH of final product. The final concentration of acid as acetic acid in the finished pickle shall not be less than 2%. However, vegetables are placed in strong vinegar of 10 % acidity to avoid dilution of the vinegar by the water

liberated from the tissues. This treatment helps to expel the gases present in the intracellular spaces of vegetative tissues and prevents subsequent dilution of the vinegar in the pickle. Spiced vinegar can be prepared by soaking the ground spices in vinegar, boiling the spices in the vinegar or by adding essential oil of spices and added to the prepared pickle.

3. Lactic Acid: Though bacteria do not grow in acidic media, yet lactic acid bacteria are capable of growing in acidic media and can also produce acid through their action on the substrate. They can also grow in high salt concentration of 8-10%. This principle is used in pickling as growth of undesirable organism is inhibited by adding salt and allowing the lactic fermentation to proceed.

The pickled vegetables (onion, garlic, green chilies, olives etc) are then packed in to the glass jars without damaging the shape and appearance of the pieces and covered with fresh vinegar to fill up the spaces between the pieces. The closed jars are then stored in a cool dry place for some time to allow thorough absorption of vinegar before sending them to the market. Brined vegetables and raw mango slices are also used for preparing different types of pickles by using combinations of spices, salt and vinegar.

Types of Pickles: Pickles are generally categorized into fermented pickle and partial or non- fermented pickles. Cucumber and olive pickles are examples of fermented pickles. While non-fermented pickles are of four general types depending upon the covering medium used.

Pickles preserved with salt: lime and mango pickle.

Pickles in oil: Mango, lime, lemon, cauliflower, aonla, karonda.

Pickle in vinegar (acetic acid): Garlic, green chilli etc.

Pickle in mixture of salt, oil, spices and vinegar: Cauliflower, carrot, jackfruit, mixed vegetable pickle etc.

A. Fermented pickles: Cucumber pickle, dill pickle and olive pickle.

i. Fermented cucumber pickle: For preparation of fermented cucumber pickle, the immature cucumber are washed, placed in barrels or tanks and filled with brine (salt solution). Salt is added either by using low salt method or high salt method. In low salt method 8% brine (30o salometer) is added to the cucumber along with 9 kg salt per 100kg cucumber. In high salt method, the brine of 10.5% salt (40o salometer) and 9 kg salt per 100 kg cucumber is used. The cucumbers are kept submerged in brine and brine strength is increased weekly by about 3o salometer up to 60o salometer (15.9% salt). In low salt method, increase in brine strength is about2o per week up to 50o salometer and 1o per week up to 60osalometre. It lakes about 6-9 weeks for completion depending upon the method of salting and temperature of fermentation. During fermentation, most of the lactic acid is produced by the action of Lactobacillus planetarium. However, Lactobacillus brevis, Streptococcus faecalis, Pediococcus cereviseae, Leuronostoc mesenteroides and Coliform bacteria. Total titratable acid on completion of fermentation

range between 0.6-0.8 percent. Initial colour of the cucumber from chalky white and opaque in cross section changes to olive or yellow green with translucent flesh after completion of fermentation. The prepared pickle is too salty to taste which is freshened by soaking and made into sour, sweet sour or mixed pickles.

ii. Dill pickle: Dill pickle is also a cucumber pickle prepared by using dill herbs as flavourant along with spices, garlic and onion. Overnight dill pickle and genuine dill pickle are the common types of dill pickle.

iii. Olive pickle: In preparation of olive pickle, fully developed but still green or straw yellow olives are treated by dipping in 1-2% lye solution to remove the bitterness of olives due to glucoside oleuropein. During this treatment, the lye penetrate up to ½ to ¾ towards the pit; which is detected by placing a drop of phenolphthalein to give faint pink colour. This treatment removes most of the bitterness of olives. The fruit after washing are placed in barrels containing 10-15% brines which results in a salt concentration in olives of about 6-9% after stabilization. During fermentation the salt concentration is mainted 7-8% throughout by adding more salt. Lactic acid fermentation takes about 6-9 months depending upon the atmospheric temperature. Generally 29oC is the optimum temperature for rapid fermentation. During the initial stage of fermentation lasting for 7-14 days the brine stabilizes, food for micro-organissum leach out from the olives and potential spoilage organism like Pseudomonas, Enterobacter, Clostridium, Bacillus and yeasts may grow in Leuconostoc mesenteroides starts. In the next intermediate state lasting for 2-3 weeks Lectronostoc become permanent in growth and acid production and Lactobacillus brevis began to grow and produce acid. In the final stage, Lactobacillus plantarum become predominant and produce acid. The final acidity is about 0.7-1.0 percent with a pH of 4.0 -3.8 or lower. After fermentation, the olives are sorted and graded, washed and packed into glass jar or other containers and covered with fresh brine (7% salt) containing edible lactic acid. They may be pasteurized in container at 60oC or brined at 79-82oC for good keeping quality.

iv. Spiced olive pickle: The fermented olives can also be used for preparation of spiced pickles. For preparation of spiced pickles, the olives after draining from brine are kept in shade for removal of surface moisture. Chopped onion, garlic and ginger are fried in oil to which olives are mixed. Ground spices like cumin, cardamon, black pepper along with salt and turmeric are mixed thoroughly. Acetic acid and sodium benzoate are mixed during the packing of pickle in glass jars. Jars after filling with mustard oil are sealed and stored in cool and dry place.

B. Pickles preserved with salt: Lime and mango pickle.

i. Mango pickle

Recipe: Mango slices 1.0 kg, Salt 200g, red chilli powder 10g, turmeric powder 10g, asfoetida (heeng) 5g, black pepper, cardamom (large), fenugreek, cinnamon (ground) and cumin 10g each.

Procedure: Wash the mature green mango fruits, cut into 4 equal pieces (depending upon fruit size) and remove the kernel. Mix the fruit slices with salt and turmeric powder. Fill mango slices in glass jars and keep the covered jars in sunlight for 7-10 days. Shake the jar at least 2-3 times during drying. Mix the ground spices in well dried mango slices. Store the pickle in cool and dry place.

ii. Lime pickle

Recipe: Lime 1.0 kg, Salt 200g, red chilli powder 15g, black pepper, cardamom (large), cumin 10g each.

Procedure: Wash the lime fruits, cut into 4 equal pieces. Squeeze the juice from ¼ of fruits and mix the salt and ground spices with juice. Mix the lime pieces with the mixture and fill into glass jars. Cover the jars with lid and keep in sunlight for 4-6 days. Shake the jars atleast 2-3 times during drying. Store the pickle in cool and dry place at ambient temperature. Similarly the sweet pickles from mango and lime is made by adding 500-700g jaggery or sugar to the above recipe.

C. Pickles in oil: Mango, lime, lemon, cauliflower, aonla, karonda etc.

i. Mango pickle

Recipe: Mango slices 1.0 kg, salt 150g, powdered fenugreek 25g, red chilli powder 10g, turmeric powder 15g, black pepper, cardamom (large), cinnamon (powdered), cumin, powdered aniseed 15g each, asafoetida 2g and mustard oil 350ml.

Procedure: Wash the mature green mango fruits, cut into 4 equal pieces length wise (depending upon fruit size) and remove the kernel. Dip the mango slices in 2% salt solution to prevent browning. Drain off the water and dry the slices in shade for 4-5 hours (Mango slices preserved in salt can also be used for pickle preparation). Heat the oil, cool and mix spices in a little oil and mix the fruit slices thoroughly. Fill mango slices in glass jars and keep the covered jars in sunlight for a week. Shake the jars atleast 2-3 times during drying. Press the mango slices to remove the air, add remaining oil to cover the mango slices. Store the pickle in cool and dry place at ambient temperature

ii. Aonla pickle

Recipe: Aonla 1.0 kg, salt 150g, powdered fenugreek 30g, red chilli powder 10g, turmeric powder 10g, cumin 10g and mustard oil 350 ml.

Procedure: Wash the mature healthy aonla fruits. Boil for 15 minutes to soften segments, cut and remove the seed. Heat the oil and fry all spices. Mix the segments with spices. Mix salt with aonla segments and fill in the jar. Keep the jar in sunlight for a week. Press the aonla pieces to remove the air, add remaining oil. Store the pickle in cool and dry place.

iii. Karonda pickle

Recipe: Karonda 1.0 kg, salt 200g, red chilli powder 15g, turmeric powder 10g, cumin 10g, powdered fenugreek 10g, aniseed 10g and mustard

oil 300 ml.

Procedure: Select mature, pink colour karondas and wash in clean water. Cut into two pieces and remove the seed. Mix salt with karonda and fill in the jar. Keep the jar in sunlight for 4 days. Heat the oil, fry all spices and mix the segments with spices thoroughly. Add remaining oil and store the pickle in cool and dry place.

iv. Green chili pickle

Recipe: Green chilies 1.0 kg, salt 150g, mustard 100g, lime juice 200ml, powdered fenugreek, aniseed, turmeric, cardamom large, cumin, 15g each and mustard oil 400 ml.

Procedure: Select healthy green chilies and wash in clean water. Make incision and mix all spices in a little lime juice. Mix all spices in chilies and fill in clean jars. Add lime juice and keep the glass jars in sunlight for a week. Store the pickle in cool and dry place.

D. Pickle in vinegar (acetic acid): Garlic, green chili, papaya etc.

i. Papaya pickle

Recipe: Green papaya slices 1kg, salt 150g, red chilli powder 10g, black pepper, cardamom (large), cinnamon (powdered), cumin 10g each and vinegar 750ml.

Procedure: Select green but mature papayas. Wash the fruits, peel, cut into equal sized slices and remove the seeds. Dip the cut pieces in boiling water to soften, remove papaya slices from boiling water. Mix with salt and dry in shade for few minutes. Mix the slices with spices thoroughly. Fill in glass jars and add vinegar to cover all the slices. Keep the covered jars in sun for a week and store the pickle in cool and dry place.

ii. Cucumber pickle

Recipe: Cucumber 1.0 kg, salt 200g, red chilli powder 15g, black pepper, cardamom (large), black pepper powder, cinnamon (ground) and cumin 10g each, clove 6 numbers and vinegar 750ml.

Procedure: Select green immature cucumbers. Wash, peel, cut into equal 5 cm thick slices. Mix slices with salt and fill in glass jars. Keep for about for about 6 hours and drain off water. Add all the spices and vinegar to the drained slices. Keep the covered jars in sun for a week and store the pickle in cool and dry place. Similarly pickle from other fruits can be made by following the same method.

