सत्यमेव जयते

MOFPI

IIFPT

PM Formalisation of Micro Food Processing Enterprises (PM-FME) Scheme

Training for Master Trainers

Handbook of Fruits and Vegetable Processing

Organized by

Indian Institute of Food Processing Technology (IIFPT)
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CHAPTER 1
INTRODUCTION

1.1. Status, Market Size and Scope

India being the second-largest producer of fruits and vegetables (311.17 MT in 2018-19), facilitates the fruit and vegetable processing industry in acquiring its primary resources. Canning, dehydration, pickling, provisional preservation, and bottling are some of the methods used in fruit and vegetable processing which help increase the shelf life of seasonal fruits and vegetables.

1.1.1. Major producing states

Maharashtra, Andhra Pradesh, Uttar Pradesh, Gujarat, and Karnataka are the leading producers of fruits in India, having a combined share of around 51% in the total fruits production. For vegetables, major producers include West Bengal, Uttar Pradesh, Bihar, Madhya Pradesh, and Gujarat, together accounting for around 55% of the national production.

1.1.2. Market insights

The fruit and vegetable processing industry in India is likely to expand at a compound annual growth rate (CAGR) of ~7.62% between FY 2018 and FY 2023 to reach a value of INR 256.4 Bn in FY 2023.Currently, commercial processing of fruits and vegetables is extremely low in India, at around 2.2% of the total production as compared to countries like Philippines at 78%, China at 23% and the United States (U.S.) at 65%. The unorganized sector witnesses a stiff competition, owing to the presence of a large number of players competing for small shares in the overall market. Organized players compete with each other to maintain their market share and gain brand loyalty.

1.1.3. Exports

During 2018-19, India exported fruits and vegetables worth Rs. 10236.93 crores/ 1,469.33 USD Millions which comprised of fruits worth Rs. 4817.35 crores/ 692.01 USD Millions and vegetables worth Rs. 5419.48 crores/ 777.25 USD Millions. Grapes, Pomegranates, Mangoes, Bananas, Oranges account for larger portion of fruits exported from the country while Onions, Mixed Vegetables, Potatoes, Tomatoes, and Green Chilly contribute largely to the vegetable export basket. The major destinations for Indian fruits and vegetables are Bangladesh, UAE, Netherland, Nepal, Malaysia, UK, Sri Lanka, Oman and Qatar.

1.1.4. Key growth drivers

The demand for processed fruits and vegetables is expected to rise significantly due to the growing penetration of organized retail in the country. Increasing number of nuclear families are also increasing the demand for processed food. Busy lifestyles of such families have increased their dependence on food items that require less time to prepare.

1.1.5. Key deterrents

Lack of sufficient storage facilities and improper distribution are hampering the growth of the market. Existing stand-alone and integrated companies and logistics offering cold storage and transportation solutions are unable to meet the entire demand for such services. These factors are adversely affecting the development of the fruit and vegetable processing industry in India.

1.2. Selection and Procurement

Maturity is the stage of fully development of tissue of fruit and vegetables only after which it will ripen normally. During the process of maturation, the fruit receives a regular supply of food material from the plant. When mature, the abscission or corky layer which forms at the stern end stops this inflow. Afterwards, the fruit depend on its own reserves, carbohydrates are dehydrated and sugars accumulate until the sugar acid ratio form. In addition to this, typical flavour and characteristic colour also develop. It has been determined that the stage of maturity at the time of picking influence the storage life and quality of fruit, when picked immature like mango develop white patches or air pockets during ripening and lacking in normal brix acid ratio or sugar acid ratio, taste and flavour on the other hand if the fruits are harvested over mature or full ripe they are easy susceptible to microbial and physiological spoilage and their storage life is considerably reduce. Such fruits persist numerous problems during handling, storage and transportation. Therefore, it is necessary or essential to pick up the fruits or vegetables at correct stage of maturity to facilitate proper ripening, distant transportation and maximum storage life.

1.2.1. Factors affecting maturity

a) **Temperature:** Higher temperature gives early maturity e.g. Gulabi (Pink) grapes mature in 100 days in Western India but only 82 days are enough in the warmer Northern India. Lemon and guava takes less time to mature in summer than in winter. Sun-scorched portions of fruits are characterized by chlorophyll loss, yellowing, disappearance of starch and other alcohol insoluble material, increase in TSS content, decrease in acidity and softening.

b) **Soil:** Soil on which the fruit tree is grown affects the time of maturity. e.g. Grapes are harvested earlier on light sandy soils than on heavy clays.

c) **Size of planting material:** This factor in propagated fruits affects fruit maturity. e.g. In pineapple, the number of days taken from flowering to fruit maturity was more by planting large suckers and slips than by smaller ones. 4. Closer spacing: Close spacing of hill bananas hastened maturity.

d) **Pruning intensity**: It enhanced the maturity of Flordasun and sharbati Peaches.

e) **Girdling:** Process of constricting the periphery of a stem which blocks the downward translocation of CHO, hormones, etc. Beyond the constriction which rather accumulates above it. In Grape vines it hastens maturity, reduces the green berries in unevenly maturity cultivar and lowers the number of short berries. It is ineffective when done close to harvest. CPA has an additive effect with girdling.

1.2.2. Maturity index

The factors for determining the harvesting of fruits, vegetables and plantation crops according to consumer's purpose, type of commodity, etc and can be judged by visual means (colour, size, shape), physical means (firmness, softness), chemical analysis (sugar content, acid content), computation (heat unit and bloom to harvest period), physiological method(respiration). These are indications by which the maturity is judged. Various indices are as Follows;

a) **Visual indices:** It is most convenient index. Certain signals on the plant or on the fruit can be used as pointers. E.g. drying of top leaves in banana, yellowing of last leaf of Peduncle in jackfruit. Flow of sap from cut fruit stalk of mango slows down if the harvest is done after maturity but in immature fruits, exudation is more and comes with force in a jet form. in papaya, the latex becomes almost watery. The flow gets reduced on maturity in Sapota. In fruits like banana and Sapota, floral ends become more brittle and shed with a gentle touch or even on their own. In Sapota, the brown scurf on the fruit skin starts propping. In mango, lenticels become more prominent and the waxy bloom gradually disappears. Grapes develop translucent bloom. Other changes like angularity in banana, development of creamy wide space between custard apple segments and the flattening of the eyes in pineapple and tubercles in litchi serve as reliable maturity indices.

b) **Seed development:** It can also be used as an index of fruit maturity, e.g. endocarp hardening for stone and fiber development for dessert in mango.

c) **Start of bud damage:** Occasionally it can be used as an index of fruit maturity in mango.

d) **Calendar date:** For perennial fruit crops grown in seasonal climate which are more or less uniform from year to year, calendar date for harvest is a reliable guide to commercial maturity. This approach relies on a reproducible date for the time of the flowering and a relative constant growth period from flowering through to maturity. Time of flowering is largely dependent on temperature, and the variation in number of days from flowering to harvest can be calculated for some commodities by use of the degree- concept.

e) **Heat units:** Harvest date of newly introduced fruits in a widely varying climate can be predicted with the help of heat unit. For each cultivar the heat requirement for fruit growth and development can be calculated in terms of degree days: Maturity at higher temperature is faster as the heat requirement is met earlier. This heat unit helps in planning, planting, harvesting and factory programmes for crops such as corn, peas and tomato for processing.

1.2.3. Maturity of Fruits

a) **Banana:** A maturity index for Banana varies depending on the variety, proximity of the market and mode of transportation. In general, number of days from flower emergence (110-150), pulp: peel ratio (1.2-1.6), disappearance of the angles/ribs, thumping sound of fruits, brittleness of the floral remnant and it's natural shedding, dullness of the fruit skin and odor are used as index for harvesting. For long distance transportation, harvesting is done at 75-80% maturity. While harvesting and transporting, Care should be taken to avoid direct contact of fingers, which otherwise turn black on ripening.

b) **Guava:** Guava TSS acid ratio, specific gravity and colour are determined the maturity in guava.

For e.g.: Allahabad safeda - 35.81, Apple colour guava - 26.39, Chittidar guava - 28.13, Lucknow - 49 -34.25, Specific gravity - Less than 1, Colour - Light green to yellow.

c) **Apple:** Apple maturity indices are, TSS of fruit pulp(10.5 -12.5%), ease in separation of fruit from spur, and change in ground surface color from green to pale, change in seed color to light brown, fruit firmness (18-23 lbs per sq. inch) and number of days from full bloom to harvest.

d) **Custard Apple:** Custard apple usually starts bearing fruits at the age of 4-5 years. Fruiting declines by about 15th year depending upon orchard maintenance. Custard apple produces single crop in a year during August-October in South India and September-November in North India. On maturity, fruits turn light green.

e) **Fig:** Fresh figs should be harvested when they are soft and slightly wilted at the neck and droop and little and no milky latex flow at the cut end of the stalk. Sudden increase in fruit size and opening of ostiole are other maturity indices.

f) **Grape:** Grapes are harvested when they are fully ripe (TSS 14 – 17.5 % depending upon variety), Grapes do not ripen after harvesting. In seeded grapes, the seeds become dark brown when they are fully ripe. In seedless varieties, their characteristic berry color develops fully. Grapes should be harvested carefully in order to avoid berries separation from bunches

g) **Jamun:** Fruits take 3-5 months to ripen after full bloom. This is non-climacteric fruit; hence it does not ripen after harvesting. Therefore, fully ripened fruits, when they change their color from green to deep red or bluish black should be plucked. Fruits are harvested daily by hand picking or by shaking the branches and collecting the fruits on a polythene sheet.

h) **Lemon:** Lemons are harvested from (Dec – Jan) in north India and (May – Sept) in southern India. Color break of fruits from green to yellow is ideal time for harvesting. However, they should be harvested when mature but still green so that their acidity remains at the peak. Generally, lemons are harvested with a pole harvester having an iron hook and a net at one end. Lemon should have at least 30% juice content by volume before harvesting.

i) **Litchi:** Harvesting of Litchi is usually done in May and June. Generally, Litchi fruits mature 50 – 60 days after fruit set. In general, fully ripened fruits are harvested when turn to deep red for local markets. However, for distant markets; fruits are harvested when they start turning reddish. Fruits harvested at this stage possess excellent fruits quality. Maturity of fruits is also determined by the shape of tubercles, which on ripening become flattened, and the epicarp become smooth. Fruits are harvested in bunches along with a portion of the branch and a few leaves. It prolongs the storage life of fruits. After harvesting, fruits should be packed as quickly as possible, as their quality

deteriorates soon if they are exposed to sun even for a few hours. In packed litchi fruits, air should circulate freely.

j) **Orange:** Fruits should be harvested when they attain full size, develop attractive orange color (Minimum 25%) with TSS (optimum sugar: acid blend) (8-10), since it is a non – climacteric fruit. Fully ripen fruits when turn to yellow color from green should be harvested. The common commercial practice of harvesting is to pull the fruits from the branch, which may rupture the skin near the stem end leading to fungal infection and subsequent rotting. Therefore, fruits should neither be plucked nor torn off, but should be cut off preferably with clipper, shears or secateurs.

k) **Mango:** The fruits are ready for harvesting after 4 – 5 months of flowering. Since mango fruits are climacteric, they can be harvested before ripening but they should be fully matured. Fruits should be harvested when the shoulders are filled and change color from dark green to light green / light yellow / red for distant markets. However, for local markets, fully ripened fruits can be picked. Mangoes should be harvested with pedicel in order to avoid latex spots. To protect mango fruits from latex spots, which looks very shabby when mango is ripe, their stem end portion should be immediately placed into the soil for 30 minutes. After harvesting, fruits are stored in shady place using hay to hasten ripening. Dipping in water can also check maturity in mango. Fruits, which are floaters, are considered immature.

l) **Papaya:** Usually fruits are harvested when they are of optimum size, light green with tinge of yellow at epical end. On ripening, fruits of certain varieties turn yellow while some of them remain green. However, when the latex ceases to be milky and become watery, the fruits are suitable for harvesting. Normally fruits are ready for harvesting after 9 – 10 months of planting. Fruits are available throughout the year.

m) **Pineapple:** Pineapple plants flower after 10 – 12 months of planting and fruits become ready for harvest after 15 – 18 months of planting. Under normal conditions, pineapple is ready to harvest during May – August. For the fresh market fruits should be harvested when they change color to golden yellow from green. However, for canning, fruits should be harvested with a slight color change at the base. The fruits with the crown can be kept without damage for 10 –15 days after harvest.

n) **Pomegranate:** Pomegranate being non – climacteric fruit should be picked when fully ripe. Harvesting of immature or over mature fruits affect quality. The fruits become ready

for picking after 120 – 130 days of fruit set. The calyx at the distal end of the fruit gets closed on maturity. Ripe fruits give a distinct sound of grains cracking inside when slightly pressed from outside. At maturity, they turn to yellowish red and get suppressed on sides.

o) **Sapota:** Sapota takes about 7 – 10 ½ months from full bloom to maturity of fruits depending on variety and climate. Properly developed fruits have high TSS and sugar and reduced acidity, astringency and latex. Maturity is decided on the basis of ease with which brown scruff gets off the fruit surface and development of yellowish tinge intermixed with corky brown color on the surface of the fruits. At this stage, practically no green tissue and milky latex are seen on fruits when scratched with nails. Harvested fruits should be cleaned of latex and scurf by washing in clean water to make them look attractive

p) **Strawberry:** Strawberries are generally harvested when half to three fourths of skin develops color. For distant shipment green/white and hard berries are harvested. Delay in picking usually increases the proportion of overripe and rotted berries. Usually picking starts after 6-8 weeks of planting depending upon cultivars and season. Depending upon the weather conditions, picking should be done every second or third day. Ripening is faster in hot weather. Do not leave any ripe or rotten berry in the field. Berries should be picked along with a small stem portion attached. Picking should be done preferably in the morning hours, this facilitates better shelf life

q) **Sweet Orange:** Since sweet orange is a non – climacteric fruit, there is no improvement in color, taste and flavor after harvesting. Therefore, fruits should be harvested when they are fully ripe and attain proper size, attractive color and acceptable sugar: acid ratio. Main harvesting season in north India is from Dec – Feb, while in south India, it is Oct – Mar. Usually when fruits develop color to yellow / golden yellow, they should be plucked.

1.2.4. Maturity of Vegetables

a) **Drumstick:** Normally drumstick starts bearing fruits from 6 – 8 months onwards after planting. Green colored, tender fruits should be harvested. Delayed harvesting leads to fibrous fruits with over mature hard seeds inside.

b) **Garlic:** Garlic becomes ready for harvesting when its top turn yellowish or brownish showing signs of drying up and bending over. The bulbs mature after 130 – 180 days of planting depending upon cultivars and season. Early harvesting results in poor quality

bulbs where loss due to driage is more. Delayed harvesting results in splitting and sprouting in field itself. After harvesting curing is done in the field for about a week with tops to remove excess moisture and to allow the bulbs to become compact and to go into dormant stage. Bulbs are also cured in the shady place for about 7 – 10 days with or without tops, leave top 2.5 cm above the bulbs to avoid sun injury. After curing the bulbs are graded. The thick necked, splitted, injured, and diseased or bulb with hollow cloved are sorted out and then packed in Hessian bags. Bags can be stored at ambient temperature with 60-70% relative humidity. Humidity more than 70% is not suitable for its storage as it favors the mould growth.

c) **Ginger:** The crop is ready for harvesting in about 8 months after planting depending on variety, when the leaves turn yellow and drying up. Rhizomes are washed thoroughly in water 2 – 3 time to remove the soil and dirt and sun dried for a day.

d) **Green Peas:** The quality of the green pea depends on sugar content and tenderness of the pods. Pods should be tender with high sugar content and filled with tender peas. During maturity sugar content decreases rapidly and starch and other compounds increase. Toughness of seed coat also increases with maturity. Toughness of seed coat and firmness of pulp are indices of maturity and measured by tenderometer. Values of tenderometer / texturometer increase with maturity and are negatively correlelated with quality. Tenderometer reading at optimum maturity of peas will be between 100 and 110. In general, the pods should be deep green, plump but not overly swollen, smooth and turgid. Slight yellowing indicates peas are starchy, tough and over mature. Seeds must be dark green and round.

e) **Jack Fruit Tender:** Jack fruit are harvested when it is green in color, tender and well grown and the fruit maturity is judged by dull sound and appearance. Fruits should not have prominent spines.

f) **Onion:** Onion is ready for harvesting in 3-5 months after transplanting depending upon cultivars. The optimum time for harvesting bulbs for fresh sale or for storage is when neck tissues begin to soften and leaves start discoloring and falling. The optimum time is one week after 50% leaves have fallen or when leaves start turning yellow and becoming dry at the top. Harvesting of immature bulbs result in sprouting and shriveling with poor storage life and delay in harvesting results in splitting, doubles, sunburn and formation of secondary roots during storage. After harvest, the crop is spread in the field for about 2-4 days for drying

g) **Potato:** Potato crop is ready for harvesting after 75 – 120 days of sowing depending upon cultivars and season. The crop should be harvested when leaves start yellowing and drying up. If harvesting is delayed, it is best to leave the soil dry and irrigate the field lightly about the time of harvest. Digging of tubers should be done carefully to avoid damage/cuts and bruises to the tubers.

h) **Tomato:** The stage of harvesting depends upon the purpose for which they are grown and the distance they are to be transported. The various stages recognized are immature green, mature green, breaker, pink, full ripe and over ripe. For long distance markets tomatoes, at mature green or breaker stage with waxy gloss, for local markets, tomatoes at pink (30-60% of the surface shows pinkish red or red) and full ripe stage (>90% of the surface shows red color) and for processing, tomatoes at over mature stage are picked.

1.2.5. Composition of fruits and vegetables

Vegetables and fruits contain a high amount of water. They also contain carbohydrates, dietary fibre, protein, vitamins and other nutrients that are important for human health. Lettuce, cucumbers and leafy vegetables contain about 95% water, therefore only 5% of their mass is dry matter. Hard vegetables like carrot and pumpkin have around 12-15% dry matter.

a) **Carbohydrates:** Carbohydrates are the main component of vegetables and fruit represent more than 90% of their dry matter. Carbohydrates are present as starch, sugars and dietary fibre. Starch is mainly found in root vegetables, such as potatoes and sweet potatoes. Sugars are found primarily in cytoplasm and ranges from about 0.9% in limes to 16% in figs. Sucrose content ranges from a trace in cherries grapes and pomegranate to more than 8% in ripe bananas and pineapples.

b) **Lipids:** Lipids are in vegetables in low amounts (0.1-2%). Lipids are very important because they make up surface wax, which ontributes to fruit appearance and cuticle which protects fruits against water loss and pathogens. Denaturation of fattyacids occurs upon chilling, in chilling sensitive fruits, in which case, membrane undergo a phase change at chilling temperatures, resulting in disruption of normal metabolism. Among the saturated fatty acids, palmitic, myristic, and stearic acids can be found in peas, beans, and spinach, and low amounts of saturated fatty acids are in almonds and peanuts. Of the monounsaturated fatty acids, oleic acid was identified in peas and palmitoleic acid in spinach (23%). The polyunsaturated fatty acid omega-3 is found in soybeans and beans.

Moreover, soybean is a known source of lipids (47 mg/100 g; with a linoleic to linolenic acid ratio of 7.5:1) and glycerophospholipids such as lecithin.

c) **Proteins:** The protein content of most vegetables ranges from 0.5 % to 1.5 %; the exceptions are green legumes (5–6 % in peas and beans) and dried legumes (20–34 % in lentils, dried beans, and soybeans which contain globulin-type protein: phaseolin in beans, legumelin in peas and lentils, and glycine in soybeans). From a nutrition point of view, soybean proteins are incomplete proteins because they contain all of the essential amino acids but not in equal proportion (methionine and lysine are in limited amounts). A protein is considered incomplete if it contains all essential amino acids but not in equal proportion, such as dried legumes which has methionine in limited amounts, or if it is missing one or more essential amino acids. Soybean is used to make flour and concentrate/protein isolates are used in the food industry for the production of soy milk, energy drinks, and other products

d) Minerals: Vegetables contain minerals, mainly K, Ca, Mg, P, and Fe. They also contain traces of oligoelements (Cr, Cu, I, F, Zn, Mg, Mo, and Se), which are absorbed from the soil together with water; therefore, their proportions vary. Ca is found in vegetables such as cabbage, cauliflower, broccoli, parsley, onions, peas, and beans (with an absorption rate >50 %). Soybeans and beans contain relatively large amounts of Ca. Oxalic acid in spinach and tomatoes limits the bioavailability of minerals by forming insoluble calcium oxalate salts. Ca:P ratios are optimal in cabbage, lettuce, and onions which helps their uptake. The vegetables provide < 30 % of P needed by the body. Phosphorus has been identified in dried legumes in the form of phytic acid, which forms insoluble complexes with a predatory effect on Ca, Fe, Zn, and Mg. It plays a major role in carbohydrate metabolism and energy transfer. Potassium is the most abundant mineral found in fruits. Because of the high content of water and K, vegetables in general have a diuretic effect. Important sources of K are dried beans (1,500 mg/100 g), spinach (700 mg/100 g), and potatoes (500 mg/100 g).

e) **Vitamins:** The amount of vitamins in a vegetable depends on its type, ripening stage, the soil it grows in, and mode of conservation. Vitamin C from vegetables is more active than synthetic vitamin C, and when accompanied by vitamin P and other antioxidants, its uptake is enhanced. Vitamins and minerals have a significant presence in most green vegetables. Large amounts of ascorbic acid (vitamin C) are found in leafy greens and some vegetables (tomatoes and peppers), tubers (asparagus and potato), and bulbs (onions). The concentration of vitamin C in vegetables depends on the development and

maturation of crops. Vitamin C is present in higher quantities in the shell than in the core, so when the outer layer is removed vitamin C is lost. The presence of vitamin C in plants depends on ascorbic oxidase activity (metalloenzymes containing Cu), which oxidizes vitamin C to dehydroascorbic acid with reduced vitamin activity or to compounds with no vitamin activity (dicetogulonic acid). The amount of vitamin C is inversely proportional to the amount of ascorbic oxidase. Vegetables with a high proportion of ascorbic oxidase (cucumbers, zucchini, and carrots) are almost devoid of vitamin C. Vitamin C in the form of dehydroascorbic acid is found in red pepper, parsley, dill, and horseradish.

Deficiency in Fe and vitamin C may affect the status of folic acid in an organism. Vitamin B1 is in legumes (dried beans at 0.6 mg%), leafy vegetables (spinach and lettuce), cabbage (0.5–1.5 mg%), and potatoes (0.56 mg%). B2 is found in green leafy vegetables (broccoli, spinach, and parsley at 0.2–0.3 mg%) and pulses (lentils at 0.2–0.3 mg%). Niacin in the form of nicotinic acid is in dried legumes (2–3 mg% in lentils) and other vegetables such as potatoes, tomatoes, eggplant, spinach, cauliflower, green peas, and beans. The most important plant sources of vitamin B5 are broccoli, potatoes, and tomatoes. Vitamin B6 is present in pulses (soybeans, lentils, and beans) and vegetables such as potatoes, cauliflower, and spinach. The bioavailability of vitamin B6 in vegetables is lower than that in animal sources because it is affected by long-term storage, prolonged heat treatment, and freezing techniques. Vitamin B7 (H) is in vegetables such as cabbage, spinach, beans, peas, carrots, and tomatoes. Leafy green vegetables (spinach, lettuce, broccoli) are a good source of folic acid (vitamin B9), which is also found in potatoes and pulses. Reduced B9 from vegetables is oxidized and destroyed at a rate of 50–90 % during boiling. The bioavailability of B9 varies depending on the presence or absence of B9-conjugated metal chelates, inhibitors, and chelating agents (B9-linked vegetables), the form of which determines an individual's nutritional status. B9 uptake from lettuce is twice as small as that of yeasts or bananas. Cyanocobalamin (vitamin B12) is found in vegetables in small amounts and is synthesized by bacteria. Vegetarians have lower circulating concentrations of vitamin B12 after 5–6 years if they do not take a supplement.

Vitamin D is found in vegetables, with the highest content in spinach and cabbage. Tocopherols/tocotrienols are synthesized only by plants, with the oils extracted from plants being the richest sources. Soybean oil contains 80–95 % α-tocopherol/γ-tocopherol. Vitamin E, known for its role as an antioxidant, is in seeds, legumes, spinach, lettuce, peas, cabbage, and celery. Vitamin K is found in green leafy vegetables such as parsley, spinach, broccoli, lettuce, turnips, and cabbage (40–50 % of total intake). The

bioavailability of vitamin K1 depends on the vegetable (e.g., higher in broccoli than in spinach) and the composition of the diet (e.g., the addition of fats increases absorption).

f) **Pigments:** The attractive colour of the many fruit is due to sugar derivate of anthocyanins. At the time of ripening, loss of chlorophyll and accompanied by synthesis of anthocyanins or carotenoids which present in vacuole and chloroplast, respectively.

- Anthocyanins-gives colour from red to blue
- Carotenoids-are synthesized in green tissue

  Eg. Beta-carotene and lycopene

Phenolics and antioxidants: Major class of plant compounds, it comprising of anthocyanins, leucoanthocyanins, anthoxanthins, hydroxybenzoic acids, glycosides, sugar esters of quinic and shikimic acids, esters of hydroxycinnamic acids and coumarin derivatives. The phenols are impotent in determining the colour and flavour of the fruit. Phenols are by products of the metabolism of the amino acids and contribute the sensory qualities of the fruits (colour, astringency, bitterness and aroma) and play the vital role in the resistance to attack of pathogen and stress. It is known for its antioxidant activities.Organic acids impart taste and flavour. The major acids are malic (apple), citric(citrus), tartaric(grape), quinic, succinic and shikimic acids. Organic acids plays important role in - photosynthesis and respiration.

1.3. Supply Chain of Fruits and vegetables

A supply chain is a network of producer/supplier, manufacturing assembly, distribution and logistics facilities that perform the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these products to the customers. Supply chains are principally concerned with the flow of products and information between supply chain member organization- procurement of materials, transformation of materials into finished goods and distribution of these products to end customers. These supply chains are enabling organizations to reduces inventory and costs, add product value, extend resources, accelerate time to market and retain consumers.

Supply chain of perishable food products or fresh fruits and vegetables constitute the processes from production to delivery of the agri-fresh produce (farmer to customer). The supply chain of fresh fruits and vegetables is complex compared to other supply chains due to the perishable nature of the produce, high fluctuations in demand and prices, increasing consumer concerns for safety and quality and dependence on climate conditions. The supply chain involves different people such as farmers/producers/importers, local traders/wholesalers/commission agents, transporters, processors, retailers, exporters etc.

The fruit and vegetables reach the consumer through a chain of intermediaries who carry out different functions such as transfer of ownership of commodities, movement, maintenance or preservation of quality and quantity, payments and delivery to consumer. All these links or intermediaries constitute the supply chain of the fruits and vegetables.

1.3.1. Different types of models in supply chain

There are three different types of models in supply chain of fruits and vegetables in India (Halder and Pati, 2011).

a. Traditional supply chain
b. Hub and Spoke Model
c. Value chain model

a) Traditional supply chain: Common type of supply chain followed in India. It involves agents (commission agents), auctioneers, wholesalers, traditional retailers (carts, roadside shops, pavement shops, etc). Farmers are the producers and source of fruits and vegetables. Here the local traders or auctioneers and commission agents perform the function of aggregators who procure from small farmers and sell to mandi. Large producers sell directly to local mandi without local agents help. The wholesalers buy from mandis, transport and sell to retailers at different locations.

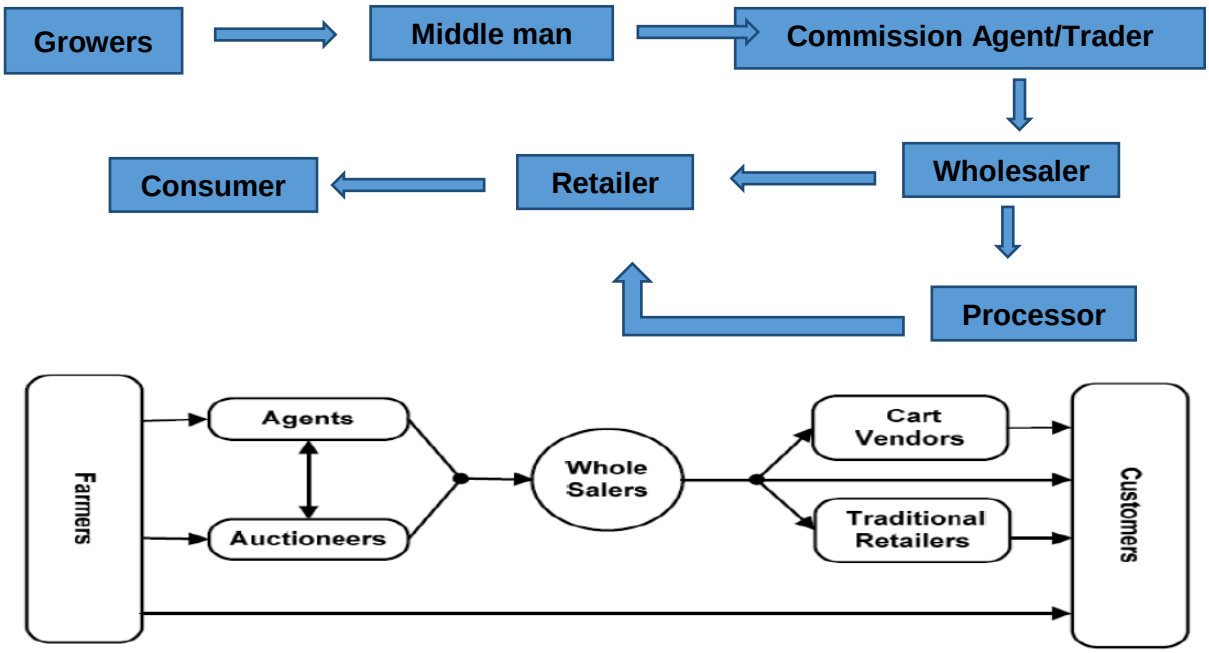


Fig. 1.1: Traditional supply chain (Source: Halder and Pati, 2011)

b) Hub and Spoke model: This type of supply chain is followed by organized retailers such as Food bazaar, spencer's retail, more and others. Only few players involved in

comparison to traditional supply chain. Famers, organized retailers, wholesalers and customers are partners in this supply chain. Buying centres, hubs and stores are operational units. Small farmers and contract farmers are the main source of supply. They collect the fruit and vegetables directly at the buying centres and then transport to hub, and distributed to the retail outlets. To meet the demands, they also buy from the local wholesale markets.

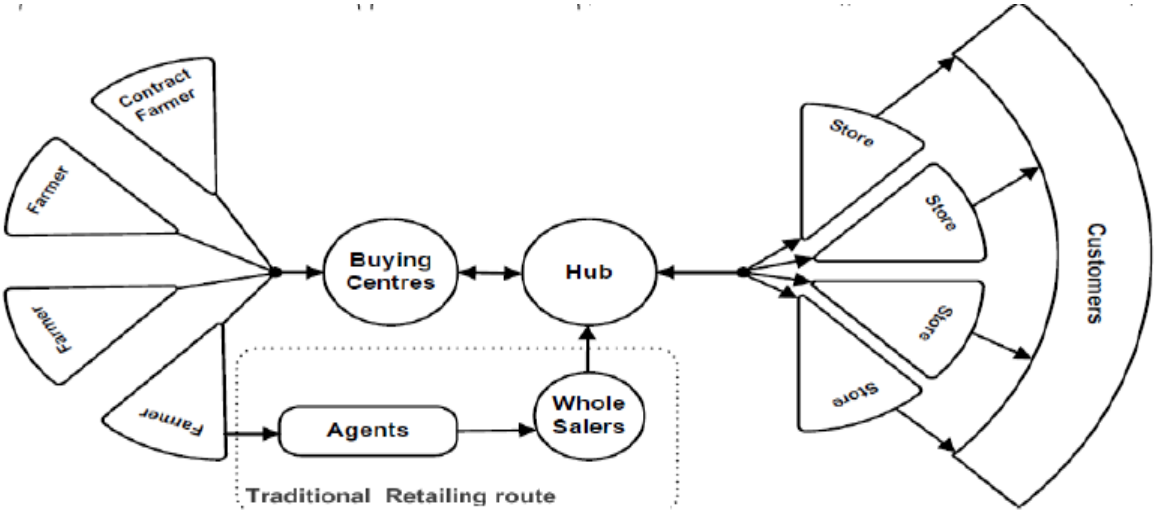


Fig. 1.2: Hub and spoke model (Source: Halder and Pati, 2011)

c) **Value chain Model:** Procure fruits and vegetables directly from farmers through contract farming or taking the farm on lease and sell to consumers without intermediaries. It mainly involves backward integration and focused towards building the entire supply chain. In involves only few partners, i.e, farmers/producers, organized retailers/processors and consumers.