E. Pickle in mixture of salt, oil, spices and vinegar: Cauliflower, carrot, jackfruit, mixed vegetable pickle, etc.

i. Cauliflower pickle

Recipe: Cauliflower florets/slices 1.0 kg, salt 150g, ginger (chopped) 25g, garlic 10g, red chilli powder, turmeric, black pepper, cardamom (large), cinnamon (powdered), cumin, aniseed powder 15g each, tamarind pulp 50g,

mustard seeds 50g, vinegar 150ml and mustard oil 400ml.

Procedure: Select healthy and fresh cauliflowers. Wash and cut into equal pieces 2-2.5 cm. Blanch in boiling water for 2-4 minutes, drain and keep in sunlight for 2 hours. Fry all the spices in a little oil and mix them with cauliflower slices. Heat for 5 minutes and cool. Make paste of tamarind pulp in vinegar and add with cauliflower slices. Fill in the jar, keep in sunlight for a week. Add oil after heating and cooling to keep the pickle for long time. Store the pickle in cool and dry place. Sodium benzoate @ 250 ppm can be added as a preservative.

ii. Turnip pickle (sweet)

Recipe: Turnip 1.0 kg, salt 100g, ginger (chopped) 20g, garlic 10g, red chilli powder, turmeric, black pepper, cardamom (large), cinnamon (powdered), cumin, aniseed powder 10g each, tamarind pulp 100g, mustard 20g, vinegar 100ml, jaggery 200g and mustard oil 200ml.

Procedure: Select healthy, sound and tender turnip. Washing, trimming and peeling is done to remove rough and thick skin. Cut into equal pieces of 1-1.5cm thickness. Blanch for 5 minutes, drain the water and dry in shade to remove moisture. Fry the spices in a little oil except tamarind. Mix the turnip slices with spices thoroughly. Make paste of tamarind pulp in vinegar along with jaggery and mix paste with turnip slices. Fill in the jar and keep in sun for a week. Add oil after heating and cooling to keep the pickle for longer time. Store the pickle in cool and dry place. Sodium benzoate @ 250 ppm can be added as a preservative.

iii. Mixed vegetable pickle

Recipe: Cauliflower + carrot + turnip 1.0 kg, salt 100g, red chilli powder 15g, ginger (chopped) 20g, onion chopped 50g, red chilli, turmeric, black pepper, cardamom (large), cinnamon (powdered), cumin, aniseed powder 10g each, mustard 50g, vinegar 200ml and mustard oil 350ml.

Procedure: Mixed vegetable pickle is prepared similarly to that of sweet turnip pickle. If sweetness is required then jaggery may be added by making a paste with vinegar. Sodium benzoate @ 250 ppm can be added as a preservative.

iv. Jackfruit pickle (sweet)

Recipe: Jackfruit slices 1.0 kg, salt 100g, red chilli powder 15g, ginger (chopped) 20g, turmeric, black pepper, cardamom (large), cinnamon (ground), cumin, aniseed powder 10g each, mustard 20g, vinegar 150ml, jaggery 250g and mustard oil 350ml.

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

FPO specifications for pickles:

According to FPO specifications the minimum percentage of salt (w/v) in pickle in brine shall be 12% while for pickle in citrus juice the acidity as citric acid shall not be less than 1.2% and only citrus fruit juices should be used . For oil pickles any edible vegetable oil like rapeseed, mustard, olive etc can be used. Other general characteristics for these pickles include use of wholesome fruit and vegetables which are free of fungal or insect attack or any rotting. All ingredients shall be thoroughly clean and free from of extraneous matter. Only substances that may be added are spices, salt, sugar, jaggery, onions, garlic, benzoic acid, soluble calcium salts. Pickles shall be free from added copper, alum, mineral acids or other preservatives.

Common defects noticed in different pickles during storage.

S.No.	Common Defects	Cause
1.	**Blackening**	It is mainly due to the presence of iron which enters through the brine or from the equipments. Blackening may also be caused by the action of microorganisms.
2.	**Dull and faded pickle**	It is due to either insufficient curing or use of water of inferior quality.
3.	**Shriveling**	It occurs when vegetables like cucumber are placed directly in a very strong solution of salt or vinegar. To avoid this, use weak solution at the start and increase gradually.
4.	**Softness and slipperiness**	It is the most common type of spoilage caused by the action of bacteria. Use of weak brine or improper covering with brine results in these defects. Thus this defect can be checked by using brine of proper strength and keeping the pickle well below the surface of the brine.
5.	**Bitter Taste**	It is due to the use of very strong vinegar or cooking the spices for a long time or by using spices in excess.
6.	**Scum formation**	It is due to growth of film yeast on the brine kept for curing of vegetables. The scum may be thin or thick varying from imperceptible film to a thick wrinkled layer. It retards the formation of a lactic acid and helps in the growth of putrefactive bacteria which makes the vegetable soft or slippery. The scum may be removed as soon as it is formed. Use of 1% acetic acid to the brine prevents the growth of wild yeast on

		the brine, without hindering the formation of lactic acid.
7.	**Cloudiness**	In many fermented solid vegetables like onion, cucumber, olives etc the vinegar becomes cloudy and turbid, thus spoiling the appearance of the product. It is due to non-penetration of acetic acid from vinegar deep in to the tissues to check the activity of bacteria or other micro organisms. This results in fermentation which make the vinegar cloudy. Use of brine and vinegar of proper strength prevents cloudiness.
8.	**Blemishes in pickles**	In onion pickle in brine, white blotch is seen under the first layer of the skin which is termed as blemish. Blemishes are generally caused by improper fermentation or non removal of all brine prior to the final pickling of cured onion in vinegar.

Chutney and sauces are the important products prepared from fruits and vegetables. Salt, spices, sugar, acid in these products is added to improve taste and to act as a preservative. These products are well known for their palatability and appetizing nature. Mango, apple, plum, apricot, tomato, carrot etc are the raw materials for these products. Mango chutney, plum chutney and mixed fruit chutney are quite popular. Fruit chutney is a product-made in the same way as that of jam except that spices, salt and vinegar are also added. Vinegar extract of the spices is added most preferably in place of whole spices. The chutney shall contain minimum of (40% fruit)(w/w) in the final product with total soluble solids not less than 50% and acidity not exceeding 2.1%. Sauces are also prepared from more or less similar ingredients and in same manner as chutney. Except the fruit pulp is sieved after cooking to remove the skin, seeds and stalks of vegetables; to give a smooth consistency to the final product. The consistency of sauce is comparatively thin than of fruit chutney. According to FPO specifications, the quantity of total soluble solids and acidity as acetic acid in the sauce shall not be less than 15% and 1.2% respectably. Sauces may be of two kinds. Thin sauces of low viscosity mainly consist of vinegar extracts of flavouring spices, herbs etc and thick sauces which are highly viscous.

Fruit Sauce:

A fruit sauce of better quality should be cooked to such a consistency that it can be poured freely without fruit tissues separating out in the bottle. The colour should be bright. The neck of jar/bottle should be covered with paraffin wax layer for airtight sealing.

Fruit chutney:

The recipe for preparation of fruit chutney from different fruits is given

in following table as a general guideline and method is discussed as under

Recipe for preparation of chutney from different fruits.

Recipe	Mango	Apple	Plum	Apricot	Papaya
Fruit slices/pulp, kg	1	1	1	1	1
Sugar, gm	750	750	750	1000	750
Cumin, black pepper, cinnamon, aniseed, g (each)	10	10	10	10	10
Cardamom (large), red chillies powder, g (each)	10	10	10	10	10
Salt, g	45	45	45	45	45
Onion chopped, g	50	250	50	50	100
Garlic chopped, g	15	15	15	10	15
Vinegar, ml	170	200	175	150	200
Clove (headless), No's	4-5	4-5	5	5	5
Sodium benzoate (ppm)	250	250	250	250	250

Procedure for preparing chutney

The fruit/vegetable is cut into slices of suitable size. Softened by dipping in boiling water. Slow cooking is preferred to yield better product than that of bristle heating at high temperature. Onion and garlic are added at the start to mellow their strong flavour. Spices are coarsely powdered and added. Spices can also be added by placing all ingredients in a cloth bags, loosely tied and placed in the mixture during cooking. Vinegar extract of spices can also be added. The vinegar is added just little before final stage of boiling. In place of vinegar, acetic acid can also be used as source of acidity. The product is cooked to a consistency of jam and filled hot into sterilized jars. The product can be pasteurized and processed at 820C for 30 minute. The storage of chutney in done at ambient temperature in cool and dry place.

Sweet mango chutney

Recipe

Mango slices (or) shreds – 1.0 kg, sugar (or) gur – 1.0 kg, salt – 45 g, onions (chopped) – 50 g, garlic (chopped)-15 g , ginger (chopped) – 15 g, red chilli powder – 10 g, black pepper, cardamom, cinnamon, cumin – 10 g each, cloves – 5 nos. and vinegar – 170 ml.

Process

Mature mangoes → washing → Peeling →Grating (or) slicing → cooking with a little water to make highly soft → Mixing with sugar and salt and

leaving for an hour → Keeping all ingredients (except vinegar) in cloth bag, tied loosely, putting in mixture and cooking on low flame →During cooking, spice bag pressed occasionally Cooking to consistency of jam (upto 105°C) with stirring occasionally → Removal of spice bag after squeezing → Addition of vinegar→ Cooking for 2-5 min. → Filling hot into bottles → Sealing (airtight) → Storage at ambient temperature.

PREPARATION OF SAUCES / KETCHUPS

Sauces are of thinner consistency as compared to ketchups and contain not less than 150B total soluble solid. Plum apple, papaya and mushroom etc are used successfully for preparation of sauces. High quality sauces are prepared by maceration of spices, herbs, fruits and vegetables in cold vinegar or by boiling. Thickening agents can also be added to sauces to prevent sedimentation of solid particles.

Recipe for preparation of sauces from different fruits

Recipe	Tomato	Apple	Plum	Mushroom	Papaya
Fruit pulp, kg	1	1	1	1	1
Sugar, g	75	250	100	75	50
Salt, g	10	10	20	25	14
Cardamom, red chilies powder, g (each)	5	10	10	5	5
Ginger chopped, g	10	100	25	10	10
Onion chopped, g	50	200	50	100	50
Garlic chopped, g	5	50	10	10	5
Acetic acid, ml	5	50	40	40	40
Aniseed powder, cumin, g (each)	10	15	10	10	10
Sodium benzoate, g/kg sauce	0.25	0.7	0.7	0.25	0.7

Apple sauce

Recipe : Apple – 1.0 kg, sugar – 250 g, salt – 10 g, onion (chopped) – 200 g, ginger (chopped) 100 g, garlic (chopped) - 50 g, red chillipowder – 10 g, cloves – 5 Nos. cinnamon, cardamom 15 g (each), vinegar – 50 ml, sodium benzoate – 0.7 g/kg of finished product.

Process

Apples → Washing → Peeling → Removal of core and seeds → Making into fine pulp → Straining of pulp → Cooking pulp with one third quantity of sugar → Putting spice bag in pulp and processing occasionally → Cooking to one - third of original volume of pulp → Removal of spice bag (after squeezing in pulp) →Adding remaining sugar and salt → Cooking to one – third its original volume → Addition of vinegar and preservative → Filling hot into bottles → Crown corking → Pasteurization at 85-90oC for 30 min. → Cooling → Storage at ambient temperature.

Tomato ketchup

Tomato ketchup 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 not less than 12% tomato solids and minimum of 25 % total soluble solids (w/w). The juice or puree prepared earlier can be used for preparation of tomato ketchup. Generalized recipe for preparation of tomato ketchup is as under:

Recipe for soup

Ingredient	Quantity
Tomato juice	1 litre
Onion (chopped)	35-40 g
Garlic (Chopped)	5-10 g
Red chillies powder	2-3 g
Spices (Cloves, cardamom, black pepper, cinnamon)	4 g (each)
Glacial acetic acid	2-3 ml
Sugar	20-30g
Salt	10 g
Benzoic acid	750 ppm

Method for preparation of tomato ketchup:

The tomato juice is concentrated with spices, salt, sugar etc. About 1/3 of the sugar is added initially at the time of commencing the boiling and the balance is added a little before the ketchup is ready. The sugar added initially helps to intensify and fix the red tomato colour. However, if whole sugar is added initially with the pulp, it will require the boiling of pulp for longer duration, which will adversely affect the colour of the ketchup. Salt is added towards the end of boiling, as otherwise, it bleaches the tomato colour. Spices are placed in the muslin cloth and cloth is placed in boiling mixture. At the

end cloth bag is pressed to squeeze the spices and cloth is taken out. Vinegar should be added when the ketchup has thickened sufficiently, so that the acid does not volatize away. Tomato ketchup generally contains 1.25-1.50% acid. The tomato ketchup is generally concentrated to 25-30% solids, out of which 12% solids are tomato solids. The ketchup is filled hot (88^{o}C) into pre-sterilized glass bottles, crown corked and processed for 30 minutes and cooled at room temperature. Tomato ketchup may also contain benzoic acid as preservative.

Topic:- 12MUSHROOM PROCESSING

Mushroom, a form of fleshy edible fungi is a rich source of high quality protein, minerals, folic acid and vitamins. Because of pleasant flavour, taste and freshness, mushroom are considered as an important delicacy in human diet. They are praised for their characteristic meaty biting texture and flavour.

White button mushroom (Agaricus bisporus), oyster mushroom or dhingri (Pleurotus sajorcaju) and paddy straw mushroom (Volvariella volvacea) are commercially cultivated in India. White button mushroom contributes more than 90% of the total production. However owing to high moisture content and delicate nature, mushroom are highly perishable and cannot be stored for more than 24 hours at ambient temperature. The deterioration is mainly caused due to their high metabolic activity, respiration rate and susceptibility to enzymatic browning. Drying, canning and freezing are the accepted methods for preservation of mushrooms and by converting into different products like pickle, chutney, soup etc their availability can be increased.

I. Canning of mushroom

White button mushrooms (Agaricus bisporus) are preferred over other types of mushroom for canning. Commercially mushrooms are canned in brine.

1. Sorting and grading: Diseased, damaged, bruised, shriveled and browned mushroom are discarded. Only the healthy white and tight buttons are selected and separated into two grades i.e. cap diameter up to 2.5cm with compact head as 'A' and cap diameter beyond 2.5 cm as 'B' grade.

2. Washing: Graded mushrooms are thoroughly washed 3-4 times in cold running water to remove dirt, soil etc without damaging or rubbing them excessively.

3. Blanching: To inhibit enzymes activity blanching in necessary. It also removes the air from the tissues of raw material to enable a satisfactory and uniform pack. Mushrooms are blanched in boiling water for 2-3 minutes followed by immediate cooling in water. The steam blanching is preferred because the blanching losses in boiling water have been estimated to be about 30 percent.

4. Filling of cans: For mushroom canning, lacquered cans (sulphur resistant) are recommended in order to avoid sulphur staining of canned mushroom. The blanched mushrooms are filled into cans to its declared drained weight i.e. 230 g in A 1 tall can and 430gm in A2½ can size.

5. Brining: After filling mushroom in cans, add hot brine solution having a ratio of 2% common salt, 1% sugar and 0.05 % citric acid. Fill upto the brim of the can. Brining adds flavour to the product, reduces processing time and helps in increasing the shelf-life of canned mushroom.

6. Exhausting: After brining, cans are exhausted to remove any entrapped air and other occluded gases from the product to ensure longer shelf-life. Cans filled with brine solution are fed to the exhaust box for a specified period of time depending upon the length of exhaust tunnel and size of can. Exhausting can also be performed by placing the filled cans in boiling water till temperature of the centre of can reaches 85-900C for 1-2 minutes.

7. Double Seaming /can closing: Immediately after exhausting cans are sealed with the help of double seamer to get the hermetic seam. Sealed cans are then placed in upside down position to sterilize the coded lids.

8. Processing/sterilization: Processing is also designated as sterilization is an indispensable unit operation in canning. This is accomplished by processing the hermetically sealed cans at a pressure of 15 lbs psi for a specified period of time depending upon the size of the can and altitude of processing place. However for A1 tall and A21/2 size cans, processing is required for 35 and 45 minute respectively.

9. Cooling: Cooling of cans is done immediately after sterilization in cold running water to room temperature in order to give an abrupt shock to the micro-organisms to get rid of their adverse activities.

10. Labeling and storage: The cooled cans are stored in a cool and dry place and smeared with grease to remove any adhering moisture from the can body to avoid rusting. Cans are kept at ambient temperature for 8-10 days to check any swell, leakage, puffing and other disorders before labeling. Before the cans are exposed for sale, proper labeling is done to meet statutory requirements of Indian Food Laws.

II. Mushroom pickle in oil

Recipe for pickle

Ingredient	Quantity
Mushroom	1kg
Salt	100 g
Red chillies Powder	10 g

Turmeric powder	10 g
Coriander powder	10 g
Aniseed and cumin powder	5 g (each)
Spices (fenugreek, black pepper, cinnamon powder)	2 g (each)
Garlic chopped/paste	20 g
Onion chopped	100 g
Vinegar	80-100 ml
Mustard oil	200 g

Method for mushroom pickling:

Wash and cut mushroom into pieces. Blanch by holding the pieces in muslin cloth in boiling water containing salt for 3-4 minutes followed by immersing in cold water. Remove excessive moisture by spreading the pieces on a muslin cloth. Fry onion garlic and ginger in oil, mix other ingredients and mushrooms except vinegar and mix thoroughly. Add vinegar and pack in a clean jar.

II. Mushroom soup

Recipe for soup

Ingredient	**Quantity**
Mushroom	1kg
Salt	30 g
Red chillies powder, cardamom, fenugreek, black pepper, cinnamon powder	5 g (each)
Butter	100 g
Wheat flour (maida)	12 g (each)
Vinegar	20-30 ml
Milk	200 ml

Preparation of mushroom soup:

Take fresh mushroom and wash in water and mash in blender. Pass slurry through an aluminum or plastic sieve to remove the fibrous portion. Melt the butter in a pan and fry the slurry till it is just brown. Add wheat flour, spices and milk to the mixture. Boil the whole mass to a reasonable

consistency. After this process, the soup is ready for use. Fill boiling hot soup into the cans and process in a similar way as explained under canning of mushroom.

IV. Mushroom sauce

Recipe

Ingredient	Quantity
Mushroom	1kg
Salt	20 g
Red chillies powder	10 g
Cardamom powder	5 g
Dry ginger powder	5 g
Garlic paste	2 g
Mace	4 g
Vinegar	100 ml

Preparation of mushroom sauce

1. Wash the mushroom thoroughly. Keep them in porcelain or an enameled can for 12hr after sprinkling with salt, alternatively dip the mushroom in vinegar.
2. Blend the soaked or salted mushroom into fine slurry.
3. Add vinegar and spices.
4. Heat the mass till it thickens to the consistency of sauce.
5. Fill hot in sauce bottles and seal with crown corks.
6. Sterilize for 30 minutes at 82-85^{0}C.
7. Store in cool and dry place.

V. Mushroom chutney

Recipe

Ingredient	Quantity
Mushroom	1kg
Sugar	250 g
Salt	100 g
Red chillies Powder	5 g
Ginger chopped	75 g
Aniseed and cumin powder	5 g (each)

Spices (fenugreek, black pepper, cinnamon powder)	2 g (each)
Garlic chopped/paste	25 g
Onion chopped	100 g
Vinegar	10-15 ml
Mustard oil	100 g

Preparation of mushroom chutney:

The mushrooms are thoroughly washed in water and cut into small pieces and cooked with a small quantity (100-150ml/kg) of water in a pressure cooker for 15-20 minute. Chopped onion, garlic and ginger are fried in oil and mixed with mushrooms, cook until the whole mass thickness (30-45 minutes). Now add spices and cook for 2-3 minutes. Finally, add sodium benzoate (dissolved in small amount of water) and acetic acid. Final TSS should be in the range of 55-58^{o}Brix. Pack the material in clean glass container while still hot.

VI. Dehydration of mushroom

Material required

Ingredient	Quantity
Mushroom	10kg
Potassium meta-bi-sulphite	150gm
Citric acid	20gm

Method for mushroom dehydration

1. Select sound white button mushroom and wash the fresh produce thoroughly in running cold water and then in salt and 0.1% KMS.
2. Cut into two equal halves longitudinally and wash again quickly in running cold water. If desired these can also be kept as such without cutting into halves. Keep the mushroom in 2 % salt water to check browning.
3. Blanch in boiling water for 4-5 minutes.
4. Cool immediately in cold water.
5. Steep the blanched mushrooms in water containing 1.5% potassium meta-bi-sulphite + 0.2% citric acid for 30 to 45 minutes.
6. Drain the mushroom and wash with water thoroughly.
7. Dry the product by placing over trays.
8. Place the loaded trays in dehydrator maintaining 60^{o}C temperature for 6-8 hours.
9. Pack in polyethylene bag.