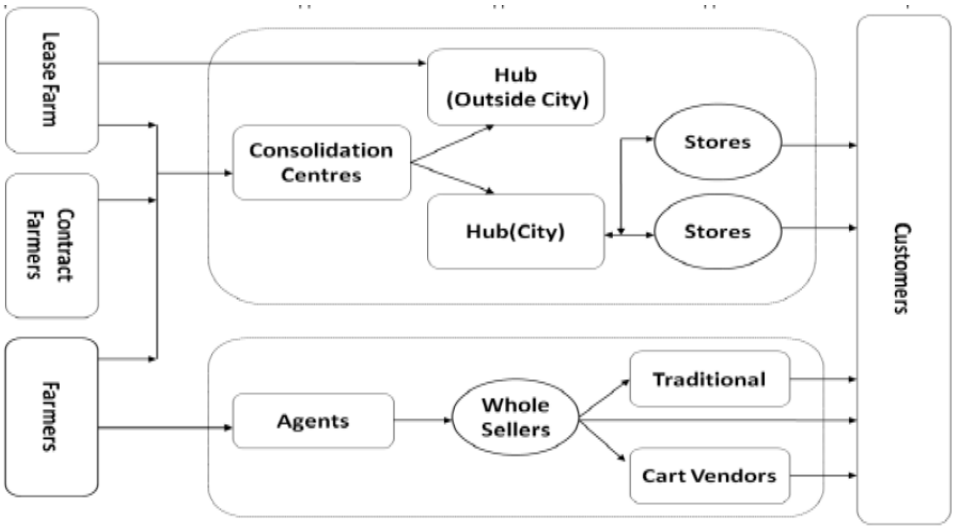


Fig. 1.3: Value chain model (Source: Halder and Pati, 2011)

Below are few examples of the supply chain

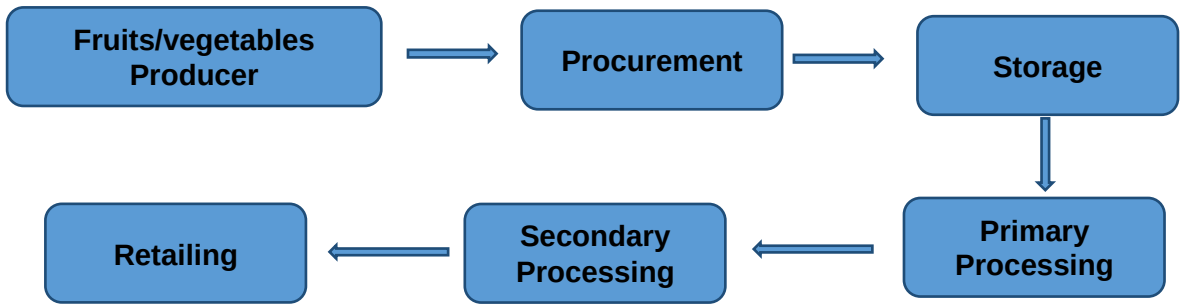


Fig. 1.4: Supply chain in food industries

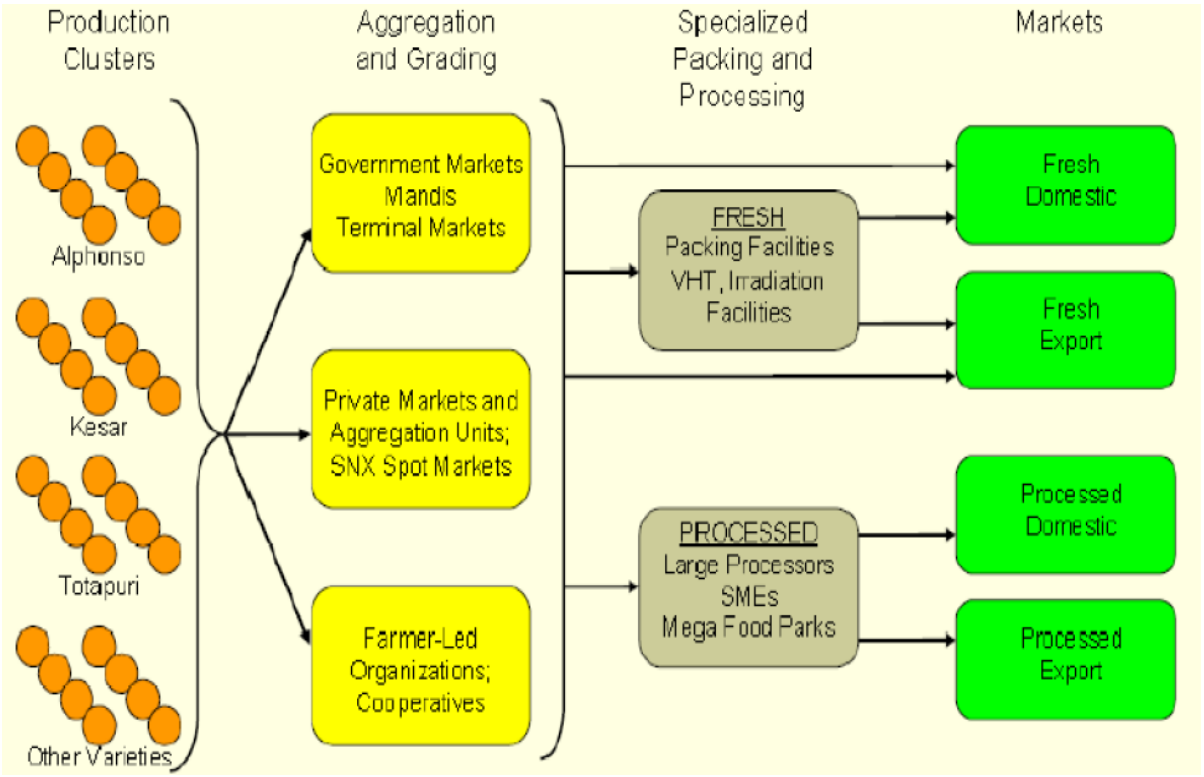


Fig. 1.5: Mango Supply chain (Source:IIFT, GoI)

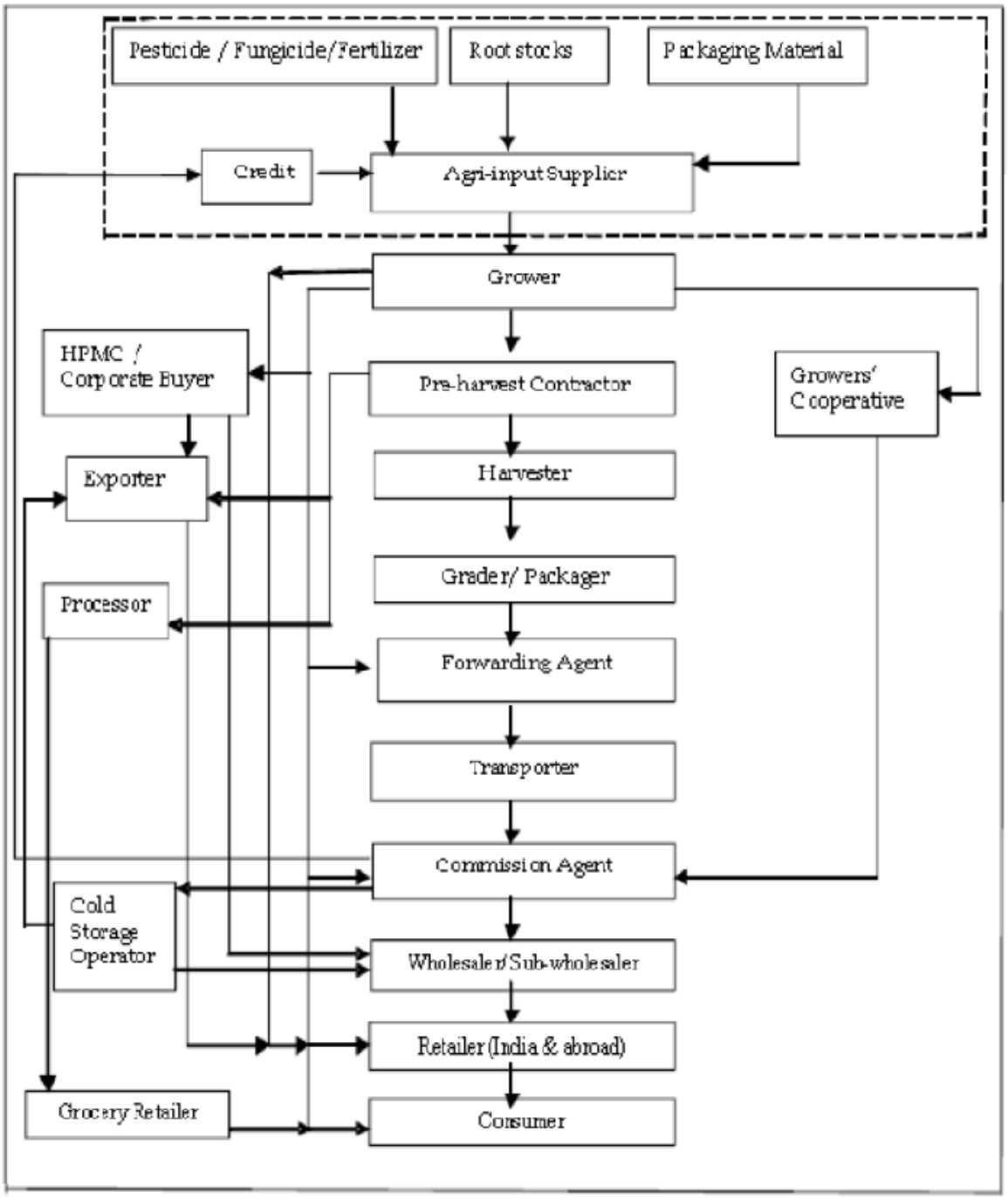


Fig. 1.6: Apple Supply chain (value Chain) in Himachal Pradesh (Source; IIFT, GOI)

1.4. Pack House Handling of Fruits and Vegetables

The harvested or procured produce is often brought to a common facility for preparation and storage pending transport to market. In its various forms, this facility is referred to as a packing-shed, a pack-house or a packing-house. A packing-house can be defined as “a designated facility where fresh produce is pooled and prepared in order to meet the requirements of a target market. The packing-house is the site or location where, post-harvest treatments are applied and quality standards are monitored. Pack houses can be

used by producers, importers, co-operatives or clusters, traders, exporters and processors. Pack house have certain benefits such as; increased productivity of workers, extend produce shelf life and improved produce quality.

1.4.1. Functions of a pack house

The packing-house system integrates components (raw materials, utilities, technologies, equipment and personnel) that function together to prepare produce for the market. It serves as a control point where quality management can be applied to assure a reliable supply of produce of good quality to consumers. It also serves as a suitable site for the implementation of effective strategies to eliminate or minimize microbial, chemical and physical contamination. Apart from the above, it is used as an accumulation or collection point, as a temporary holding area prior to distribution and as adispatch point of produce to different destinations

A good pack house should have adequate protection from sun and rain, proper flooring, good ventilation, good lighting and good handling practices should be implemented. While designing a pack house certain considerations has to be taken such as: functionality, quality and volume of produce handled, worker safety and comfort, level and scale of operations handled, location of the pack house and site of the pack house. Pack house is classified as ***conventional*** and ***specialized*** pack house. Conventional pack houses are intended for usual preparatory steps for fresh produce packaging and are located in strategic areas whereas specialized packing house is used for produce destined for high-end or export. Here facilities such as screened area, quarantine treatment, laboratory and cold room will be available.

The total area required for a pack house is the sum of the area required for different components such as; receiving area, sorting area, working area, storage area, office space, area for temporary holding or cold storage rooms, area for work flow and area for rejects. Apart from the pack house have functional facilities such as; cold storage room, ripening room, laboratory, stock rooms, tool room, administrative offices, worker sanitation facilities, eating facilities, lockers and waste disposal area.

1.4.2. Key unit operations of a pack house

Receiving, maturity assessment, trimming, sorting and grading, sizing, delatexing/desapping, cleaning/washing, surface drying, waxing, ripening/degreening, curing, packaging, pre-cooling, storage, treatments for disease control, quarantine treatments and labelling. Some examples of process flows for different fruits and vegetables are shown below.

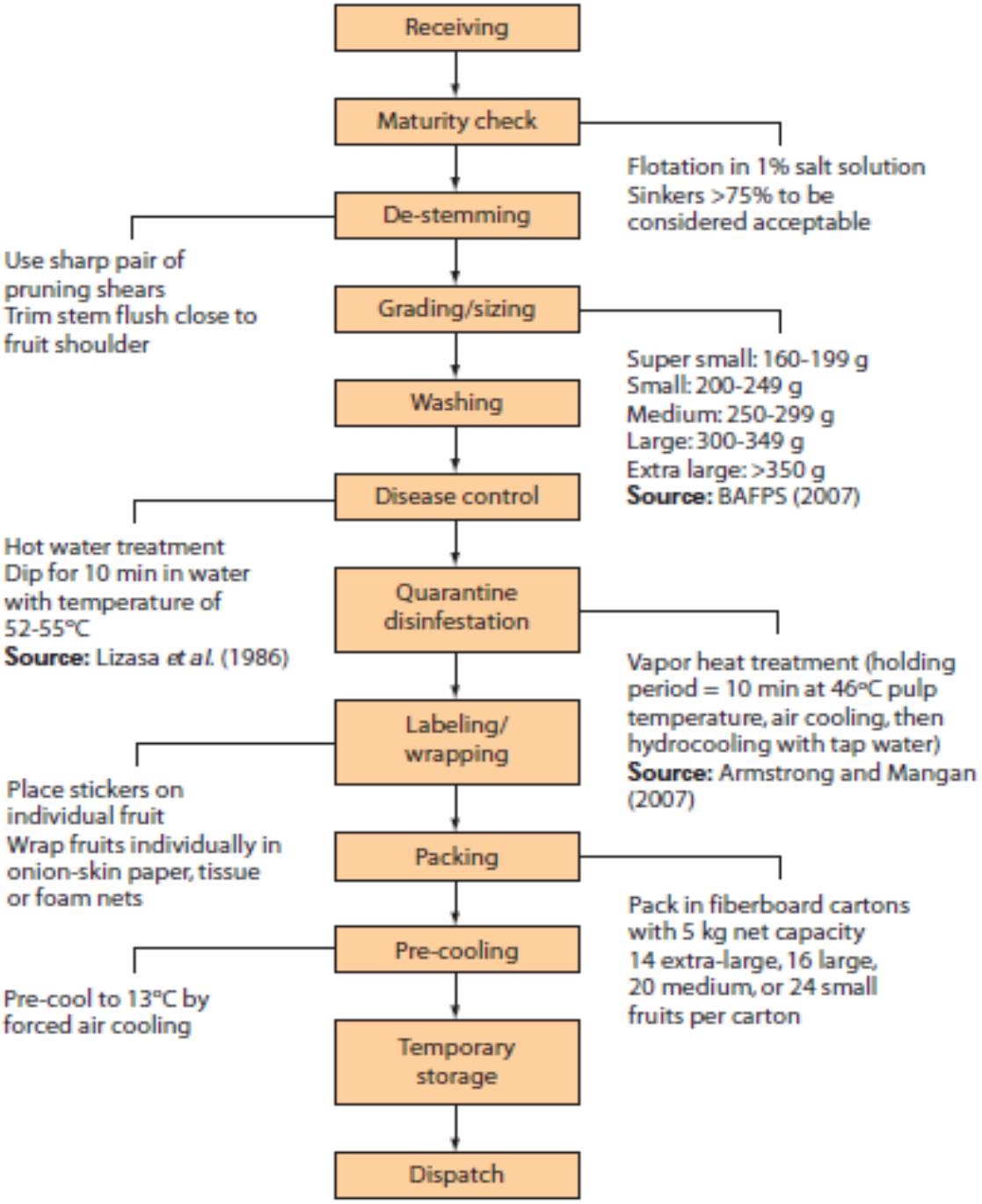


Fig. 1.7: Process flow for 'Carabao' mangoes destined for export market (FAO, 2012)

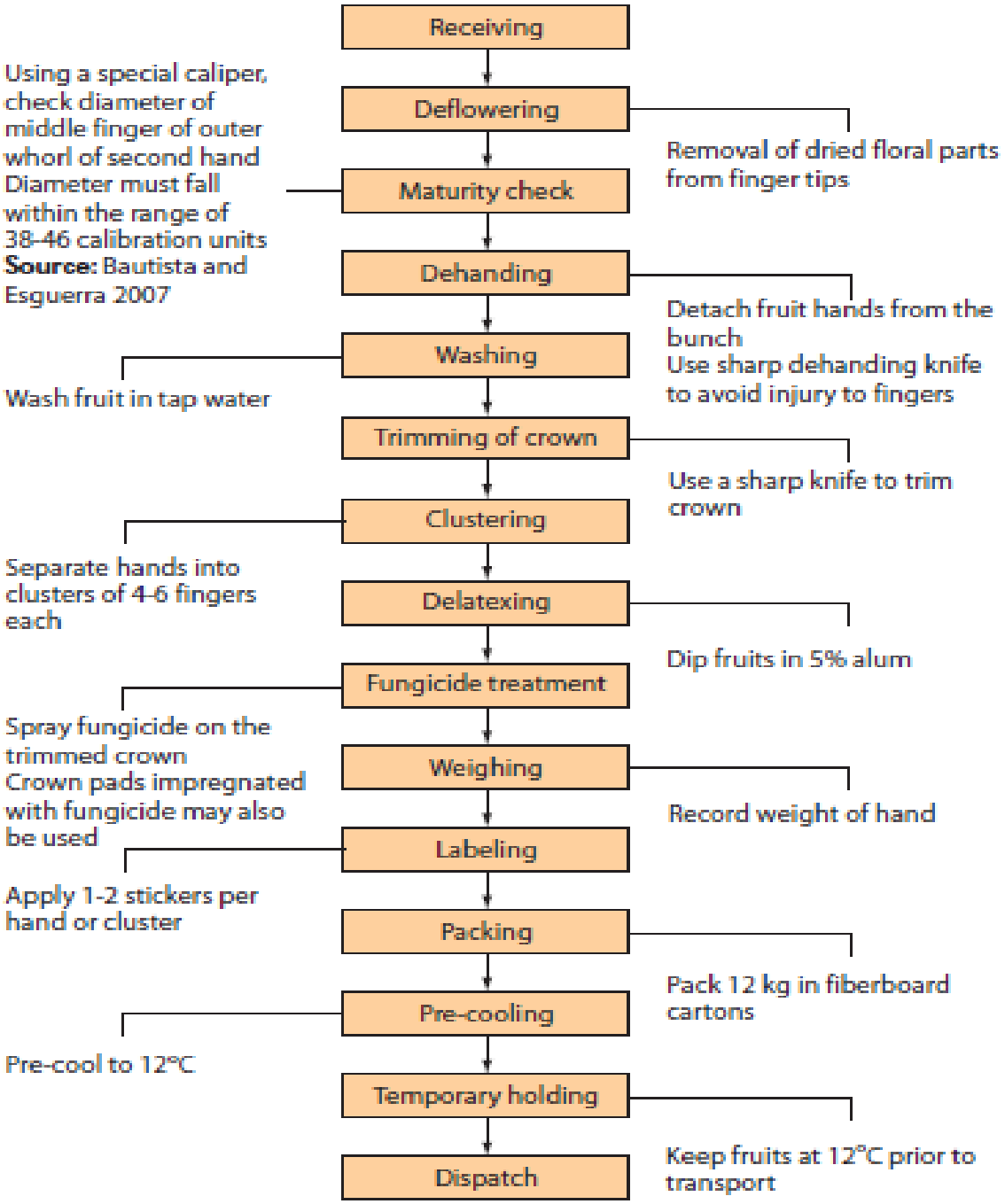


Fig. 1.8: Process flow for bananas destined for export market (FAO, 2012)

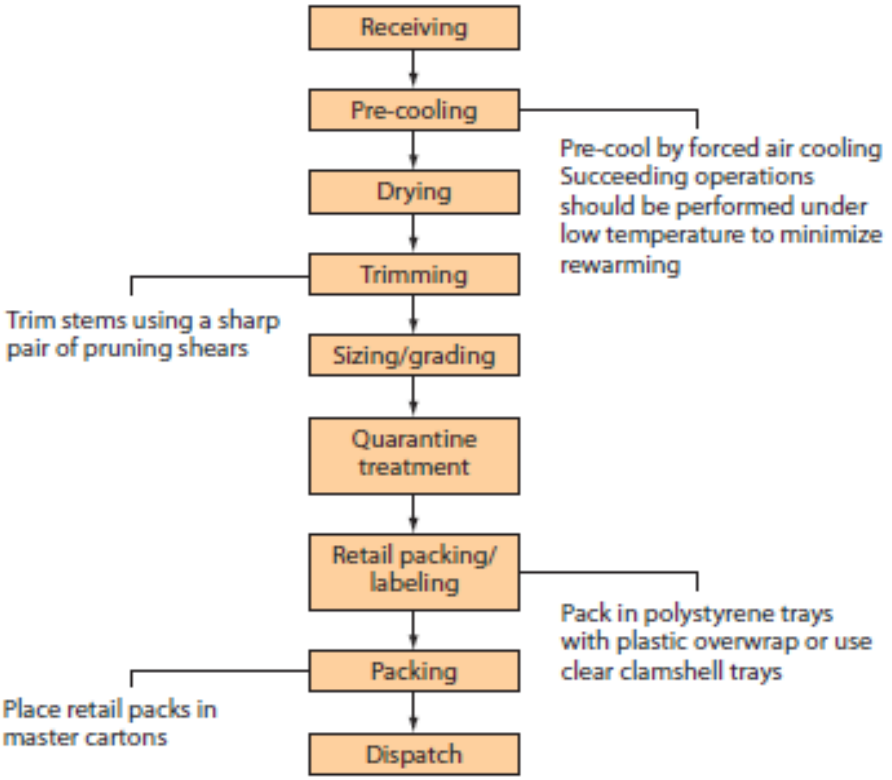


Fig. 1.9: Process flow for Okra destined for export market (FAO, 2012)

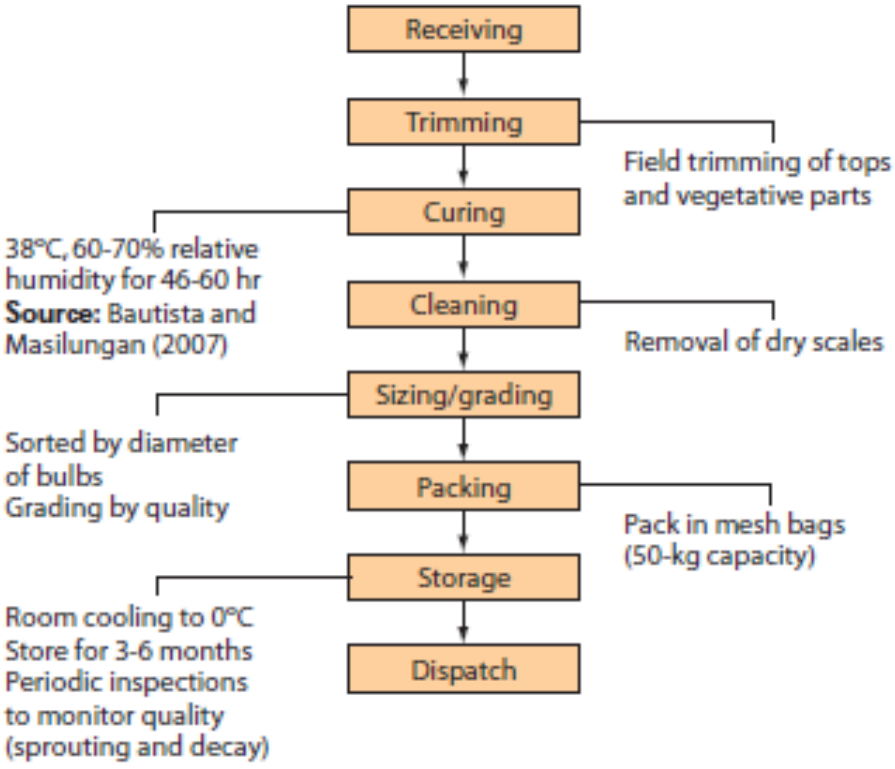


Fig. 1.10: Process flow for bulb crops destined for institutional and domestic market (FAO, 2012)

1.4.3. Equipment layout or flow layout in a pack house

Planned according to sequence of operations and space availability. The layout should facilitate produce flow and movement of personnel and to minimize cross- contamination within the facility. For maximum efficiency straight line flow better as fewer turns and lower damage to commodity. Other types of layouts are U type and L type.

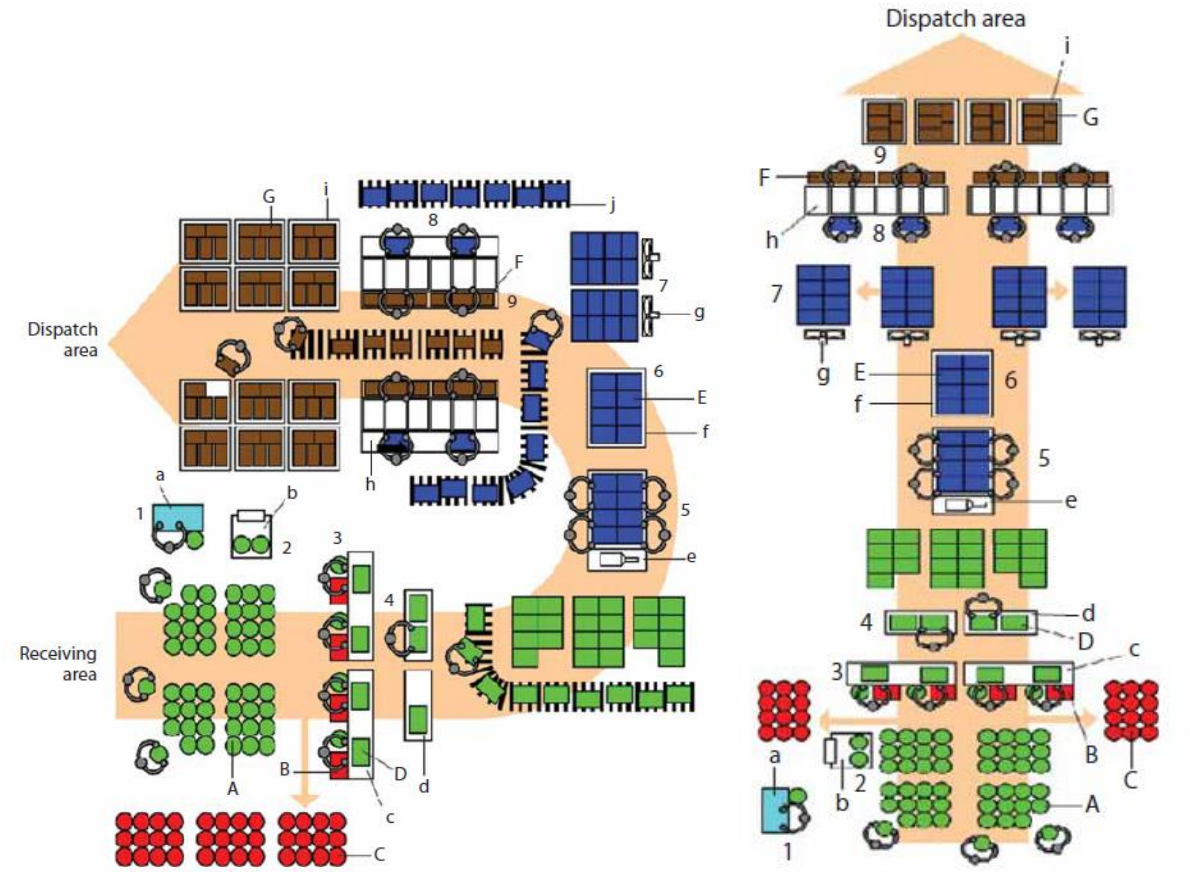


Fig. 1.11: U type configuration and Straight line configuration of mango packing house (FAO, 2012) (1) Maturity test, (2) weighing, (3) sorting and trimming, (4) delatexing, (5) hot water treatment, (6) cooling, (7) air-drying, (8) sizing, (9) packing. Equipment: (a) flotation tank, (b) weighing scale, (c) sorting table, (d) delatexing tank, (e) hot water tank, (f) cooling tank, (g) fans, (h) sizing table, (i) pallets. Materials: (A) full baskets, (B) reject fruit, (C) empty baskets, (D) full crates, (E) treated fruit in crates, (F) empty cartons, (G) full cartons

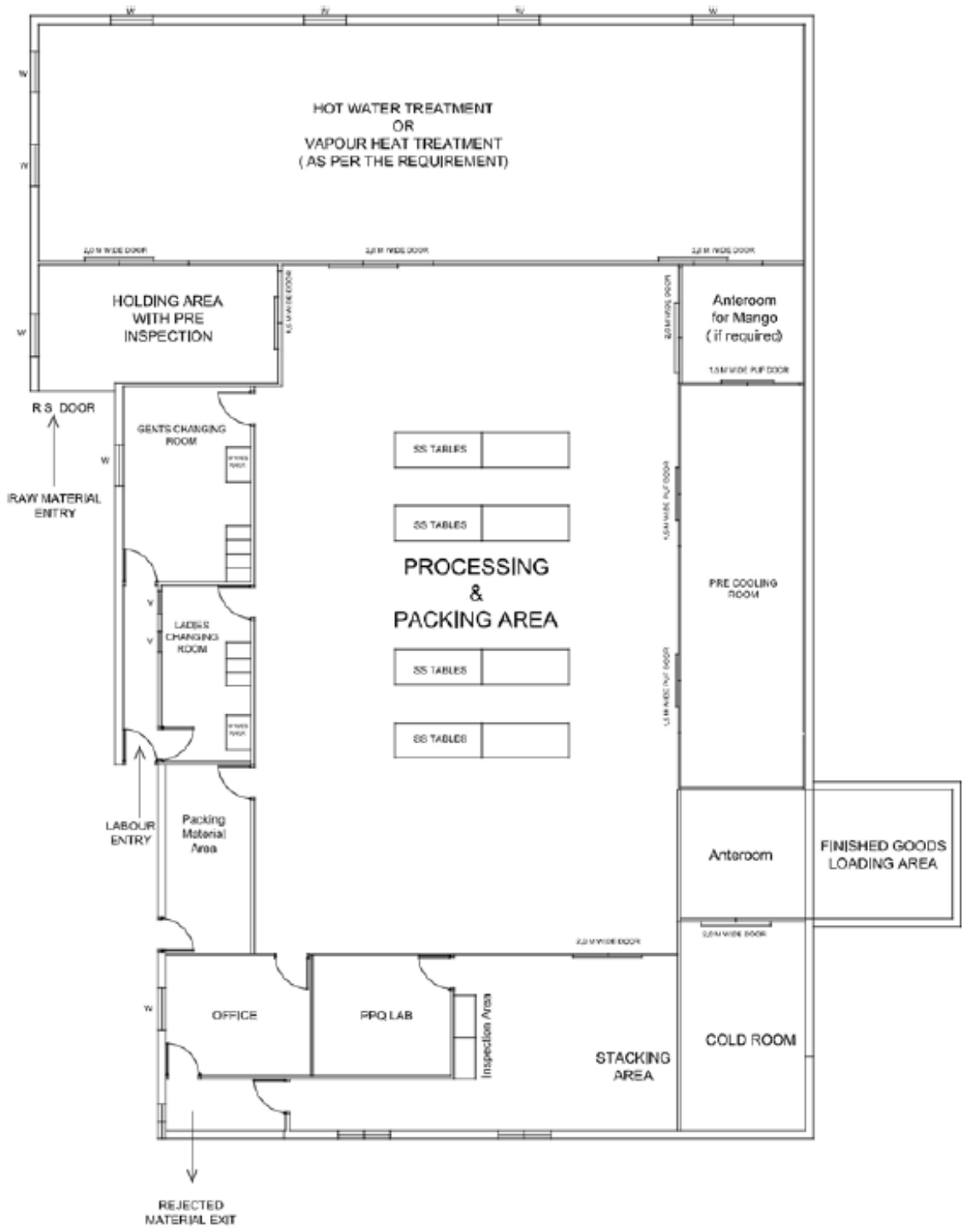


Fig. 1.12: A typical pack house layout (APEDA)

Equipment used in packing house operations (Primary processing)

1. Weighing scales
2. Washers - dipping tanks, spray washers, hydro cooler cum washer, cleaner cum graders
3. Dryers- surface dryers, air blowers for surface moisture removal.

4. Sorting tables
5. Conveyor belt sorters.
6. Sizers - mechanical graders, table top sizers, weight sizers etc
7. Dipping tanks
8. Waxers
9. Blowers
10. Conveyors for handling or movement of produce from one operation to other-gravity roller conveyors, belt conveyors
11. Pallets
12. Forklifts/carts etc
13. Racks for curing/air drying
14. Bagging machines
15. Sticker applicators
16. Quality measurement equipment such as Vernier calipers, screw gauge, temperature measurement devices, colour meters, refractometer and pH meters etc.
17. Cold storage
18. Ripening chambers

1.5. Primary Processing of Fruits and Vegetables

For preparing the fruits and vegetables for the market, simple primary processing operations such as cleaning, sorting, trimming, grading, washing, surface drying (removal of excess moisture) and packaging is used. Also curing, waxing, ripening, degreening and pre-cooling are some primary processing operations. Apart from above operations in some cases such as roots and tubers; peeling, slicing and drying with washing are some of the primary processing operations used. Similarly, in case of mango delatexing is done.

a) **Trimming**: It is the process of removal of unwanted plant parts or those likely be rejected by consumers or those parts that can contribute to deterioration. Some examples of trimming are; removal of dried floral parts from the fingers in banana, removal of wrapper leaves in cabbage, removal of vegetative parts and trimming of tops in onions, garlic and radish, removal of crown in pineapple and removal of silk and husk in sweet corn and baby corn. Trimming is done by tools such as stainless steel knives or pruning shears.

b) **Sorting and Grading:** Sorting can be defined as removal of defective, pest damaged mechanical damaged, decay or misshapes etc., from the produce. Grading is defined as classifying the produce into groups to set criteria of quality, size accepted by

governments or industry. Grading is done on some common properties such as appearance, stage of maturity and/or ripeness, texture, presence of damage or defect and safety and wholesomeness. Some of the specifications or quality factors for grading and sorting are given by codex standards for fruits and vegetables. Grading or size classification can be done based on weight (ex-pineapple), diameter (ex-grape fruit) and length (ex-baby corn). Sorting can also be done at field level to reduce the volume of handling and also reduce damage to the produce. Field sorting can be done under tree shades or small tents can be put up.

In case of large scale operations, sorting may be semi or fully automatic for handling large quantities depending on the market (export or local). Sorting and grading is also done manually using conveyors. The produce will move on the conveyors in front of the trained personnel standing along the sides of the conveyors. In case of fully automated sorting and grading machine, machines equipped with machine vision capability (soft x-ray, image processing, etc.) is used which grade the produce based on colour and size. Methods such as near-infrared systems are used for sorting based on sweetness and detect physical injury. Also grading dis such as pictorial guides on quality defects can be used as reference source for the classification.

c) **Delatexing/desapping:** Removal of latex from fruits such as mango, banana and papaya is followed, as the latex stains and latex burns are caused by latex. When pedicel of a fruit is removed, latex exudes from the point of attachment which has to be removed. Latex in mangoes are removed by placing the fruit stem down in wire meshed tray for 30 minutes to allow latex to drip. The latex stains can be prevented or removed by dipping in anionic commercial detergent, 1 percent alum solution or washing in water.

d) **Cleaning/Washing**: Cleaning is removal of latex, dirt, chemical residues, reduce microbial load, insects, and other extraneous materials from surface of the produce. Different methods used for cleaning are: *Washing*- dump washing/immersion dipping, spray washing, Brush spraying; *Wiping*-wet or moist cloth; *dry brushing*- use brushes in water sensitive produce-ginger; *Forced air*. Apart from the above methods, antimicrobials (Cholrine, Hydrogen peroxide, Peroxyacetic acid, ozone, electrolyzed water) or sanitisers can be used for cleaning.

After washing or dipping excess water on the surface of the produce has to be removed prior to other operations such as waxing, packing or transportation to avoid

decay, wetting of package etc. fans or blowers can be used, or conveyed through heated drying tunnel for removal of surface moisture.

e) **Curing:** This operation of primary processing is done in case of bulb crops such as onions and garlic to prevent entry of microorganisms. This process allows closing of the neck and drying of outer scales. Rapid curing is done by forced heated air through produce placed in curing bins or racks.

f) **Waxing:** Waxing is done for improving the appearance, reduce moisture loss and decelerate ripening process. Natural and edible wax is used for coating of fruits and vegetables. Waxes can also be impregnated with antifungal compounds for disease control. The coatings should impart gloss, be transparent, odourless and tasteless, biodegradable, impermeable to water and semi-permeable to oxygen and carbon dioxide. Some fruits which are waxed in wider scale are- apples, oranges and kinnow. Wax is applied by dipping/foaming/brushing/spraying methods.

g) **Ripening/Degreening:** It is the process of artificially accelerating the ripening process from a mature green stage to semi or fully ripe stage. Hormone responsible for initiating ripening is ethylene. Artificial ripening is done by generating ethylene using alcohol and acetylene which is analogue to acetylene. Fruits harvested at mature green stage have to be degreened such as sweet lime for acceptance by consumers. Ethylene level of 100 to 1000 ppm is used for banana ripening and 100 ppm for mango ripening.

h) **Packaging**: Packing of the fruits and vegetables as per the material requirements. They can be packed as bulk packaging or retail pack. Different types of packaging used in fruit and vegetables are plastic crates, baskets, wooden crates, cartons, plastic films, plastic trays, MAP packs etc. The package should have information about volume, source, country of origin, date of packed, etc.

i) **Precooling:** It is the process of removal of field heat from the produce before it is stored in cold store at standard storage temperature or before loading refrigerated trucks for transportation. This helps to reduce the heat load injury on the produce. Different types of precooling are: room cooling, forced air cooling, hydro cooling, vacuum cooling and package icing.

j) **Cold storage:** Storage of produce at lower temperatures is done to minimize deterioration and maintain quality and also to hold the produce before dispatch. The storage of fruits and vegetables are done at different temperatures and RH.