Note: Dhingri can also be dried by using this method.

Topic:- 13 PROCESSING OF PLANTAION CROPS

Plantation crops are high value industrial crops grown in the tropics having great economic importance. They have great potential for utilization of waste land like rainfed dry land, hilly, arid and coastal areas to provide nutritional security, earn foreign exchange and to ensure livelihood security. The major plantation crops grown in India are tea (Camellia sinensis L), coffee (Coffea arabica L.), rubber (Hevea brasiliensis), coconut (Cocos nucifera), arecanut (Areca catechu L.), oilpalm (Elaeis guinensis), cashewnut (Anacardium occidentale L.) and cocoa (Theobroma cacao L.). India is the leading producer of most of these plantation crops. Among all fruit crops, the processing plays an important role in plantation crops as they are generally consumed only after processing. Coconut, arecanut, cashewnut, black pepper and cardamom are known as small holder plantations whereas, crops like rubber, tea and coffee are known as estate crops or conventional plantation crop.

A. TEA (Camellia sinensis L)

Tea is an evergreen woody perennial grown in many Asian countries including China, Japan, Java, Sumatra and India. Tea belongs to family Camelliaceae. 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 followed 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 broadly involves picking, withering, rolling, oxidation/fermentation, drying and curing/ageing. The steps involved are as follow:

1**. Picking:**

Tea leaves and flushes, which include a terminal bud and two young leaves, are plucked from Camellia sinensis bushes twice a year during early spring and early summer or late spring. Generally hand picking is preferred for picking of tea leaves. Hand picking is done by pulling flush with a snap of wrist and does not involve twisting or pinching of flush, as twisting generally reduce the quality of leaves. Machine picking results in more broken leaves and is not suitable on mountain slopes where tea is grown.

2. Withering:

Withering is used to remove excess water from the leaves and sometimes loose more than a quarter of their weight. Newly picked leaves are thinly spread in the sun or left in a cool breezy room to pull moisture out from the leaves. Heated air is sometimes forced over the leaves if the climate is not

suitable. By the end of this process, the leaves become pliable enough for rolling. In order to quicken the oxidation process, the leaves may be bruised by tumbling in baskets or rolled-over by heavy wheels. The main purpose of this process is the partial expulsion of moisture and thus saving fuel consumed in drying operation and allows a very light oxidation.

3. Rolling:

From the withering racks, the leaves are twisted and rolled 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. The leaves can be rolled with rolling machine or by hand.

a) CTC processing: The CTC (crush, tear, curl) machine consists of two cylindrical rollers (61 or 91 cm long and 20 cm in diameter) having stainless steel segment having fine tooth like sharp ridges (3-4 ridges/cm in lengthwise and 50-60 ridges over circumference). The rollers are having marginal clearance and rotate in opposite direction at different speed in the ratio of 1:10 between slow: high speed rollers. The speed of 70:700 and 100:1000 rpm have good effects. The crush, tear and curl (CTC) maceration takes only few minutes.

b) Orthodox processing: The rolling is done normally in 36" or 46" diameter rollers. A tea roller consists of 3 main parts; a table fitted with cones and battens, a bottomless jacket and pressure cup fitted with adjusting screw to enable pressure to be applied to a desired extent. The roller may be table or jacket moving, normally rotates at 45 rpm speed. The battens are provided to form obstruction in the leaf path. It increases frictional effect of roller table and breaks the leaf at the same time. Battens help in cutting the leaves in roller. The cone fitted at centre of table intensifies leaf circulation by causing a greater turning action provided by batten alone. 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.

4. Oxidation/fermentation:

Oxidation begins once the leaf membranes are broken down enzymatically during the rolling process. It is an important stage in black tea processing. During this stage, the most important properties of tea are produced. It is a chemical process where oxygen is absorbed and the leaves turn progressively darker. The tannins are released and transformed during this process. Oxidation causes the leaves to turn bright copper in colour. This process is the main deciding factor to prepare different types of teas like Green, Oolong or Black tea. 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 (200C) and high humidity (95%) are desirable.

5. Kill-green and shaping:

After oxidation, kill-green is done to stop tea leaf oxidation at a desired level. Heating tea leaves moderately deactivate their oxidative enzymes without destroying tea flavour. The leaves after kill-green are allowed to be lightly heated in a closed container, which causes the previously green leaves to turn yellow. The damp tea leaves are then rolled to be formed into wrinkle strips.

6. Drying:

The leaves are then dried evenly and thoroughly without burning. Drying of leaves stops the oxidation process. The main objective of drying is to arrest fermentation and to remove moisture and produce good quality tea. This can be done in different ways including conventional drying, fluidized bed drying and air drying or baking. Curing/ageing: Curing is not required for all types of teas however, some type of teas require additional aging or secondary fermentation to enrich their drinking potential. Flavoured teas are manufactured by spraying with aromas - and flavours or by storing them with their flavourants.

Different types of tea:

On the basis of manufacturing method, commercial tea is broadly classified as black tea, green tea, oolong tea, yellow tea etc. The basic difference is in the degree of fermentation adopted during manufacturing of tea from the Camellia sinensis evergreen plant. Brief detail about type of teas is as under:

1. Black tea:

Black tea is the most common form of tea in Southern Asia (Sri Lanka, India, Pakistan, Bangladesh etc.) and many African countries including Kenya, Rwanda, Malawi and Zimbabwe. The Black tea process goes through the most stages of processing like withering, leaf maceration, fermentation, drying and grading. After picking, the leaves are left to wither for several hours and allowed to oxidize completely. Rolling or maceration is done to bruise and disrupt the leaf cell structures to release the oil which aid in oxidation. The last step consists of placing the leaves in an oven with temperature reaching up to 93.3oC. When the leaves are 80% dry, the leaves complete their drying over wood fires. The final product is sorted accordingly to size, the larger size is considered "leaf grade," and smaller size "broken grade" which are usually used for tea bags. Black tea is further classified as either orthodox or crush, tear and curl (CTC) process tea.

2. Green tea:

Green tea undergoes least amount of oxidation and the oxidation process is halted by quick application of heat, either with steam or by dry cooking in hot pans. Steaming of the leaves is done to prevent the leaves changing their colour from green to black and to inactivate the enzyme. It is

followed by rolling. The leaves retain much of its original green colour especially the finer leaves whereas the older leaves have a blackish gray colour. For drying, the leaves are either stacked in hot air rack driers or are exposed to natural heat of sunlight. The tea is processed within one to two days of harvesting and retains most of the chemical composition of the fresh leaves in tea if processed properly.

3. Oolong tea:

It is partially fermented tea. Oxidation is stopped somewhere between the standards for green and black tea. The fermentation period is short to change the colour of the leaf completely. The processing typically takes two to three days from withering to drying with a relatively short oxidation period. It is partially blackened. In oolong tea, the outer edge of the tea leaf is fermented while heart of leaf remains unfermented. The beverage is intermediate between those produced from green and black tea. The term "oolong" is used specifically as a name for certain semi-oxidized teas.

4. White tea:

White tea is produced in lesser quantities than most other styles and is therefore, more expensive than tea from the same plant processed by other methods. It is mostly produced in China and is classified as organic or premium tea. It is produced from the young leaves or new growing buds that have undergone minimal oxidation. The oxidation is halted after a slight amount of wilting with heat. Leaf buds processed into white tea are usually dried immediately after wilting/withering.

5. Yellow tea:

Yellow tea is processed in a similar manner to green tea but instead of immediate drying, leaves are stacked, covered and gently heated in a humid environment. This initiates oxidation in the chlorophyll of the leaves through non-enzymatic and non-microbial means, which results in a yellowish or greenish-yellow colour. This tea is popular in Japanese tea ceremonies due to its appearance and distinctive flavour.

B. COFFEE

Coffee is an important beverage used all over the world. Brazil and Columbia are the largest coffee producers in the world. Coffea arabica accounts for 75-80% of world production. The domestic consumption of coffee in India stands at 85,000 tonnes valued at about Rs 2292 crores. Coffee is harvested during dry season when the coffee cherries are bright red, glossy and firm. Picking is done by hand or by using machine. After picking, the coffee can be prepared either by dry method which produces natural coffee or by wet method which produces washed coffee.

Coffee is harvested in one of two ways:

a) Strip picked: The entire crop is harvested at one time. This can either be done by machine or by hand. In either case, all of the berries are stripped off of the branch at one time.

b) Selectively picked: In this method, only the ripe berries are picked individually by hand. Pickers rotate among the trees every 8-10 days, choosing only the cherries which are at the peak of ripeness. This method being labour intensive and costly is used primarily to harvest the finer arabica beans.

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 processing of coffee includes; dry method and wet method to produce unwashed and washed coffee respectively.

1. 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.

2. 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.

3. 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^{o}C and in this process the beans are kept moving to avoid burning. When the bean temperature reaches 209^{o}C they start turning dark brown and oil (called coffee oil or caffeol or coffee essence) start to emerge. This process

is called Pyrolysis is the heart of roasting, as it produces aroma and flavour of coffee. After roasting, beans are cooled by air or water. The cooling must be quick in order to preserve the flavour, aroma and keeping quality.

4. 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.

5. 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.

6. 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. There is a prominent segment of consumer preferring decaffeinated coffee owing to health consciousness.

2. Estate Coffee: Production of good quality coffee by highlighting special features of estate can be classified as estate branded coffee. The estate coffee are generally more expensive and actually define the specialty coffee market.

3. Monsooned Coffee: These are prepared by the special natural process which possesses a special monsooned flavour, mellow taste and golden look. It is also produced in India. It is graded as Monsooned Malabar AA, Monsooned Basanally and Monsooned Robusta AA.

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) due to slower development of beans is called high grown coffee. 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. Arabica plantation coffee (worked coffee) is grown in the Mysore, Coorag and Billigiris regions. It is a premium coffee that represents the best quality coffee in India.

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.

C. COCOA

Cocoa (Theobroma cacao L. family Sterculiaceae) beans are the primary raw material for confectioneries, beverages, chocolates and other edible products. Cocoa powder, butter and chocolate are the major products.

The harvesting of cocoa pods is done at 7-10 days interval and the harvested pods may be kept for 2-4 days before they are opened for fermentation. Hitting pods against hard surface may be adopted for opening of pods. The main characteristics of cocoa beans are initial moisture contents (52-55%), final moisture content (6-8%), fat contents (55-58%) and acidity of 5.8 percent. The pod husk contains 6-8% crude protein and 24-56% crude fibre.

Processing of cocoa:

Curing is the process by which cocoa beans are prepared for the market. Curing involves two unit operations; fermentation followed by drying. Fermentation involves keeping cocoa beans well insulated so that heat is retained whole, at the same time air is allowed to pass through the mass. The process lasts up to 7 days and immediately followed by drying. The flavour of cocoa is developed only when it undergoes fermentation.

1. Fermentation:

Fermentation of cocoa beans is essential to remove mucilaginous pulp, to develop flavour and aroma precursors, reduce bitterness, kill germ of seed and to loosen the testa. The cocoa pods after harvesting are cautiously opened. The beans and the mucilage are scooped out and subjected to natural fermentation. They are piled in heaps in perforated wooden bins for a period of 3-12 days. The heat produced during fermentation raise the temperature to about 45-60oC. The fermentation is complete when temperature of mass begins to fall. At the end of fermentation, the pulp breaks down and the seed colour change from pale yellow to violet to brown. For fermentation the heap, box, tray and basket methods can be followed.

2. Drying:

The fermented beans contain 33% moisture. They are dried to reduce moisture to 6-8% in sun or hot air dryers. During this process, the colour of the shell changes to dark brown. The dried beans are packed in polyethylene lined gunny bags and stored in a cool and dry place. The dried beans can be used for manufacture of different products

Chocolate from cocoa beans

Important steps used for making chocolate from dry cocoa beans include roasting, grinding, refining, conching and tempering.

1. Roasting: The dried beans are cleaned, sorted and roasted at 150-160oC for 40-50 minutes. Roasting develops characteristic flavour and colour. It also causes changes in chemical structure of polyphenols producing less astringency compound.

2. Shelling: Shelling is done to remove the shells from the beans and grains become regular in size. Shelling is carried and by milling, sifting and winnowing. Shelled beans can be made into fine, smooth chocolate.

3. Milling: The roasted, shells and crushed beans are milled to reduce them to even finer particles.

4. Refining: Refining converts the milled particles into liquid cocoa mass created as cocoa butter in the beans binds dry particles.

5. Conching: Conching involves powerful machines called conches to stir the chocolate in a controlled way. It is done in two steps.

Dry conching: The chocolate is slowly stirred at above 80oC temperature to remove any residual moisture and improve viscosity.

Liquod conching: It is followed immediately after dry conching in the same conch without stopping the machine to affect the texture and creaminess. Little quantity of cocoa butter is also added in the process.

6. Tempering: it is done to transform liquid or semisolid chocolate into a solid. Chocolate is heated to melt the cocoa butter crystals and then cooled carefully. Properly tempered chocolate is smooth and glossy and produces smooth texture in mouth with good flavour and aroma.

D. ARECANUT (Areca catechu L.)

Arecanut 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 45-750C.

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.

E. 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 170-200oC 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 70-800C 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 CO2 with help of vita pack process. This consists of removing all air from can and substituting it with CO2 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 450Brix and is increased @ 50Brix for 4 days and then @ 100Brix for 6th and 7th day so that the final strength of syrup reaches to 700Brix. 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.

F. 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.

Copra

Coconut oil

Raw kernel

Coconut cake

Tender coconut water

Coconut toddy

Coconut shell based products

Coconut wood based products

Coconut leaves

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.

G. 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 Fig 15.3 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 104-110oC.

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.

H. RUBBER (Hevea brasiliensis)

Rubber 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 inot 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 H2SO4, 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 pre-coagulation 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 40-60oC. 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 typesof crepe rubber depends upon which the raw material used.

i) 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.

ii) 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.

a) Estate brown crepe: It is made from the cup lumps and other higher grades of field coagulum.

b) Thin brown crepe: It is made from wet slab coagulum as starting material.

c) Thick blanket crepe: it is made from wet slabs, unsmoked sheets or other high grade scraps.

d**) Smoked blanket crepe:** It is derived from ribbed smoked sheets or cuttings

e) 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.

Topic:- 14 SPOIAGE IN PRCESSED FOOD

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 25-30oC with maximum limit up to 35-47oC. 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 25-30oC but some can grow at 37oC 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 20-53oC. On the basis of temperature requirement, bacteria are categorized as thermophiles (requiring temperature higher than 45oC), mesophiles (requiring temperature between 20-25oC) and psychrophiles (requiring temperature less than 20oC).

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 (4oC). The deterioration includes off-colour development, surface biting and various forms of decay. Thus banana, tomato, lemons etc are stored above 10oC 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 B2, 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: The spoilage of canned products during storage may be caused due to two main reasons:

Chemical reaction on the can producing hydrogen swells or perforations, and

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.

III Causes of spoilage of canned/bottled products

Food is mostly subjected to physical, chemical and biological changes which lead to quality deterioration and ultimately spoilage.

1. Chemical spoilage: Hydrogen swell is the important type of chemical spoilage of canned food. The hydrogen gas formed inside the can, by the action of food acid on the iron of the can causes the can to swell which is termed as Hydrogen swell. Major causes of hydrogen swell are:

Presence of high acid in the can.

Storage at high temperature.

Imperfections in tinning and lacquering inside of the can.

Insufficient exhausting during canning.

Presence of soluble sulphur and phosphorus in the can contents.

Interaction between steel base of can and contents of the food leading to chemical spoilage and may also cause following defects:

discolouration of the food

discolouration inside the can

production of off flavour in the food

cloudiness of liquors or syrups or brines

corrosion or perforation of the metal and loss of nutritive quality.

2. Biological spoilage: Biological spoilage in the canned food is caused by either survival of organisms after heat treatment or entry of micro-organisms through leakage of the container after heat processing. The types of micro-organisms involved in spoilage of canned foods are thermophilic bacteria and mesophilic micro-organism and kind of spoilage brought about by these groups is characterized and discussed further in this chapter.

A) Spoilage by mesophilic organisms: This type of spoilage is caused by spore forming bacteria of genera Bacillus and Clostridium growing in the food as a result of under processing. Besides, spoilage of lightly heated food like acidic foods can also be caused by non-spore forming bacteria or even yeasts or moulds. Spoilage by mesophilic Clostridium & Bacillus sp. and sugar fermenting species of Clostridium like Clostridium butyricum and Clostridium pasteurianum cause the butyric acid type of fermentation in acid or medium-acid foods. This lead to swelling of container due to the production of hydrogen gas and carbon-dioxide gas. The mesophilic organisms responsible for spoilage are as under:

Putrefactive anaerobes

Butyric anaerobes

Aciduric Flat sour and Lactobacilli

Yeast

Moulds

i) Putrefactive anaerobes: The species of Clostridium like C. sporogenes, C. putrefaciens and C. botulinum are proteolytic or putrefactive causing decomposition of proteins with the production of off odorous compounds such as hydrogen sulphide, and ammonia. Besides, putrefactive anaerobes also produce carbon dioxide and hydrogen gas, thus causing the can to swell. The spores of some putrefactive anaerobes are very heat resistant thus putrefaction along with flat sour and TA (thermophilic anaerobes) spoilage constitutes the major type of biological spoilage of canned foods resulting from under processing. Putrefactive anaerobes grow best in the low acid canned

foods like peas, corn, meats, fish and poultry. C. botulinum is main putrifier causing food poisoning.

ii) Butyric anaerobes: The spores of saccharolytic Clostridia commonly called as butyrics having comparatively low heat resistance, cause spoilage of canned foods which have been processed at 100oC or less such as commercially canned acid foods processed by hot water or steam. Canned acid foods such as pineapple, tomato and pears are generally spoiled by Clostridium pasteurianum. The spoilage by Saccharolytic bacteria is characterized by the production of butyric acid, carbon dioxide and hydrogen. Similarly, canned peas, asparagus, spinach, peach and tomatoes can be spoiled by aerobacilli or gas forming Bacillus species (B. polymyxa and B. macerans) by entering possibly through the leakage in the container. The heat resistance of Bacillus sp. is same as that of Clostridium pasteurianum.

iii) Aciduric flat sour and Lactobacilli: It is also referred as spoilage by non-spore forming bacteria. The presence of viable non-spore forming bacteria in the canned food indicates that the product has received either a very mild heat treatment or the bacteria entered through a leakage in the container. Common micro-organisms found in under processed fruit products such as tomato and pear includes acid forming Lactobacillus and Leuconostoc species. Some thermoduric bacteria which can withstand pasteurization are Streptococcus thermophillus, some species of Micrococcus, Lactobacillus and Microbacterium. An important bacterium found in cooling water is coliform bacteria, which produce gas and cause the can to swell. However, spore forming bacteria can also enter the can through the leakage. Further non-spore forming and non-gas forming bacteria that may enter the can through leakage include those in the genera Pseudomonas, Alcaligenes, Micrococcus, Flavobacterium, Proteus etc.

iv) Spoilage by yeast: Detection of yeasts and their spores in the canned foods is the result of either gross under processing or leakage as the yeasts and their spores are readily killed by most heat processing methods. Canned fruits, jams, jellies, fruit juices, syrups etc are generally spoiled by fermentative yeasts, with swelling of the cans owing to the production of carbon dioxide. Presence and growth of film yeasts on the pickles, olives etc. indicates contamination, lack of heat processing and poor evacuation.

v) Spoilage by moulds: Growth of moulds is the common cause of spoilage of high sugar containing processed and canned foods as they enter through a leak in seal of the container. Though jams, jellies and marmalade having sugar concentration as high as 70% with normal acidity of 0.8 to 1.0%, practically removes the risk of mould spoilage yet sometimes mould growth

can be seen on the surface of the product. Strains of Aspergillus, Penicillium and Citromyces found growing in jellies and canned fruits are able to grow in sugar concentration up to 67.5 percent but can be killed by heating the food at 90oC for 1 minute. Some moulds are fairly resistant to heat like Byssochlamus fulva, a pectin fermenting moulds which resist the heat processing.