Table 1.1: Recommended storage temperature and RH for selected fruits (FAO, 2012)

Commodity	T (°C)	RH (%)	Storage life
Avocado ('Fuerte', 'Hass')	7	85-90	2-3 wk
Banana (green)	13-14	90-95	1-4 wk
Breadfruit	13-15	85-90	2-6 wk
Cactus pear (dragon fruit)	2-4	90-95	3 wk
Calamondin	9-10	90	2 wk
Canistel	13-15	85-90	3 wk
Carambola	5-10	85-90	4-7 wk
Cashew apple	0-2	85-90	5 wk
Cherimoya	8-9	85-90	1-2 wk
Custard apple	5-7	85-90	4-6 wk
Durian	10-13	85-90	2-3 wk
Grapefruit	14-15	85-90	6-8 wk
Grapes	-0.5-0	85-90	3-8 wk
Guava	10-13	90	2 wk
Jackfruit	13	85-90	2-6 wk
Lanzones	11-14	85-90	2 wk
Lemon	7-10	85-90	2-3 mo
Lime	9-10	85-90	6-8 wk
Longan	1.5	90-95	3-5 wk

Commodity	T (°C)	RH (%)	Storage life
Lychee	0-2	90-95	3-5 wk
Mango	13	85-90	2-3 wk
Mangosteen	13	85-90	2-4 wk
Oranges, mandarin	3-4	85-90	3-4 wk
Papaya	10-13	85-90	2-3 wk
Passion fruit	7-10	85-90	3-4 wk
Pineapple	7-10	85-90	2-3 wk
Plantain	13-15	90-95	1-5 wk
Pomegranate	5	90-95	2 mo
Pomelo	7-9	85-90	4-6 wk
Rambutan	12	90-95	1-2 wk
Santol	7-9	85-90	3 wk
Sapote	15-20	85-90	1-2 wk
Soursop	13	85-90	1-2 wk
Starapple	3	90	3 wk
Strawberry	-0.5-0	90-95	5-10 d
Sugar apple	7	90-95	4 wk
Tamarind	7	90-95	3-4 wk

Sources: Yon and Jaafar (1993); McGregor (1987); Pantastico *et al.* (1975); PHTRC-UPLB Annual Project Reports

Table 1.2: Recommended storage temperature and RH for selected vegetables (FAO, 2012)

Commodity	T (°C)	RH (%)	Storage life	Commodity	T (°C)	RH (%)	Storage life
Amaranth	0-2	95-100	10-14 d	Jicama	13-18	65-70	1-2 mo
Asparagus	0-2	95-98	2-3 wk	Leek	0	95-100	3 mo
Bean, snap	4-7	95-98	7-10 d	Lettuce	0-1	95-100	2-3 wk
Bean, lima (in pod)	5-6	95	5 d	Melon, honeydew	7-10	90-95	2-3 wk
Beet, topped	0	98-100	4-6 mo	Okra	7-10	90-95	2-3 wk
Bittermelon	12-13	85-90	2 wk	Onion, green	0	95-100	4 wk
Broccoli	0	95-98	10-14 d	Onion, bulb	0	65-70	6-8 mo
Cabbage	0	98-100	3-6 wk	Parsley	0	95	2-3 wk
Carrot	0	95-100	4 wk	Peas	0-1	95	1-2 wk
Cauliflower	0	95-98	2-4 wk	Pepper, sweet	7-10	90-95	2 wk
Celery	0	95-98	2-4 wk	Potato	4	95	3-5 mo
Chayote	7	85-90	1-2 wk	Radish	0	95	3-4 wk
Chinese cabbage	0	95-100	2-3 mo	Squash	5-10	95	1-2 wk
Corn, sweet	0	95-98	4-8 d	Taro	7-10	85-90	3-5 mo
Cucumber	10-13	90-95	10-14 d	Tomato	10-13	85-90	7-10 d
Eggplant	12-15	90-95	7 d	Watermelon	10-15	90	2-3 wk
Garlic	0	60-70	6-7 mo	Winged bean	10	90	2-3 wk
Ginger	13	65-75	4-6 mo	Yam	16	70-80	3-6 mo

Sources: McGregor (1987); Pantastico (1975); PHTRC-UPLB Annual Project Reports

1.6. Unit operations in fruits and vegetables processing

India is Second Largest producer of fruits and vegetables in the world. India Post Harvest losses in fruits and Vegetables are ranging from 5.8-18%. Processing of fruits and vegetables account for about 2% to overcome the post-harvest losses, various processing techniques are needed to be implemented. The study of process engineering is an attempt to combine all forms of physical processing into a small number of basic operations, which are called unit operations. Important unit operations involved in the food industry are fluid flow, heat transfer, drying, evaporation, contact equilibrium processes (which include distillation, extraction, gas absorption, crystallization, and membrane processes), mechanical separations (which include filtration, centrifugation, sedimentation and sieving), size reduction and mixing.

1.6.1. Blanching

Blanching is the treatment of vegetables in hot water or steam to inactivate oxidative enzymes. Blanching serves a variety of functions, one of the main ones being to destroy enzymatic activity in vegetables and some fruits, prior to further processing by heat. To achieve adequate enzyme inactivation, food is heated rapidly to a pre-set temperature, held for a pre-set time and then cooled rapidly to near ambient temperatures.

- The maximum processing temperature in freezing and dehydration is insufficient to inactivate enzymes.
- If the food is not blanched, undesirable changes in sensory characteristics and nutritional properties take place during storage.
- In canning, the time taken to reach sterilizing temperatures, particularly in large cans, may be sufficient to allow enzyme activity to take place. It is therefore necessary to blanch foods prior to these preservation operations.
- Enzymes which cause a loss of eating and nutritional qualities in vegetables and fruits include lipoxygenase, polyphenol oxidase, polygalacturonase and chlorophyllase.
- Two heat-resistant enzymes which are found in most vegetables are catalase and peroxidase.
- Although they do not cause deterioration during storage, they are used as marker enzymes to determine the success of blanching. Peroxidase is the more heat resistant of the two, so the absence of residual peroxidase activity would indicate that other less heat-resistant enzymes are also destroyed.
- Blanching reduces the numbers of contaminating micro-organisms on the surface of foods and hence assists in subsequent preservation operations. This is particularly important in heat sterilization, as the time and temperature of processing are designed to achieve a specified reduction in cell numbers.
- Blanching also softens vegetable tissues to facilitate filling into containers and removes air from intercellular spaces which increases the density of food

1.6.2. Canning

Canning is a method of preservation of food in which the food is processed and hermetically sealed in containers (of metal, glass, thermo stable plastic, or a multi-layered flexible pouch) by the application of heat. Canning provides a shelf life ranging from one to five years, although under specific circumstances it can be much longer. Heating is the principle factor to destroy the microorganisms and the permanent sealing is to prevent re-infection.

Why is Canning done?

- The high percentage of water in most fresh foods makes them very perishable. They spoil or lose their quality for several reasons.
- Microorganisms live and multiply quickly on the surfaces of fresh food and on the inside of bruised, insect-damaged, and diseased food. Oxygen and enzymes are present throughout fresh food tissues. Proper canning practices minimize the effects of these microorganisms.

- However, the main objective of canning is to preserve the food by the application of heat so that it can be safely eaten at a later time. Safety of the consumer is the primary concern when food is canned.

Foods that are canned:

a) Low acid foods: Meat, fish, poultry, dairy fall into a pH range of 5.0 to 6.8. This large group is commonly referred to as the low acid group.
b) Acid foods: With pH values between 4.5 and 3.7. Fruits such as pear, oranges, apricots and tomatoes fall in this class.
c) High acid foods: Such as pickled products and fermented foods. The pH values range from 3.7 down to 2.3, also Jams and Jellies are in this classification.

The factors which influence blanching time are:

- type of fruit or vegetable
- size of the pieces of food
- blanching temperature
- Method of heating.

Processing steps

a) Selection:

- For canning, fruits and vegetables should be absolutely fresh.
- The fruit should be ripe, but firm and evenly matured.
- It should be free from all unsightly blemishes, insect damage and malformation.
- Over-ripe fruit is generally infected with microorganisms and would yield a pack of poor quality.
- The vegetables should be tender and reasonably free from soil, dirt etc.

b) Sorting and Grading:

- After the preliminary sorting, the fruits and vegetables are graded.
- The grading is done with respect to size, color etc.
- Generally done by hands or the grading machines (screen graders, roller graders etc.).

c) Washing:

- The graded fruits and vegetables are washed with water in different ways such as soaking or agitation in water, washing with cold or hot water sprays, etc.
- Vegetables may preferably be soaked in a dilute solution of potassium permanganate to disinfect them.
- Spray washing is the most efficient method.

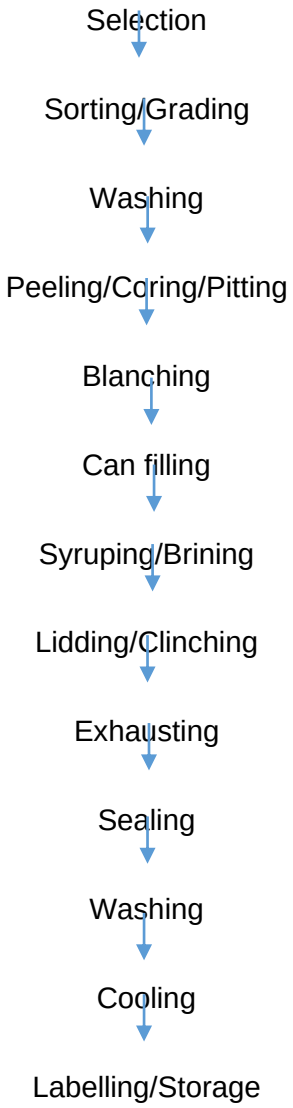


Fig. 1.13: Flow chart of Canning Process

d) Peeling, Coring, Pitting:

Peeling of fruits and vegetables can be done in many ways:

- by hand or with knife
- by machine
- by heat treatment (Scalding)
- by lye solution (dipping the fruits and vegetables in a solution of boiling caustic soda or lye solution of strength 1-2%for 30 seconds to 2 minutes.

e) Blanching:

- Treatment of fruits and vegetables with boiling water or steam for short periods, followed by cooling prior to canning, is called 'blanching'.
- Blanching is done with the objective of:
- Loosening the skin of the fruit or vegetable.
- Eliminate the no. of microorganisms.
- Inactivating the enzymes, thus preventing the possibility of discoloration.
- Improving the flavor by reducing the astringency in some foods.

f) Can Filling:

- Before filling of the contents (fruits and vegetables) a small amount of syrup (for fruits) or brine (for vegetables) is poured in the can so as to provide a medium to the contents.
- Can filling can be done by machine or hand filling. The cans are washed and subjected to a steam jet remove any adhering dust or also employed.

g) Syruping and Brining:

- The cans are filled with hot sugar syrup for fruits (concentration 35-40%) and hot brine for vegetables (concentration 1-2%).
- The syrup or brine should be added to the can at a temperature of 79°C to 82°C, leaving a headspace in the can so that when the filled can is closed on the double seaming machine, the headspace left inside ranges from o.32 cm to 0.47 cm.
- Objective of this step is to improve the taste of the canned product and to fill up the inter space between fruits and vegetables.

h) Lidding or Clinching:

- Cans after being filled, are covered loosely with lid and passed through the exhaust box.
- Lidding is now replaced by CLINCHING in which the lid is partially seamed to the can by a single first roller action of double seamer.

i) Exhausting:

- By exhausting, risk of corrosion of tin plate and pin holing during the storage and discoloration of the product is reduced as the oxidation process is prevented.
- During exhausting, expelling of all the gases takes place which prevents spoilage of the canned product by ceasing the chemical reactions and also the bulging of can.

j) Sealing:

- After exhausting, the cans are sealed by special closing machines known as double seamers.
- There is hand operated as well as semi-automatic and fully automatic seamers.

k) Processing/Sterilization:

- Processing consists of heat treatment which is sufficient to eliminate the growth of spoilage causing microorganisms.
- All fruits can be satisfactorily processed at 100°C and vegetables at 116-120°C.
- The total time required to sterilize canned food is largely depending on:
  - Size of can
  - Processing temperature
  - Rate of heat penetration at the center of the can.
  - pH of the food
  - The type and number of organisms present

l) Cooling:

Immediately after processing, the cans are COOLING in water to a temperature of 36°C to 42°C. to avoid thermophilic spoilage or can rust. If the cans are cooled much below 36°C, they may not dry thoroughly and rusting well result. If the cans are cased at temperatures much over 42°C, thermophilic spoilage may occur.

m) Labeling and Storage:

After the completion of the canning process, the cans are labeled, packaged and stored at a clean and dry place.Storage temperatures of sterile canned meat products should not be above 21.1°C, because higher temperatures markedly accelerate deterioration during storage, thus limiting shelf life.

Defects in cans

- Swell: bulging of both can ends by positive internal pressure due to gas generated by microbial or chemical activity. Either hard or soft swell.
- Flipper: a can with normal appearance but one end flips out when the can is struck against a solid object but snaps back to the normal under light pressure.
- Springer: a can bulged from one end which if forced back into normal position, the opposite end bulges.
- Leakage: perforated can.
- 5-Overfilled can: has convex ends due to overfilling and not regarded as spoiled.

1.6.3. Drying and Dehydration

Drying refers to the removal of small amount of moisture from a solid or nearly solid material by evaporation to a predetermined level. Drying involves heat and mass transfer operations. Complete removal of moisture content to bone dry condition.

Need for drying

- To produce stable produce
- In the preparation of Powder and granules
- Reducing the bulk weight
- Prior to grinding and to prevent product deterioration

Choice of method of drying

- Based on heat sensitive foods
- To be carried out in aseptic condition
- Quantity of products to be dried
- Available source of heat
- Cost effectiveness

Different types of dryers

Dryers are classified according to drying process into:

- Adiabatic drying – Solids are dried by direct contact with hot air.
- Non-adiabatic drying – External medium is used to transfer heat.

Based on the above two process different types of drying are:

a) **Sun drying:** Sun and solar drying are the ancient methods. The fruits and vegetables are spread on the ground in thin layers and expose to direct sun light for drying. It is a time consuming and inexpensive process. The major disadvantages are the environmental contamination, insect infestation, and microbial deterioration which causes low quality food.

b) **Tray or Cabinet Dryers:** These types of dryers use trays or similar product holders to expose the product to heated air in an enclosed space. The trays holding the product inside a cabinet or similar enclosure are exposed to heated air so that dehydration will proceed. Air movement over the product surface is at relatively high velocities to ensure that heat and mass transfer will proceed in an efficient manner.

Cabinet dryers are batch systems and major disadvantage is non-uniform drying of a product at different locations within the system. To overcome and to produce a uniformly dried produce is achieved by rotating the trays.

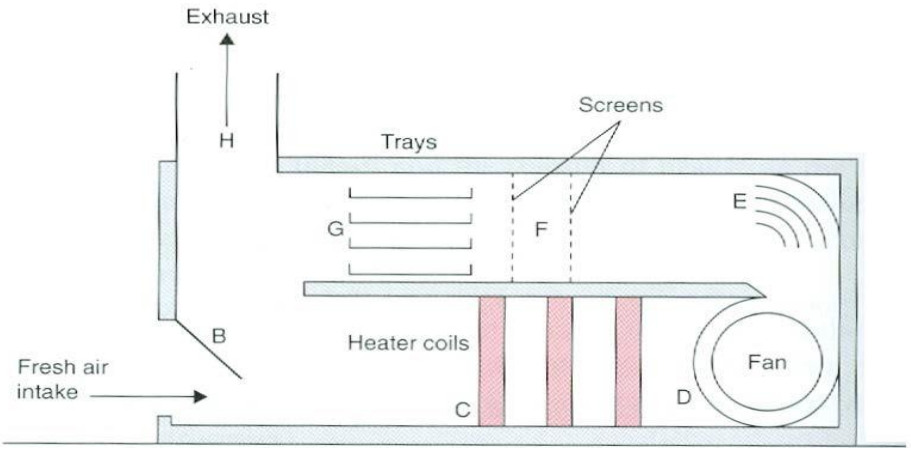


Fig. 1.14: Tray drying

c) Tunnel dryer: Modified form of tray dryer where the feed is at the one end and the product is obtained at the other end of the tunnel. The air and product can move either in concurrent or counter current manner. With concurrent systems, a high-moisture product is exposed to high temperature air, and evaporation assists in maintaining lower product temperature. At locations near the tunnel exit, the lower-moisture product is exposed to lower-temperature air. In counter current systems, a lower-moisture product is exposed to high-temperature air, and a smaller temperature gradient exists near the product entrance to the tunnel.

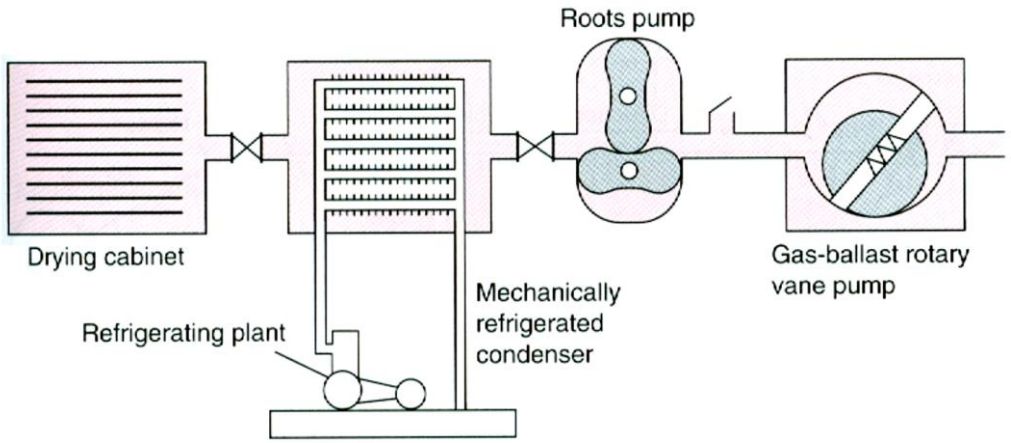


Fig. 1.15: Concurrent flow tunnel drying

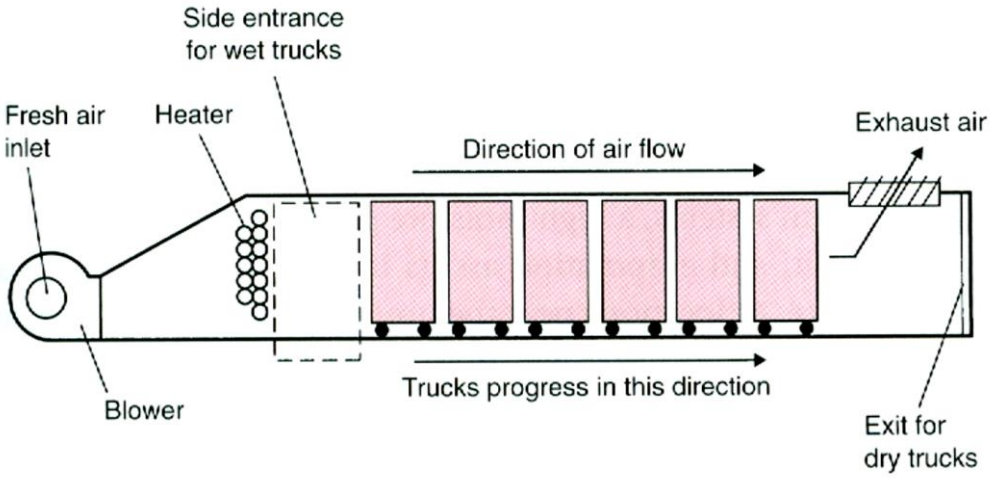


Fig. 1.16: Counter current flow tunnel drying

d) Fluidized-Bed Drying: The products are suspended in the heated air for drying throughout the processing. In this drying, heat is transferred to food material by convection. An air flow helping to convey the food through the dryer.

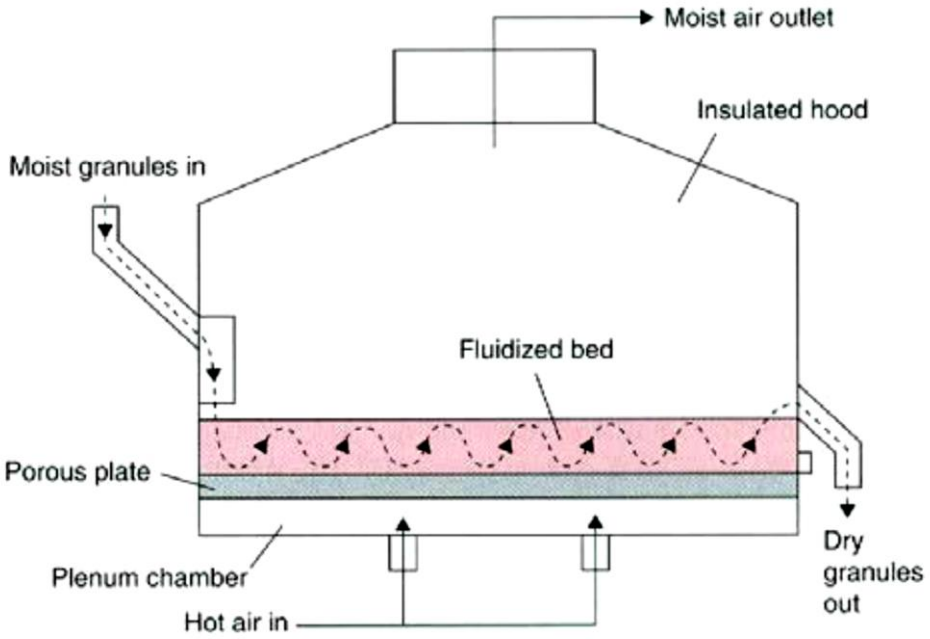


Fig. 1.17: Fluidized bed drying

e) Drum drying/Film/Contact drying: In this liquid food to be dried are made to spread over the heated drum surface. During the time of drying, food remains stuck on the drum surface which will be scraped off using doctor blades.

It can be classified based on the number of drums (Single, double or twin), Pressure (Atmospheric or vacuum) and the method of the feed input (nip, splash, dip feed or roller).

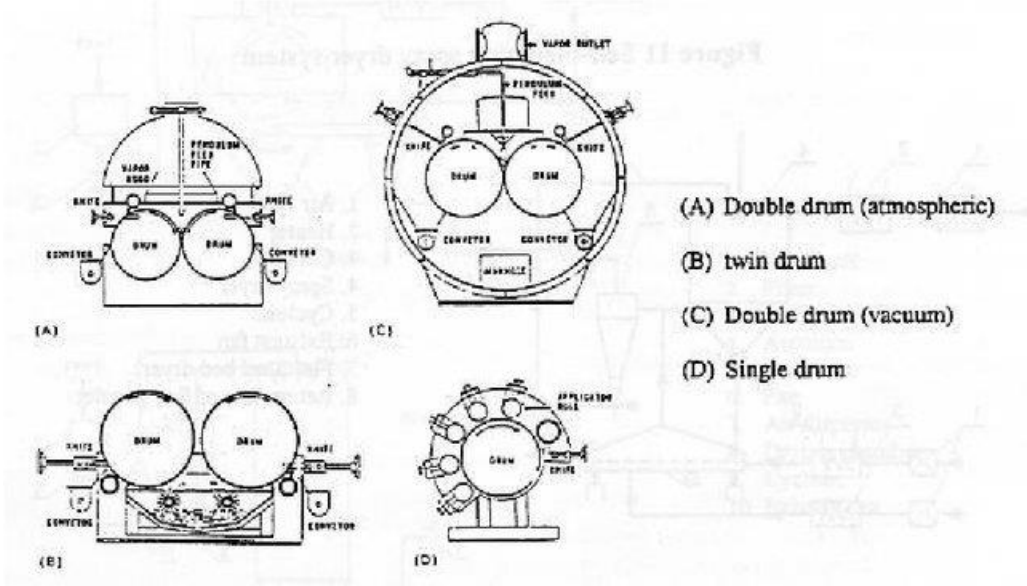


Fig. 1.18: Different types of Drum drying

f) Spray drying: Slurry of liquid or fine solid material is injected into a blast of hot air in the chamber through the spray nozzle at the top of the drying chamber. Hot air is blown inside the chamber and the water evaporates and solid part of product remains in powder form. Air and solids may move in parallel or counter current flow. It is suitable for producing powder foods which are heat sensitive in nature.

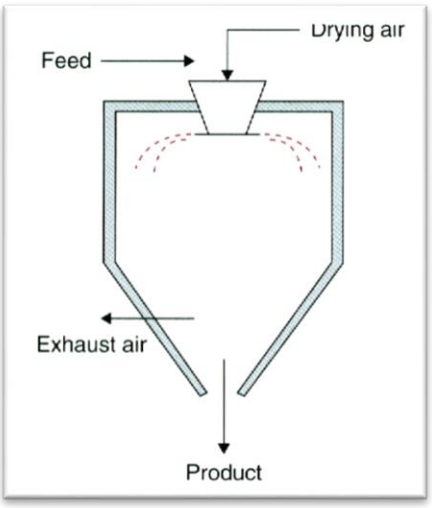


Fig. 1.19: Spray drying

e) **Vacuum drying:** Removal of moisture is done at the reduced pressure below the water vapor pressure or creating a vacuum for heating the heat sensitive and hygroscopic produce. This is processed at a very low temperature.

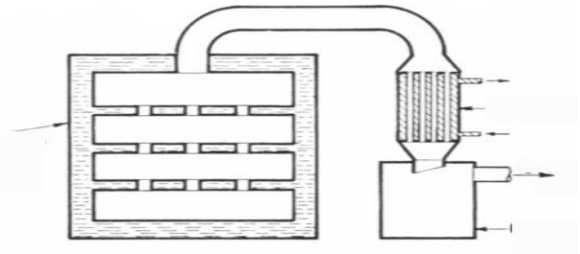


Fig. 1.20: Vacuum drying

f) **Osmotic drying or dehydration:** Efficient and simple process for the preservation of fruits and vegetables. Sugar and salt are the major solute used in this process. Sugar syrup is used in terms of fruits and brine for vegetables. It is the process of removal of water from fruits & vegetables to an osmo-active solution and transfer of solute in the food material. This is preferred method due to their color, aroma, nutritional constituents and flavor compound retention value.

g) **Freezing:** The process of removing sensible and latent heat in order to store the food in temperature of –18°C or below. It is also defined as the process of reducing the temperature of the food below its freezing point. Water in the food transforms to ice crystals.

Principles:

It is mainly done to lower temperature of food to reduce microbial spoilage because of the water unavailability for microorganisms to grow and chemical reaction. This results in slowing down microbial activity and chemical changes. It does not sterilize the food. Freezing involves two successive processes. Nucleation phase in which results in the formation of ice crystals and growth phase which increase in crystal size (growth). During freezing, freezing time and freezing rate are the Important factors to be considered for a freezing system.

Methods of freezing

- Air freezing: Air is the cooling medium. Ex. Blasts, fluidized bed, spiral.
- Indirect contact freezing: Food comes in contact with a cooled metal surface. Ex- Plate freezer.

- Immersion Freezing: Direct immersion in refrigerants (glycols, glycerol, sodium chloride, calcium chloride, and mixtures of salt and sugars)
- Cryogenic Freezing: Exposing food directly to a cold refrigerant (Liquid nitrogen) undergoing phase change.

Selection of freezing method:

Freezing method chosen for each product will depend on:

a. Product quality and freezing rate desired

b. Type and shape of product, package, etc.

c. Flexibility required in freezing operations.

d. Costs of freezing for alternative techniques.

a) Freeze drying: This method is also called as lyophilization. It is works on the principle of sublimation process. It dehydrates the produces at a very low temperature by freezing the produce at first, lowering the pressure and remove the moisture my sublimation process. There are 4 stages in this: Pretreatment, freezing, primary drying, and secondary drying. It is suitable for heat-sensitive food material. Freeze-dried product is easy to reconstitute also. Major disadvantage is its cost.

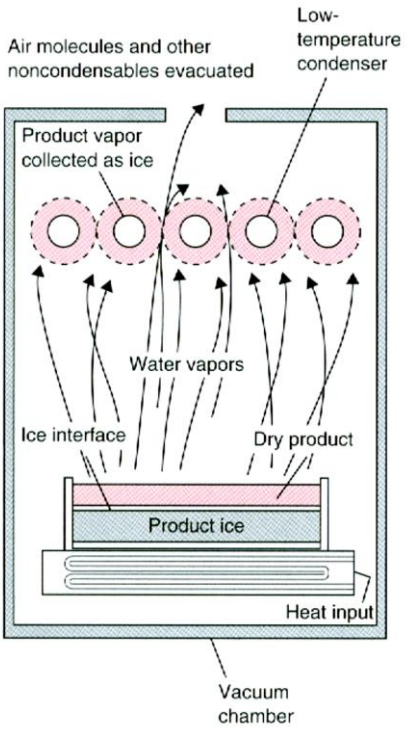


Fig. 1.21: Freeze drying

b) Extraction: Fruits play an important role in human nutrition. Before the 20th century, drinking squeezed fruit juices was the privilege of only a few. A wide range of drinks can be made using extracted fruit juice or fruit pulp as the base material. There are several methods to extract juice depending on the type of fruit. For citrus fruits which are naturally juicy, the best option is to use a presser. Whereas, some fruits such as melon and papaya are steamed to release the juice. Apples are pressed (hydraulic, pneumatic, screw, or basket press) and fruits such as mango, guava, sour soup, pineapple, strawberry must be pulped to extract the juice. The fruit pieces are pushed through a perforated metal plate that crushed and turns them into a pulp. Some fruits can be pulped in a liquidiser and then filtered to remove the fruit pieces. There is a range of equipment available that varies in size and in the type of power supply. Polygalacturonase and pectinlyase and cellulase are used to hydrolyze pectin and fruit cell wall, facilitating juice release during pressing and increasing yield. Enzyme treatment requires heating because it is most effective at around 50 ºC and requires some reaction time. Juice yield is affected by pressing conditions (temperature, pressure, presence, and type of pressing aid). The typical fruit juice yields range between 70% and 95%.

1.7. Minimal Processing of Fruits and Vegetables

Minimally processed fruits and vegetables are fresh fruits and vegetables processed to increase their functionality without greatly changing their fresh like properties. The industry of fresh-cut fruits and vegetables is constantly growing due to consumers demand. There is a general trend to increase fresh fruit and vegetable consumption mainly due to their health properties. Different organizations recommend the increasing fruit and vegetable consumption to decrease the risk of cardiovascular diseases and cancer. The fresh-cut fruit and vegetable industry is constantly growing mainly due to the consumer's tendency of health consciousness and their convenience.

Minimally processed fruits and vegetables are fresh fruits and vegetables processed to increase their functionality without greatly changing their fresh like properties. Fresh-cut produce industry has been on a double-digit growth rate in response to an increased demand by consumers, particularly in developed countries. Demand of Minimal Processed fruits and vegetables has increased rapidly in Europe and USA, where demand is expected to represent 25% of the total food market in the near future. This increase is due in part to

two key trends observed in this comprehensive study: a growing focus on health, which includes the consumption of fresh vegetables, and the increased preference for convenience. To the extent possible, consumers want healthy products for their meals, available at a good value, convenient, safe, and with good quality.

This beneficial effect has been attributed to non-essential food constituents, phytonutrients, that posse a relevant bioactivity when frequently consumed as a part of regular diet. This also corresponds to one of the traditional claims in proper dietary habits which aims for an increasing intake of fruits and vegetables. However, it is well-known that modern ways of life usually trend to a reduction of suitable intake of rich sources of antioxidant compounds, such as fruit and vegetables, being more emphasized in some parts of the population, especially children. It is known that a food which meets nutritional requirements is unlikely to be accepted by consumers if they do not like the flavor or other quality attributes. Additionally, it has been shown that consumer's needs for convenience are correlated with food choice. Therefore, the fresh-cut fruit and vegetable industry is still working to increase the assortment of minimally processed vegetable products that meets consumer's needs for 'quick' and convenient products that preserve their nutritional value, retain a natural and fresh color, flavor and texture, and contain fewer additives such as preservatives.

Fresh-cut fruits and vegetables emerged to fulfill new consumer's demands of healthy, palatable and easy to prepare plant foods. 'Minimal processing' describes non-thermal technologies to process food in a manner to guarantee the food safety and preservation as well as to maintain as much as possible the fresh-like characteristics of fruits and vegetables. In the fresh produce industry- especially with F & V, minimally processed products- defined as "any fruit or vegetable, or any combination thereof, which has been physically altered from its original form, but has remained in its fresh condition". As per USDA and FDA, fresh-cut (pre-cut) products have been freshly cut, washed, packaged and maintained with refrigeration. Fresh-cut products are in a raw state and even though processed they remain in a fresh state, ready to eat or cook, without freezing, thermal processing, or treatments with additives or preservatives. The International Fresh-cut Produce Association defines a fresh-cut product as fruits or vegetables that have been trimmed and/or peeled and/or cut into 100% usable product that is bagged or pre-packaged to offer consumers high nutrition, convenience and flavor while still maintaining freshness.

Although between processing and consumption a span of several days occurs, consumers still want to have fresh or fresh-like vegetables on their dishes or pans. A major challenge facing the industry however are the rapid quality deterioration and reduced shelf life of fresh

cut products compared with whole vegetables due to physiological disorders and decays. Microbiological, sensory and nutritional shelf life of minimally processed fruits and vegetables should be at least 4-7 days but preferably even longer.

Among others, visual properties of fresh-cut fruit and vegetable commodities are one of the most important parameter to evaluate the total quality of the product by consumers. Looking at the package, it will be possible to evaluate absence or presence of discoloration (enzymatic browning of cut surfaces, yellowing of green vegetables and pale color of bright vegetables), mechanical damage (foiled lettuce leaves, absence of cutting damage), as well as decay. However, it is well-known that processing of vegetables promotes a faster physiological deterioration, biochemical changes and microbial degradation of the product even when only slight processing operations can be used which may result in degradation of the color, texture and flavor. Storage temperature is the single most important factor affecting spoilage of minimally processed fruit and vegetables.

1.7.1. Preparation of Minimal Processed Products

Minimally processed products can be prepared at the site of production or at processing centers. Preparation procedures involved usually are washing, peeling, cutting, trimming, slicing, shredding, dicing and coring. Major factors affecting fresh-cut fruit or vegetable quality are cultivar, pre-harvest cultural practices, harvest maturity, physiological status of the raw product, postharvest handling and storage, processing techniques, sanitation, packaging and temperature management during shipping and marketing.

The first essential step in reducing overall contamination of raw material is by removing the outer leaf layer or surface dirt. Washing also helps to remove the sugars and other nutrients at the cut surface of the produce, which favour microbial growth and discoloration. Peeling process depends on raw material types and influences quality of finished products. Different methods involved are

- Hand peelers
- Knives
- Abrasion method (for bulk, using carborandum disc and running water, generally for peeling of potatoes and root vegetables)
- Lye peeling
- Steam peeling
- Freeze/lame/vacuum peeling where chemicals like acid, calcium chloride and ammonium salts are used to peel various fruits and vegetables

Some fruits and vegetables require more operations before packaging like slicing, shredding, dicing etc. They become more susceptible to spoilage by releasing nutrient rich vascular and cellular fluids on disruption of protective epidermal layer. Slicing caused physical damage, physiological stress and enhanced microbial growth in peeled carrot. Sharpness of blade also has effect on injury to commodity.

1.7.2. Physiological Responses and Bio-Chemical Changes

Physiology of minimally processed fruits and vegetables is generally same as that observed in plant tissues wounded or exposed to stress conditions. Intrinsic and extrinsic factors affect the deterioration due to physiological processes. Increased respiration rate causes major tissue disruption as enzymes and substrate become mixed with each other and with other cytoplasmic and nucleic substrates and enzyme. Fruits and vegetables also demonstrate wound induced ethylene production and increased surface area per unit volume, thus exacerbate water loss. Cold injury during low temperature storage and physical abrasion resulting from processing and packaging induce abusive atmosphere or desiccation, resulting in undesirable changes in product flavor, texture and nutritional quality. Other deterioration types include chemical and enzymatic changes and microbial deterioration. Physical damage during harvesting, handling, transportation, processing and packaging can also affect shelf life of minimally processed fruits and vegetables.

However, there are many other preservation techniques that are currently being used by the fresh-cut industry such as antioxidants, chlorines and modified atmosphere packaging (MAP). Nonetheless, new techniques for maintaining quality and inhibiting undesired microbial growth are demanded in all the steps of the production and distribution chain as microorganisms adapt to survive in the presence of previously effective control methods.

New techniques for maintaining quality and inhibiting undesired microbial growth are demanded in all the steps of the production and distribution chain. The use of ultraviolet-C, modified-atmospheres, heat shocks and ozone treatments, alone or in different combinations have proved useful in controlling microbial growth and maintaining quality during storage of fresh-cut produce

During minimal processing (including peeling, cutting and grating operations), many cells are broken and intracellular products, such as oxidizing enzymes, are released, accelerating the decay of the product. The physical damage - during minimal processing - causes disruption of the cellular membrane- enzymes and their substrates in direct contact - accelerates the

loss of quality. The newest tendency is called the immersion therapy. Cutting a fruit while it is submerged in water will control turgor pressure, due to the formation of a water barrier.

1.7.3. Effects of different deteriorative mechanisms

a) **Respiration:** Higher the respiration shorter will be the shelf life. The effect of minimal processing varies in climacteric and non climacteric fruits and with the age of the fruit. The reserved energy will be utilized during the oxidative reduction process which leads to ageing of the products.
b) **Ethylene:** Ethylene production in minimally processed fruits and vegetables is more which will accelerates ripening, softening and senescence. Stress induced ethylene production (due to chilling injury or wounds) can enhance fruit ripening and also chlorophyll loss and yellowing of leafy vegetables. It stimulates many enzymes and because of the formation of compounds like lignin cell wall thickening and other such defects can also occur.
c) **Browning:** Acceptability and shelf life of the fresh cut products decreases due to browning or discolouration. The main reason is exposure of substrates to enzymes due to the peeling, cutting or slicing operations. Wounding also induces synthesis of some enzymes involved in browning reaction or synthesis of their substrates.
d) **Water loss:** Fresh cut products are more susceptible to weight loss because internal tissues are exposed to atmosphere without skin or cuticle. However RH is generally very high in film bags or containers overwrapped with film, so dehydration is not a big issue.
e) **Microbial Contamination:** Microbial population in minimally processed fruits and vegetables will be more as cell disruption leads to release and intermixing of enzymes and substrates that may be used by native or exogenous microorganisms to grow on the product. The chances of food borne illness due to pathogens or spoilage micro organisms growing in these products are very high. HACCP an effective and rational means of assuring safety can be applied throughout the food chain from primary production to final consumption. HACCP identifies potential avenues of contamination; establishes control measures to eliminate or minimize these hazards; and monitors and documents effectiveness of the program.