B) Spoilage by thermophilic organisms

Major cause of spoilage of heat processed foods by thermophilic spore is due to under processing as their spores are more heat resistant than those of mesophilic bacteria. Spoilage by thermophiles includes flat sour, TA spoilage and sulphide spoilage.

i) Flat sour spoilage: In this kind of spoilage, the ends of the can of food remain flat during souring or during the development of lactic acid in the food by the flat sour bacteria. Due to normal appearance of the can, this type of spoilage can not be detected by the examination of the unopened can. Flat sour spoilage occurs in low-acid foods such as peas, lima bean and corn etc and is caused by species of Bacillus which form acid without production of gas. They include mesophiles, facultative thermophiles or obligate thermophiles. In acidic foods like tomato and tomato juice, flat sour is caused by facultative thermophilic species such as Bacillus coagulans. The spores of mesophiles being least heat resistant are killed by heat processing and are therefore not involved in flat sour spoilage of low acid foods, but the spores of thermophiles are considerably more heat resistant and survive the heat process to cause flat sour spoilage.

ii) TA spoilage: TA is a nick name for the bacterium thermophillic anaerobe not producing hydrogen sulphide or for Clostridium thermo-saccharolyticum causing this type of spoilage. This bacterium is a thermophilic spore-forming anaerobe that forms acid and gas in foods. The gas (mixture of CO2 and H2) developing inside the container cause the can to swell and when cans are stored for too long at high temperature they may result in bursting. The spoiled food has sour or cheesy odour. The source of bacteria for both flat sour and TA spoilage is starchy/sugary foods.

iii) Sulphide spoilage: TA spoilage producing H2S and cause sulphide spoilage. The micro-organism responsible for sulphide spoilage is Desulfotomaculum nigrificans and is found in low acid foods like peas and corn. The spores of this bacterium are less heat resistant than those of flat sour and TA bacteria; as such the appearance of sulphide spoilage in canned food is the indication of gross under-processing.

C). Classification of microbial spoilage on the basis of acidity

The low acid food with pH above 5.3 is subject to flat sour spoilage and putrefaction. Medium acid foods with pH between 5.3 and 4.5 are likely to undergo TA spoilage. Acid food with pH between 4.5 and 3.7 are spoiled by special flat sour bacterium or by saccharolytic anaerobe. However, high acid food with a pH below 3.7 generally does not undergo spoilage by bacteria, but in the cans it may result in hydrogen swell. The type of the spoilage in the canned food can be classified on the basis of acidity of the food.

Classification of microbial spoilage based on acidity of the food

Type of food	Foods involved	Type of spoilage
Low acid pH $\geq$ 5.4 Medium acid pH 5.3-4.6	Meat and fish products milk, vegetables like corn, lima beans, peas, meat and vegetable mixers.	Thermophilic flat sour group. (*Bacillus sterothermophilus, B. coagulans*). Sulphide spoilage (*Clostridium nigrificans, C. bifermentans*). Gas formers (*Clostridium thermosaccharolyticum).* Mesophilic spoilage like putrefactive anaerobe. Spoilage and toxin production by *Clostridium botulinum.*
Acid food pH 3.7-4.6	Fruits, pears, figs, tomato etc.	Thermophilic spoiler *Bacillus coagulans* Mesophilic spoiler *B. polymyxa, Clostridium pasteurianum, C. butyricum, Lactobacilli* etc.
High acid pH<3.7	Fruits like grape fruit, citrus, rhubarb etc and products like sauerkraut, pickles etc.	Non-spore forming mesophiles, yeast, mould and/or lactic acid bacteria.

Discolouration of fruit products

Besides microbial spoilage, the processed products may experience discolouration, which may be caused by various reactions brought by the action of enzymes, metallic contamination or through the reaction between different components.

i) Enzymatic browning: Browning of cut and peeled apples, potatoes and pears is caused by the oxidation of phenolic compounds brought about by the action of oxidase enzyme (Polyphenol oxidase) in the presence of air. The browning can be checked by placing the cut and peeled fruit in 2-3% NaCl solution until used for canning.

ii) Non-enzymatic browning: Browning of fruit products brought out by the reactions other than enzymes is called as non-enzymatic browning. The changes in colour of fruit products may be caused by reactions between i) nitrogenous matter and sugar ii) nitrogenous matter and organic acids iii) sugar and organic acids and iv) organic acids among themselves like ascorbic acid degradation and sugar degradation. The browning reactions between nitrogenous matter and sugar are known as Maillard reactions.

iii) Metallic contamination: The browning of canned fruit products is generally caused by the presence of iron and copper salts. Important metallic contaminations in fruit products include ferric tannate, iron sulphide, copper sulphide etc.

a) Ferric tannate: The natural tannins present in fruit and vegetables react with the iron of the tinplate of can to form ferric tannate which make the product black and spoils the appearance of the canned product.

b) Iron sulphide: Sulphur dioxide may be formed inside the can due to decomposition of protein in the product or it may come from the sulphited sugar used in canning. The SO2 may react with hydrogen formed by the fruit acid acting on the tin plate and get reduced to H2S, which in turn may react with the iron of the can and form the black iron sulphide. Ferrous sulphide releases obnoxious smell of H2S, besides spoiling the appearance of product.

c) Copper sulphide: The copper from the plant and equipment made of copper or brass may find its entry into the product and such product when comes in contact with H2S formed inside the can may form black copper sulphide, which causes discolouration of the product.

d) Black deposit in canned pumpkin. The amino compounds present in the pumpkin react with the iron of the can forming deposits in the canned product.

e) Discoloration in canned corn. Canned corn turns grey in colour. This is due to the formation of sulphides of iron and copper as a result of corrosion of the tin plate and tarnishing of the metal of the equipment, respectively. To prevent it only 'C-enamel' cans should be used.

f) Black deposit in canned fruits. In the case of fruits canned in syrups prepared from sugar, which sometimes contain sulphur dioxide, cause blackening of the tin plate due to the formation of iron sulphide.

g) Pink discoloration in canned pears, guava and peaches. Pears, peaches and guava turn pink, if the cans are not cooled properly after sterilization.

Thus major cause of spoilage of canned products are under processing, cooling of cans in contaminated water, defects in seaming operation, use of non-lacquered cans in some products etc which may be avoided during processing of canned products.

Quality control

Quality is a measure of the degree of excellence or degree of acceptability by the consumer. It is also defined as the combination of attributes or characteristics of the products that has significance in determining the degree of acceptability of the product to a user. Industry defines quality as the measure of purity, strength, flavour, colour, size, maturity, workmanship or any other distinctive attribute or characteristics of the product. The quality standards of fresh and processed fruit or vegetable products vary with their intended use. For marketing purposes; size, attractiveness, maturity, organoleptic quality and freedom from defects are to be kept in mind. While for processing, physico-chemical attributes of raw material such as presence of soluble solids, development of uniform colour, flavour, juiciness, uniform maturity, tenderness in some vegetables etc are taken into consideration. During processing of fruit or vegetables into value added products; colour, flavour and texture etc also become important.

Quality standards: Common standards used for measuring product quality are:

Legal standards

Voluntary standards

Industry standards

Consumer oriented or Grade standards

1. Legal standards: These are the standards commonly established by the central or state or local agencies like corporation, municipal committees etc and are usually mandatory. These mandatory standards are established by law or through regulations for maintaining quality. Legal standards are generally concerned with freedom from adulteration and mostly include insects, moulds, yeasts, residual pesticides and maximum limits of additives allowed or established specific condition in processing so that foods are not contaminated with extraneous matter. Examples of legal standards include Food Safety and Standards Act, 2006 (FSSA), Food Safety and Standards Rules, 2011 and Food Safety and Standards Regulations, Food and Drug Administration Act (FDA) etc. Minimum standards of quality for establishment of unit, labeling and packaging, and physico-chemical attributes for different food products are specified under FSSA, (2006) and

Food Safety and Standards Regulations, (2011) which arte mandatory to be followed for any food business operations.

2. Voluntary standards: These represent the standards recommended by various segments of the food industry. Company standards generally represent the consumer image and may become trade mark or symbol of product quality. Mostly these standards are used by private firms and tend to vary depending upon the organization. Companies like pepsi, kissan and coca cola, etc sets their own standards for different products.

3. Industrial standards: These are the standards where an organized group attempts to establish certain limits of quality for any given commodity. Generally these become effective by pressure from marketing organization for specific commodities, where the legal standards are not involved.

4. Consumer oriented or grade standards: These standards represent the consumer requirement of particular product and are based on experience. For example few consumers do not prefer a product with preservatives.

Methods for determining quality

A. Objective methods

B. Subjective methods

A. Objective methods: Objective methods of quality evaluation are based on observation from which the attitude of investigator is entirely excluded. They are based on recognized standards, scientific tests and are applicable to any sample of the product without regard to its previous history or ultimate aim. They represent the modern ideas in quality control because the human element is completely excluded.

Objectives methods are of three types i.e., Physical methods;, chemical methods and microscopic methods.

1. Physical methods: These are the quicker methods and require least training for the evaluator. They include visual appearance, colour, texture, consistency, size, shape or some process variables like head space, fill, vacuum, drain weight etc. The colour of the food products can be measured using calorimeter, tintometer or Hunter colour difference meter. While texture can be determined by using texture analyser or firmness of fruit is estimated

by penetrometer. On the basis of texture profile, the product can be classified as chewy, grainy, crispy, mealy etc. These methods are called as instrumental methods. Detail of common method used in fresh and processed products is shown in Table 16.1.

2. Chemical methods: These are the standard analytical methods and are used for quantitative chemical evaluation of nutritive value and quality levels. However, such analytical methods are lengthy, tedious and expensive. For routine analyses quick tests are developed like pH, acidity, TSS, jellification etc. Detail of some method used in fruit products is shown in Table 16.1.

3. Microscopic methods: They are also called as microbiological methods. They are used extensively in quality control programmes but require considerable training for proper interpretation of results. Two types of microscopic methods are:

a) To check adulteration and contamination of product with mould, yeast, bacteria, insect excreta etc.

b) Differentiate between cell type, tissue type and identification of micro-organisms in fresh and processed products.

B. Subjective method: In subjective method, the quality evaluation is based on the opinion of the investigator. It is usually a physiological reaction which is a result of past experience, training, individual preference and power of perception. These methods are subjective because an individual is required to give his opinion for quantitative and qualitative value of characteristics. These methods involve the use of sense organs and are thus called as sensory methods. Sensory perception includes colour, flavour, odour, taste, touch etc. The food is selected by making use of all physical senses like sense of sight, touch, smell, taste and even hearing. The snap of chip, crackle of a breakfast cereal, crunch of apple or celery are textural characters.

Objective of quality control

Control over raw materials by setting up specifications

Improvement of product quality

Improvement in processing methods by reducing cost of production and improving profits

Standardization of the finished product according to label specifications

Maintenance of sanitary conditions in the plant

Greater consumer confidence towards quality of the product

Factors affecting quality

Quality of processed fruit and vegetables is affected by the following basic factors, either individually or in combination.

(1) Cultivar: It is an important factor for producing quality product. The varieties/cultivars differ in size, shape, colour and chemical composition. High yield, attractive appearance and good shipping and keeping quality are the important characters taken in to consideration.

(**2) Cultural practices:** These include organic matter, moisture, fertilizer, method of cultivation, irrigation and pest control methods. Any of these factors may be the limiting factor in producing a quality processed product. The best example of a limiting quality factor is the use of insecticides that give good control of the pests, but produce or leave a residue.

(3) Maturity: The maturity of fresh produce is more important than the specific cultivar in many cases. Any recommended fruit or vegetable cultivar for processing should mature uniformly, should be resistant to insects and diseases. The crop harvested at its optimum condition need to be processed promptly otherwise the quality may drop down into the next lower grade in just a few hours.

(4) Harvesting and handling: Harvesting and handling methods of fresh fruit and vegetables go hand in hand with maturity and other quality characteristics. The fruit or vegetable should be harvested at the desired stage of maturity and should be delivered to the processing plant immediately to preserve the quality.

5) Processing: The important factors that must be carefully controlled during the processing of fruits and vegetables include efficiency of washing, trimming, cutting, inspecting and sorting, time and temperature of blanch or scald, fill weights, brine or syrup characteristics, closing machine vacuums, can seam formation and processing time (cooking and cooling times.

Following procedures are followed for quality control of processed products:

1. Identify the critical points in the process flow sheet which contributes to the major quality characteristics.
2. Sample each critical point (batch or continuous operation) and identify what is being sampled and to what extent it is critical.
3. Evaluate and relate quality at critical successive stages to costs and its application in field.
4. Relate costs to deviation from specified levels.
5. Evaluate data collected against standards and legal requirements.

6. Provide consistent system for the orderly continuous evaluation of quality from the selection of raw material through different stages of processing.
7. Diagnose problems and predict troubles before they occur.
8. Determine the extent of drifts and shifts in production and minimize or localize deficiencies.
9. Evolve a system to determine how well the quality control program is succeeding.

Quality control during processing

The sequence of operations in quality control followed during processing are as under:

1. Raw material control
2. Process control or the control of the manufacturing process
3. Production and processing inspection
4. Sensory evaluation
5. Packaging
6. Labeling and storage.

1) Raw material control: The quality of a food material is judged in terms of its nutritional value, purity, wholesomeness and palatability. If any of these properties is not optimal, the food quality is affected. Raw material examinations include test for genuineness and composition, freedom from contaminant, and conformity with official or factory standards.
The manufacturing of a desired food product depends upon the close collaboration between plant breeders, agronomists, horticulturists and food technologists. After all parameters of raw materials are met, a sample batch of raw materials is put through a trial run to get a preview of the end product. All control tests are run on the sample and any adjustments as required are made in the processed product. The equipment is examined for any sign of corrosion due to the acidity or alcohol content of the materials used. Approval for processing is given only after all quality specifications on the sample run have been met.

2) Process control: During processing, attention should be given to the processing procedure. In order to get the product of desired quality, all treatments standardized such as use of correct amount of ingredients, use of accurate method of preparation, mixing, processing time and temperature etc should be followed. The quality control tests should run continuously and concurrently with a 24-hr production schedule. The intermediary samples are taken for routine tests to establish that specific targets of quality are being achieved. The desired composition, consistency, colour and concentration are checked and ensured. Where processing controls are not properly employed e.g., during dehydration, the quality of the product may be seriously impaired. Satisfactory hygienic conditions are also maintained during processing, in order to protect the product from bacterial

contamination.

3) Production, processing inspection: Examination of the finished product is carried out to determine as to what extent the desired quality specifications have been achieved. Careful inspection is made of the external conditions of the can. A can where both ends are concave is said to be 'flat' and is said to be good while the cans which have the problem of flipper, springer or smell do not pass inspection.
In case of canned products, a sample of the passed cans is opened and the contents are inspected. Where the product is dried, samples are examined for a blemish count. The dried product is regularly checked for its reconstitution value to enable the correct cooking instructions to be supplied on the package for the user.
Tests are also performed to check certain physical properties, such as crispiness, colour, viscosity and texture. Microbiological examinations are carried out to check whether proper hygienic procedures have been followed and whether the finished product is safe to eat or not.

4) Sensory evaluation: After physical, chemical and microbiological examination have been performed on a finished product with a satisfactory result, the product is considered ready for distribution, but only after its sensory quality has been assessed. To the processor, a palatable product ensures sales because palatability attracts consumers and to the consumer, palatability satisfies his gustatory senses.

5) Packaging: The primary purpose of manufacture is to produce a food product, to keep it in good condition and to preserve the flavour until it reaches the consumer. Therefore, it is essential that a suitable packaging material is chosen for packing a finished product. The material used for packaging must not contaminate the product and must be effective in preventing the product from deterioration. A variety of containers have also been designed to handle products that are sensitive to light, temperature, oxygen, moisture and contact with the chemicals.

6) Labeling and storage: After packing, labels are pasted on the finished products which are intended for sale. The information on the label shall include name of product, ingredients used, date of manufacture, name and address of the manufacturer, sale price, net weight or volume etc. A good and an attractive label is an aid to the successful marketing of the product. The product should be stored in a cool and dry place.

Critical control points of inspection
The critical control points of inspection followed during canning of foods in syrup are as under:

1. Raw material: The important material used is fruit sugar and citric acid.

Water used in making syrup should be suitable for purpose of canning.

- Fruit: Variety, maturity, extent of spoilage or damage, pesticide residues, deterioration in handling and storage, potential contamination etc.
- Sugar and citric acid with respect to physical and chemical characteristics.

2. Tin containers

- Type of tin plate, weight of tin coating, side seam, and double seam accuracy.

3. Washing of fruits

- Quality of water

4. Preparation of fruit

- Efficiency of preparatory operations like peeling, slicing, coring, trimming and freedom from damaged or diseased portion.
- Uniformity with respect to colour, texture and maturity.

5. Preparation of syrup

- Calculation of strength of covering syrup required in relation to total soluble solids in fruit, filled weight of slices, weight of covering syrup added and cut-out degree brix required in the finished product.
- Control of weight, temperature and uniformity of strength at the time of filling.

6. Filling: The coefficient of variation in the weight of empty cans is generally about 4%. The fill-in-weight of fruit required to get the desired drained weight in the canned product should be carefully determined.

7. Exhausting: Periodic checks should be made to ensure that the cans coming out of the exhaust box have attained the desired can centre temperature. It has direct relation to ultimate vacuum and is related to shelf life and behavior at different altitudes.

8. Container closure operation

- Protection of empty containers
- Cleaning of containers before filling
- Maintenance of can seamers
- Measurement of can seams

9. Processing

- According to good manufacturing practices
- Pasting of process schedules near retorts
- Recording of retorting operation

10. Cooling Water

- Microbiological quality
- Chlorine content

11. Post process handling

- Prevention of filled containers from damage and contamination
- Cooling
- Warehousing-temperature, humidity etc.

12. Clean up and sanitation

13. Steam quality

14. Examination of finished product

15. Sanitation control

- Sampling
- Location
- Visual appearance
- Microbiological level
- Rating-good, fair or poor.

16. General inspection

- Raw material receiving department
- Product preparation area
- Packing and dispatching area
- Windows, doors, wall surfaces, floor etc.

Hazard analysis and critical control points, or HACCP

is a systematic preventive approach to food safety from biological, chemical, physical hazards and more recently radiological hazards in production processes that can cause the finished product to be unsafe and designs measures to reduce these risks to a safe level. In this manner, HACCP attempts to avoid hazards rather than attempting to inspect finished products for the effects of those hazards. The HACCP system can be used at all stages of a food chain, from food production and preparation processes including packaging, distribution, etc. The Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA) require mandatory HACCP programs for juice and meat as an effective approach to food safety and protecting public health. Meat HACCP systems are regulated by the USDA, while seafood and juice are regulated by the FDA. All other food companies in the United States that are required to register with the FDA under the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, as well as firms outside the US that export food to the US, are transitioning to mandatory hazard analysis and risk-based preventive controls (HARPC) plans.

Principal of HACCP

Conduct a hazard analysis

Plan to determine the food safety hazards and identify the preventive measures the plan can apply to control these hazards. A food safety hazard is any biological, chemical, or physical property that may cause a food to be unsafe for human consumption.

Identify critical control points

A critical control point (CCP) is a point, step, or procedure in a food manufacturing process at which control can be applied and, as a result, a food safety hazard can be prevented, eliminated, or reduced to an acceptable level.

Establish critical limits for each critical control point

A critical limit is the maximum or minimum value to which a physical, biological, or chemical hazard must be controlled at a critical control point to prevent, eliminate, or reduce that hazard to an acceptable level.

Establish critical control point monitoring requirements

Monitoring activities are necessary to ensure that the process is under control at each critical control point. In the United States, the FSIS requires that each monitoring procedure and its frequency be listed in the HACCP plan.

Establish corrective actions

These are actions to be taken when monitoring indicates a deviation from an established critical limit. The final rule requires a plant's HACCP plan to identify the corrective actions to be taken if a critical limit is not met. Corrective actions are intended to ensure that no product is injurious to health or otherwise adulterated as a result if the deviation enters commerce.

Establish procedures for ensuring the HACCP system is working as intended

Validation ensures that the plants do what they were designed to do; that is, they are successful in ensuring the production of a safe product. Plants will be required to validate their own HACCP plans. FSIS will not approve HACCP plans in advance, but will review them for conformance with the final rule.

Verification ensures the HACCP plan is adequate, that is, working as intended. Verification procedures may include such activities as review of HACCP plans, CCP records, critical limits and microbial sampling and analysis. FSIS is requiring that the HACCP plan include verification tasks to be performed by plant personnel. Verification tasks would also be performed by FSIS inspectors. Both FSIS and industry will undertake microbial testing as one of several verification activities.

Verification also includes 'validation' – the process of finding evidence for the accuracy of the HACCP system (e.g. scientific evidence for critical limitations).