1.7.4. Treatments for Quality Maintenance

Minimally processed fruits and vegetables are preserved by refrigeration, chemical preservatives, additives, bio-preservatives, mild heat treatments, microwave processing, reduction of water activity ionizing irradiation, disinfectants (electrolyzed water treatment, chlorination, hydrogen peroxide), high hydrolytic pressure technology, high intensity pulsed

electric field, pulsed light, ozone technology, manothermosonication, oscillating magnetic field, ohmic heating, vacuum /hypobaric packaging, edible coating and hurdle technology.

1.7.5. Effect of Storage Conditions on Quality

Temperature is the most important extraneous factor which affects the shelf life of minimally processed foods. Temperature has a great effect on the respiration and transpiration rates of the commodity and also biological and bio chemical reactions. A 10 ºC decrease in temperature usually will decrease the respiration rate by a factor of 2-3. Minimally processed products should be refrigerated (0-5 ºC) to prolong their quality and safety. Duration of cold storage also has an impact on final product quality.

1.7.6. Modified Atmospheric Packaging (MAP)

The most common atmosphere consists of reduced O_2 (3-5 %) and elevated CO_2 (3-10%) levels, however some other gases like CO, acetylene, ethylene, propylene are sometimes included. MAP reduces unwanted metabolic reactions and protects the commodities against contamination by microorganisms and also slowdown the ageing process. MAP also inhibits the biosynthesis and action of ripening hormone ethylene (slows down softening, browning, decay etc) and protect the color of green leafy vegetables. Extremely low concentration of O_2 induces anaerobic respiration and off-flavor. Nitrogen is often utilized to displace oxygen in MAP, delaying the oxidative browning and inhibiting aerobic microorganisms.

Quality deterioration of packaged minimally processed products may takes place due to improper film selection or flushing protocols, variation in respiration from different cultivars or varieties, seasonal variation and storage duration of products prior to fresh cut processing. Treatment of super atmospheric O_2 is an effective means for both inhibiting microbial growth and enzymatic discoloration and preventing anaerobic fermentation reactions. But negative effects are also reported.

Another interesting MAP method is **moderate vacuum packaging** where respiring produce is packed in a rigid airtight container. Initial gas composition is same as normal air but at a reduced partial gas pressure. **Equilibrium Modified Atmospheric Packaging** is another effective method of packaging fresh cut fruits and vegetables and used to prolong the shelf life. Equilibrium is established inside the package, when O_2 transmission rate of packaging film is matched to O_2 consumption rate of packaged commodity.

Active or smart packaging is a type of packaging that changes the condition of packaging to extend the shelf life or improve safety or sensory properties while maintaining quality. In

sense-and-response technology, some components of package would sense a signal such as an increase in temperature and initiate a marked increase in permeability to compensate for perceived change signal. Some tissues produce ethanol on fermentation when lower O_2 limit is surpassed. A truly smart package will continuously monitor ethanol and adjusts O_2 permeability. To control undesirable micro organisms on foods, antimicrobial substances can be incorporated in or coated onto food packaging materials. Principle action of antimicrobial films is based on the release of antimicrobial entities, some of which could pose a safety risk to consumers if release is not tightly controlled within the packaging material.

A characteristic feature of minimally processing is the need for an integrated approach, where raw material handling, processing, packaging and distribution must each be properly managed to achieve extended shelf life of the produce. Quality of fresh cut products can be controlled by observing the initial quality and maturity of the product, sanitation practices, optimum processing conditions, temperature and relative humidity during processing, handling, transit and marketing period. Because of the highly perishable nature of the product, a long shelf life similar to the whole commodity should not be expected. Much research is still to be done to develop minimally processed fruits and vegetables products with high acceptability, high sensory quality, microbiological safety and nutritional value. Strict temperature control of MP produce is of eminent importance. More information on growth of pathogenic bacteria or nutritional changes in MP fruits and vegetables with longer shelf life is needed.

CHAPTER 2
VALUE ADDITION OF FRUITS AND VEGETABLES

2. Fruit Products Preserved by Sugar

Syrups containing 66% and more sugars do not ferment. Sugar absorbs available water with the result that there is very little water for the growth of microorganisms and has no multiplication of microorganisms. Sugar acts as a preservative by osmosis. Fruit Jam, Jelly, Marmalade, Preserve, Candy are preserved by sugar.

Jam, jelly, marmalades, and concentrated fruit juices are the examples of concentrated fruit based products. The main ingredients in these products are fruit, sugar, pectin and acids. These products contain high concentration of sugar (minimum TSS of 60%). Fruit based concentrated product remains shelf stable, even without refrigeration.

2.1. Fruit Pulp/Puree

Fruit or Vegetables concentrates are made out of fresh products. The idea is to be able to manufacture derivate from fruit and vegetables all year round, and not be seasonal like fresh fruit and vegetables are. This way soups, juices, creams, pastes, etc; can be manufactured along the whole year, by using fruit or vegetable pastes or concentrates regardless of the fresh product season. Another objective of making concentrate is to reduce transport costs versus the fresh product transport costs. Concentrate processing lines could be located more near the fresh products while products using fruit and vegetable concentrate can be located everywhere more near the local consuming markets. Concentrate processing lines start with the fresh fruit or vegetable washing, leaf cleaning, boning, enzyme deactivation and aseptic processing. From this first processing phase the result is a paste that passes on to the evaporation process where water is reduced from the paste and thereof the name of concentrate. If the concentrate is going to be frozen, pasteurization normally takes place before evaporation. It is also possible to pasteurize and evaporate at the same time. Combinations can be many and they depend upon the manufacturing process selected and the product recipe. The pulp which is obtained by hot or cold break method is concentrated to manufacture puree and paste. Fully mature pulpy fruits and vegetables are preferred for the manufacture of puree and paste.

2.1.1. Processes of making fruit puree (For example Mango)

a) **Selection of fruits:** The mangoes are selected based upon its maturity, fruit firmness and colour.

b) **Ripening of fruits:** The ripening of fruits are done by either natural ripening process or by passing ethylene gas to fruits in ripening chamber over a period of 24hrs and is stored at 28ºC for 6 days.

c) **Washing, tip cutting and sorting of fruits:** The washing of the fruits is done using chlorinated water of concentration of 70 ppm and washed again with soft water. After washing the mango tips are cut and lower quality mango fruits are rejected at this stage.

d) **Destoner and pulper:** The good quality mangoes are destoned and pulped with the help of the destoner and pulper respectively.

e) **Preheater:** The preheating of the pulp is done at 60ºC to loosen its structure as it reaches the decanter and separator.

f) **Separator and decanter:** These help in the removal of fibres, black and brown specs by the centrifugal force.

g) **Evaporator:** In the evaporator the excess amount of water is removed to concentrate the mango pulp.

h) **Sterilization:** In the sterilizer the pathogenic microbes are killed and the enzymatic activity is inhibited at 107 – 110ºC

i) **Aseptic filling:** The sterilized mango pulp is then filled in the aseptic bags and stored at room temperature with a shelf life of about 24 months.

j) **Uses of pulp:** It can be used in the preparation of beverages, jams, jellies and desserts.

2.2. Fruit Jam

Jam is a fruit product prepared by boiling the pulp of the fruits with sufficient amount of sugar to obtain the desired consistency. Fruits such as apple, pear, sapota, papaya, plum, strawberries, mango, grapes etc are used in the jam preparation.

Jams are prepared from different variety of fruits. These can be used either singly or in combination. Pectin is used as the thickening agent in the jam preparation. It is formed during the ripening and also during the cooking of unripened fruits from the parent compound known as protopectin. Different fruits contain different amount of pectin. The high level of pectin is found in the apples, crabapples, and citrus peel and less amount of pectin is found in the fruits like blueberries, strawberries, cherries or huckleberries. Sweetening agent used in the preparation of jam is sugar. The proper balance in the preparation of jams is maintained by the citric acid.

2.2.1. The manufacturing process

In order to obtain the desired quality of jam, the required and accurate amount of ingredients must be added. Ideally, the following ingredients of jam must be mixed or combined to obtain

the best quality jam: 1% pectin, 45 - 50% sugar and acid to obtain the pH of 3.1. Jam is prepared by using the following steps.

a) **Quality inspection of fruits:** The best quality fruits which are selected for jam making are loaded into hopper which is funnel shaped. Through this hopper the fruits are carried for cleaning and crushing.
b) **Cleaning, crushing and chopping:** The surface dirt from the fruits is removed using the gentle water spray. Some fruits like citrus and apples are subjected to manual peeling, slicing and dicing.
c) **Pulping:** Fruits are pulped using pulper.
d) **Cooking:** The required pre measured amount of fruits, sugar and pectin are mixed in the cooking kettles. This mixture is subjected to cooking and cooling three times. Cooking of the jam is stopped exactly at the setting time. Jam will not be set properly if this point is not reached. If cooking process is carried out beyond this setting point, jam will undergo crystallization and darkening. There are three ways by which setting time of the jam can be determined; Saucer method, Spoon method and Temperature method
    - **Saucer method:** In this method a cold small saucer obtained from freezer is used. A drop of jam is dropped into this saucer. Setting of the jam should occur as it cools. If the jam still sticks onto plate after turning it upside down, then it shows that setting point is reached.
    - **Spoon method:** In this method, metal spoon is dipped into the jam and it is held horizontally until the jam is slightly cooled. By turning the spoon gently, if the jam falls in the form of heavy flakes, then it is said to be setting point.
    - **Temperature method:** In this method, the setting point of the jam is determined using sugar thermometer. When the jam reaches the temperature of 221º F, the setting point is reached. When the jam attains required consistency and sweetness, it is transferred into filling machines.
e) **Filling:** Jars which are pasteurized are used to fill up the required amount of jam. The top of the jars are vacuum sealed using metal caps. The process of filling and vacuum packaging of the jars remove all air out resulting in maintaining the sterility of the product.
f) **Labeling and packaging:** The sealed jam jars are conveyed through the labeling machine. These labels must contain the specific information about the ingredients used in the preparation of jam. The jars are later packed into cartons for shipment and further distribution

Process flow for preparation of jam

Fruits (matured and firm)

↓

Washing

↓

Extraction of juice / pulp

↓

Boiling

↓

Addition of sugar (50: 45 to 50)

↓

Addition of pectin (mixed with sugar in 1:10 ratio, based on pectin grade)

↓

Boiling till the end point reached when TSS is 68°Bx

↓

Filling and Cooling

↓

Labeling

2.2.2. End point for jam

The finishing or end point of jam concentrations can be determined by any of the following methods.

a) Drop test
b) Refractometer test
c) Boiling point method
d) By weighing method

Fig. 2.1: Drop test

a) Drop test: In this method, a little quantity of jam is taken from the boiling pan in a teaspoon and allowed to air cool before putting a drop of it in a glass filled with water. If the drop of jam touches the bottom of glass without disintegrating in the water, jam is considered to be ready. The only drawback of this method is that jam sometimes gets overcooked while it is being cooled for testing.Condition of jam or jelly flakes ready for pouring

b) Refractometer method: The cooking of jam is stopped when the refractive index reading of refractometer indicates 68.50°brix. The jam should be immediately cooled before placing a drop of it on the refractometer glass as the reading is calibrated at 20°C. The main advantage of the method is its ease of handling.

c) **Boiling point method:** Most jams should be concentrated to a boiling point of 106°C at sea level. Correction will however, be necessary for higher locations as the boiling point decreases with increase in altitude. Generally, end point for making jam should be 13°C higher than the boiling point of water at the location. A jelly thermometer may be used with advantage for determining the boiling point of jam. The method is simplest and best to determine the finishing point of jam.

d) **By weighing method:** The weight of the jam prepared from the fruits rich in pectin is one and half times the weight of the sugar taken. The disadvantage of the jamis that weighing is required frequently at the end of boiling which is practically time consuming and uneconomic as heat energy is wasted during weighing.

2.2.3. Problems in the jam production

a) **Crystallization:** In the jam invert sugar must be present in the concentration of 30 – 50%. If this concentration reduces below 30%, cane sugar may undergo crystallization upon storage and if the concentration of invert sugar increases above 50%, the jam will form into honey like mass due to the formation of small glucose crystals. This crystallization can be prevented by addition of corn syrup or glucose along with cane sugar in the jam preparation.

b) **Sticky or gummy jam:** High percentage of total soluble solids makes the jam sticky and gummy in nature. This can be prevented by the addition of sufficient amount of citric acid, pectin or both.

c) **Premature setting:** This problem arises because of the presence of low total soluble solids and high pectin content. It can be solved by the addition of more amount of sugar.

d) **Surface graining and shrinkage:** Jam must be stored in cool place to prevent the moisture loss due to evaporation. This moisture loss results in shrinkage and surface graining which affect on the appearance of the product.

e) **Microbial spoilage:** During the storage there may be mould growth in the jam which can be prevented by storing jam in 80% humidity.

f) **Fermentation:** It occurs due to improper sealing of the jars. This problem can be solved by using boiling water bath process.

2.2.4. Mixed fruit jam

Jam is prepared by boiling the fruit pulp with sufficient quantity of sugar to a reasonably thick consistency, firm enough to hold the fruit tissues in position. It can be prepared from one kind of fruit (or) from two (or) more kinds.

Ingredients

Fruit pulp	-	1.0 kg
Sugar	-	0.75 kg
Citric acid	-	0.3 %
Preservation	-	40 ppm of SO_2 (or) 200 ppm of benzoic acid (for commercial and longtime storage)

Method

- Select sound good matured fruits.
- Wash the fruits to remove dust and dirt.
- Peel the fruits and remove the unwanted portions.
- Cut the peeled fruits into small portions.
- Pulp the cut pieces either by making use of hand pulper (or) by mixie.
- Take the pulp and sugar (required amount) in a vessel and heat it over fire by stirring continuously, till the final TSS reaches 68.5^0bx.
- Remove from fire and allow it to cool to room temperature.
- Pack it in sterilized bottle and cover it with airtight cover.
- Label it with suitable information.
- Fruits used for mixed fruit jam: Guava, mango, pineapple, grapes, banana, papaya, sapota and apple.

Note: The end point of the jam is judged by sheet (or) flake test. A small portion of jam is taken out during boiling in a spoon (or) wooden ladle 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.

2.3. Fruit Jelly

2.3.1. Process of making jelly

Jelly is a semitransparent fruit product made from fruit or vegetable juice with the help of pectin. Jelly is prepared by boiling the fruit with or without water, straining, mixing the strained and clear juice extract with sugar and boiling the mixture until it forms a clear gel. Guava, apple, plum are the fruits generally used for the preparation of jelly. Jelly should have 65% total soluble solids and 45% juice in final product as per FSSAI specification on weight by weight basis. Sulphur dioxide / benzoic acid / sorbic acid in its calcium / sodium / potassium salts is permitted at maximum limit of 40/200/500 ppm.

Process flow on Jelly making

Ripe fruits

↓

Washing

↓

Cutting into thin slices

↓

Boiling with water for 30 min

↓

Straining of extract with clean muslin

↓

Cloth in hot condition

↓

Testing for pectin content

↓

Addition of sugar accordingly

↓

Boiling

↓

Judging end point

↓

Addition of citric acid and synthetic colour in concentrated mass

↓

Filling into clean sterilized bottles

↓

Cooling

↓

Washing

↓

Capping and storage at room temperature

2.3.2. Role of ingredients used in jelly preparation

a) **Sugar:** Sugar lends sweetness as well as structure. It enters in the inter-fibril structure of pectin and helps in the formation of gel. The jelly holds less water thus resulting in a stiff body in the presence of higher sugar.

b) **Acid:** The fibrils of pectin become tough in the presence of acid and are thus able to hold sugar solution in the inter-fibrillar spaces. In the presence of large quantity of acid,

the fibrils lose their elasticity and subsequently the jelly becomes syrupy. However, the lower amount of acid results in the formation of weak fibrillar structure. The jelly becomes weak and tender.

c) **Pectin:** Pectin substances present in the form of calcium pectate are responsible for the firmness of fruits. Pectin is the most important constituent in the gel formation with sugar and acid. Pectin tends to keep the sugar from crystallizing by acting as a protective mixture. But its effectiveness towards the prevention of crystallization is lost when the concentration of sugar is 70% or more. The jellying power depends upon the amount of pectin as well as its degree of polymerization.

2.3.3. Determination of pectin quality

The pectin quality in strained fruit juice or pulp is usually determined by two different methods:

a) Alcohol test: One part of extracted fruit juice or filtered pulp is mixed with three parts of 95% alcohol and is allowed to stand for few minutes. A single transparent lump or clot will be formed in case of extract rich in pectin. In that case, an equal amount of sugar is to be added. The formation of less firm and fragmented clot suggests the presence of moderate amount of pectin. Three-fourth of the amount of sugar is to be added. The formation of numerous small granular clots shows the poor content of pectin in the extract in which half the quantity of sugar is to be added.

b) Jelmeter test: The jelmeter is held in the left hand with the thumb and forefinger. The bottom of jelmeter tube is closed with little finger. With the help of the spoon, the strained extract is poured into the jelmeter and held in the right hand, till it is filled to the brim. The little finger is removed from the bottom and the extract is allowed to drip for one minute, and the finger is replaced at the end. The reading of the level of extract in the jelmeter is noted. This reading indicates that how many parts of sugar are to be added to one part of juice.

c) Jelly test:

- **Temperature test:** The temperature of the jelly with a candy or jelly thermometer is taken. It should be 220°F.
- **Spoon or sheet test:** A cool metal spoon is dipped into the boiling jelly mixture and lifted out. The drops will be light and syrupy when the mixture begins to boil. As the syrup continues to boil, the drops will become heavier. When two drops form together and sheet off the spoon it indicates that the jellying point is reached.
- **Refractometer test:** The end point is determined with the refractometer to 68 Brix

2.3.4. Problems in jelly making:

a) **Failure of jelly to set:** It is due to improper balance between various constituents of jelly e.g. lack of acid or pectin, addition of too much sugar, inaccurate measurement, insufficient cooking, over cooking and slow cooking prevents the pectin from building a proper network of gel.

b) **Cloudy jelly:** Unclarified juice or pectin extract, under ripe fruit, non-removal of scum, premature gelation, over-cooking or pouring so slowly into containers can result in a cloudy jelly.

c) **Colour changes:** Darkening at the top of the jars can be caused by storing them in too warm a place or by an imperfect jar seal.

d) **Colour fading:** Fading can occur with red fruits if they are stored in too warm and too bright areas or stored too long as the natural colourants are highly susceptible to high temperature and light. Another possible cause of colour fading could be the insufficient processing to destroy the enzymes affecting colour on the elevated processing temperature might cause destruction. Trapped air bubbles can also contribute to the chemical changes by oxidation.

e) **Crystal formation:** An excess of sugar can "Seed" the jelly when high methoxyl pectin is used. This excess sugar comes from overcooking, too little acid or from undercooking. Tartarate crystals can be formed in grape jelly, if juice is left to stand in cold for several hours before being used.

f) **Gummy and Excess softness jelly:** Gummy jelly is the result of prolonged or over-cooking in which more than desired inversion of sugar occurs. Excess soft can be caused by an imbalance of the proportions of sugar, juice or fruit, acid and pectin used. It can be solved by choosing fully ripened fruits.

g) **Weeping jelly:** Synergetic is the phenomenon of spontaneous exudation of fluid from a gel and it is also called weeping jelly. It can be due to over-cooking, addition of too low sugar or premature gelation, insufficient pectin and storing in a warm place. “Weeping” occurs during quick-setting and is due to an imbalance of acid and pectin in fruit mixture or in the pectin quality of the fruit.

h) **Presence of mold and bubbles:** The appearance of mold can be the result of imperfectly sealed jars and air borne contamination if insufficient sugar is used. The availability of water makes a favourable environment for contamination from the jars if they are not properly sterilized or left under processed. Mold is visible before the taste is affected. Presence of bubbles is usually caused when the jelly is not brought to the correct temperature before it is filled in jar. This can be rectified by filling them in a boiling water canner.

i) **Stiff and Tough jelly:** Over cooking or using too much pectin makes too tough jelly which fails to spread when applied on bread. Toughness happens because of excess natural pectin content of the fruit. It can be solved by choosing fully ripened fruit rather than unripened ones.

The concentration process has been found to be effective method to increase the shelf life by reducing the water content. The methods used for the concentration of liquid foods depend on the factors such as the composition, heat sensitivity and the economics of the process. The products such as jam, jelly are fruit based sugar concentrates which can be produced from single fruit type or combination of different fruits.

- The concentration of liquid foods is done by removal of water content from the initial liquid food that which gets condensed to give a concentrated final product with lesser water activity.
- As the liquid food is concentrated, it helps to improve the product stability for a longer period of time and can be stored in room temperature without refrigeration.
- Concentrating the liquid food is the most convenient way of extending the shelf life of foods by removing water or by destroying enzymes and microorganisms, responsible for food spoilage.
- Jelly is a semitransparent fruit preserve made from fruit juice with the help of pectin.
- Jelly should have 65% total soluble solids and 45% juice in final product as per FSSAI specification on weight by weight basis.
- Sulphur dioxide / benzoic acid / sorbic acid in its calcium / sodium / potassium salts is permitted at maximum limit of 40/200/500 ppm.
- There are three methods to test jelly for its completeness.
  - Temperature test
  - Spoon test
  - Refractometer test
- Sugar lends sweetness as well as structure.
- The finished jelly should contain 30-50% invert sugar.
- Jelly becomes gummy and sticky in the presence of high amount of sugar. The presence of excess sugar in the fruit pulp can be rectified by adding pectin and acid or both.
- Pectin is the most important constituent in the gel formation with sugar and acid and the jellying power depends upon the amount of pectin as well as its degree of polymerization.
- Pectin quality is determined by alcohol and jelmeter test.

- Jam is a fruit product prepared by boiling the pulp of the fruits with sufficient amount of sugar to obtain the desired consistency which is able to hold the fruit tissues in position.
- Pectin is used as the thickening agent in the jam preparation.
- Sweetening agent used in the jam preparation is sugar or high fructose corn syrup or the combination of these two.
- There are two ways by which setting time of the jam can be determined;
  - Saucer method
  - Spoon method
  - Temperature method
- In the jam preparation, fruit pulp and sugar are mixed and heated. Throughout the process, the total soluble solids must be monitored until it reaches the value of 550 Brix.
- Pectin is used in the form of solution and citric acid is added to to maintain the desired
- pH in the range of 2.5 – 3.2.

2.4. Osmotic dehydrated products

The osmosis is a natural phenomenon of water removal from biological materials. Osmotic treatment is actually a combination of dehydration and impregnation processes. Osmosis process provides the modification of functional properties of food material and improving the quality of the final products, leads to attractive new products, and potential energy saving. Water is a solvent and this is the major component of food. The plant and animal cell is protected by cell wall and this cell wall is act as a semipermeable membrane which allows the water to pass through. Osmosis is a process that explains the movement of solvent such as water through a semi-permeable membrane. The sugar molecules cannot pass through due to the smaller pore size of the cell wall. There is net movement of water into or out of the cell and which direction it moves depends on whether the cell's environment is isotonic, hypotonic, or hypertonic. Higher concentration of solute (sugar) and lower concentration of solution (Water) is called hypertonic solution. Higher concentration of solution (Water) and lower concentration of solute (sugar) is called hypotonic solution. When cell is in an isotonic solution, movement of water from out of the cell is equal to the movement of water into the cell. When water move from lower solute concentration (hypotonic) to higher solute concentration (hypertonic) side through the cell membrane due to its concentration gradient. This mass transfer occurs until the equilibrium state is achieved.

Osmotic dehydration is a partial dehydration of perishables such as fruits and vegetables. When fruits and vegetables are dipped in hypertonic syrup solution, the following two effects occur. The water present in the fruit flows out to the solution and solutes present in the syrup

enters in to the fruit due to osmosis process. During the osmotic process, the product's solution removal and osmotic solute uptake are simultaneous and countercurrent flows without any phase change. A negligible effect on the components present in the food such as acids, vitamins, minerals and colorants also occurs. Due to the complex internal structure and diffusion of solute in food systems leads an imperfect semi permeable membrane.

During osmotic dehydration, the following actions happen; 1. Movement of water from the product to the solution. 2. Solute transfer from hypertonic solution to the food product. 3. Trace of natural solutes present in the food material leach from food into the solution. 4. Gas present in inter cellular space also removed.

This osmotic dehydration process is a multi-component transfer process of two simultaneous, countercurrent solution flows and one gas flow. The solution flow out of food material is water mixed with solutes such as organic acids, reducing sugars, minerals, and flavor compounds that affect the organoleptic and nutritional characteristics of the final products. Soluble solids present in the osmotic solution are taken up by the food material. Gas flow is also out of intercellular space. The water loss during osmotic dehydration is divided into two phases. The rate of water removal is high for the initial period of 2 hours and the rate of water removal is slowly decreased from 2-6 hours. Water removal during osmotic process is mainly by diffusion and capillary flow, whereas solute uptake or leaching is only by diffusion.

2.4.1. Factors involving in osmotic dehydration process

a) **Nature of the product:** In osmotic dehydration, the water loss and solid gain is controlled by maturity, variety, tissue compactness, total soluble solids, intra cellular spaces, size and shape of the fruit and vegetables.

b) **Pretreatments:** In general most of the dehydration process ends with significant quality losses like Chlorophyll degradation, enzymatic browning, structural disintegration occurs in the final product due to thermal application. Some preliminary treatment like blanching is required to retain the quality of the final product.

2.4.2. Blanching

Blanching is a process prior to freezing, canning, or dehydration wherefruits or vegetables are heat treated to

- Inactivate enzymes that cause the development of off- flavors and off-colors.
- To avoid structural modification.
- To removes trapped air.

- To water replacement with metabolic gases within vegetable cells.
- To facilitates peeling and dicing.
- To reduce microbial load.

How blanching is performed?

Blanching is performed by different methods like water blanching, steam blanching, microwave blanching and gas blanching. Among these, hot water and steam blanching are the most commonly used methods. To prevent enzymatic browning reaction, fruits and vegetables are dipped in citric acid or calcium chloride (CaCl2) solution and to prevent discolouration fruits are treated in alkaline or acid solution prior to osmotic dehydration process.

a) **Characteristics of biological materials:** Cell unit consists of a cell, extracellular space, and cell wall. The eventual cellular dehydration will strongly depend on the intercellular space present in the fruit tissue. The complex cell wall structure of plant materials acts as a permeable membrane. The variety and maturity of fruits and vegetables is an important factor that control water loss and solid gain in the osmosis process. The tissue compactness, inter cellular space, protopectin to soluble pectin ratio, entrapped air enzyme activity initial insoluble and soluble solids content of the fruit influences the osmotic dehydration process. Chemical composition such as carbohydrates, protein, fat, mineralsand vitamins, physical properties like porosity, cell arrangement, orientation of fibre and thickness of peel also an important factor that affects the osmotic dehydration process. Inter cellular space of the raw material has significant effect on shrinkage and rehydration ration of the product. The phenomena of volume change, water loss and solids gain can affect the different physical properties of the cellular material. Due to severe osmotic shock, first layer of cells at the depth of 1-2 mm from the surface dies.

b) **Osmotic agents and concentration:** The most commonly used osmotic agents are sucrose and sodium chloride. Other osmotic agents such as lactose, maltodextrin, ethanol, glucose, glycerin, sorbitol, fructose, corn syrup, monohydroxy ethanol, honey, jiggery and corn syrups are also used. These agents are termed as humectants. The combination of different solutes can be used. Concentration of solution is a key factor in the osmotic dehydration process. Sugar diffusion rate is a function of its concentration. The change in sugar concentration and temperature are directly proportional to the water loss and sugar gain. In general, syrup strength in the range of 60 to 70 0Brix is optimum.

c) **Circulation of syrup:** The rate of osmotic process increases with circulation process. Due to agitation of syrup, at the surface of the food material localized dilution is reduced. But sometime that makes damage to the product. Generally, a ratio of cut fruits and osmotic solution is highly essential and 1:2 or 1:3 ratio is commonly practiced.

d) **Temperature and immersion time:** The temperature is an important factor that highly influencing the osmotic process. Though the temperature enhances the osmotic process, the cell membrane is highly sensitive and gets damaged when temperature is beyond 60oC.In general increase in immersion time results in increased water loss. The mass exchange took place at the maximum rate within the first two hours of the osmotic treatment.

2.4.3. Advantages of osmotic dehydration

- The effect of temperature is reduced in order to maintain the food quality such as flavor, colour, texture and rehydration properties.
- This process uses less energy for dehydration.
- Enzymatic browning is prevented and polyphenol oxidases activity is reduced.
- This process is highly recommended for fruits and vegetables in order to reduce the volume and enhance the storage and transport.

2.4.4. Amla Candy

A fruit/vegetable impregnated with cane sugar or glucose syrup and subsequently drained free of syrup and dried is known as candied fruit/vegetable. The most suitable fruits for candying are amla, pineapple, cherry, papaya, apple, grapefruit etc. The process for making candied fruit is practically is similar to that for preserves.The ingredients are required for amla candy is amla (1 kg) and sugar (1 kg).

Process flow for Amla candy:

Selection of Amla

↓

Washing

↓

Preparation for sugar treatments

↓

Keeping fruit and sugar in alternate layers

↓

Removal of amla

↓

Increasing consistency of syrup to 60% TSS by boiling

↓

Steeping of fruit

↓

Repeating the process and raising strength of syrup 70% TSS

↓

Steeping in 70% TSS for a day/week

↓

Draining

↓

Shade drying

↓

Packing

↓

Storage

2.5. Preservation by chemicals

"Preservative" is any substance which is capable of inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food, but does not include commom salt (sodium chloride) saltpeter (sodium or potassium nitrate), sugar, acetic acid or vinegar, alcohol or potable spirits. Spices, essential oil or any other substance added to the food by the process of curing known as smoking. Chemical preservatives are of two types. There are:

- Class-1 preservatives: Common salt sugar, dextrose, spices, vinegar, edible vegetable oil, honey and glucose syrup.
- Class-2 preservatives

- Benzoic acid and its salt
- SO_2 and the salts of sulphuric acid
- Nitrates
- Sorbic acid and its salts
- Propionic acid and its salts
- Lactic acid and its salts.

Among the class-2 preservatives, only two chemical preservatives are used in fruits and vegetables Preservation

(i) Potassium meta bisulphite (KMS)

(ii) Sodium Benzoate

2.5.1. 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 molds 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 non-enzymatic browning or discoloration (after killing the enzyme) of the product. It is generally used in the form of its salts such as sulphite, bisulphate and metabisulphite.

Potassium Meta bisulphite is commonly used as a stable source of sulphur di oxide. Being a solid, it is easier to use than liquid or gaseous sulphur di oxide. It is fairly stable in neutral or alkaline media but decomposed by weak acids like citric, tartaric and malic acids.

The advantages of using sulphur dioxide are:

- It has a better preserving action than sodium benzoate against bacterial fermentation.
- It helps to retain the colour of the beverage for a longer time than sodium benzoate
- Being a gas, it helps in preserving the surfave layer of juices also
- Being highly soluble in juices and squashes, it ensures better mixing and hence their preservation, and
- Any excess of sulphur dioxide present can be removed either by heating the juice to about 71^{o}C or by passing 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.

The major limitations of sulphur dioxide are:

- It cannot be used in the case of some naturally coloured juices like those of phals, jamun, pomegranate, strawberry, coloured grapes, plum etc., on account of its bleaching action,
- It cannot be used for juices which are to be packed in tin containers, because it not only corrodes the tin causing pinholes but also forms hydrogen sulphide 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.
- Sulphur di oxide gives a slight taste and odour to freshly prepared beverages but these are not serous defects if the beverage is diluted before drinking.

2.5.2. Benzoic acid

It is only partially soluble in water hence its salt, sodium benzoate, is used. Pure sodium benzoate is tasteless and odourless. In the long run benzoic acid may darken the product. It is therefore, mostly used in coloured products of tomato, phalsa, jamun, pomegranate, plum, watermelon, strawberry, coloured grapes. The antibacterial action of benzoic acid is increased in the presence of carbon di oxide and acid. E.g Bacillus subtilis cannot survive in benzoic acid solution in the presence of carbon dioxide. Benzoic acid is more effective against yeasts and molds. It does not stop lactic acid and acetic acid fermentation.

2.6. Sauces

A fruit/vegetable 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. Recipe used for preparation of fruit sauce as a general guideline is given in following table and explained as under:

2.6.1. Procedure for preparing sauces

Sauces are of thinner consistency as compared to ketchups and contain not less than 15^0B 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.

Table 2.1: 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

The fruits are washed and cut in to pieces (plum and apricot are used as whole). Cook for 10 minutes by adding little quantity of water in stainless steel (SS) pan or in pressure cooker. Pass heated fruits through pulper to separate skin and seeds. Fruit pulp can also used in preparation of sauce. Add half the quantity of sugar and place the spices in a muslin cloth bag and immerse in the pulp during cooking. Cook till the pulp is reduced to half the original volume. Remove the muslin bag and squeeze into pulp. Add acetic acid salt and remaining sugar. Heat the mass for few minutes. To judge the end point, place a spoon of sauce in plate, if no water oozes out, it indicates the end point or else more cooking is needed. Fill the finished product in sterilized glass bottle, crown corked and process in boiling water for 25-30 minutes. Keep the bottles in cool and dry place.

2.6.2. Problem during preparation of sauce

Black neck: It is a formation of black ring in the neck of the bottles. It is caused by the iron which gets into the product from equipment metal or cap/crown cork. This iron when come in contact with tannins in spice forms ferrous tannate which on oxidation change to black colour. Prevention of black neck details are as given below:

- Fill hot sauce at temperature not less than 85^0C.
- Leave less head space in bottles (more air in bottles will result in more blackening).
- Reduce the chances of iron contamination.
- Partial replacement of sugar by corn syrup or glucose may prevent blackening.
- Store bottles in horizontal or inverted position to diffuse the entrapped air/oxygen.

2.7. Ketch up

Tomatoes are the widely used raw material for ketch up processing. It is made from strained tomato juice or pulp with the addition of spices, salt, sugar and vinegar (onion and garlic are added optionally) and contains not less than 12 per cent tomato solids and 25 per cent total solids. About one-third of the total sugar required is added at the time of commencement of boiling to intensify and fix the red tomato colour. If the whole quantity of sugar is added initially, the cooking time will be longer and the quantity of pulp will be adversely affected. Generally, the sugar content in ketch up/sauces varies form 10-26 per cent. On the other hand, salt bleaches the colour of the tomato product; it is therefore, desirable to add it towards the end of the cooking process. Spices are generally added in powdered form to the product by spice bag method. Instead of whole spices, essential oils of spices, oleoresins and spice extract can also be used. Essential oils, however, do not give the characteristic true aroma of whole spice but oleoresins provide true aroma. At present, spice extract is used in many industries for sauce/ketchup preparations. These do not adversely affect the colour of the product and are generally added a few minutes before the end of cooking.

The salt content of the product should be 1.3-3.4 per cent. Good quality vinegar is essential for the preparation of high quality sauce/ketchup. It should contain 5.0-5.5 per cent acetic acid and should be added when the product has thickened sufficiently, so that the acid is not lost by volatilization. Tomato sauce/ketch up generally contains 1.25-1.5 per cent acetic acid. Sometimes glacial acetic acid (100 per cent acetic acid) is used which is colourless and cheaper than vinegar. In order to increase the viscosity and prevent the separation of pulp from clear juice, pectin can be added to the extent of 0.1 –0.2 per cent by weight of the finished product.

2.7.1. Role of ingredients

a) Spices: The spices should be of good quality and they should be added in the proper proportions to give an agreeable taste and flavour to the product. No single spice dominates the natural flavour of the tomato. The spices which are preferred in ketchup manufacture include red chili, black pepper, nutmeg, clove, cinnamon, cardamom, mace and cumin. Beside these spices seasonings like onion, ginger and garlic may also be used in ketchup recipe. While adding spice certain precautions are recommended to produce excellent quality ketchup or sauce.

- ✓ Red chili powder, spices, onion and ginger should be tied loosely in bag for better diffusion of flavoring principles in ketchup.
- ✓ The head portion of clove should always be removed before its grinding as it may lead to black neck defect in ketchup.

- ✓ Normally garlic is not preferred seasoning in ketchup or sauce manufacture as its flavour may predominate over other spices.
- ✓ Essence of clove, cinnamon and cardamom is preferred in place of using coarsely ground powder because of the convenience of use and better flavour note in finished product.

The spices may be used in the following way during the manufacture of ketchup or sauce.

a) Bag method: The coarsely ground spices are tied loosely in a muslin cloth bag and the bag placed in the tomato juice during boiling. The bag is pressed intermittently to release the flavouring component during processing. The proportion these spices should be standardized in such a way that they should not affect the colour of the resultant product and does not impart bitterness. This bag can be used for second batch also. This method has following drawbacks:

- By chance opening of bag may spoil the whole batch. Even if we want to remove these, spice particles by passing it through sieve, it may darken the product.
- Incomplete extraction of flavouring component, so, flavour of ketchup may vary from batch to batch.
- Some of the volatile constituents may get lost during boiling.

Still bag method yield ketchup of superior quality and it is most preferred for ketchup or sauce preparation at small scale or batch methods. The spice bag may also be used for subsequent batches and used spices may also be in pickle preparation.

b) Use of oleoresins: Oleoresins are pure and natural extracts of spices, obtained by solvent extraction. These concentrated extracts contain all the flavour components, be it volatile oils or non-volatile resinous fractions. These are the resins of active flavouring component in some solvent. The active flavouring molecule is extracted with a suitable solvent and it can provide the full flavour profile of the raw spice with quick release of the flavour. Application of oleoresins is advantageous in commercial production of ketchup or sauce. The only limitation while using oleoresin is the cost of production. Oleoresins are added few minutes before the final boiling during the manufacture of ketchup or sauce.

c) Use of extracts: Spice extract is prepared on large scale by steeping or boiling spices in vinegar. The aroma component of the spices gets extracted in vinegar and vinegary extract may be used in place of whole spice. It assists in maintaining the same taste and aroma and also standardizes the proportion of spices in the recipe. Nowadays, it is one of the most widely accepted methods of spice addition.

d) **Sugar:** Sugar is mainly used to adjust the sugar-to-acid ratio of the ketchup or sauce. Sugar may be added in the form of granular sugar, corn syrup and other syrups are used. However, granular sugar is most preferred one. About 1/3rd of sugar is added in the initial stage of boiling. This help in preserving the natural colour of the product. Rest of the sugar is added minute before final concentration is reached. Initial addition of sugar will adversely affect the colour of the product as cooking of the product with higher amount of sugar under acidic conditions flavour brown coloured ,Furfural, Commercial level, sugar level varies between 10-26%. Higher amount of sugar may impart higher sweetness which is not liked by consumers.

e) **Common salt:** Salt bleaches the colour of the tomato and also dissolve to some extent copper from the processing equipment. It is, therefore, desirable to add towards the end point of the process. Range of common salt varies between 1.5 to 3.5%, salt is added to enhance flavour of the product and exert preservative action to a lesser extent. Salt of very high purity is preferred for the ketchup manufacture. Salt also counteract the highly acidic flavour of the tomato pulp.

f) **Vinegar:** Well matured salt-vinegar, cider vinegar or malt vinegar may be used as acidulant in the product. However, these vinegars are not colourless; hence they may affect the colour of the finished product. Vinegar contains not less than 5 percent acetic acid. On industrial scale commercially available glacial acetic acid is preferred because of the following reasons.

- Lower cost as compared to malt, or cider or salt vinegar
- Glacial acetic acid is 100% acetic acid; hence it will have lesser effect of heating.

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

g) **Thickening agent:** Insufficient quantity of pectin in tomato juice, puree or paste invariably results in serum separation in ketchup during storage. Ketchup prepared by cold pulping process contains very less amount of pectin due to incomplete solubilization and extraction of pectin. Likewise using variety with low pectin content may also necessitate addition of certain thickening agents. Hence, pectin (0.1 to 0.2%), corn starch (1%) and other hydrocolloids may be added to control this problem. Xanthan gum is an ideal thickener for this type of products because of its acid stability and pseudoplastic flow properties it imparts. The glass or sheen, which xanthan gum imparts

to these sauces or ketchup is another appealing factor for the consumer. Pectin may also be added @ 0.1-0.2 percent by weight of finished product in clear juice or pulp to check the problem of serum separation and to also increase viscosity.

2.7.2. Processing of ketchup

a) **Cooking & concentration:** The tomatoes juice along with other ingredients is cooked and concentrated to get the desirable flavour, uniform taste and fine thickness or body. The cooking of ingredients may be carried out in open jacketed kettle or vacuum concentrator. The cooking continues till the concentration reached 25 percent TSS. However, concentration of 28-30 percent total solid is ideal as further increase may adversely affect the flavour of the product. However, to improve the stability of ketchup slightly higher amount of sugar, salt and vinegar is added.

b) **Bottling & Packaging:** The ketchup after attaining the desired total solid level and consistency is finally passed through a finisher to remove any tomato fibre, seeds and any other suspended solids. The Ketchup or sauce after cooking should be bottled hot at 85-88℃ to prevent browning and loss of vitamin during subsequent storage and distribution. Hot filling of bottle also assist in creation of vacuum in the headspace during the cooling of ketchup. The crown cork used for ketchup bottle should be lined with polyvinyl chloride (PVC) to prevent the contact of ketchup with the metallic portion to avoid the black neck formation. However, nowadays sauce and ketchup is also packed in laminated flexible packaging materials consisted of polyethylene (PE), polyester (PET) and aluminum. These polymers may be co-extruded in different combinations to get the desired functional and mechanical properties. Sauce and ketchup require protection from oxidation and moisture migration/ingress. Moreover, certain squeezable bottles are also used for the packaging of these products. Bottled and packaged products are stored under ambient temperature (30-35℃) under dry places.

c) **Pasteurization:** Although, hot filling of the ketchup in bottle is considered safe for consumption and have sufficient shelf-life, but still come manufacturers prefer further thermal treatment. The hot filled bottles are pasteurized in hot water (85-88℃) for 30-35 minutes. Care must be taken to cool the bottle immediately after pasteurization to avoid the degradation of nutrients and over-processing. Shelf-life is also enhanced by using preservatives.

2.7.3. Recipes

a) Tomato ketchup

Ingredients

Tomato juice	1 kg
Sugar	75 g
Salt	10 g
Onion (chopped)	5 g
Garlic (chopped)	10 g
Ginger	5 g
Red chillie powder	5 g
Cloves (heads removed)	5 no
Cinnamon	10 g
Cardamom	10 g
Black pepper	10 g
Cumin	10 g
Vinegar	25 ml (or)
Sodium benzoate	0.25 g/kg

Method

- Select well ripened tomatoes with red colour. Wash thoroughly in water
- Chop into pieces and boil for 5 to 6 minutes and extract the pulp
- Weigh the ingredients. First add 1/3 of the sugar to the juice and start heating
- Place the spices (onion, garlic, cloves, cardamom, black pepper, cumin, mace, cinnamon and chilli powder) in a muslin or cloth bag
- Tie it loosely and immerse it in the juice
- Continue heating till the juice volume is reduced to 1/3 of the original volume,
- Remove the spice bag and squeeze it well. Add back the spice extract
- Add vinegar, salt, and remaining sugar. Mix well and heat again for about a minute to bring it to boiling point
- Mix sodium benzoate of the finished product.
- Fill the hot material into sterilized narrow mouth bottles up to the brim and seal them air tight using crown corks.
- Wash the bottles in hot water and allow them to air cool.
- Store them in a cool and dry place.

b) Tomato Soup

Ingredients

Tomato pulp	- 10 kg
Water	- 3.5 kg
Onion (chopped)	- 150 g
Salt	- 180 g
Butter	- 180 g
Sugar	- 200 g
Corn flour	- 100 g
Garlic (Chopped)	- 10 g
Pepper (ground)	- 10 g
Cinnamon, cardamom Cumin, cloves Pepper, mace	5 g each

Method

Use firm and fully ripened red tomatoes and chop them into pieces

- Heat for 5 to 10 minutes till the skin separates out from the pulp. Strain the pulp through mosquito net cloth to remove seeds and skin
- Heat the tomato pulp to boiling point and add butter
- Add onions and garlic and simmer for 30 minutes
- Add salt, sugar and pepper and simmer for further 30 minutes
- Make corn flour into a thick paste, boil and strain it through cloth
- Mix the strained liquid with boiling tomato juice
- Heat it again and fill hot into A1 tall cans (not below 70°C)
- Seal the cans and process for 45 minutes at 115.5°C or 0.7 kg per sq. cm pressure in pressure cooker
- Cool the cans and store

  Note: Coarsely ground spices, chopped onion and garlic may be tied in a cloth bag and immersed in pulp while cooking

2.7.4. Defects in Ketchup

The two most common observed defects in ketchup are: serum separation and blackening specially around the neck. The latter defect is referred as Black neck defect. The tannins present in spices get extracted into the ketchup and when these phenolic compounds come in contact with iron leached out either from processing vessels or from the closure of ketchup

bottles, they form ferrous tannate. This compound undergoes oxidation and form ferric tannate and it is a black coloured compound. To check it one should not use iron or copper utensils and headless clove should be used. The inner lining of bottle cap should be of PVC. Problem of serum separation as already been discussed in Section 2.4.5. Among the microbiological problem mold growth is the most serious one. Microbial growth can be taken care by adding chemical preservatives especially benzoic acid. Benzoic acid is added in the form of its sodium or potassium salt because of almost 54 times higher solubility of salt as compared to benzoic acid. As per FSSA guidelines the maximum permissible limit of benzoic acid is 750 ppm.

2.8. Pickles

Pickles mean the preparation made from fruits or vegetables or other edible plant material including mushrooms free from insect damage or fungal infection, singly or in combination preserved in salt, acid, sugar or any combination of the three. The pickle may contain onion, garlic, ginger, sugar jaggery, edible vegetable oil, green or red chillies, spices, spice extracts/oil, lime juice, vinegar/ acetic acid, citric acid, dry fruits and nuts. It shall be free from copper, mineral acid, alum, synthetic colours and shall show no sign of fermentation.

Pickle is one of the most ancient methods of preserving fruits and vegetables. Pickles are good appetizers and add to the palatability of a meal. They stimulate the flow of gastric juice and thus help in digestion. Pickling is the process by which fresh fruits and vegetables are preserved and with the addition of salt, chilly and spices. There are several varieties of pickles and they are consumed throughout the year by people from all walks of life. Unimaginable quantities of pickles are consumed round the year. On an average, each family consumes about 2 kgs of pickles every year. Several kinds of pickles are sold in the Indian market. Mango pickle ranks first followed by cauliflower, onion, turnip and lime pickles. These are commonly made in homes as well as commercially manufactured and exported. Millions of tonnes of mangoes, lemons, chillies and other items are used in India to prepare a variety of pickles. It is estimated that in our country numerous varieties of pickles are available for which the total annual market is valued at Rs. 40,000 million.

2.8.1. Preservation by salt

Salt at a concentration of 15- 25 % is sufficient to preserve most products. It inhibit enzymatic browning and discolouration and also acts an antioxidant, salt in the form of brine is used for canning and pickling of vegetables and curing of meat. Salt has been reported to have the following effects:

- It causes high osmotic pressure and hence plasmolysis of cells

- It dehydrates food by drawing out and tying up moisture and dehydrates microbial cells.
- It ionizes to yield the chloride ion which is harmful to organisms
- It reduces the solubility of O_2 in the moisture
- It sensitizes the cell against CO_2
- It interferes with the action of proteolytic enzymes.

Sodium chloride is an indispensable component of food. At lower concentration it contributes significantly to the flavour. At higher concentrations it exhibits an important bacteriostatic action.

Uses of salt

Application of salt in commercial food processing may be classified on the basis of objective on the product in which it is used or on the basis of particular operations.

The most important uses includes the following:

- As a flavouring ingredient with universal appeal. Salt is the major ingredient of the brines in which vegetables are canned. In canned products it also improves the flavour and acceptability.
- Sodium chloride reduces the sourness of acids and increases the sweetness of sugar.
- It reduces the bitterness of the products
- It controls the lactic acid fermentation in sauerkraut and other types of pickles.
- It acts as a preserving agent in the brine storage of cucumbers and citrus peels.
- Inhibit enzymatic browning and discoloration in the peeled, sliced or cut vegetables and fruits.

Salt water blanching has been used to prevent absorption by peas and beans of Ca and Mg salts from hard water and reduces losses by leaching of soluble constituents. Several kinds of pickles are sold in Indian market. Mango pickle ranks first. These are commonly made in homes as well as commercially manufactured and exported. Fruits are generally preserved in sweetened and spice vinegar, while vegetables are preserved in salt:

2.8.2. Pickling process

Pickling is the result of fermentation by lactic acid forming bacteria which are generally present in large numbers on the surface of fresh vegetables and fruits. These bacteria can grow in acid medium and in the presence of 8-10% salt solution where as the growth of a majority of undesirable organisms is inhibited. Lactic acid bacteria are most active at 30 C, so this temperature must be maintained as far as possible in the early stage of pickle making.

When vegetable s are placed in brine, it penetrates into the tissues of the vegetables and soluble material present in them diffuses into the brine by osmosis. The soluble material includes fermentable sugars and minerals. The sugars serve as food for lactic acid bacteria which convert them into lactic acid and other acids. The acid brine thus formed acts upon the vegetables tissues to produce the characteristics taste and aroma of pickle. There are two methods for pickling:

Dry salting method

Alternate layers of vegetables and salt are kept in a vessel which covered with a cloth and wooden board and allowed to stand for about 24 hrs. During this period, due to osmosis, sufficient juice comes out from the vegetables to form brine.

The amount of brine required is usually equal to half the volume of vegetables. Brining is the most important step in pickling. The growth of a majority of spoilage organisms is inhibited by brine containing 15% salt. Lactic acid bacteria, which are salt tolerant, can thrive in brine of 8-10% strength. Though fermentation takes place fairly well even in 5% brine, in brine containing 10% salt to some extent up to 15% but stops at 20% strength. It is therefore, advisable to place the vegetables in 10 % salt solution for vigorous lactic acid fermentation.

As soon as the brine is formed, fermentation process starts and CO2 begins to evolve. The salt content is now increased gradually, so that by the time the pickle is ready, salt concentration reaches 15% when fermentation is over gas formation ceases.

Under favourable conditions fermentation is completed in 7 – 10 days. When sufficient lactic acid has been formed, lactic acid bacteria cease to grow and no further change takes place in the vegetables. However, precautions should be taken against spoilage by aerobic microorganisms, because in the presence of air , pickle scum is formed which brings about putrefaction and destroyed the lactic acid. Properly brined vegetables keep well in vinegar for a long time.

Fermentation in brine

Steeping of the vegetable in a salt solution of pre determined concentration for a certain length of time is called brining. This type of treatment is adopted in case of cucumbers and similar vegetables which do not contain sufficient juice to form brine with dry salt. Brine can be prepared by dissolving in common salt in water and filtering it through the cloth to remove insoluble impurities. The remaining process is similar to that dry salting method.

2.8.3. Raw materials used in pickling

a) **Salt:** Free from impurities and salts such as lime, iron, magnesium and carbonates.

b) **Vinegar:** Vinegar of good quality should contain at least 4% acetic acid, Synthetic vinegar or low quality vinegar is not suitable for pickle preparations. Usually malt or cider vinegar is used. In order to ensure good keeping quality pickle, the final concentration of acetic acid in the pickle should not be less than 2%. Acetic acid is also used because it is highly concentrated.

c) **Sugar:** Used in the preparation of sweet pickles should be of high quality.

d) **Spices:** Spices are added practically to all pickles the quantity added depending upon the kind of fruit or vegetable taken and kind of flavour desired. The spices generally used are bay leaves, cardamom, chillies, cinnamon, cloves, coriander, dill herb, ginger, mace, mustered , black pepper, cumin , turmeric, garlic, mint fenugreek, asfoetida etc.

e) **Water:** Only potable water should be used for the preparation of brine. Hard water contains salts of Ca, Na, Mg, etc., which interfere with the normal salt curing of the vegetable. If hard water is to be used , a small quantity of vinegar should also be added to the brine to neutralize its alkalinity. Iron should not be present in the water in any appreciable quantity as it causes the blackening of the pickle.

f) **Cooking utensils:** Metallic vessels should be non corrodible. Vessel made of iron or copper are not suitable. Glass lined vessel and stainless steel vessels are preferred. The ladles, spoons and measuring vessels should also be made on non corrodible materials. At present pickles are prepared with salt, vinegar, oil or with a mixture of salt, oil, spices and vinegar. These methods are discussed below.

2.8.4. Types of Pickles

a) Preservation with salt: Salt improves the taste and flavour and hardens the tissues of vegetables and controls fermentation. Vegetable do not ferment when they are packed with a large quantity of salt, bringing its final concentration in the material from 15-20%. At this high salt concentration, mould and even lactic acid forming bacteria do not grow. This method of preservation is applicable only to vegetable which contain very little sugar because sufficient lactic acid cannot be formed by fermentation to act as preservative. Some fruits like lime, mango, etc. are also preserved with salt.

Lime pickle:

Lime	- 1 kg
Salt	- 200 g
Red chilli powder	- 5 g
Cinnamon, cumin, cardamom and black pepper each	- 10 g
Cloves	- 5 nos

Process: Lime →Washing →Cutting into 4 pieces →Squeezing out juice from ¼ amount of fruit →Mixing spices and salt with juice →Mixing with lime pieces →Filling in jars →Covering with lid →Keeping in sun for 4-6 days→ Storage at ambient temperature.

b) Preservation with vinegar: In vinegar pickles, vinegar acts as a preservative. The final concentration of acids in the finished pickle should not be less than 2%. To avoid dilution of vinegar below this strength by the H2O liberated from the tissues, the vegetables or fruits are generally placed in strong vinegar of about 10% acidity for several days before final packing. This treatment helps to expel the gases present in the intercellular spaces of vegetable tissues. Papaya, pears, onion, garlic, chilli, mango and cucumber pickles are prepared in this method.

Cucumber pickle:

Cucumber	- 1kg
Salt	- 200g
Red chilli powder	- 15g
Cardamom, cumin,	
Black pepper each	- 10g
Cloves	- 6nos
Vinegar	- 750ml

Process: Cucumber →Washing →Peeling →Cutting into 5 cm round pieces →Mixing with salt →Filling in jar →Standing for 6-8 hrs →Draining off water →Adding spices and vinegar →Keeping for a week →Storage.

c) Preservation with oil: The fruit or vegetable should be completely immersed in the edible oil. Cauliflower, lime, mango, amla, karonda, bittergourd, brinjal, turnip pickles are prepared from this method.

Green chilli pickle:

Green chilli	- 1kg
Salt	- 150g
Mustard	- 100g
Lime juice	- 200ml or
Amchur powder	- 200g
Fenugreek, cardamom,	
Turmeric, cumin each	- 15g
Mustard oil	- 400ml

Process: Green chillies→Washing →Drying→Making incision→Mixing all spices in a little lime juice→Mixing with chillies→Filling into jar →Adding lime juice and oil →Keeping in sun for a week →Storage.

d) Preparation with mixture of salt, oil, spices and vinegar:

Tomato pickle:

Tomatoes	- 1kg
Salt	- 75g
Garlic Ginger	- 10g
Red chilli powder	- 50g
cumin, cardamom, cinnamom, turmeric, fenugreek each	- 10nos
Asafoetida	- 2g
Vinegar	- 250 ml
Oil	- 300ml

Process:

Tomatoes →Washing → Blanching for 5 mints →Cooling immediately in water→Peeling →Cutting into 4-6 pieces or mashing →Frying all ingredients in a little oil except vinegar →Mixing with pieces →Heating for 2 min →Cooling →Addition of vinegar and remaining oil →Filling in jar →Storage.

e) Preservation of onion in brine solution: Steeping preservation of onion is convenient as well as economical for extension of the shelf-life of onion and also for transport to the distant places. The method is simple, economical and onion can be preserved for periods ranging from 3-6 months by steeping them in concentrated solutions of salts and or acids. Steeping preservation of onion helps to extend shelf life. Cleaned onion are washed in plain water or chemical-added water and filled in large plastic containers. Five minutes blanching in brine solution is done before filling them in containers. Brine solution is then added into the cans or containers.

Method

- Selection of small onion with good quality.
- Peel the onion and trim it well.
- Blanch the small onion into steam for 3 minutes.

- Keeping in 2% salt, 0.2 % vinegar and 0.1 % Potassium Meta bisulphite solution in glass bottles.
- Store in refrigerated temperature.

Onion pickle

Onion	- 1 kg
Oil	- 300ml
Mustard	- 10 g
Fenugreek powder	- 5 g
Asafetida	- 5 g
Turmeric powder	- 2 g
Tamarind	- 30 g
Salt	- 30 g
Chilli powder	- 30 g
Vinegar	- 20 ml
Sodium benzoate	- 0.1 g

Method

- Add oil into the pan.
- Add mustard, fenugreek powder, asafetida powder turmeric powder.
- Then add onion, fry it well.
- Add salt, tamarind pulp in medium flame.
- Then add chilli powder.
- Allow it to cook till oil ooze out.

2.8.5. Problems in pickle making

a) **Bitter taste:** Use of strong vinegar or excess spices or prolonged cooking of spices imparts a bitter taste to the pickle.

b) **Dull and faded product:** This is due to use of inferior quality material or insufficient curing.

c) **Shrivelling:** It occurs when vegetables are placed directly in a very strong solution of salt or sugar or vinegar. Hence a dilute solution should be used initially and its strength gradually increased.

d) **Scum formation:** When vegetables are cured in brine, white scum always form on the surface due to the growth of wild yeast. This delays the formation of lactic acid and also helps the growth of putrefactive bacteria which cause softness and slipperiness. Hence,

it is advisable to remove scum as soon as it is formed. Addition of 1% acetic acid helps to prevent the growth of wild yeast in brine, without affecting lactic acid formation.

e) **Softness and slipperiness:** Due to inadequate covering with brine or use of weak brine.

f) **Cloudiness:** In some vegetables the acetic acid cannot penetrate deep enough into its tissues to inhibit the activity of bacteria and other microorganisms, present in them. Fermentation stars from inside the tissues, rendering the vinegar cloudy. This microbial activity can only be checked by proper bring Cloudiness may also be caused by use of inferior quality vinegar or chemical reaction between vinegar and minerals.

g) **Blackening:** It is due to the iron in the brine or in the process equipment reacting with the ingredients used in pickling. Certain microorganisms also cause blackening.

2.9. Chutney

Chutney is one 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%.

2.9.1. Different Formulation of 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	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

2.9.2. Procedure for preparing chutney

The fruit/vegetable is cut into slices of suitable size and 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 82^0C for 30 minute. The storage of chutney is done at ambient temperature in cool and dry place.

a) Apple chutney: Apple chutney is also prepared as mango chutney. The fruit slices are cooked with salt. All spices except vinegar and sugar are added and the mixture is cooked gently to the desired consistency. Sugar is then added and cooking for 5 minutes is done. Hot filling of chutney in glass jars followed by sealing helps to keep chutney for longer time. The jars are stored in dry and cool place.

Note: Chutney from plum, apricot, papaya etc is also prepared similarly as mango chutney.

b) Tamarind chutney Tamarind chutney is a sour, spicy pickle that is eaten as an accompaniment to curries and other main meals. It is a mixture of tamarind and spices with a layer of oil on the surface. The product will store well for several months.

Ingredients: Tamarind 1kg, Sugar 1kg, Spices (per kg pulp): Coriander 40g, Cumin 50g, Black cumin 30g, Cloves 3-4 pieces, Cardamom 3-4 pods, Cinnamon 3-4 pieces, Chillies 10-12, Salt 30g, Vegetable oil 250ml, Caraway seeds 15g and Pepper 30g

Process details

- Select fresh mature but unripe tamarind fruits. Discard fruits that are ripe, over-ripe, infected or damaged. Rinse well in clean water. Crack the pods by hand and separate the pulp from the broken shells.
- Peel and remove the fibres, shell pieces and seeds from the pulp. For dried tamarind, soak the fruit in water for up to 12 hours until the fruit has softened. Remove the stones and fibres and drain off the excess water.
- Add sugar to the pulp (1kg sugar per kg pulp)
- Heat the pulp and sugar. Stir continuously to prevent it burning at the base of the pan.
- Dry roast the individual spices and grind. Mix with the oil and salt to make a paste.

- Add the spice paste to the thick tamarind pulp. Mix thoroughly and continue to heat for 20 minutes. 7. Pour the hot pickle into pre-sterilised jars and seal. Cool to room temperature, and label.

2.10. Processing of Fruit Juices

Tropical countries, like India, have a vast scope of providing delicious cold drinks during hot summer particularly the fruit beverages. Due to increased consumer awareness with respect of quality, safety and health, these fruit beverages are becoming more and more popular and are gradually acquiring a chunk of the market share of cold drinks. Fruit beverages are easily digestible, highly refreshing, thirst quenching, appetizing and nutritionally far more superior to the synthetic aerated drinks. Fruit beverages can be classified as fermented and unfermented.

Fruit juices are made from pure filtered fruit juice with nothing added. Sodium benzoate can be added as a preservative to extend the shelf life, but this is not essential. Properly pasteurised juice has a shelf life of several months. Most fruits can be used to make juice. The most popular ones are pineapple, orange, mango, grapefruit and passion fruit.

Some fruit juices, such as guava juice are not filtered after pulping. These are bottled and sold as fruit nectars.

Squashes and cordials are concentrated, sweetened drinks made from a 30% mix of fruit pulp and sugar syrup. They are diluted before drinking. The sugar concentration must be high enough (12-14%) to preserve the squash after the bottle has been opened.

2.10.1. Principle

Fruit beverages are prepared from fruit juices or pulp and preserved by chemical preservatives or by heat application.

2.10.2. General method for preparation of fruit juice

The general process for the preparation and preservation of unfermented fruit beverages is as follows:

- Select only fully ripe and quality fruits. Care should be taken not to include either over ripe or under ripe fruits as it affects the final product quality.
- Sort and reject/trim diseased, damaged or decayed fruits. Wash them properly with water or dilute hydrochloric acid (1part acid: 20 parts water) to remove dirt and spray residues of arsenic, lead, etc.

- Extract juice from fresh fruits by crushing and pressing them by using suitable juice extractors, basket presses or fruit pulpers. Fruits, which require preheating, should be preheated before extraction.
- Strain and filter the juice to remove suspended matter consisting of broken fruit tissue, seed, skin, etc. Clarify the juice if required using a suitable method.
- Fortify the juices with vitamins to enhance their nutritive value, to improve taste, texture or colour and to replace nutrients lost in processing, if required.
- The preservation could be by physical methods (pasteurization, sterilization, etc.) or by chemical preservatives.
- Wash packaging bottles thoroughly with hot water and fill them leaving 1.5 to 2.5 cm headspace. Seal with crown corks (by a crown corking machine) or with caps (by capping machine).

2.10.3. Processing details for juice

a) Preparation of the fruit: Fruit should be washed in clean water, peeled and the stones removed. All fruit should be ripe and free from bruising. Any rotten or bruised fruit should be thrown away as this will spoil the flavour of the juice. Pineapple contains an enzyme that damages the skin. Therefore, gloves should be worn when handling pineapple. The juice must be heated to a higher temperature for a longer time to destroy the enzyme (it must be boiled for 20 minutes). Soft fruit, such as berries and apricots, are delicate and should be handled carefully to avoid bruising.

b) Pulp/Juice Extraction: Juice is extracted in a number of different ways - steaming, reaming, pressing and pulping. Fruit can be pulped in a liquidiser. A range of fruit presses are available to extract the juice. Some machines combine pressing with filtration to remove the fine particles. To make fruit squash or cordial, the extracted fruit juice is mixed with sugar syrup to give a final sugar concentration of 12-14%. See added ingredients.

c) Added Ingredients: Pure fruit juices have no added ingredients, but sometimes preservatives such as sodium benzoate or citric acid are added. Fruit squashes have sugar added to preserve the squash after opening.

d) Sugar: Sugar is added to fruit juice to make a fruit squash or cordial. It is added to give a final concentration of 12-14% sugar. The amount of sugar present in the fruit has to be taken into account when calculating the amount of sugar to add. The amount of sugar added to a fruit squash is also determined by consumer taste and demand for

sweetness. The amount of sugar syrup to be added to the juice to give a final concentration of 12-14% can be calculated by using the Pearson Square. Sugar syrups should be filtered through a muslin cloth to remove particles of dirt that are present in the sugar.

e) **Filtration:** To make clear bright juice, the juice should be filtered to remove the fine suspended particles. The juice can be strained in a muslin cloth bag, or filtered using a steel filter. Pectic enzymes are sometimes added to the juice to break down the pectin which is naturally present and which gives the juice a cloudy appearance.

f) **Fill and seal:** At the small-scale, containers can be filled simply using a funnel and a jug. For larger scale operations a range of filling machines are available. The juice containers should be thoroughly washed and sterilised before filling. Bottles that are recycled should be checked for cracks and chips. Only new caps should be used for sealing the bottles.

g) **Heat Treatment/Pasteurize:** At the small-scale, the filled bottles of juice can be pasteurized in a stainless steel, enameled or aluminium pan over a gas flame. Care should be taken to avoid localized overheating. A range of small-scale pasteurizing units are available. To make fruit squash, the sugar syrup is heated to boiling in a large pan. A measured amount of syrup is mixed with the fruit juice in a stainless steel pan, which increases the temperature of the juice to 60-70deg C. The juice/syrup mixture is quickly heated to pasteurizing temperature and hot filled into sterilized bottles and sealed. Fruit juice is pasteurized after it has been bottled. The filled bottles are heated in boiling water for 5-10 minutes depending on the size of the bottle. Both the time and temperature of pasteurization are critical to achieve the correct shelf life and to retain the colour and flavour of the juice. The time depends on the size of bottles.

Size of bottles (litres)	Pre-heating	Pasteurization time (minutes)
0,33	yes	20
0,5	yes	25
0,75	yes	30

The principles of pasteurization: Pasteurization is a relatively mild form of heat treatment, generally at a temperature lower than the boiling point of water. Because it is a mild heat treatment, pasteurization causes minimal changes in the taste, colour and nutritive value

of a food. Foods (fruit and vegetable juices and purees) are generally pasteurized to reduce enzyme and microbial activity and thereby increase the shelf life. Pasteurization extends the storage life of bottled fruits and juices by several months. Pasteurization is often combined with another form of preservation such as concentration, acidification and chemical preservation. The severity of heat treatment and the resulting extension of shelf life are mostly determined by the pH of the food. In low acid foods (pH>4.5) the main purpose is to destroy pathogenic bacteria. In foods with pH below 4.5, the main purpose is to destroy spoilage micro-organisms and prevent enzyme activity. Blanching is a form of pasteurization that is applied to vegetables to inactivate enzymes and to preserve colour. Blanching, when carried out for long enough, can also destroy some micro-organisms. Some low pH foods, for example fruit juices and pickles, are pasteurized in their containers after packaging. The process is similar to canning, but the heat treatment is less severe. The benefit of pasteurizing in containers is that the risk of contamination of the product after packaging is greatly reduced. The main factors that influence pasteurization of a food are as follows:

- Temperature and time
- Acidity of the products
- Air remaining in the containers

h) Cooling: After heating, the bottles are cooled to room temperature by immersing them in clean cold water. If the bottles are cooled too quickly they will crack and break.

i) General: All equipment must be thoroughly cleaned each day to prevent contamination by insects and micro-organisms.

2.10.4. Calculation for pilot scale juice production

The calculation details of fruit beverages are processing from fruit juices or pulp and preservation by chemical preservatives or by heat application are discussed below:

a) Squash

Squash should contain at least 25% fruit juice or pulp and 40 to 50% total soluble solids commercially. About 1% citric acid and 350 ppm Sulphur dioxide or 600 ppm sodium benzoate are added as preservatives.

Method of preparation: For the preparation of 10 litres of squash follow the procedure given below:

- Calculate the amount of juice required as per commercial specification

Required juice = (25/100) X 10 = 2.5lts.

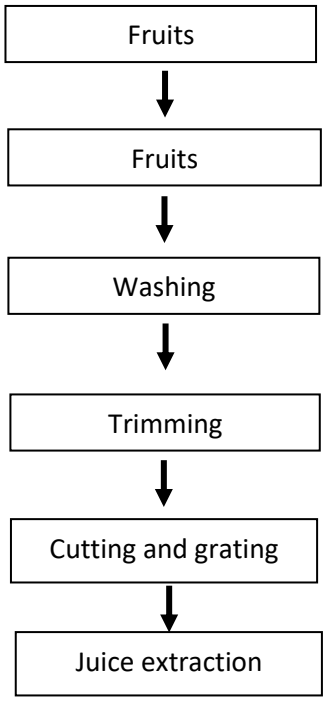
- Measure the TSS using a refractometer (say the TSS is30%)
  Calculate the total solids content of the juice i.e. 0.3 X 2.5 = 0.75 kg
  The final required TSS content in the product is to be say 50%
  The TSS required to be added to obtain the final product is (0.5X10–0.75) kg=4.25 kg
- The amount of soluble solids in the form of citric acid and KMS is Citric acid @ 1%, in the final produce is 100 g i.e. 0.1kg.600 ppm SO_2 (1.5g/litre of KMS being equivalent to 1000 ppm) @ 0.9g KMS/litre. i.e. 0.9 x 10 = 9 g i.e 0.009kg.
- Amount of solids to be added in the form of sugar is4.25 – (0.1+0.009) = 4.141 kg.

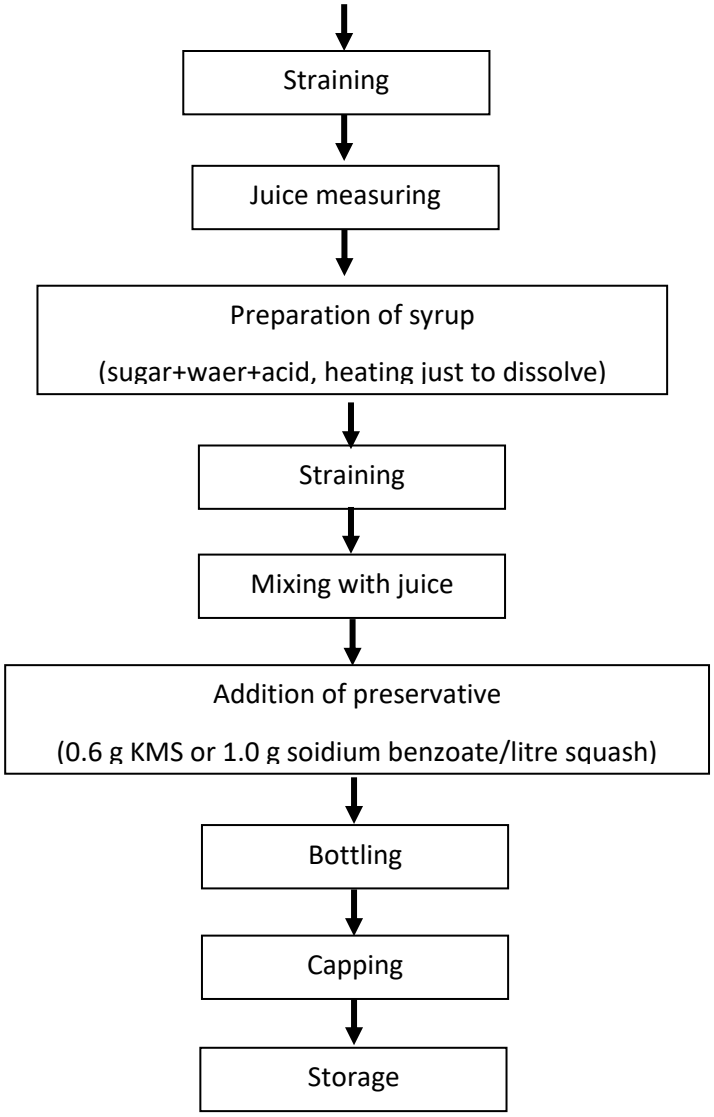
Ingredients

Juice	-	2.5 kg	
Sugar	-	4.141 kg	
Citric acid	-	100 g 4.25 Kg	
KMS	-	9 g	
Water	-	(10-2.5+4.25)	= 3.25 Lts

- As prescribe dissolve sugar in water, add citric acid and give a boil, strain through a fine muslin cloth. Cool the syrup completely. Mix the fruit juice with syrup. Add colour as required and then essence. Grind the preservative in a saucer with a spoon. Add little water. Pour into squash. Add more juice and transfer all the preservative to the squash.

Flow sheet for the preparation of Fruit Squash





b) RTS Beverage

This is a type of fruit beverage containing at least 10% fruit juice and 10% total soluble solids besides about 0.3% acid. It is not diluted before serving and, hence, is known as ready-to-serve (RTS) beverage.