Establish record keeping procedures

The HACCP regulation requires that all plants maintain certain documents, including its hazard analysis and written HACCP plan, and records documenting the monitoring of critical control points, critical limits, verification activities, and the handling of processing deviations. Implementation involves monitoring, verifying, and validating of the daily work that is compliant with regulatory requirements in all stages all the time. The differences among those three types of work are given by Saskatchewan Agriculture and Food.

GMP

Good manufacturing practices (GMP) are the practices required in order to conform to the guidelines recommended by agencies that control the authorization and licensing of the manufacture and sale of food and beverages.

Good manufacturing practice guidelines provide guidance for manufacturing, testing, and quality assurance in order to ensure that a manufactured product is safe for human consumption or use. Many countries have legislated that manufacturers follow GMP procedures and create their own GMP guidelines that correspond with their legislation.

All guideline follows a few basic principles

Manufacturing facilities must maintain a clean and hygienic manufacturing area.

Manufacturing facilities must maintain controlled environmental conditions in order to prevent cross-contamination from adulterants and allergens that may render the product unsafe for human consumption or use.

Manufacturing processes must be clearly defined and controlled. All critical processes are validated to ensure consistency and compliance with specifications.

Manufacturing processes must be controlled, and any changes to the process must be evaluated. Changes that affect the quality of the drug are validated as necessary.

Instructions and procedures must be written in clear and unambiguous language using good documentation practices.

Operators must be trained to carry out and document procedures.

Records must be made, manually or electronically, during manufacture that demonstrate that all the steps required by the defined procedures and

instructions were in fact taken and that the quantity and quality of the food or drug was as expected. Deviations must be investigated and documented.

Records of manufacture (including distribution) that enable the complete history of a batch to be traced must be retained in a comprehensible and accessible form.

Any distribution of products must minimize any risk to their quality.

A system must be in place for recalling any batch from sale or supply.

Complaints about marketed products must be examined, the causes of quality defects must be investigated, and appropriate measures must be taken with respect to the defective products and to prevent recurrence.

Prevention of food adulteration act

One of the early acts to be promulgated in this connection was the Prevention of Food Adulteration Act of 1954, which has been in force since June 1,1955. The objective of this act was to ensure that food articles sold to the customers are pure and wholesome. It also intended to prevent fraud or deception and encourages fair trade practices. The act was amended in 1964 and again in 1976 in the light of experience gained, to plug loopholes of escape in the Act and to insure stringent punishment for those indulging in this nefarious practice.

Prevention of Food Adulteration Act, 1954 will be repealed from the date to be notified by the Central Government as per the Food Safety and Standards Act,2006. Till that date new standards are specified, the requirement and other provisions of the PFA Act, 1954 and Rules, 1955 shall continue to be in force as a transitory provision for food standards.

Fruit Products Order

The Government of India promulgated a Fruit Products order in 1946. In 1955, the order was revised. The Fruit Products Order (FPO) lays down statutory minimum standards in respect of the quality of various fruits and vegetable products and processing facilities. The FPO and PFA, are enforced by the Department of Health.

The minimum requirements laid down in the Fruit Products Order for hygienic production and quality standards:

Location and surroundings of the factory
Sanitary and hygienic conditions of premises
Personnel hygiene
Portability of water
Machinery & Equipment with installed capacity
Quality control facility & Technical staff
Product Standards
Limits for preservatives & other additives

Food safety and standards act, 2006

The law established in the year 2006

Salient features of the Act:

The Act integrates eight different food related statutes i.e Prevention of Food Adulteration Act, 1954 , Fruit Products Order , 1955, Meat Food Products Order , 1973, Vegetable Oil Products (Control) Order, 1947,Edible Oils Packaging (Regulation)Order 1988, Solvent Extracted Oil, De- Oiled Meal and Edible Flour (Control) Order, 1967, Milk and Milk Products Order, 1992 .

The Act also aims to establish a single reference point for all matters relating to food safety and standards, by moving from multi-level, multi-departmental control to a single line of command.

Food Safety and Standards Authority of India (FSSAI)

The Act establishes the Food Safety and Standards Authority of India (FSSAI) as an apex regulatory authority consisting of a Chairperson and 22 members. The Act provides the general administrative principles to be followed by the Central Government, State Governments, and FSSAI while implementing the provisions of this Act.

The functions of the FSSAI

Framing of Regulations to lay down the Standards and guidelines in relation to articles of food and specifying appropriate system of enforcing various standards thus notified.

Laying down mechanisms and guidelines for accreditation of certification bodies engaged in certification of food safety management system for food businesses.

Laying down procedure and guidelines for accreditation of laboratories and notification of the accredited laboratories.

To provide scientific advice and technical support to Central Government and State Governments in the matters of framing the policy and rules in areas which have a direct or indirect bearing of food safety and nutrition.

Collect and collate data regarding food consumption, incidence and prevalence of biological risk, contaminants in food, residues of various, and contaminants in foods products, identification of emerging risks and introduction of rapid alert system.

Creating an information network across the country so that the public, consumers, Panchayats etc receive rapid, reliable and objective information about food safety and issues of concern.

Provide training programmes for persons who are involved or intend to get involved in food businesses.

Contribute to the development of international technical standards for food, sanitary and phyto-sanitary standards.

Promote general awareness about food safety and food standards.

Cold storage order

The cold storage order, 1980, promulgated under the Essential commodities Act, 1955, has the objective of ensuring hygienic and proper refrigeration conditions in a cold store, regulating the growth of cold storage industry and

rendering technical guidance for a the scientific preservation of food stuffs.

Standards

I.S.I. Standards

Various committees, including representatives from the government, consumers and industry, formulate the Indian Standards Institution (ISI). Standards are laid for vegetable and fruit products, spices and condiments, animal products and processed foods.

The products are checked for quality by the ISI in their own network of testing laboratories at Delhi, Bombay, Calcutta, Madras, Chandigarh and Patna or in a number of public and private laboratories recognized by them.

The AGMARK Standard

The AGMARK standard was set up by the Directorate of Marketing and Inspection of the Government of India by introducing an Agricultural produce Act in 1937. The word 'AGMARK' seal ensures quality and purity. A sample AGMARK seal is as below

AGMARK BESAN
SL.NO. B-162002
GRADE-STANDARD
PLACE OF PACKAGING
DATE OF PACKAGING
NET WEIGHT

The quality of a product is determined with reference to the size, variety, weight, colour, moisture, fat content and other factors are taken into account. The grades incorporated are grades 1,2,3 and 4 or special, good, fair and ordinary.

The Meat Food Products Order, 1973:

The main objectives of the MFPO, 1973 are to regulate production and sale of meat food products through licensing of manufacturers, enforce sanitary and hygienic conditions prescribed for production of wholesome meat food products, exercise strict quality control at all stages of production of meat food products, fish products including chilled poultry etc.

Under the provision of MFPO all manufacturers of meat food products engaged in the business of manufacturing, packing, repacking, relabeling meat food products meant for sale are licensed but excluding those manufacturers who manufactures such products for consumption on the spot like a restaurant, hotel, boarding house, snack bar, eating house or any other similar establishment.

The Vegetable Oil Products (Control) Order, 1947:

The Vegetable Oil Products industry is regulated by this Order through the Directorate of Vanaspati, Vegetable Oils & Fats, Department of Food, Public Distribution, Ministry of Consumer Affairs, and Food & Public Distribution. The earlier two Orders – Vegetable Oil Products (Control) Order, 1947 and

Vegetable Oil Products (Standards of Quality) Order, 1975 have been replaced by a single Order called "Vegetable Oil Products (Regulation) Order, 1998 for proper regulation of manufacture, distribution and sale of Vegetable Oil Products.

Salient Features of the Order:
The procedure of Registration has been simplified.
The Standards of quality prescribed under the Schedule have been tightened.
The requirement where which are vogue and non measurable and thus open to arbitrary interpretation have been done away with.
Consumers' protection through quality assured.
The Edible Oils Packaging (Regulation) Order, 1998:
The Department of Sugar and Edible Oil under Ministry of food and Consumer Affairs regulate this-order.

The Solvent Extracted Oil, De oiled Meal, and Edible Flour (Control) Order, 1967
It applies for oils and fats and deals with the licensing, manufacture, distribution and trade of solvent extracted edible oils and quality thereof and operated by Directorate of Vanaspati, Vegetable Oil and fats.

M**ilk and Milk Products Order(1992):**
The production, distribution and supply of milk products are controlled by the Milk and Milk Products Order, 1992. The order sets sanitary requirements for dairies, machinery, and premises, and includes quality control, certification, packing, marking and labeling standards for milk and milk products. Standards specified in the order also apply to imported products. The Department of Animal Husbandry, Dairying and Fisheries at the Ministry of Agriculture is the regulatory authority.

Livestock Importation Act(1898):

India has established procedures for the importation of livestock and associated products under the Livestock Importation Act, 1898. Under the regulations, the import of meat products, eggs and egg powder and milk products require a sanitary import permit from the Department of Animal Husbandry, Dairying and Fisheries at the Ministry of Agriculture. A detailed import risk analysis is carried out, taking into account the disease situation prevailing in the exporting country compared with the disease situation in India.
Essential Commodities Act, 1955 The main objective of the Act is to regulate the manufacture, commerce, and distribution of essential commodities, including food. A number of Control Orders have been promulgated under the provisions of this Act. These are:

Standards of Weights and Measures Act, 1976 and the Standards of Weights and Measures (Packaged Commodities) Rules, 1977: The Act governs

sale of packaged commodities and provides for mandatory registration of all packaged products in the country.

Consumer Protection Act, 1986:The Act provides for constitution of District Forum/State/National Commission for settlement of disputes between the seller/service provider and the consumer.

The Infant Milk Substitutes, Feeding Bottles and Infant Foods (Regulation of Production, Supply and Distribution) Act, 1992 and Rules 1993: This Act aims at promoting breast feeding and ensuring proper use of infant milk substitutes and infant food.

The Insecticide Act, 1968: The Act envisages safe use of insecticides so as to ensure that the leftover chemical residues do not pose any health hazard.

Export (Quality Control and Inspection) Act, 1963: The Act aims at facilitating export trade through quality control and inspection before the products are sold to international buyers.

Environment Protection Act, 1986: This Act incorporates rules for the manufacture, use, import and storage of hazardous microorganisms / substances / cells used as foodstuff.

Pollution Control (Ministry of Environment and Forests): A no-objection certificate from the respective State Pollution Control Board is essential for all dairy plants.