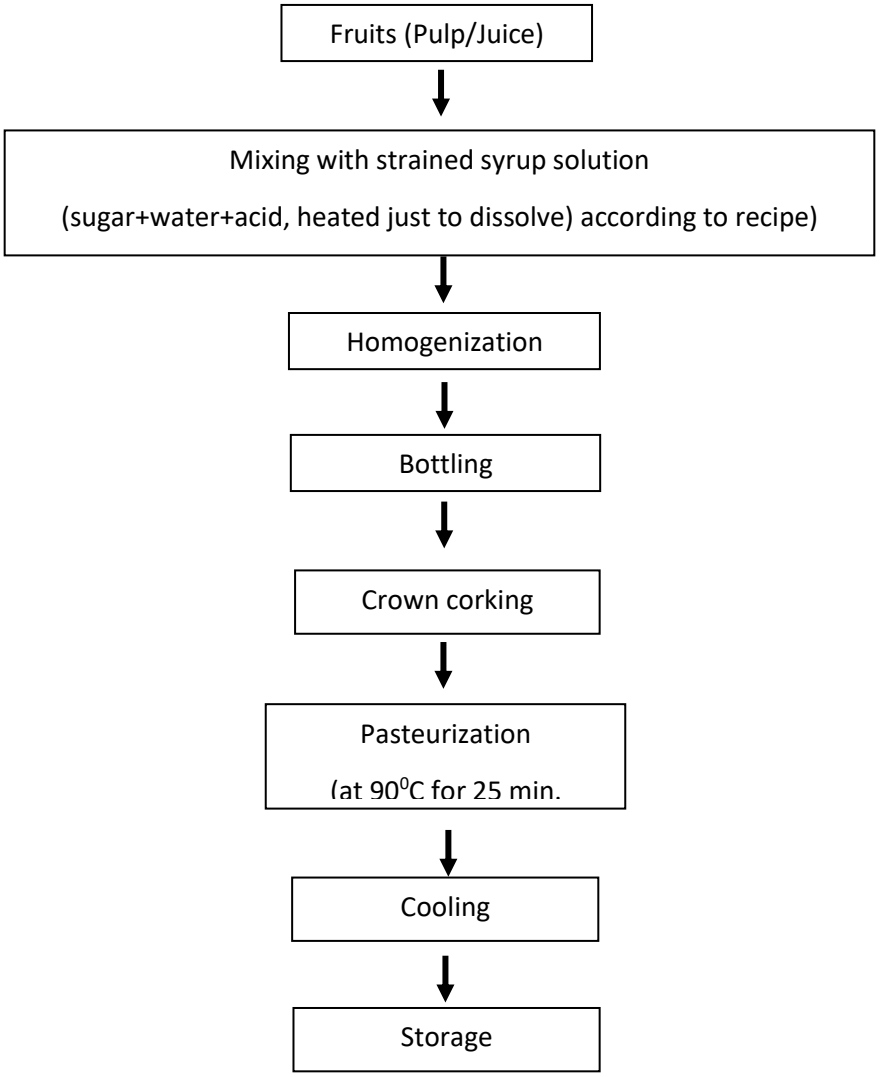
Method of preparation

For the preparation of 10 lts of RTS beverage, follow the procedure given below:

- Calculate the amount of juice required as per commercial specification
  Required juice = (10/100) X 10 = 1.0lts.
- Measure the TSS using a refractometer (say the TSS is30%)
  Calculate the total solids content of the juice i.e. 0.3 X 1.0 = 0.30 kg
  The final required TSS content in the product is to be say 10%.
  The TSS required to be added to obtain the final product is (0.1X10–0.30) kg=0.70kg

- The amount of soluble solids in the form of citric acid and KMS is
  Citric acid @ 0.3%, in the final produce is 30 g i.e. 0.03kg.
- Amount of solids to be added in the form of sugar is0.70–0.03=0.67kg.
- Add calculated amount of sugar to about 2 lts of water and heat it till it dissolves completely.
- Add citric acid and juice to the sugar syrup and makeup the volume to 10 lts. Mix it well.
- Heat up to 90°C, fill hot in clean pre-sterilized glass bottles up to brim, seal and cool in the air or fill in bottle, seal and heat process (90°C for 25 min.).

Flow sheet for the preparation of RTS Beverage



c) Fruit Nectar

This is a type of fruit beverage containing at least 20% fruit juice/pulp and 15% total soluble solids besides about 0.3% acid. It is also not diluted before serving.

Method of preparation

For the preparation of 10 lts of fruit nectar, follow the procedure given below:

- Calculate the amount of juice required as per commercial specification
  Required juice = (20/100) X 10 = 2.0lts.
- Measure the TSS using a refractometer (say the TSS is30%)
- Calculate the total solids content of the juice i.e. 0.3 X 2.0 = 0.60 kg.
- The final required TSS content in the product is to be say 15%.
- The TSS required to be added to obtain the final product is (0.15 □ 10 – 0.60) kg = 0.90kg.
- The amount of soluble solids in the form of citric acid and KMS is Citric acid @ 0.3%, in the final produce is 30 g i.e. 0.03kg.
- Amount of solids to be added in the form of sugar is0.90–0.03=0.87kg.
- Add calculated amount of sugar to about 2 lts of water and heat it till it dissolves completely. Add citric acid and juice to the sugar syrup and makeup the volume to 10 lts. Mix itwell.
- Heat the RTSB / Nectar up to 90°C, fill hot in clean pre-sterilized glass bottle up to brim, seal and cool in the air or Fill in bottle, seal and heat process (90°C for 25 min.).

d) Cordial (Lime)

- Extract the juice and strain through a fine muslin cloth to remove all pulp
- Add preservative (KMS) 2 gms per litre of limejuice
- Pour in bottles and keep for 1-2 months. All the sediment settle down and the juice becomes clear
- Pour all clear juice without disturbing the sediment. Use the recipe and proceed as for squash.

Note: Flow sheet same as RTS Beverage

e) Sharbet

Sharbet should contain at least 65% total soluble solids, suitably acidified and may or may not contain fruit juice.

Method of preparation

For the preparation of 10 lts of sharbet follow the procedure given below:

- Take about 6 lts. of water and add approx. 6.5 kg of sugar and dissolve it properly.
- Add the required flavour.
- Make up the volume to 10 lts and adjust the TSS to65%.

2.10.5. Product definition as per the regulation

Thermally Processed Fruits Juices

Thermally Processed Fruits Juices (Canned, Bottled, Flexible And/Or Aseptically Packed) means unfermented but fermentable product, pulpy, turbid or clear, intended for direct consumption obtained by a mechanical process from sound, ripe fruit or the fresh thereof and processed by heat, in an appropriate manner, before or after being sealed in a container, so as to prevent spoilage. The juice may have been concentrated and later reconstituted with water suitable for the purpose of maintaining the essential composition and quality factors of the juice. It may contain salt

One or more of the nutritive sweeteners may be added in amounts not exceeding 50 g/kg but not exceeding 200g/kg in very acidic fruits except in case of apple juice, orange juice, reconstituted from concentrate, grape juice, pineapple juice (reconstituted from concentrate).

The container shall be well filled with the product and shall occupy not less than 90.0 percent of the water capacity of the container, when packed in the rigid containers. The water capacity of the container is the volume of distilled water at 20ºC which the sealed container is capable of holding when completely filled.

Thermally Processed Fruit Nectars

Thermally Processed Fruit Nectars (Canned, Bottled, Flexible Pack And / Or Aseptically Packed) means an unfermented but fermentable pulpy or non-pulpy, turbid or clear product intended for direct consumption made from fruit singly or in combination, obtained by blending the fruit juice / pulp/fruit juice concentrate and/ or edible part of sound, ripe fruit(s), concentrated or non-concentrated with water, nutritive sweeteners/ artificial sweeteners and any other ingredient appropriate to the product and processed by heat, in an appropriate manner, before or after being sealed in a container, so as to prevent spoilage. Lemon and Lime juice may be added as an acidifying agent in quantities which would not impair characteristic fruit flavour of the fruit used.

The container shall be well filled with the product and shall occupy not less than 90.0 percent of the water capacity of the container, when packed in the rigid containers. The water capacity of the container is the volume of distilled water at 20ºC which the sealed container is capable of holding when completely filled.

Thermally Processed Fruit Beverages / Fruit Drink/ Ready to Serve Fruit Beverages

Thermally Processed Fruit Beverages / Fruit Drink/ Ready to Serve Fruit Beverages (Canned, Bottled, Flexible Pack And/ Or Aseptically Packed) means an unfermented but fermentable product which is prepared from juice or Pulp/Puree or concentrated juice or pulp of sound mature fruit. The substances that may be added to fruit juice or pulp are water, peel oil, fruit essences and flavours, salt, sugar, invert sugar, liquid glucose, milk and other ingredients appropriate to the product and processed by heat, in an appropriate manner, before or after being sealed in a container, so as to prevent spoilage.

The container shall be well filled with the product and shall occupy not less than 90.0 percent of the water capacity of the container, when packed in the rigid containers. The water capacity of the container is the volume of distilled water at 20ºC which the sealed container is capable of holding when completely filled.

Squashes, Crushes, Fruit Syrups/Fruit Sharbats and Barley Water

Squashes, Crushes, Fruit Syrups/Fruit Sharbats and Barley Water means the p2.10.roduct prepared from unfermented but fermentable fruit juice/puree or concentrate clear or cloudy, obtained from any suitable fruit or several fruits by blending it with nutritive sweeteners, water and with or without salt, aromatic herbs, peel oil and any other ingredients suitable to the products. Cordial means a clear product free from any cellular matter, obtained by blending unfermented but fermentable clarified fruit juice with nutritive sweeteners & water with or without salt and peel oil and any other ingredients suitable to the products.

Barley water means the product prepared from unfermented but fermentable fruit juice by blending it with nutritive sweeteners, water with or without salt and peel oil and barley starch not less than 0.25 percent and any other ingredient suitable to the product.

Any syrup/ sharbats containing a minimum of 10 percent of dry fruits shall also qualify to be called as fruits syrups.

The container shall be well filled with the product and shall occupy not less than 90.0 percent of the water capacity of the container, when packed in the rigid containers. The water

capacity of the container is the volume of distilled water at 20ºC which the sealed container is capable of holding when completely filled.

Thermally Processed Fruit Cocktail / Tropical Fruit Cocktail

Thermally Processed Fruit Cocktail / Tropical Fruit Cocktail (Canned, Bottled, Flexible Pack And/Or Aseptically Packed) means the product prepared from a mixture of fruits which shall be declared on the label. Such fruits may be fresh, frozen, dehydrated or previously processed. The fruit mixture may be packed with any suitable packing medium and processed by heat in an appropriate manner before or after being sealed in a container so as to prevent spoilage. The packing medium along with its strength when packed shall be declared on the label.

The name of the fruits used in the product and prepared in any style shall be declared on the label along with the range of percentage of each fruit used in the product. The drained weight of fruits shall be not less than the weight given below:-

(a) Liquid pack - 50.0 percent of net weight of contents

(b) Solid Pack - 70.0 percent of net weight of contents

The container shall be well filled with the product and shall occupy not less than 90.0 percent of the water capacity of the container, when packed in the rigid containers. The water capacity of the container is the volume of distilled water at 20ºC which the sealed container is capable of holding when completely filled.

CHAPTER 3
PACKAGING OF FRUITS AND VEGETABLE PRODUCTS

3.1. Introduction

Food packaging today has been an integral part of food production as almost all food is marketed as packaged. Food packaging has evolved as science and technology, is interdisciplinary in nature, since knowledge of polymer science, metals, glass, paper, properties of food and physics and engineering is applicable in food packaging, and it has evolved to give solutions to various hazards of food during packaging chain.

Packaging

1. Packaging is an operation that ensures delivery of goods to the ultimate consumer in the best condition intended for their use.
2. Packaging is function of enclosing products in containers to perform one or more of the functions of containment, protection, preservation, communication, utility and performance.
3. Packaging is a coordinated system of preparing goods for transport, distribution, retailing and end use i.e. a means of ensuring delivery of product to the ultimate consumer in sound condition.

3.1.1. Levels of packaging

1. Primary package: It is in direct contact with the product. For example, a product in can (canned food).
2. Secondary package: It contains number of primary packages. For example, a fibre board box containing several of cans.
3. Tertiary package: It is made up of number of secondary packages. For example, a stretch-wrapped pallet of fibre board boxes of canned food.
4. Quaternary package: It is used to facilitate handling (during transportation, shipping) of tertiary packages. For example, large container containing number of stretch-wrapped pallets of fibre board boxes of canned food.

3.1.2. Packaging chain (distribution chain)

Food production--->Packaging operation (primary packaging, secondary packaging) ---> Palletizing and warehousing ---> Transportation for distribution and delivery to market (distributor → wholesaler→ retailer) ---> Home or consumer ---> Product use/consumption

Hazards: Food during the time elapsed between production and ultimate consumption is exposed to various hazards (agents or conditions) which make the food unavailable for consumption or significantly affect the quality of food (by damage and any other harm).

3.1.3. Type, factors and effects of hazard

1. Physical hazard
   - Operations: handling during warehousing, transportation, distribution
   - Actions: stacking, loading and unloading in/from transport vehicles, carrying
   - Factors and effects: dropping, tearing, crushing by rope by tying, compression, stack impact (force) resulting in breakage, leakage, burst, bruising, distortion (deformation), crushing, spilling and ultimately loss of food
2. Mechanical hazard
   - Operations: handling during packing, warehousing, transportation, distribution
   - Actions: stacking, lifting, loading, unloading, transportation
   - Factors and effects: piercing, puncturing and tearing by hooks, straps, nails; dropping, bumping, bouncing, vibration (engine of truck, rail, aeroplane) and impact resulting in breakage, distortion, spilling and exposure to adverse climate leading ultimately to loss of food.
3. Biological hazard
   - Pests (rats, rodents, moths, etc) and microorganisms (molds, etc) are the causing factors
   - Operations: handling during warehousing, transportation, distribution
   - Effects: different types of spoilage, insect infestation and loss of food.
4. Climatic hazard
   - Operations: handling during warehousing, transportation, distribution
   - Factors: rain, sunlight, oxygen and other gases, high and low temperature, high and low humidity, high and low pressure, chemical pollutants like sulphites, chlorides and acids
   - Effects: extreme climatic conditions produce stress and results in stress crack and other kind of damage
5. Miscellaneous hazards

   Caused by fire, floods, tampering, pilferage, foreign odours, corrosive chemicals, contamination by other commodities stored together

3.1.4. Functions of Packaging

The primary functions of packaging are:

- Containment: The package contains its content secured within itself.
- Protection: The package provides protection to the contained food from physical, mechanical, biological, climatic and miscellaneous hazards during warehousing, loading, unloading, transportation and distribution.
- Preservation: The package prevents spoilage of food by post-process contamination of microbiological agents, prevents microbial growth by not providing suitable conditions for growth, checks abiotic deterioration caused or accelerated by agents such as oxygen, humidity, light etc (lipid oxidation, oxidation of food constituents, maillard reaction, texture changes, etc).
- Information (communication): The package provides information to consumer about the product. The information includes the net weight, ingredients used, nutritional composition, price, ideal storage conditions, name and address of manufacturer, date of manufacture and batch number, minimum and maximum storage or shelf life etc.
- Convenience: Packaging provides convenience (comfort) in terms of carrying, storing and handling of foods.
- Sales promotion: An attractive package (attractive design, colour, graphics) is by itself an advertisement of the product and enhances product sales.

3.1.5. Desirable features of packaging

- Product-package compatibility: The package serves all necessary purposes, no undesirable changes occur in food due to the reaction between the product and package
- Disposability and environment-friendly: Reuse and recycle as much as possible
- Machinability: Good performance in filling and closing in high speed machines
- Convenience to use in terms of opening, dispensing and re-closing

3.2. Packaging materials and their properties

Ancient use: leaves, bamboo, straw, leather, stoneware, clayware

Modern and main packaging materials: paper, plastics, metal, glass and laminates

Packaging materials to less use: wood, ceramics, fabrics of cotton lintre, jute, rubber

3.2.1. Paper and paperboard

Common packaging materials

Advantages:

- Billboards the product
- Can be used in combination with plastic to make aseptic packaging
- Microwavable
- Light in weight
- Can contain products with a variety of geometric shapes

Disadvantages:

- Less strong
- Offers few barrier properties

Table 3.1: Main type of packaging papers, their properties and use

Basic material	How made	Properties and use
Kraft paper	From sulphate pulp on soft woods	High strength, bleached, natural or coloured; may be wet-strengthened or made water-repellent. Used as heavy duty paper, used for manufacturing bags, multiwall sacks (e.g. grocery bags) and liners for corrugated board. Bleached varieties for food packaging where strength is required.
Sulphite paper	Generally made from mixture of soft wood and hard wood; usually bleached	Clean bright paper of excellent printing nature Used for making smaller bags, pouches, envelopes, waxed papers (*wax impregnated*, to improve wet resistance), labels and foil laminating etc.
Greaseproof paper	Made from heavily beaten pulp	It is resistant to oil and grease Used for baked goods, chicken roll, pizza
Glassine	Similar to grease-proof paper but super calendered	It is resistant to oil and grease; it is odour barrier Used for lining bags, boxes etc.

Vegetable parchment	Made by treatment of unsized paper with conc. sulphuric acid; later passed through bath of dil. Sulphuric acid and water, and then dried.	Non-toxic, high wet strength, grease and oil resistant Used for packaging of wet food and greasy food, e.g. butter, fats, fish

Mechanical pulp produces paper of relatively high bulk and low strength

Plastic coated paper, parchment, glassine, grease proof paper have grease resistance property in decreasing order.

Paperboard

Paperboard (cheaper type) may also be made from straw and grass.

Type of paperboard

(i) Solid fibre board (ii) corrugated fibre board

Solid fibre board is composed of paperboard (usually chipboard) lined on one or both faces with kraft or similar paper. The total caliper of the board is 0.80 to 2.8 mm.

Single ply, double ply and multi-ply (up to 8 plies)

A single ply board has a single layer of paperboard; double ply board has two layers and so on.

Structure of a 3-ply board: a 3-ply board is made up of liner (top layer), under liner and back liner (back layer)

Structure of a multi-ply board: liner (top layer), under liner, middles, back liner (back layer or back)

CFB has corrugating medium (flutes) between two layers of board for better compression impact resistance. The flutes bear compression (impact) and govern stiffness of the board. Greater flute height exhibits better property.

Table 3.2: Main types of paper board

Board type	Uses
Cream lined chipboard (liner of chemical, mechanical or mixed pulp, back as chipboard)	Board of lowest grade and price; Folding box
White lined chipboard	Folding cartons for breakfast cereals

(white pigment + binder/top layer of bleached chemical pulp/under liner of mechanical pulp /middles of mixed recycled fibres/back liner of selected recycled fibres)	(e.g. porridge, beaten rice, corn flakes)
White lined manila (triplex)	Cartons for cheese etc
Solid white board (board made entirely from sulphate pulp; waxed)	Strong board; carton and box for frozen and speciality foods, especially liquids
Duplex board (liner and back both made from new pulp, middles mixture of both)	As white lined chipboard
Liquid packaging board (construction similar to solid white board; extra coating or lamination for improved barrier properties)	For packaging of milk, cream, fruit juice, etc.

Chipboard is made from re-pulped 100% waste pulp.

Quality of chipboard can be improved by various treatments, as a result different types of board are produced such as white lined chipboard and cream lined chipboard
Barrier properties (e.g. liquid, oil, gas barrier) of board can be improved by such treatments as coating and lamination (wax, glassine, plastic materials are used).

Kraft paper

Sulfite paper

Wax Paper

Greaseproof Paper

Parchment paper

3.2.2. Plastics

- Greek word *plastikos*
- "Plastics is a group of synthetic resins or other substances that can be moulded into any form" (Oxford dictionary)
- The word *Plastics* is used to describe the vast range of materials based on macromolecular organic compounds

- The structures built by the repeated joining of small basic building blocks called monomers, the resulting compound being called a **polymer**

Type of plastics (selected) and description of properties:

1. **Low density polyethylene (LDPE)**
   - Accounts for the biggest proportion of plastics used in packaging
   - Versatility
   - Prepared in films, bottles, closures, dispensers
   - Coating on paper, aluminium foil
   - Relatively inert chemically, almost insoluble in all solvents at room temperature
   - Some softening and swelling can occur with chlorinated hydrocarbons
   - Low water vapour permeability
   - Excellent heat sealing property
   - High permeability to oxygen and other gases
2. **Linear low density polyethylene (LLDPE)**
   - Properties similar to LDPE
   - Stronger and tougher than LDPE
3. **High density polyethylene (HDPE)**
   - Harder than LDPE
   - Barrier properties superior to LDPE
   - gives higher rigidity to bottles than LDPE for same wall thickness
4. **Polypropylene (PP)**
   - Chemically similar to LDPE and HDPE
   - Harder than both
   - Excellent grease resistance
   - High stress crack resistance
   - Steam-sterilizable

   LDPE, LLDPE, HDPE, PP are called polyolefins (a family of plastics based on ethylene and propylene), olefin meaning "oil-forming" and constituting "thermoplastics" (melt on heating and stiffen on cooling)
5. **Ionomers (**a family of polymers in which there are ionic forces between the polymer chains, as well as the usual covalent bonds between the atoms in each chain)

   – Surlyn has properties similar to polyethylene,

   – TPX has good impact strength
6. **Polyvinyl chloride (PVC)**
   - Good gas barrier properties

- Moderate barrier to water vapour
- Resistant to weak or strong acid, and alkali
- Excellent resistance to oil and grease

7. Polyvinylidene chloride (PVDC)

- Outstanding property of low permeability to water vapour and gases
- Used as shrinkable film (skin wrapping) for wrapping poultry, ham, cheese and other similar items to keep fresh

8. Polyvinyl alcohol (PVA)

Soluble in water

9. Ethylene vinyl acetate copolymer (EVA)

- Good flexibility
- Used for making snap-on caps
- Permeability to water vapour and gases is higher than LDPE
- Good stress-crack resistance

10. Polystyrene (PS)

- Colourless, transparent, hard, brittle
- Fairly high tensile strength
- Resistant to strong acids and alkalies; soluble in esters, aromatic hydrocarbons, higher alcohols, ketones, chlorinated hydrocarbons

11. Polycarbonate (PC)

- High impact strength, high softening point
- High clarity

12. Cellulose acetate (CA)

- Sensitive to moisture and not dimensionally stable
- Tensile strength and impact strength are comparable to PS

13. Nylons

- Tough material, high tensile strength
- Good resistance to abrasion
- High softening point and resist steam sterilization
- Slightly hygroscopic
- Fairly high water vapour permeability
- Good gas and odour barrier property and used in laminates for vacuum packaging
- Excellent transparency

Fig. 3.1: Nylon packaging

14. Polyester/Polyethylene terephthalates (PET)

- High softening point
- Used in boil-in-bag
- Not easily heat-sealable

Table 3.3: Some important properties of plastics

Type of plastic	Sp. gr.	Softening point (ºC)	Yield (m^2/Kg) 25 µ	Tensile str. (kg/cm^2)	WVTR (g/m^2/d/atm) at 90% Rh, 38 ºC 25 µ	OTR (cc/m^2/d/atm) at 25 ºC 25 µ
Low density polyethylene (LDPE)	0.92-0.94 (low)	85-87 (low)	42	80-240	14-18 (high)	7000-8000 (fairly high)
High density polyethylene (HDPE)	0.95-0.96 (higher)	120-130 (high)	41	220-350	5-7	1500-2000
Cast polypropylene (CPP)	0.91	150 (high)	44	300-400	7-9	2000-3000
Biaxially oriented polypropylene (BOPP)	0.91		44	500-550	4 (v. low)	2000-2500
Polyester (PET)	1.34-1.39	250	28	800-1700 (high)	21	50-90 (v. low)
Polyvinyl chloride (PVC)	1.3-1.6	82	28	460-560	30-40 (high)	300-400
Polyvinylidene chloride (PVDC)	1.5-1.7	80	24	500-850 (high)	2-4 (v. low)	5-25 (v. low)
Ionomer	0.94	68-76	42	350	20-30	7000-8000
Polystyrene (PS)	1.05	78-103	37	360-530	100-150 (v. high)	4000-5000
Polycarbonate (PC)	1.20	165 (high)	32	680-720	50-150	3000

Ethylene vinyl alcohol (EVOH or EVAl)	1.14-1.21		33	400-1600 (high)	20-50	0.5-20
Ethylene vinyl acetate (EVA)	0.93	95		155-280	20-50	10000 (high)
Cellulose Acetate	1.23-1.33	70	42		100-300	2000-3000
Nylon 11	1.04	216 (high)	34	700-1000	60-100	400

3.2.3. Metal packaging material

Advantages:

- High strength
- Offers the best barrier properties after glass
- Provides the tensile strength needed for operation across aerosol sprays
- Can be re-used as a container and offers “collectible” image/dual image

Disadvantages:

- Limits re-usability (sardines, nuts, cat food). Problem of corrosion.
- Can affect taste of food or beverage. Metallic taste
- Metal cannot be microwaved unless special protective coating or layer is provided

Type of metal packaging material:

Tin, tin free steel, tinless steel, aluminized steel, aluminium, aluminium alloy, anodised aluminium, anodised and laquered aluminium

Tin

Advantages of tin:

1. Fabricated readily
2. Strong to withstand processing and handling
3. Easy to handle
4. Light weight
5. Can be handled on high speed machine

Type of steel plate: The type depends on the degree of workability, strength and corrosion resistance. The properties depend on the content of phosphorous (0.01-0.1%) and copper (0.02-0.6%). Phosphorous gives strength. Steel containing higher amount of copper are more corrosive.

Type L: used for highly corrosive products

Type MR: moderately corrosive products
Type MC: used for making high strength tinplate

Process of tin coating:

1. Hot dipping: Steel plate is dipped in molten tin bath
2. Electrolytic coating: It is electrolysis process of coating where tin acts as anode and steel acts as cathode. The tin is deposited on the steel plate.

Tin coating thickness: 0.4 -2.5 um (2.8-17 gsm)
Electrolytic coating method gives thinner coating with the substance as low as 5.6 gsm when it is minimum of 22 gsm by hot dipping method (11 on each side).
Differential tin coating: it refers to the coating method with different amounts of tin deposit on the two sides of steel plate. Nomenclature, for example D 100/50.

Tin free steel: It is mild steel coated electrolytically with chromium (chromic acid). It is cheaper than tin. It may be lacqured to improve its performance.

Tinless steel: It is also called Black Plate. It is mild steel sheet coated with phosphate for facilitating lacquering. The coating is done by dipping in hot phosphate solution and the process is called bonderizing (bonderizinf produces good adherend surface for subsequent paint coating). After bonderizing, cleaning and drying the sheet is lacquered and baked.
Aluminized steel: The steel plate is coated with aluminium by hot dipping process or vapour coating (vapour deposition coating).

Alluminium:
Light in weight, good gas and light barrier properties, non-corrosive for large number of food products, expensive

Aluminium alloy: It is Al-Mn alloy and contains 1% manganese as alloying agent. Manganese increases strength and corrosion resistance. Without manganese to have the same strength as tin the thickness of aluminium has to be 20% greater.

Anodized aluminium: *Anodising* is an electrochemical process used to produce durable and decorative finishes on components made of aluminium or aluminium-based alloys; the process thickens and toughens the naturally occurring protective oxide.
Anodizing actually makes the aluminium stronger and more durable. Anodizing involves placing a sheet of aluminium into a chemical acid bath, quite often acetone in laboratory experiments. The sheet of aluminium becomes the positive anode of a chemical battery and

the acid bath becomes the negative. An electric current passes through the acid, causing the surface of the aluminium to oxidize (essentially rust). The oxidized aluminium forms a strong coating as it replaces the original aluminium on the surface. The result is an extremely hard substance called anodized aluminium. Anodized aluminium can be nearly as hard as diamond under the right anodizing process. Many modern buildings use anodized aluminium in places where the metal framework is exposed to the elements.

Anodized and lacquered aluminium: The aluminium plate is anodized and painted with a protective coating of resins

Lacquer and lacquering:

Lacquer (UK), enamel (US)

Lacquering is done to prevent corrosive reaction between the can and content.

Lacquer type based on resistance to corrosion:

1. AR lacquer (Acid Resistant lacquer): e.g. oleoresin lacquer, gold coloured
   Used for anthocyanin (water soluble red pigment) rich fruits like blue grapes, cherry, plums)
2. SR lacquer (Sulphur Resistant lacquer): e.g. Epoxy lacquer.
   Used for sulphur containing foods like meat, fish, poultry

Lacquer type based on composition and synthesis:

1. Natural lacquer: It is oleoresin lacquer and made of natural resin*, solvent, drying oil and drier. It is used for fruits containing anthocyanin.

   * Resin is an inflammable adhesive substance insoluble in water and secreted by most plants and exuding naturally or upon incision, esp. fir and pine.
2. Synthetic lacquer:
   2.1 Phemolic lacquer: made of synthetic resin and solvent. It is made by the acid of alkaline condensation of a phenol with formaldehyde.
   2.2 Vinyl lacquer: Made of synthetic resin and solvent. It is made by copolymerzation of vinyl chloride and vinyl acetate. It is used for beer and soft drinks cans which are not processed at high temperature.
   2.3 Epoxy lacquer: It is made from eiphlorohydrin and bis-phenol (produced from phenol). It has fair resistance to sulphide staining.
   2.4 Epoxy phenolic lacquer: It is made from polybutadienes and resins based on diphenolic acid. It is also called general purpose lacquer and used for high acid foods and condensed milk.

Properties of metal containers:

- Resistance to fracture on sharp bending
- Chemical inertness
- Continuity of tin coating (in case of tin container)

It is important to ensure that no localised corrosion occurs with food in the exposed steel leading to pinholing and ultimately leakage and loss of shelf life.

Table 3.4: General types of can coatings

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

3.2.4. Glass

The principal ingredient of glass is silica from sand, flint or quartz which is molten at very high temperature during fabrication of glass containers. Silica is combined with other raw materials to form glass. Very common soda glass contains apart from silica other minerals like CaO, Na_2O etc. in small amounts.

Fig. 3.2: Glass Bottle

Advantages:

- Offers tremendous barrier properties.
- Chemical inertness. Reinforces consumer security.

- Conveys the “feel” of crystal, and creates a good impression. Good psychological attribute.

Disadvantages:

- Heavy in weight: weighs more than any other packaging material.
- Breakage problem: can break in filling, shipping, palletizing, storage or use.

Table 3.5: Packaging materials and package forms

Packaging material	Package form
Paper and paperboard	Wrapping paper, bag, box, sachet, pouch, case, carton, fitments in board, body of composite container, fittings in case, multiwall sack, fibre drum, tray, tub
Metal	Can, crate, box, pallet, collapsible tube, closure, drum, metal strapping and banding, foil, laminate and label (aluminium)
Glass	Bottle, jar, tray, tube, ampoule, vial
Plastics (including cellulose and rubber)	Film, laminate and sheet, bag, pouch and sachet, sack (film and woven tape), bottle, jar, pot, tray, pot, blister and fitment, cushioning material and fitting, cap and closure, drum, crate, box, tub
Timber (including plywood)	Box, crate, cask and keg, case, drum, pallet, basket and punnet
Textile	Sack, bag

3.2.5. Retail pack

Cans

Three-piece can: It is open top sanitary (OTS) can, so called because the top side only is open while filling the can. It is made of three pieces of top side (lid), bottom side (lid) and body.

Can size nomenclature:

A2½, A1 Tall etc

A2½ (American system) → $4^{1}/16$" (dia) x $4^{11}/16$" (ht) → 401 (dia) x 411 (ht) (ISO diameter)

Can shapes: round, rectangular, oval, oblong, pullmon

Two-piece can: It has a body and a lid and so called two-piece can.

Two-piece can (type):

1. Drawn and wall ironed (DWI): The body blank is drawn into a cup and forced by means of a punch through a series of annular dies (rings). Each die is slightly smaller

than the preceding one, thus elongating the wall by a stretching or ironing action. During ironing the wall thickness is reduced and the height correspondingly increased. For example, carbonated beverages.

2. Drawn and redrawn (DRD): This process is used to produce can of bigger height (taller can) and the can has higher height to diameter ratio. The process is similar to DWI, except that the height is increased by sequentially decreasing the diameter of container by drawing cups to smaller diameter.

Advantages of two-piece can:

1. Elimination of two seams reduces the possibility of leakage and removal of a potential source of lead contamination from solder.
2. Better aesthetic appeal presenting a smooth profile and streamline appearance.
3. Un-interrupted print decoration on the external surface.
4. Bottom of the can be designed and formed for better stackability.
5. Less metal is used in its construction due to elimination of the overlap at the two seams.

Aluminium can

Type of aluminium can

1. **Built up can:** The can is made by the process similar to making normal 3-piece can. The lid can be replaced on can and the container is reusable in household.
2. **Shallow formed can:** This is made by drawing process ("drawn can"), in which the body blank is blown with the stroke of "press". The maximum height is half the diameter of container. The shape is round or rectangular.
3. **Deep drawn can:** The maximum height is 1.2 times the diameter of container. The maximum practical diameter is 815 mm. This type of can is made by pressing.
4. **Impact extruded can:**

   In impact extrusion a disc of aluminium known as “slug” of about 2.5 to 6 mm thick is placed in specially shaped die. A container cylinder is formed inside a confining die from the cold slug, by a single stroke application of force through a punch (attached with a hydraulic press generating forces up to 250 psi) causing the metal to flow around the punch. Tall cans are formed by this process. The maximum height of can is 3 times the diameter. The practical diameter is 105 mm.

Can by design

Collar can: It is a reclosable type round can (the lid can be replaced after use unlike the lid of three-piece can) incorporating a removable tear strip and internally fitting collar.

Seamless can: It is a two-piece can with no seam and made by drawing method.

Lever lid can: It is usually round shaped built-up can, the ring component being secured to the body and having an orifice into which inverted (hat shaped) lid is pressed.

Slip lid can: The body is usually seamless. The lid fits over the mouth (slip and close). It provides simple reclosure feature.

Box and carton

Box and carton are similar containers. They can be set up type and folding type. Box is normally made from paper board and wood. Carton is box shaped container made normally from light paper board or card board.

Fig. 3.3: Carton

Folding carton

- Made from sheets of light paperboard (thickness 300-1100 um).
- Type: Coated solid bleached and unbleached sulphate board, and recycled board used. Coating and laminating may be done to improve barrier (water vapour, grease) properties.
- Cut and scored for bending into desired shape and delivered in collapsed state for assembly at packing point

Beverage carton

- Packaging of liquid food such as fruit juice, milk, wine etc
- Carton impermeable to liquid

  Carton for aseptic packaging:

  Aseptic paperboard carton (liquid tight, hermetically sealed, preserves food) consists of layers of unbleached and bleached paperboard coated internally and externally with PE and also containing thin layer (6.3 um) of aluminium foil.

  It usually contains six layers as PE (outermost layer)/unbleached paper/bleached paperboard/PE/Al. foil/PE

PE: heat sealing; Bleached paperboard: mechanical rigidity & printing; PE: binds al foil to PB; Al. foil: gas and light barrier; PE (2 layers of different grammage): liquid barrier.

- Form-fill-seal carton and system of packaging
- TetraPak packages: tetrahedron, tetrabrik, gable top (purepak)
- Retortable version

Moulded pulp container: carton and tray shaped containers for egg, fruits etc made by pressure injection and suction moulding processes

Tube

Metal tube, plastic tube, laminated tube

Plastic tube

Coloured PE (LDPE, MDPE, HDPE, L LDPE) granules are mixed and blended and extruded in continuous tubing; the tubing is cut to desired length; shoulder and nozzle are formed; after colour printing lacquering is done to give glossy finish; drying by UV light system

- Does not collapse but retains its shape and length on bending and squeezing
- Rust proof
- Strong seals (the seal does not open easily)

Laminated tube:

Plastic/al. foil/paper

Complete ply composition: LDPE with antistat (outermost layer)/LDPE/printing ink/pigmented white LDPE/paper/LDPE/ethylene acrylic acid copolymer/al. foil/EVA/LDPE (innermost layer)

Advantages

Far better barrier properties than plastic tube

Easily squeezable and eliminated waste

Resistant to cracking, creasing and denting

Superior appearance

Corrosion free

Tray, tub and cup

Tray, a shallow container is made up of fibreboard (e.g. biscuits and snacks) and plastic (e.g. meat); may be portioned. Portioned tray suitable for assorted (classified) items e.g.

biscuits Laminate is used to fabricate lid and body of tub, e.g. lid (PET/Al.foil/PP), body (PP/EVOH or PVDC/PP)

Plastic tray, tub (deep) and cup come under semi-rigid type moulded plastic containers.

Flexible type containers lack stand up rigidity.

Semi-rigid and rigid containers have advantage of speedy filling/packing

Bottle

Manufacturing process of glass container:

Silica and cullet (returns) are mixed and heated in furnace (T~1500 °C) to melt and remove gases like CO_2, SO_2 and water vapour (refining), Forming is done to form the desired container, followed by annealing (heating the glass to temp. of ~540°C and give the product stability) and surface treatment (treatment with different elements and organic compounds to increase the strength).

Bottle and its parts

Plastic bottle: viz. HDPE, PET bottles

Wrap and closure

Wrap

Wrapping may be performed on individual item of product (confection, overwrap over a tray of food) or for unitizing purpose. Wrapping an individual product offers protection to the product whereas wrapping for unitization would mean making a bundle of the packages (or holding the load together) for easy handling, for example, stretch (film)-wrapping of a case of milk bottles or beer cans or strapping or netting of boxes piled up on a pallet (tertiary packaging). Unitizing thus saves labour costs, warehousing costs (space saving) and simplifies the handling thus increasing the efficiency of shipping and warehousing.

Shrink-wrapping:

1. Evacuation of air from bag followed by shrinking by immersion in hot water (e.g. PVDC) for odd shaped product e.g. dressed poultry, cheese
2. Collating of cans, cartons, bottles by exposing to hot air (e.g. LDPE)

Stretch-wrapping:

1. The film is stretched over/around the object e.g. a dressed poultry and then allowed to retract to its original dimensions.
2. Wrapping around the objects (unitizing) followed by heat sealing

Plastic films: LDPE, EVA, PVC

Materials for strapping: steel, PP, nylon, PET or rayon cord

Closure

Cap, lid, seal

Functions

1. Provide effective hermatic (air tight) seal to prevent the passage of solid, liquid or gas into or out of the container; exposure of content to atmosphere
2. Provide easy opening and reclosing
3. Provide evidence of unlawful access (tampering, pilferage) to the content. For example, Roll-on pilfer proof (ROPP) closure such as alluminium roll-on closure used on beverage bottle, and tell-tale ring around the bottom of the neck of bottle (any tampering is evident of breaking the seal)

Material of construction: metal (tin, alluminium), plastic (resins, PS, LDPE, HDPE, PP, PVC), cork (pulp)

Form (shape) of metal closure: roll-on (spin-on), crown, screw, lug cap

Roll-on tamper evident:

The rotary head rolls to press the closure against the finish of bottle, forms the threads to match that of bottle thread, and simultaneously forcing the skirt of closure to crimp it onto the finish.

Crown cork

The rotary capper (manual batch or automatic) exerts straight downward force on crown to compress the liner on sealing surface of bottle while clinching heads crimp the corrugated skirt into a groove on the bottle neck.

Normal, pressure and vacuum seals (closure)

Normal seal: inside and outside pressure are equal.

Pressure seal: the content is filled under pressure e.g. carbonated beverages.

Vacuum seal: inside pressure is lower than outside

3.2.6. Shipping containers/transportation containers/ containers for distribution (secondary package)

Box, case, crate, barrel, cask, drum, sack etc.

Material of construction and package:

- Wood, fibreboard, plastic, metal, jute
- Wooden box, fibreboard box or case, wooden barrel or cask (wine, whiskey etc), plastic crate e.g. PP and HDPE (milk, beer, soft drinks etc), metal drum, plastic (PE, expanded PET) drum (fruits, fish etc)

3.3. Special Packaging systems

Objectives: delay deterioration and extend shelf life of food, maintain quality

Modified atmosphere packaging, controlled atmosphere packaging, vacuum packaging, gas packaging, hypobaric storage, aseptic packaging

3.3.1. Modified Atmosphere Packaging (MAP)

It is enclosure of food in a package in which the atmosphere (gaseous composition) surrounding the food is modified or altered to give optimum atmosphere for extension of shelf life (by 40-50%) and maintaining quality of food.

MAP is normally used in combination with low temperature

Type of MAP

1. Active MAP (active modification): It involves displacing the air with a controlled, desired mixture of gases (gas flushing).

   Active packaging is also sometimes referred to as Active MAP, whereby an active substance is used to perform some active role. For example, an O_2 adsorber, e.g. ferrous carbonate is used to adsorb O_2.

Method:

1. Vacuumizing
2. Vacuumizing followed by gas flushing
3. Injecting gas without vacuumizing

Equipment:

1. Form-fill-seal
2. Chamber method (filling → vacuumizing → gas flushing → sealing)
3. Snorkel machine (continuous process, similar operation as chamber method)

2. Passive MAP (passive modification): an atmosphere high in CO_2 and low in O_2 occurs as a consequence of the food's respiration or the metabolism of microorganisms associated with the food over time.

   The package film permeability is such that O_2 can enter the package to avoid anoxic condition and anaerobic respiration at the same time excess CO_2 can diffuse from the package (avoids injurious effect).

3.3.2. Controlled Atmosphere packaging CAP

In CAP, the atmosphere inside the package is continuously monitored and adjusted to maintain the optimum composition within quite close tolerances (so called controlled atmosphere). In strict sense, CAP is enclosure of food in a gas impermeable package, the gaseous composition inside which with respect to CO_2, O_2, N_2, water vapour etc has been changed to increase the shelf life of food.

- Normally bulk packaging and storage
- Normally fruits and vegetables, and fresh produce

3.3.3. Vacuum packaging

Sometimes considered as active MAP method.

Package, normally retail package, evacuated mechanically (vacuum pump), and the food is held in air free atmosphere.

- package is skin-tight
- longer shelf life in oxygen free system
- Normally applied to meat, fish, poultry, cheese
- Suitable packaging materials: PVDC, EVOH (v. low GTR). Nylon may be used in laminate

Method: batch and continuous process

Fig. 3.4: Vacuum packaging

3.3.4. Gas packaging

Package is first evacuated, and then filled with inert gases, CO_2 or N_2

- Package is devoid of O_2, provides protection to food against O_2, packaging of oxygen sensitive products, viz. milk powder
- Provides protection from compressive impact; packaging of fragile food, viz. potato wafer & chips;
- Production of pillow pouch
- Suitable packaging materials: PVDC, EVOH. Nylon may be used in laminate

Fig. 3.5: Gas Packaging

3.3.5. Hypobaric storage

It is a storage system (structure) for the storage of food in an environment of precisely controlled air pressure, temperature and humidity, and the rate at which air is changed is closely regulated. Air pressure (which is proportional to O_2 concentration) is the most important parameter, and it is closely monitored and regulated.

3.3.6. Aseptic packaging

It refers to filling food in package in contamination free (asepsis/sterile) condition.

- Most cases: filling pre-sterilized food in sterilized container under sterile environment
- Rare case: filing non-sterile product (yoghurt and similar products) in sterile container under aseptic condition

Method:

- Product sterilization by heat. Heat exchangers: tubular, plate, scrap film
- Sterilization of packaging materials by irradiation, heat (superheated steam, saturated steam or hot air) and chemicals (H_2O_2), in singles or combination
- Sterilization of packaging atmosphere by superheated steam

Advantages:

1. Application of HTST process - efficient heat transfer, superior product quality (nutritional, sensory)
2. Filling irrespective of container size
3. Product is shelf stable at normal temperature

Packaging materials:

- Packaging materials: metal, glass, plastic or laminate (PE/paper board/PE/foil/PE)
- Package type: carton, can, bottle, bag, pouch, sachet, cup
  Filling in pouch, sachet and carton is by form-fill-seal system

3.4. Properties/characteristics of foods, their packaging requirement and packaging methods

3.4.1. Fruits and vegetables

General characteristics:

- High moisture content (85-90%)
- High perishability due to over-ripening, maturing, shriveling, microbial rot. Maturation is undesirable in vegetables
- Easily damaged mechanically and by heat and cold

3.4.2. Postharvest physiology:

- Respiring organisms; main metabolic process involves respiration (utilization of oxygen) with liberation of energy in form of heat, carbon dioxide and water and breakdown of large organic molecules
- Factors: temperature, level of oxygen, carbon dioxide and other gases affect the metabolic process and respiration rate

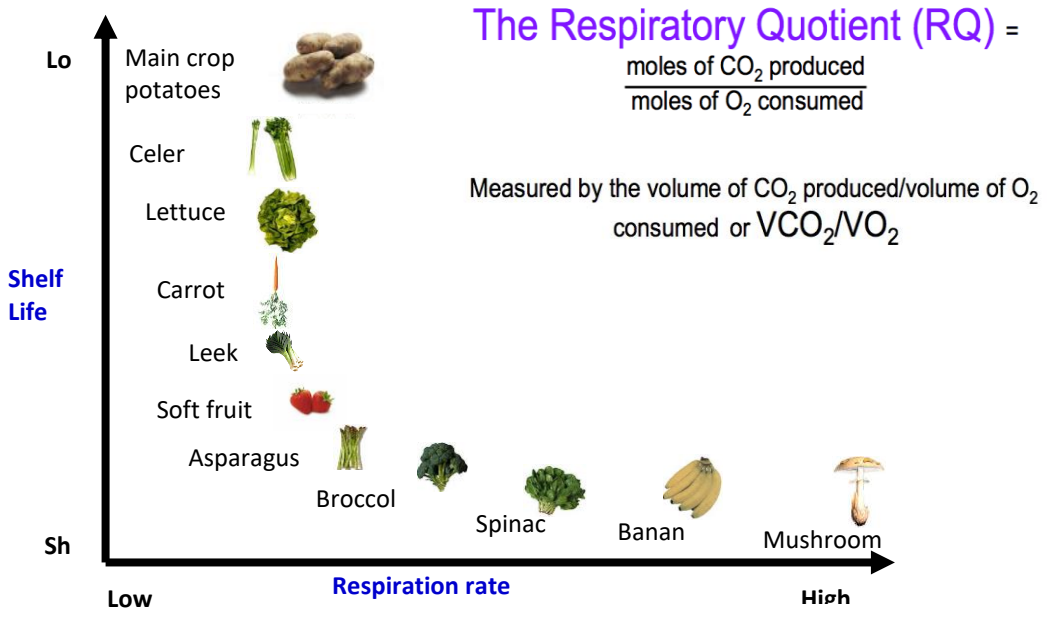


Fig. 3.6: Respiration of fruits and vegetables

3.4.3. Techniques of shelf life extension:

Low temperature storage

Temperature effect: Metabolic process is dependent on temperature and its rate is high at higher temperature

- Fruits have their optimum ripening temperature. E.g. tomatoes best ripen at 20-25°C, bananas 15-22°C
- Most fruits and vegetables are damaged by temperature as high as 38°C and higher
- Cold injury at low temperatures esp. tropical and subtropical fruits e.g ≤ 10°C, banana, ≤7°C pineapple
- Store at their proper temperatures
- Remove heat of respiration by venting

3.5. MAP of fruits and vegetables

Shelf life can be increased and quality of fruits and vegetables can be maintained by controlling the metabolic process by maintaining O_2 and CO_2 (and other gases) concentrations at proper levels.

- High oxygen concentration → high respiration rate → early ripening → early decay;
- V. low O_2 conc. → anaerobic respiration (ethanol, acetaldehyde, CO_2) and plant tissue damage
- Desired O_2 concentration: 2-3 %
- High CO_2 depresses respiration, delays ripening, competitive inhibition of C_2H_4 production
- Desired CO_2 concn: 10% (acceptable for many fruits); range 1-10%
- Very high CO_2 conc. (> 20%): acceleration of respiration rate of root and bulb type vegetables; ethanol, acetaldehyde produced during anaerobic respiration are toxic to plant tissue and damage them; pressure build up inside package results in bulging and bursting

Packaging materials and methods

- Packaging materials: normally plastics of selected gas (O_2) permeability; normally high GTR is desired to allow O_2 to enter the package and there is no anoxic condition and anaerobic respiration; Commonly used plastics: PVC, PS, PE, PP
- Pillow pouch (prevents mechanical injury) of oriented PP used for vegetable salad cuts like lettuce, green pepper, chopped onion, carrot sticks; PS with high GTR for lettuce and tomato

- Perforations in plastic pouch or bag or overwrap with high GTR maintains desired atmosphere
- Venting in flexible packaging for maintaining desired atmosphere

3.5.1. Active packaging

Packaging is termed as active packaging when it performs an active role (inhibition of microbiological, biological, chemical reactions) besides providing an inert barrier to external environment. The effect is obtained by introducing materials having definite functions into the packaging or other special techniques. The active substances act by adsorption, absorption and reaction. It is that packaging technique that dynamically changes permeation properties or the concentration of different volatiles and gases in the package headspace during storage. AP is mostly applied to plastic packaging.

3.5.2. Oxygen scavenging

Oxygen scavengers/oxygen adsorbers: iron, oxygen scavenging enzymes, ascorbic acid, light activated scavenger, oxygen scavenging reaction system

3.5.3. CO_2 scavenging or scrubbing

1. Absorption of CO_2 in hydrated lime or activated carbon. Calcium hydroxide reacts with CO_2 under high humidity condition and produces $CaCO_3$.
2. The scavenger, CaO is packed in a porous envelope and put in a sachet containing hydrating agent like silica gel. Water is absorbed by the hydrating agent and CaO reacts with CO_2.

3.5.4. Ethylene scavenging

Ethylene, respiration product of ripening fruit, anaerobic respiration, has detrimental effect on fruits Yellowing

Ethylene scavenger e.g. $KMNO_4$

3.5.5. Humidification and humidity buffering

- Fruits and vegetables have high moisture content; leafy vegetables > 90%, and larger surface area, other vegetables and fruits 85-90%
- Transpiration →loss of moisture → weight loss, wilting, shriveling, shrinkage

Fig. 3.7: Active packaging of fruits and vegetables

Packaging to control of moisture loss and maintain high Rh

- Active packaging: humidification and humidity regulation by use of humectants and like alcohol, propylene glycol, carbohydrate, etc. impregnated between the layers of water vapour permeating plastic films
- Humidity buffering (maintaining desired humidity without condensation or drying of packed goods)
    1. Packaging in fibre board cartons with a LDPE liner (low WVTR) or waxed carton (protection from drying and wilting or shriveling)
    2. Active packaging: 1. inclusion of microporous bag or pad of inorganic salts (antifogging agents) in the carton (prevention of condensation), 2. a multilayer is provided on the side of carton which absorbs moisture released by the packed produce and releases the moisture (water vapour) when the humidity is low.

3.6. Mechanical injuries of fruits and vegetables

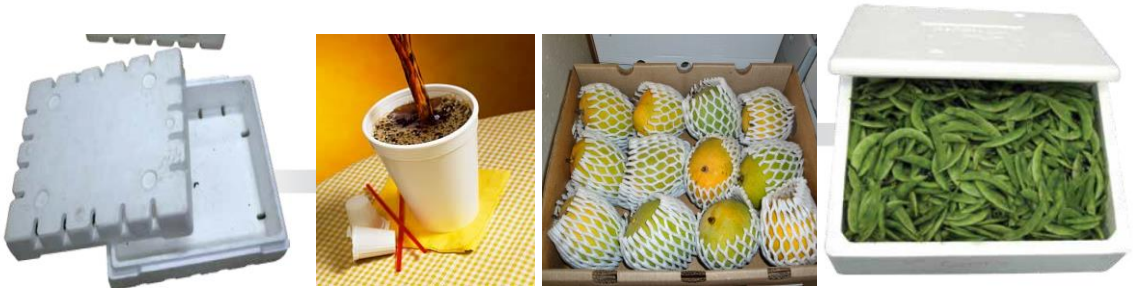
- Mechanical injuries (bruises, cuts, abrasion, puncture) cause loss of fruits and vegetables.
- Mechanical injury gives easy access for infection; damaged fruits (increased contact with oxygen, increased surface are for reaction) respire at higher rate (do not pack damaged with undamaged ones); enzymatic browning

3.6.1. Packaging to prevent mechanical injuries:

- Use of cushion pads to protect from impact bruising caused by drop on hard surface
- Proper filling (no over filling) and proper stacking to protect from compression bruising

- Selection of proper package size and internal filler and packaging material e.g paper shreds, wrap etc to protect from vibration and abrasion bruising during transportation and movement, including moulded pulp or expaned PS foam trays containing individual items and separating.

Retail packaging: Fruits are packed in fibre board or plastic tray (e.g. foamed PS or PVC or PP) with stretch-overwrap or shrink overwrap, LDPE, HDPE bags
Transport container: wooden box, CF box, plastic crate, sacks etc.



3.6.2. Packaging of whole fruits and vegetables:

- Retail packaging: ventilated plastic bag (25-40 µ LDPE or 12.5 µ HDPE), net bags, tray of foamed PS or PVC or PP overwrapped with heat shrinkable or stretch films, semi-rigid containers with a cover of CA and PS for soft-textured highly perishable fruits like cherries, grapes, strawberries, plums
- Bulk packaging- gunny bags*, bamboo baskets, wooden cases and boxes, sacks (with cushioning or filling of straw, waste paper), CFB boxes, plastic corrugated boxes (PP or HDPE), MAP, vacuum packaging, active packaging, Controlled Atmosphere storage

3.6.3. Other Methods of packaging:

Edible film packaging: An edible film or coating is simply defined as a thin continuous layer of edible material formed on, [placed on, or between the foods, which can be eaten as a part of the whole food product. Selection of material for use in edible packaging is based on its properties to act as barrier to moisture and gases, mechanical strength, physical properties, and resistance to microbial growth. The types of materials used for edible packaging include lipids, protein and polysaccharides or a combination of any two or all of these. The most common form of coating fruits and vegetables is wax coating to retard respiration, dehydration and senescence. Edible films selected should meet the requirements such as physiochemical and microbial stability, good sensory qualities, high carrier and mechanical

efficiencies, free to toxic and safe for health, simple technology, non polluting and low cost of material and process.

Shrink wrap/Individual seal packaging: Individual seal packaging involves the use of heat that shrinkable film (usually HDPE) that is wrapped around the individual units of ruits and vegetables and shrink by blowing hot air over the package. Advantages of this packaging are ripening is delayed by micro atmosphere created around the product. The films acts as a good barrier to water. Prevents the spread of disease from one product to another, improve the handling and sanitation of the product, and facilitates pricing and labeling of individual may occurs with result in poor gas exchange and odors.

3.6.4. Packaging of fresh cut fruits (convenience, custard pudding and vegetables for salad):

- Higher respiration rate
- Easy microbiological spoilage
- Enzymatic browning
- High moisture loss

Solutions:

- Treatment with antimicrobial agent containing wash water
- Use of antioxidants

Dehydrated foods

Note: Packaging of some selected foods have been previously discussed

- Protection from moisture, air, oxygen, light
- Microbiological spoilage, enzymatic reactions, oxidative rancidity
- Vac. or inert gas packaging, oxygen scavenging,
- Dehydrated vegetables: laminated sacks or PE bags
- Dried meat: nitrogen flushed large cans, al. cans, foil topped glass jars, composite containers
- Bulk packaging: lever lid containers, drums

Total quality protection/Product package compatibility

It is desirable that no interaction between food and packaging material occurs which may harm the quality of food and pose health hazard to the consumers. Hence, total quality protection is a necessity.

The food-package interaction can result in:

- Unacceptable changes in food composition
- Unacceptable changes in organoleptic properties
- Toxic effects

Migration is a common process leading to food-package interaction. It refers to the process in that the monomers and other packaging material components move or transfer to food and vice versa by leaching or diffusion (evaporation).

Overall migration: Previously termed as global migration, it refers to the migration of sum of all mobile packaging material components, and measured per unit area under defined test conditions. All the migrants may not be known and may not be of toxicological interest.

Specific migration: It refers to the migration of a specific, individual and identifiable component. The terminologies are commonly and appropriately used in case of plastics

3.7. Shelf life of packaged food and its determination

Quality of packaged foods deteriorates with storage time (with exception of certain alcoholic beverages) and they become unacceptable (unsatisfactory quality and unacceptability) at one point of time (e.g. separation of oil from emulsion over storage and development of unattractive appearance, brown discolouration of tomato products, staling of bread, wilting of leafy vegetables, loss of crispness in biscuit and cracker, development of musty odour in dried herbs, development of unsatisfactory colour and quality deterioration due to non-enzymatic browning, freezer burn in meat, lipid oxidation esp. of fatty foods, etc., above all microbiological spoilage).

3.7.1. Definition of shelf life of packaged food

Time elapsed between the production of the packaged product and the point of time at which it becomes unacceptable under defined environmental conditions.

Mention of shelf life on label: “maximum shelf life”, “expiry date”, ” best before” etc.

3.7.2. Factors affecting shelf life of packaged food

1. Product nature (perishable, semi-perisheble, non-perisheble) and composition (intrinsic factors: concentration of reactive compounds, pH, a_w, enzymatic activity, microbial load etc)
2. Properties of packaging materials

3. Environment to which the product is exposed during distribution and storage (extrinsic factors: environmental factors e.g. temperature, relative humidity, oxygen, pressure, light, handling and distribution conditions
4. Processing and preservation methods
5. Product-package interaction

3.7.3 Situations for shelf life determination

1. Determine the shelf life of existing products (regular production)
2. Study the effect of factors affecting the shelf life of packaged food product
3. Determine the shelf life of newly developed product as affected by new processing or packaging

3.7.4 Indices of shelf life

- Consideration of main deteriorative reactions
- Examples

Extent of non-enzymatic browning in intermediate a_w products; degradation of chlorophyll in leafy vegetables; concentration of hydrogen gas in canned food; extent of lipid oxidation in fats and oils

3.7.5 Methodological approaches of estimating (predicting) shelf-life

- Literature study of analogous product
- Monitoring of turnover time: that is, average time the product spends on retail shelf
- End point study: random samples are collected from retail outlets and tested in the laboratory
- Laboratory test for shelf life
  - Testing shelf life in lab (plant) under actual (ambient) conditions of packaging and environmental conditions of temperature and relative humidity. Samples are drawn from time to time and tested by panel by differentiation tests or objective tests are performed e.g. degradation of ascorbic acid or lycopene.
  - Accelerated Shelf Life Testing (ASLT) is conducted under accelerated condition of extrinsic factors such as temperature, relative humidity and oxygen partial pressure present in package headspace such that product deteriorates early. It specially implies to storage temperature since high temperature accelerates the reaction rate many folds (Q_{10} effect). This test saves time and gives quick results (say, 1 month instead of 1 year by increasing storage temperature by 20°C) and thus much shorter time is needed to meet product launch schedules.

It is essential that chemical and instrumental analysis results closely correlate with sensory test results (human judgement)

Shelf life estimation of pre-packed vegetables in vented PE bag

Selection of sound vegetables, washing, draining and air drying

↓

Packaging in vented test package (PE) and weighing (net wt recoded)

↓

Store under specified test conditions (Temp, Rh)

↓

Record weight and observe for wilting, microbial infection every two days

↓

Interpret the observations and results and draw inference

3.7.6. Quality control and legislative aspects of packaging

Aspects of consideration:

- Quality control of packaging material and package

Meet standards and specifications for quality (or material) and performance, measurements (e.g. size) and properties, minimize faults in fabrication, check lowering of quality, meet performance requirements, win and retain customer goodwill.

Defects, critical, major and minor defects, tolerances and critical limits, elimination of substandard products, manufacturer-user dialogue

- Safety

3.7.7. Tetra packaging

Tetra packaging materials has 4- 6 layers-

- Polyethylene to protect against outside moisture
- Paperboard for stability and strength
- Polyethylene acts as adhesion layer
- Aluminium foil as a barrier for oxygen, flavor and light
- Polyethylene, again as adhesion layer
- Food grade polyethylene which seals in the liquid

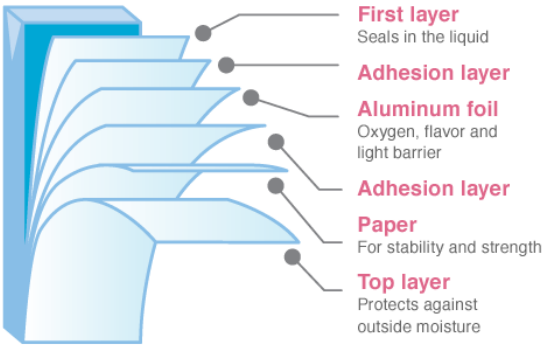


Fig. 3.8: Tetra Packaging layer

3.7.8. UHT process

Pasteurization effectively eliminate potential pathogenic microorganisms and **sterilization** refers to the complete elimination of all microorganisms. The basis of **UHT**, or ultra-high temperature, is the sterilization of food **before** packaging, then filling into pre-sterilized containers in a sterile atmosphere. Fruit juice is processed in this way using temperatures exceeding 135° C, permits a decrease in the necessary holding time (to 2-5 s) enabling a continuous flow operation.

Some examples of other food products processed with UHT are:

- liquid products - milk, juices, cream, yoghurt, wine, salad dressings
- foods with discrete particles - baby foods; tomato products; fruits and vegetables juices; soups
- larger particles - stews

3.8. Storage of Fruits and Vegetables

Proper marketing of perishable commodities such as fruits and vegetables often requires some storage to balance day to day fluctuations between harvest and sale for long term storage. Storage improves commodities quality, usefulness and also controls a market glut. The principle goal of storage is to control the rate o transpiration, respiration, disease and insect infestation. Storage life can be prolonged by harvesting at proper maturity, control of post-harvest diseases, regulation of atmosphere, chemical treatments, irradiation and refrigeration and controlled modified atmosphere.

The main goals of storage are:

- Slow biological activity without chilling injury
- Slow the growth of microorganisms
- Reduce the transpiration loss

The factors which need to be taken into account before embarking on crop storage are:

- Knowledge of the appropriate storage conditions
- Cultivar or variety of crop suitable for storage
- Availability of appropriate storage facilities
- Availability of suitable management

Fruits and vegetables are living organisms. Their condition and marketable life will deteriorate during storage through-

1. Loss of moisture
2. Loss of stored energy-carbohydrates
3. Loss of other foods
4. Physical losses through pest and disease attack
5. Loss in quality from physiological disorders,
    - Fibreness (asparagus)
    - Greening (potatoes)
    - Rooting (due to increased humidity
    - Shoot growth and elongation 9asparagus,carrot, beet)
    - Seed germination
    - Fruit growth
    - Sprouting (potatoes, ginger, onion, garlic)
    - Toughening (due to high temperature beans and sweet corn)

Factors affecting storage

- Temperature
- Relative humidity
- Air velocity
- Atmosphere composition
- Light
- Storage operations

Methods of storage: Mainly there are two methods of storage i.e. traditional methods and advanced methods

A. Traditional methods (Low cost storage structures) not requiring refrigeration include: *In-situ*, sand, coir, pits, clamps, windbreaks, cellars, barns, evaporative cooling, and night ventilation:

a) **In situ.** This method of storing fruits and vegetables involves delaying the harvest until the crop is required. It can be used in some cases with root crops, such as cassava, but means that the land on which the crop was grown will remain occupied and a new crop cannot be planted. In colder climates, the crop may be exposed to freezing and chilling injury. In some commodities development of undesirable fiber and starch occurs. There are chances of occurring damage due to insect pests and diseases.

b) **Sand or coir:** This storage technique is used in countries like India to store potatoes for longer periods of time, which involves covering the commodity under ground with sand.

c) **Pits or trenches**: These are dug 1.0-1.5m deep at the edges of the field where the crop has been grown. Usually pits are placed at the highest point in the field, especially in regions of high rainfall. The pit or trench is lined with straw or other organic material and filled with the crop being stored, then covered with a layer of organic material followed by a layer of soil. Holes are created with straw at the top to allow for air ventilation, as lack of ventilation may cause problems with rotting of the crop. This method is suitable for storing ginger.

This method is not suitable for fruits and leafy vegetables demanding high humidity because it cannot maintain high humidity. The stored commodity cannot be examined frequently for rotting etc.

d) **Clamps**: This has been a traditional method for storing potatoes, cassava etc. in some part of the world, such as Great Britain. A common design uses an area of land at the side of the field. The width of the clamp is about 1 to 2.5m. The dimensions are marked out and the potatoes piled on the ground in an elongated conical heap. Sometimes straw is laid on the soil before the potatoes. The central height of the heap depends on its angle of repose, which is about one third of the width of the clump. At the top, straw is bent over the ridge so that rain will tend to run off the structure. Straw thickness should be from 15-25 cm when compresses. After two weeks, the clamp is covers with soil to depth of 165-20 cm, but this may vary depending on the climate. Produce may desiccate because of low relative humidity. Large heaps may result in more incidence of rotting.

e) **Windbreaks:** are constructed by driving wooden stakes into the ground in two parallel rows about 1 m apart. A wooden platform is build between the stakes about 30 cm from the ground, often made from wooden boxes. Chicken wire is affixed between the stakes and across both ends of the wind break. This method is used in Britain to store onions.

f) **Cellars**: These underground or partly underground rooms are often beneath a house. This location has good insulation, providing cooling in warm ambient condition and protection from excessively low temperatures in cold climates. Cellars have traditionally been used at domestic scale in Britain to store apples, cabbages, onions and potatoes during winter. Produce may desiccate due to low relative humidity.

g) **Barns:** A barn is a farm building for sheltering, processing, and storing agricultural products, animals, and implements. Although, there is no precise scale or measure for the type or size of the building, the term barn is usually reserved for the largest or most important structure on any particular farm. Smaller or minor agricultural buildings are often labeled as shed as or out buildings and are normally used to house smaller implements or activities.

h) **Evaporative cooling**: When water evaporated from the liquid phase into the vapor phase energy is required. This principle can be used to cool stores by first passing the air introduced into the storage room through a pad of water. The degree of cooling depends on the original humidity of the air and the efficiency of the evaporating surface. If the ambient air has low humidity and is humidified to around 100% RH, then a large reduction in temperature will be achieved. This can be providing cool moist conditions during storage.

Controlled atmospheres are made of gas tight chambers with insulated walls, ceilng and floor. They are increasingly common for fruit storage at larger scale. Depending on the species and variety, various blends of O_2, CO_2 and N2 are required. Low content O_2 atmosphere (0.8to 1.5%), called ULO (Ultra -Low Oxygen) atmospheres, are used for fruits with long storage lives (e.g. apples).

B. Advanced (high cost) methods of storage

1. Low temperature storage (Refrigerated or cold storage): Microbial growth and enzyme reactions are retorted in food storage at low temperatures. Lower the temperature the greater the retardation. Low temperature employed can be
   a) Cellar storage temperature (about 15℃)
   b) Refrigerated or chilling temperature (0 ℃ to 5℃)
   c) Freezing temperature (cold storage) (-18 ℃to – 40℃)

1(a) Cellar storage temperature (about 15℃): Temperature cellar (underground rooms) where food is stored in many villages are usually not much below that of the outside air and is seldom lower than 15. The temperature is not low enough to prevent the action of many spoilage organisms and other plant enzymes. Decomposition is

however slower down considerable. Root crops, potatoes, onions, apples and similar food scan are stored for limited during the winter months.

1(b) Refrigeration or chilling temperatures (0℃ to 5℃): Refrigerated storage or low temperature storage is the most common method of storage throughout the world both for fruits and vegetables. Refrigeration is the process of removing heat from an enclosed space or room or a substance or commodity. The primary purpose of refrigeration is lowering the temperature of the enclosed space or substance or commodity and then maintains the lower temperature.

1(c) Cold storage: At temperature below the freezing point of water (-18 ℃to -40℃) groth of microorganisms and enzymes activity Are reduced to the minimum. Most perishable foods can be preserved for several months. If the temperature is brought down quickly (quick freezing) and food held at these temperatures. Food can be quick frozen in about 90 minutes or less by (1) pacing them in contact with the coil through the refrigerant flows (2) blast freezing in which cold air is blown across the food. (3) by dipping in liquid nitrogen. Quick frozen foods maintain their quality and freshness when they thawed (brought to room temperature) because of very small crystals are formed when food are frozen by these methods. Many micro-organisms can survive this treatment and may become active and spoil the food if the food are held at high temperatures. Frozen foods should always, therefore be held at temperature below -5. Enzymes in certain vegetables can continue to act even after being quick frozen and so vegetables have to be given heat treatment called blanching (above 80℃) before they are frozen to prevent development of flavors.

C. Controlled Modified atmosphere storage: In this system the products is held under atmosphere conditioned modified by package, over wrap, box liner or pellet cover. The first requirement of CAS is sufficiently gas tight envelopes around the produce and the second requirement is same means of maintaining the concentration of C02 and O2 at the desired level. This method in combination with refrigeration markedly enhanced the storage of fruits. Fruit that is most benefit by this technique is apple. Among the tropical fruits, the best atmosphere for storage of mangoes is 5 % C02 and 5% O2 at 13. CAS improved the appearance of pine apple fruit by reducing the superficial mould growth. The optimum O2 level was 2%. Levels of oxygen below that were ineffective in extending storage life. Benefits could be obtained with papaya when the fruits are stored in 5% Co2 and 1% O2 for 3 weeks at 13. Initiation of ripening in banana can be delayed for weeks or months by holding the green banana fruits in an atmosphere of 1-10% O2, 5-10% Co2 or low 02, and high Co2,

combination. In general, the response of citrus fruits to CAS has been disappointing. In MAS the composition of the storage atmosphere is not closely controlled.

D. Hypobaric (Sub atmosphere) storage: The commodity is placed in a vacuum tight and refrigerated container and evacuated by a vacuum pump to the desired low pressure. The process of ripening and senescence are greatly retarded by decreasing respiration and evacuation of ethylene given out by the produces. This is an expensive method.

The extension of fresh fruits and vegetables and its products is an old challenge for industrial producers. In recent years, many innovative solutions and packaging materials have been explored, from active and intelligent packaging to edible coatings and nanomaterials, eventually coupled with MAP. High-barrier films and special packaging machines are used in order to displace atmospheric air from the headspace. Current research trend is emerging that couples the newest technological tools, such as active sachets, with the use of preservatives of natural origin, derived from spices and herbs. Proper packaging is an effective way to decrease post harvest losses and allow an extension of shelf life. Hence, adequate packaging method, coupled with interventions in formulation, can increase a product shelf life during storage.

CHAPTER 4
FOOD SAFETY REGULATIONS & CERTIFICATION

4.1. Need for Testing of Food

Food Testing is a scientific analysis of food and its content. It is done to provide information about various characteristics of food, including the structure, composition and physicochemical properties. Food testing laboratories plays an important role in safeguarding food supply and maintaining public health.

Food testing labs are also critical for investigating and identifying sources of foodborne illness outbreaks, as well as conducting food safety tests during recall campaigns to ensure, for example, that all affected products are removed from store shelves and restaurants.

It is also conducted to analyze:

1) The quality of a food products- this is done to verify the claim made by the manufacturer of the product on certain issues eg ingredients used
2) For quality control- this is done before, during and after the manufacturing process to analyse the quality of the food ingredients and the finished products.
3) Food inspection and grading- is performed regularly to ensure food manufacturer meet the set regulations and standards.
4) Food must have a standardized nutritional label therefore food needs to be analyzed to verify the claims made
5) Research and development is necessary for manufactures to improve and provide food high quality, healthy and affordable food, this requires studying and analyzing the products already in the market.
6) To protect a manufacturer from rumors and smears. Many products in the market is being labeled by competitors or other rumor, such rumors can be sorted out.

Over time, the mandate for food testing labs has been expanding far beyond what was originally envisioned within the Food Code.

For example, large chain restaurants are now required to post the caloric content of their menu items so consumers can make more informed dietary choices.

Testing for the presence of food allergens is another example. An increasing number of people are at risk for an anaphylactic shock when exposed to certain kinds of foods, from peanuts red meat to certain kinds of seafood. As a result, food testing laboratories have

been called on to certify food products as being nut-free or to identify the exact species of fish served at restaurants.

4.2. List of Notified Reference Laboratories in India

S.No.	Name of the laboratory/ Institution/Organization	Address	Specific area
1.	Central Food Technological Research Institute	FS & AQCL Department, CFTRI, Mysore-570020	Nutritional Information and labelling
2.	Export Inspection Agency	27/1767A, Shipyard Quarters Road Panampilly Nagar, Kochi, Kerala 682036	GMO testing
3.	Punjab Biotechnology Incubator	SCO 7-8 Phase-V, SAS Nagar, Mohali-160059, Punjab	Sweets and confectionary including honey
4.	ICAR-National Research Centre for Grapes	P.O. Manjiri Farm, Solapur Road, Pune - 412307	Pesticide Residues and Mycotoxins
5.	Central Institute of Fisheries Technology	CIFT Junction, Wellingdon Island, Matsyapuri, PO - Kochi	Fish and Fish Products
6.	Centre for Analysis and Learning in Livestock and Food- National Dairy Development Board	Opposite IRMA main gate, Near Anadalaya Nagar, Anand 388001.	Dairy and Dairy products
7.	CSIR-Indian Institute of Toxicological Research	Vishvigyan Bhawan, 31 Mahatma Gandhi Marg Lucknow-226001	Toxicological Evaluation/Risk Assessment for Nutraceuticals, functional foods and novel/emerging food/food ingredients
8.	Trilogy Analytical Laboratory, Pvt. Ltd.	Plot No.7, C.F. Area, Phase II, IDA, Cherlapally, Hyderabad	Mycotoxins and PT services

9.	Edward Food Research and Analysis Centre Limited	Subhash Nagar, Nilgunj Bazar, Kolkata	Veterinary Drugs, Antibiotics and Hormones
10.	Vimta Labs Limited	Life Sciences Campus, 5, MN Park, Genome Valley, Hyderabad-500101	Water, Alcoholic and Non Alcoholic Beverages
11.	Fare labs Pvt Ltd	L-17/3, DLF, Ph-II, IFFCO Chowk, Gurugram-122002	Oils and Fats
12.	Neogen Food and Animal Secuity (India) Private Limited	Uchikkal Lane, Poonithura, PO- Kochi	Food Allergens
Ancillary National Reference Laboratory			
13.	EIA Chennai	Chennai	Support Facility in microbiological testing
14.	EIA Kolkata	Kolkata	Support Facility heavy metals in food testing

4.3. List of Notified Referral Laboratories in India

S. No.	Name of the Referral Food Laboratory	Local Areas or States or Union Territories
(1)	(2)	(3)
1.	(i) Director, Central Food Laboratory, 3 Kyd Street, Kolkata - 700016.	West Bengal, Orissa, Bihar, Jharkhand, Assam, Arunachal Pradesh, Chhattisgarh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Union Territories of Andaman and NicobarIsland
	(ii) Director, Food Research and Standardization Laboratory, Ahinsa Khand-II, Indirapuram, Ghaziabad-201014.	
2.	(i)Director, Food Safety and Analytical Quality Control Laboratory, C/o. Central Food Technological Research Institute, Mysore –570013.	Andhra Pradesh, Karnataka, Kerala Tamil Nadu, Telangana, Puducherry and Lakshadweep
	(ii) Director, State Public Health Laboratory, Stavely Road, Cantonment Water Works Compound, Pune-411 001.	

3.	(i) Director, State Public Health Laboratory, Stavely Road, Cantonment Water Works Compound, Pune-411 001.	Gujarat, Maharashtra, Madhya Pradesh, Rajasthan, Dadar and Nagar Haveli, , Goa and Daman and Diu
	(ii) Director, Food Safety and Analytical Quality Control Laboratory, C/o. Central Food Technological Research Institute, Mysore –570013	
4.	(i) Director, Food Research and Standardization Laboratory, Ahinsa Khand-II, Indirapuram, Ghaziabad-201014.	Delhi, Haryana, Himachal Pradesh, Punjab, Union Territory of Chandigarh, Uttar Pradesh, Uttarakhand and Jammu & Kashmir
	(ii) Director, Central Food Laboratory, 3 Kyd Street, Kolkata 700016.	

4.4. List of Notified Referral Laboratories and their scope

S.No.	Name of the Referral Food Laboratory	All over India - as per Scope of Testing defined here under
(1)	(2)	(3)
5.	Director, Indian Institute of Horticultural Research, Hessaraghatta lake post, Bangalore - 560 089.	Pesticide residue analysis of fruits and vegetables, cereals and pulses, water, spices (curry leaves), Nutritional, Proximate and microbiological analysis of fresh and processed food products.
6.	Director, Indian Institute of Vegetable Research, Post Bag No. 01; P.O. Jakhini, (Shahanshapur), Varanasi - 221 305.	Analysis of pesticide residue, heavy metals, microbial contaminations, mycotoxins, antibiotics, disinfectants, colouring agents, adulterants, food additives, phytohaemagglutinin, allergens etc. in Vegetables.
7.	Director, Quality Evaluation Laboratory, Spices Board, Palarivattom P.O., Kochi – 682025.	Analysis of chemical contaminants (pesticide residues, heavy metals, illegal dyes and any other chemical contaminant), mycotoxins (aflatoxins, ochratoxin etc.), microbial contaminants, physical contaminants and adulterants in Spices.

8.	Director, Quality Evaluation Laboratory, Spices Board, Chuttugunta Center, GT Road, Guntur – 522004.	-Do-
9.	Director, Quality Evaluation Laboratory, Spices Board, Plot No. R-11, Sipcot Industrial Complex, Gummidipoondi, Thiruvallur District, Chennai – 601201.	-Do-
10.	Director, Quality Evaluation Laboratory, Spices Board, First Floor, Banking Complex II, Sector 19A, Vashi, Navi Mumbai – 400703	-Do-
11.	Acting Director, Centre for Analysis and Learning in Livestock in Food (CALF), National Dairy Development Board (NDDB), Anand – 388001, Gujarat	Milk and Milk Products, Analysis of pesticides, antibiotics and veterinary drugs, microbial contaminants and mycotoxins, heavy metals, Polycyclic Aromatic Hydrocarbons, dioxin, other emerging contaminants and Microbial parameters in milk and milk products.
12.	Director, Council of Scientific and Industrial Research - Indian Institute of Chemical Technology, Uppal Road, Tarnaka, Hyderabad – 500007	Analysis of moisture, hexane insoluble matter, acid value, unsaponifiable matter, iodine value, saponification value, allyl isothiocyanate, Reichert Meissl value, peroxide value, fatty acid composition, presence of animal body fat in the vegetable fat, cold test, test for physicalproperties,nickelinvanaspati,
		phosphorous in soyabean oil, presence rancidity, soluble colors, presence of beef fat, phospholipids, tocopherol, trans fatty acid detetmination, Pesticide Residues, Heavy metal analysis in fats and oils.

13.	Director, National Research Centre on Meat, Chengicherla, Buduppal, Hyderabad – 500092	Physico-chemical analysis (meat species identification, proximate composition, pH value, water holding capacity, meat pigments, emulsifying capacity, free fatty acid, peroxide value, TBA value, cholesterol content, nitrite content, sensory evaluation, texture & tenderness of meat & meat products, instrumental colour value, COD level of slaughter house effluent), Microbiological analysis, Pesticide Residues and Fatty acid profiles of meat and meat products".
14.	Director, Indian Institute of Crop Processing Technology, Food Safety and Quality Testing Laboratory, Pudukkottai Road, Thanjavur – 613005, Tamil Nadu	Nutritional, Proximate and Microbiological analysis of fresh and processed food products; Packaged Drinking Water analysis; Analysis of pesticide residues, heavy metals and microbiological analysis of Cereals and Cereal Products and Spices."
15.	Director, Central Institute of Fisheries Technology, Indian Council of Agricultural Research, Willingdon Island, CIFT Junction, Matsyapuri P.O., Cochin – 682029, Kerala	Physio-chemical analysis, Bacteriological Tests, detection of Viruses, Bacterial toxins, Antibacterial substances, other microbiologicaltests, analysis of pesticide residues & heavy metals in Fish & Fishery Products.
16.	Director, Indian Institute of Integrative Medicine, Council of Scientific & Industrial Research, Canal Road, Jammu-Tawi-180001	Analysis of Aflatoxins, Free fatty Acids, Peroxide value, Iodine value, Pesticide residues, Metals & Other soluble Residues in Nuts; Presence of Moisture content, Specific gravity, Reducing sugar, Fructose-Glucose Ratio, Acidity, Ash content, Analysis of Heavy Metals, Pesticide residues in Honey; Analysis of Aflatoxins, Energy Organics, Vitamins, Total fatty Acids, Total Saturated Fatty & Unsaturated Fatty acids, pesticide residues & heavy metals in Nutraceuticals.

4.5. List of State/ Public Food Laboratories

S.No.	State/UT	Laboratory Address
1.	Andaman & Nicobar Island	State Food Laboratory, G.B. Pant Hospital Campus, Andaman & Nicobar Islands, Port Blair – 744103
2.	Andhra Pradesh	State Food Laboratory, Nacharam Industrial Area, Hyderabad – 501507
3.	Andhra Pradesh	Regional Public Health Laboratory, Govt Hospital Complex, Pedda Waltair, Visakhapatnam - 530017
4.	Assam	State Public Health Laboratory, Bamuni Maidam, Guwahati 21, Assam
5.	Bihar	Combined Food & Drugs Laboratory, Agamkuan, Patna - 800 007
6.	Chhattisgarh	State Food Testing Laboratory, Near Mahila Police Station, Opp. Nagar Nigam Office, Kalibari, Raipur
7.	Delhi	Combined Food & Drugs Laboratory, Directorate of PFA, NCT of Delhi, A- 20, Lawrence Road, Industrial Area, Delhi-110035
8.	Jharkhand	State Food & Drug Laboratory, Namkum, Ranchi Tata Road, Ranchi – 834010
9.	Goa	Food and Drug Laboratory, Directorate of Food & Drugs Admn. DHANWANTARI, Opp, the Shrine of Holy Cross, Bambolim – Goa – 403202
10.	Gujarat	Public Health Laboratory, Urban Health Centre Bldg, Nr. Lal Bungalow, C.G. Road, Navarangpura, Ahmedabad 380009
11.	Gujarat	Food and Drugs Laboratory, Near Polytechnic College, Nizampura, Vadodara – 390 002
12.	Gujarat	Public Health Laboratory, Municipal Corporation, Laheripura Road, Vadodara - 390 001
13.	Gujarat	Regional Food Laboratory, New Lotus Ring Road, Nr. Mahakali Temple, Opp. District Panchayat Staff Quarters, Bhuj, Kutch - 370001
14.	Gujarat	Regional Food Laboratory, University Road, Nr. Forensic Lab, Opp. Kidney Hospital, Rajkot, Gujarat - 360005
15.	Gujarat	Public Health Laboratory, Surat Municipal Corporation, 304, Ambedkar Shopping Centre, Mann Darwaza, Ring Road, Surat – 395003

16.	Haryana	District Food Laboratory, Civil Hospital, Karnal – 132001
17.	Haryana	State Food, Water and Excise Laboratory, Govt. of Haryana, Ground Floor, Sector – 11 D, Chandigarh
18.	Himachal Pradesh	Composite Testing Laboratory, Kandaghat, Distt. Solan, Himachal Pradesh
19.	Jammu & Kashmir	Public Health Laboratory, PatoliMangotrian, Jammu
20.	Jammu & Kashmir	Public Health Laboratory, Nr. CD Hospital, Dalgate, Srinagar
21.	Karnataka	State Water and Food Laboratory, Public Health Institute, Sheshadri Road, Bangalore- 560 001
22.	Karnataka	Bruhat Bangalore MahanagaraPalike Laboratory, Dasappa Hospital Compound, N R Circle, Silver Jubilee Park Road, Bangalore - 560002
23.	Karnataka	Divisional Food Laboratory, Umar Khayam Road, Tilak Nagar, Mysore- 570001
24.	Karnataka	Corporation Laboratory, Corporation of the city of Mysore, Corporation office Building, Mysore
25.	Kerala	Regional Analytical Laboratory, Kakkanand, P.O. Ernakulam, Kochi
26.	Kerala	Regional Analytical Laboratory, Malaparamba, Kozhikode – 673009
27.	Kerala	Government Analyst Laboratory, Vanchiyoor P.O Red Cross Road, Thiruvananthapuram - 695035
28.	Madhya Pradesh	State Food Laboratory, Controller Food and Drug Administration, Idgah Hills, Bhopal - 462001
29.	Madhya Pradesh	Food Laboratory, Municipal, Corporation, Shivaji Market, Nagar Nigam Road, Indore
30.	Madhya Pradesh	State Food Testing Laboratory, Municipal Corporation, Chhatrapati Shivaji Bhavan, Agar Road, Ujjain
31.	Maharashtra	Regional Public Health Laboratory, Nizam Bunglow, Cantonment Area, Aurangabad - 431002
32.	Maharashtra	District Public Health Laboratory, Dhobhi Ghat Building, General Hospital Compound, Jalgaon – 425001
33.	Maharashtra	District Public Health Laboratory, 330/2, B, Y.P. Powar Nagar, Bendre Building, Kolhapur - 416002
34.	Maharashtra	Municipal Laboratory, Room No. 49, 2nd Floor, G North Ward Office, J.K. Sawant Marg, Dadar, Dadar West, Mumbai-400 028

35.	Maharashtra	Room No. 606, Public Health Laboratory, Konkan Bhawan, 6th Floor, CBD Belapur, District Thane, New Mumbai - 400 614
36.	Maharashtra	District Public Health Laboratory, New Civil Hospital Compound, Nashik – 422 002
37.	Maharashtra	State Public Health Laboratory, Stavely Road, Cantonment Water Works Compound, Pulgate, Near St. Mary's School, Pune - 411001
38.	Maharashtra	District Public Health Laboratory, Vasantdada Co-op. Industrial Estate, Madhavnagar Road, Nr. R.T.O., Sangli – 416416
39.	Maharashtra	District Public Health Laboratory, Sai Darshan, 5 – Babanagar, Near Polytechnic College, Nanded - 431602
40.	Maharashtra	Regional Public Health Laboratory, Mental Hospital Compound, Chindwada Road, Nagpur- 440 029
41.	Maharashtra	District Public Health Laboratory, Opposite Irvin General Hospital, Amravati-444601
42.	Meghalaya	Combined Food and Drug Laboratory, Pasteur Institute, Shillong - 793001
43.	Nagaland	State Public Health Laboratory, Merhuliesta Colony, Near CMO Office, Kohima, Nagaland
44.	Odisha	State Public Health Laboratory, In front of Ram Mandir, Convent Square, Bhubaneswar - 751001
45.	Puducherry	Public Health Laboratory, Indira Nagar, Gorimedu, Puducherry – 605006
46.	Punjab	State Food, Drugs and Excise Laboratory, Govt. of Punjab, Second Floor, Sector – 11 D, Chandigarh
47.	Punjab	District Public Health, Laboratory, Nehru Garden, Jullundhar (Punjab)
48.	Punjab	District Public Health, Laboratory, Old Civil Hospital, Bhatinda (Punjab)
49.	Rajasthan	Food Safety and Standards Laboratory, E-1, Behind Kamla Nehru T.B. Hospital, Jaipur Road, Ajmer
50.	Rajasthan	State Public Health Laboratory, Mini Swasthya Bhawan, Mandir Marg, Sethi Colony, Behind Mental Hospital, Jaipur - 302004
51.	Rajasthan	Regional Public Health Laboratory, C-27, Railway Road, Jodhpur - 342001

52.	Rajasthan	Food Safety and Standards Laboratory, Rajiv Gandhi Hospital Campus, Alwar – 301001
53.	Rajasthan	Public Health Laboratory, Maharana Bhopal Cancer Hospital, Near Dhobighat, Udaipur
54.	Rajasthan	Public Health Laboratory, P.B.M. Hospital Premises, Bikaner (Rajasthan)
55.	Rajasthan	Public Health Laboratory, Sriganganagar (Rajasthan)
56.	Rajasthan	Public Health Laboratory, Banswara (Rajasthan)
57.	Tamil Nadu	Food Analysis Laboratory, No.219, Race Course Road, Coimbatore -641018
58.	Tamil Nadu	Food Analysis Laboratory, King Institute Campus, Guindy, Chennai -600032
59.	Tamil Nadu	Food Analysis Laboratory, Gandhi Nagaram, Near Gandhi Musiam, Poor Home Campus, Madurai – 625 020
60.	Tamil Nadu	Food Analysis Laboratory, Kamaraj Nagar Colony Post, Salem - 636014
61.	Tamil Nadu	Food Analysis Laboratory, Medical College Road, Near Membalam, Thanjavur - 613001
62.	Tamil Nadu	Food Analysis Laboratory, No.5, Old Police Hospital Road, Palayamkottai, Tirunelveli – 627002
63.	Tamil Nadu	Food Analysis Laboratory, Corporation of Chennai, Chennai-600 003
64.	Tripura	Regional Food Laboratory, Pandit Nehru Office Complex, Agartala - 799006
65.	Uttar Pradesh	Regional Public Analyst Laboratory, HB Training Campus, Halwai Ki Bageechi, Agra
66.	Uttar Pradesh	State Government Laboratory, UP Behind Nehru Batika, Sector C, Aliganj, Lucknow – 226020
67.	Uttar Pradesh	Regional Public Health Laboratory, Shivpur, Varanasi – 221003
68.	West Bengal	Public Health Laboratory, 2, Convent Road, Kolkata 700015
69.	West Bengal	Central Food Laboratory, Kolkata Municipal Corporation, I-A, Hogg Street,Kolkata 700087
70.	West Bengal	District Public Health Laboratory, Murshidabad, CMO Office Campus, P.O. Berhampur, Murshidabad (W.B.)

71.	West Bengal	Public Health Laboratory, GM Hospital, P.O. Netaji Subhash, Santorium,Kalyani-741 251, Nadia (W.B.)
72.	West Bengal	Assansol Mines Board of Health Laboratory, Asansol, District Burdwan-713304

4.6. GMP (Good manufacturing practices)

FSSAI has specified procedures and practices to be followed by food businesses to prevent the occurrence of food borne illnesses by actively controlling hazards throughout the food supply chain. Every food business operator is required to have a documented FSMS plan and to comply with Schedule IV of the FSS (Licensing and Registration of Food Businesses) Regulations 2011. Schedule IV introduces the concept of FSMS based on implementation of Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP) by food businesses.

Technical Panels of eminent domain experts have been set up to review and update FSMS standards, draft and review Good Hygiene practices (GHP) and Good Manufacturing Practices (GMP) by food category, identify gaps if any and prescribe new schedules and process standards wherever required from time to time.

To provide assurance of food safety, Food businesses must implement an effective Food Safety Management System (FSMS) based on Hazard Analysis and Critical Control Point (HACCP) and suitable pre- requisite programmes by actively controlling hazards throughout the food chain starting from food production till final consumption.

As per the condition of license under FSS (Licensing & Registration of Food Businesses) Regulations 2011, every food business operator (FBO) applying for licensing must have a documented FSMS plan and comply with schedule 4 of these regulations. Schedule 4 introduces the concept of FSMS based on implementation of Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP) by food businesses and is divided into two parts as under:

Part 1 - General hygienic and sanitary practices to be followed by food business operators applying for registration - Petty food operators (Food Safety & Standards (Licensing and Registration of food Business) Regulations, 2011.

- Every petty Food Business Operator shall register them with the Registering Authority by submitting an application for registration in Form A under Schedule 2 of FSSAI 2011 Regulations along with a fee as provided in Schedule 3.

- The petty food manufacturer shall follow the basic hygiene and safety requirements provided in Part I of Schedule 4 of these Regulations and provide a self-attested declaration of adherence to these requirements with the application in the format provided in Annexure-1 under Schedule 2.
- The Registering Authority shall consider the application and may either grant registration or reject it with reasons to be recorded in writing or issue notice for inspection, within 7 days of receipt of an application for registration.
- In the event of an inspection being ordered, the registration shall be granted by the Registering Authority after being satisfied with the safety, hygiene and sanitary conditions of the premises as contained in Part II of Schedule 4 within a period of 30 days.
- If registration is not granted, or denied, or inspection not ordered within 7 days as provided in above sub regulation (3) or no decision is communicated within 30 days as provided in above sub regulation (4), the petty food manufacturer may start its business, provided that it will be incumbent on the Food Business Operator to comply with any improvement suggested by the Registering Authority even later. Provided that registration shall not be refused without giving the applicant an opportunity of being heard and for reasons to be recorded in writing.
- The Registering Authority shall issue a registration certificate and a photo identity card, which shall be displayed at a prominent place at all times within the premises or vehicle or cart or any other place where the person carries on sale/manufacture of food in case of Petty Food Business.
- The Registering Authority or any officer or agency specifically authorized for this purpose shall carry out food safety inspection of the registered establishments at least once in a year.

Part 2 - General hygienic and sanitary practices to be followed by food business operators applying for license- Manufacturing/ processing/ packaging/storage/distribution

As per Section 31(1) & 31(2) of FSS Act, 2006 every Food Business Operator in the country is required to be licensed/registered under the Food Safety &Standards Authority of India. The licensing and registration procedure and requirements are regulated by Food Safety & Standards (Licensing and Registration of food Business) Regulations, 2011. Registration is meant for petty food manufacturers that includes petty retailer, hawker, itinerant vendor or a temporary stall holder or small or cottage scale industry having annual turnover up to 12 lacs. All food businesses having income more than this limit are required to take a license. The document, based on the product category, can be used by the FBOs (food business operators) as per the operations applicable to them.

General Hygienic and Sanitary practices to be followed by Food Business operators (Schedule 4)

The establishment in which food is being handled, processed, manufactured, stored, distributed by the food business operator whether holder of registration certificate or a license as per the norms laid down in these regulations and the persons handling them should conform to the sanitary and hygienic requirement, food safety measures and other standards as specified below. It shall also be deemed to be the responsibility of the food business operator to ensure adherence to necessary requirements. These are the basic - compulsory requirements for ensuring safety of the food manufactured in any premise and FBOs shall continuously try to improve the sanitary and hygienic conditions at the premises with a goal of attaining India HACCP standards within a - previously determined period.

FSSAI has issued a guidance document on Food Safety Management System (FSMS) to implement GMP (good manufacturing practices)/GHP (good hygiene practices) requirements for fruit and vegetable products. This document is applicable for food businesses involved in the fruit and vegetable sector, which includes; Thermally processed Fruits, vegitables, Vegetable Soups , Fruits Juices, Pulp/Puree, Fruit Nectars, pickles etc…

Some important regulations are given for general hygienic and sanitary practices to be followed by petty food business operators applying for registration (Regulation 2.1.1(2))

- The premises shall be located in a sanitary place and free from filthy surroundings and shall maintain overall hygienic environment. All new units shall set up away from environmentally polluted areas.
- The premises to conduct food business for manufacturing should have adequate space for manufacturing and storage to maintain overall hygienic environment.
- The premises shall be clean, adequately lighted and ventilated and sufficient free space for movement.
- Floors, Ceilings and walls must be maintained in a sound condition. They should be smooth and easy to clean with no flaking paint or plaster.
- The floor and skirted walls shall be washed as per requirement with an effective disinfectant the premises shall be kept free from all insects.
- Continuous supply of potable water shall be ensured in the premises. In case of intermittent water supply, adequate storage arrangement for water used in food or washing shall be made.
- Equipment and machinery when employed shall be of such design which will permit easy cleaning. Arrangements for cleaning of containers, tables, working parts of machinery, etc. shall be provided.

- No vessel, container or other equipment, the use of which is likely to cause metallic contamination injurious to health shall be employed in the preparation, packing or storage of food. (Copper or brass vessels shall have proper lining).
- All equipments shall be kept clean, washed, dried and stacked at the close of business to ensure freedom from growth of mould/ fungi and infestation.
- All equipments shall be placed well away from the walls to allow proper inspection

4.7. Good Hygiene Practices (GHP)

All practices regarding the conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain.

These include

- Suitable facility design and maintenance
- Thoughtful equipment design and maintenance
- Documentation that includes procedures, forms and manuals
- Process validation
- Corrective and preventive actions
- Control of non-conforming products
- Traceability
- Management of incidents and product recall
- Job training and competence
- Hygiene and sanitation
- Waste removal
- Pest control
- Chemical and physical product contamination control
- Prevention of cross contamination.
- Dispatch and transport
- Allergen management
- Product packaging and labelling
- Personal hygiene
- Internal audits for hygiene, food safety and quality

4.8. Good Laboratory Practices

Good Laboratory Practice (GLP) was first introduced in New Zealand and Denmark in 1972

Why use GLPs?

Generating reproducible, accurate analytical results is important for laboratory success, but isn’t necessarily easy to do.

- There are processes and tools that are critical components of successful laboratory quality assurance programs.
- In general many of the practices that lead to a successful quality assurance program are also required for general business success such as:
- good communication
- engaged employees
- management
- a strong training program
- a facility that supports work to be done in the lab.

An Overview on Good Food Laboratory Practices

A Good Laboratory Practice (GLP) process is an important component of all Quality Programs.

- It includes a set of principles that provides the framework within which the laboratory is planned, performed, monitored, reported and archived.
- It is applicable in all aspects of a laboratory including; implementing, validating and maintaining the laboratory compliance.

Elements of Good Laboratory Practice

Quality Assurance - Establishing Confidence in Reported Data.

- Standard Operating Procedures (SOP's)
- Statistical procedures for data evaluation
- Instrumentation validation
- Reagent/materials certification
- Analyst certification
- Laboratory facilities certification
- Specimen/Sample tracking
- Documentation and Maintenance of Records.
- Accountability.

Why use GLPs?

- Generating reproducible, accurate analytical results is important for laboratory success, but isn't necessarily easy to do.
- However, there are processes and tools that are critical components of successful laboratory quality assurance programs.
- In general many of the practices that lead to a successful quality assurance program are also required for general business success such as: good communication, engaged employees and management, a strong training program and a facility that supports the work to be done in the lab.

Scope of Good Food Laboratory Practices

These Guidelines specify the general requirements for the competence to carry out systematic sampling of food samples, conduct chemical, microbiological tests and testing of packaging materials to ascertain the quality of food. It covers the tests performed using standard methods, non-standard methods, and laboratory-developed methods.

These Guidelines are applicable to all organizations performing tests to ascertain the quality of food material including packaging material.

Structure of food lab:

Personnel:

Personnel need to clearly understand the nature of the foods they are testing and reasons for testing when undertaking contract review and method selection.

The Management Structure:

An up-to-date chart showing the organizational structure and lines of responsibility of the laboratory is an important feature of the quality assurance programme and should appear in the Quality Assurance Manual. When the laboratory is part of a larger organization it may also be desirable to have a chart showing the management and operational relationships which control the input of work requested and the output of results from the laboratory, the overall picture of the laboratory and the resources available for it. The general structure of staff is shown in Figure 4.1.

Figure 4.1 The staffing structure of a typical food testing laboratory is as follows:

Head of Laboratory			
Officer –in-Charge (Chemistry Section)	Officer –in- charge (Microbiological Section)	Officer –in-charge (Biotech. Section)	Officer –in-charge (Administrative Section)
Team Leaders Technical Staff/Analyst Supporting Staff	Team Leaders Technical Staff/Analyst Supporting Staff	Team Leaders Technical Staff/Analyst Supporting Staff	Secretarial Staff Supporting Staff

Infrastructure and Accommodation and Related requirements:

General Principles:

Facilities must allow the laboratory's work to proceed both effectively and safely.

Laboratory design should reflect the general features of the work programme anticipated in the long-term (10-20 years) rather than the specific pattern of current work.

Design of the Laboratory:

Even though the final design of the laboratory is made by architects and engineers, the analytical staff should be involved in some of the decisions that will ultimately affect their working environment and conditions. The food control laboratory has several functions such as chemical analysis of foods for proximate composition, trace metals, additives, GM testing, nutrients and toxicants, some basic food microbiology analysis and product organoleptic evaluation.

General Considerations:

Laboratory layout should be devised with efficiency in mind. For example, the distances staff have to walk for the different steps of the analytical processes they undertake should be as short as possible, though bearing in mind that some procedures may have to be segregated from others for analytical and/or safety reasons.

The Chemical Laboratory:

From a quality assurance standpoint, the design features which are important are those which can lead to erroneous results or to "lost" work, leading to missed deadlines and cost overruns. Erroneous results can arise from test materials becoming contaminated (e.g. by dust) or by cross-contamination from another sample or from a standard. Whilst good working practices will usually control most situations satisfactorily, a design which provides complete segregation of trace analyses from highly concentrated formulations and from pure substances used in preparing analytical standards is virtually essential: the segregation must apply to all facilities for washing/cleaning equipment, washing and storage of glassware, use of protective clothing and even transfer of notebooks and records.

Equipment and Instruments:

The complexity of equipping a laboratory and the consequent delay in production of useful results should not be underestimated. In the early stages, the requirements for equipment may seem large and complex but once the laboratory is established, the running costs are relatively low.

Some of the instruments and equipment needed for chemical analysis by a modern food control laboratory are: (for purposes of this listing, 'instruments' are measuring devices and 'equipment' are processing devices. Apparatus made primarily of glass are not included).

Instruments:

- Analytical Balance
- pH meter
- Spectrophotometer, UV-visible, double-beam
- Spectrophotometer, atomic absorption
- High Performance Liquid Chromatograph (with UV and differential refractive index detectors)
- Gas Chromatograph (with flame ionization and electron capture detectors)

Equipment:

- Blender
- Grinder
- Pulverizing hammer mill
- Air oven, forced draft
- Vacuum oven, with pump
- Muffle furnace
- Centrifuge
- Refrigerator
- Freezer
- Heaters and hotplates
- Steam and water baths
- Water distillation still or deionizer

Utilities:

Electricity must either be a stable supply, or the voltage must be stabilized by either one large stabilizer for the whole laboratory, or by a unit for each of the instruments requiring it. The lab should have sufficient number of electrical sockets. There must be several cold water taps per bench to allow for rinsing, condensers, etc., but hot water can be restricted to those sinks where apparatus is washed. In a larger laboratory a distribution system for distilled or deionized water would be advantageous. Fume hoods should have adequate provision for water taps, compressed air valves, electrical sockets etc.

Environment conditions, safety and related requirements:

Environmental Control:

Adequate control of temperature, humidity and dust is important to staff comfort, instrumental performance and safe working (e.g. with flammable solvents). If they are to perform properly optical instruments often require stable temperature conditions. Electronic equipment may have prescribed operating ranges for environmental temperature and humidity. Computers may need to be protected from strong magnetic fields from other equipment; any staff or visitors with heart pace-makers must avoid such fields. Cooling water, either from mains supplies or localised refrigeration may be necessary for the proper functioning of some equipment. Test materials, reagents, standards may need to be stored under controlled conditions. Some substances are affected by sunlight or fluorescent lights and must be protected from it. Delicate balances and optical instruments may need to be protected from vibration (e.g. from blenders, shakers and centrifuges) or may even need stabilised supports. All these needs have to be identified and documented so that proper procedures for monitoring them and taking necessary action can be included in the quality assurance system.

Records will be needed which show that: samples are received, stored, handled and analysed under environmental conditions that will not adversely affect analyses; temperature, humidity and light controls are adequate in sensitive areas to protect samples, extracts from them, personnel and equipment; the results of environmental sampling in laboratory areas are recorded; these should include records of air-flow rates across fume cupboard apertures.

Housekeeping Control:

As with any other aspect of the laboratory's activities, the responsibility for housekeeping activities must be clearly defined. Cleaning staff and laboratory staff must each have clear instructions as to their respective duties in relation to:

- cleaning of floors, vertical surfaces (e.g. cupboards, walls, windows and doors),
- horizontal surfaces (e.g. work surfaces, shelves), equipment, interiors of refrigerators, freezers, fume cupboards, controlled environment stores
- control of the contents of refrigerators, freezers, fume cupboards, controlled environment stores
- checking the performance of air-conditioning and dust extraction equipment and fume-cupboards
- pest control

The quality assurance programme will include work schedules, records of observations and of action required/taken covering housekeeping activities of this nature.

Safety Features:

The building and laboratory design should include a number of safety features including:

a) The fire areas of corridors should be formed of concrete blocks.

b) Services should include a shower sprinkler system near each doorway so that a worker can take an immediate shower, clothes and all, in the case of accidental general contact with corrosive or poisonous liquids or fire.

c) There should be built-in eye wash fountains or at least portable eyewash stations (obtainable from most chemical supply firms).

d) The traffic flow, the egress pattern and the proportions of the laboratory are all safety considerations. It must always be possible to leave the laboratory safely irrespective of the initial site of a fire. Serious thought must be given to the number and location of fire extinguishers and stand pipe systems, and to the availability of sprinkler systems.

e) Laboratories should be well-lit so that the operator does not have to peer too closely over potentially hazardous material in order to see what he is doing. There should be ample working space and bench tops and other surfaces should be kept clear of all material except that in current use.

f) Benches are best without shelves, only services, these being operated from the front so that the operator does not have to stretch across the bench. It is still common to see reagents on shelving at the back of benches (or above the centre of double-width benches) but it is probably safer if such reagents can be kept on side.

g) shelve or in trays which are brought to the bench as required.

h) Flooring needs to be of a non – slip material, resistant to acids and solvents, but not so hard as to be tiring to stand on for a few hours at a time. No material is entirely satisfactory. Well-laid linoleum and a filled epoxy resin on top of concrete are among the best available. It is advisable not to polish laboratory floors.

i) Pollutants generated within the laboratory must be removed safely, quickly and efficiently. In particular, toxic or noxious gases must be removed expeditiously through a duct system that does not exhaust near the building air conditioning intake.

j) The building must be planned for security. Restriction of access is of considerable importance because of the extremely valuable and sensitive equipment used in the laboratory work as well as to protect the integrity of official samples.

k) It is very advisable to have an efficient fire and smoke detection system with appropriate alarms. Common fire detection equipment is usually either rate-of- temperature-rise or fixed-temperature detector using a substance of known melting point. There are

advantages (and disadvantages) to each type of detector and the laboratory Head should select the one he feels best fits his laboratory.

Designing a laboratory to afford protection against every kind of hazard should be aimed at, but, the level of safety for the most general applications and to provide supplementary systems in areas of higher hazard has to be achieved.

A safe solvent storage area is ideally separate from the laboratory building in a stand- alone structure. It can be a small building of one room and some possible design features are:

a) Construction of cement blocks or bricks.
b) For a stand-alone building, double walls with insulation between. The exterior wall can be material other than block or brick.
c) An epoxy film to cover the entire floor plus 10 cm up the base of the walls. (Any solvent spillage will pool and evaporate, rather than soak through the floors or walls.)
d) A copper pipe (about 25 mm) inside the room, which goes through the floor and is embedded about 2 m in earth. All metal objects in the room are to be attached to the pipe using heavy guage single strand copper wire. Also, attach a short wire with an alligator clip.
e) Storage shelves of metal and connected by wire to each other and the grounding pipe.
f) Air conditioning is external, with the entrance duct at the top of one corner of the room and the exit duct at the base of the opposite corner.
g) The door is of metal and fire-rated for at least one hour, with a positive closure. It must seal well when closed. The door sill is at least 10cm high.
h) Air conditioner exits duct with a fire baffle (to prevent flashback) and ducted to exit in the outside air at building roof height.
i) An extinguisher system, which should be carbon dioxide or Freon type and not water sprinklers.

Personnel related requirements:

1) Qualification for doing specific tasks shall be judged on the basis of their education, training, specific experience and demonstrated skill.
2) The personnel should be technically competent to perform their duties as allotted to them whether operating on specific equipments / performing tests /evaluating results/signing the reports.
3) Regular and refresher training should be organized to keep the personnel update in their domain of activity.

4) Specific job description for each personnel should be defined with their role and responsibility.
5) Personnel should wear proper uniform and protective clothing's, etc as required depending upon the test method.
6) While doing test no phone calls/ cell calls should be attended to avoid any type hazards and carelessness while performing the test.
7) Normally blank determination along with the known-standards must be carried out in duplicate/replicate to check the accuracy of the results obtained and human error etc.
8) All the analysis records must be documented either through hardcopy or through soft copy to demonstrate that the tests are really been carried out.
9) Random checking of the result should be done inter-laboratory and intra- laboratory to check the proficiency of the personnel.
10) In case of hazardous analysis, special precautions as provided in the methods should be taken for self and surroundings.
11) While opening and closing the laboratory room, safety precaution should be taken care of depending upon the nature of the laboratory, equipment and test method. Special care should be taken for microbiological lab. Instructions in this regard must be displayed in the lab.
12) In case of contractual appointment, technical competency of the personnel should be judged and they should be put on job only after they are trained and their competency in the respective field is established.
13) Alternative arrangement of personnel should exist in case one is not available but not at the cost of their technical competency.
14) Personnel should be medically fit depending upon the test method he is deployed to avoid any hazards.
15) Special precaution should be taken by the personnel during break time to ensure that tests are carried out as per prescribed method and no relaxation is given in the test method.
16) Calculation should be rechecked on random basis by the supervisor.
17) Daily wages should not be put to job.
18) The personnel at the time of working in the laboratory should be alert and concentrate on their work only.
    - Supervisory officer should randomly watch the analysis activity and guide from time to time to increase the competency of analyst.
19) Eating habits should be avoided in the laboratory.
20) First Aid box should be available in the lab. along with emergency Telephone no. of hospital/doctors/contact person.

21) During odd times person should avoid working lonely.
22) Fuming chamber must be used for test requiring ash, protein determination, evaporation of solvents etc.
23) While pouring down acids etc in the basin, water taps should be kept on slowly.
24) Electrical equipments should be handled with great care.
25) Poisonous and hazardous chemicals must be kept under safe custody.
26) Manual sucking from mouth of liquid should be done with bulb type pipette.
    - Competency of the personnel should be judged regularly by giving unknown samples.
27) No external or internal pressure should be put on analyst.
    - Output should not be linked with quantum of work. More emphasis should be on quality output or results.

Test methods:

1) The laboratory shall use only official methods depending on the requirement of the test, its sensitivity and nature of the commodity which is being tested and quality/safety factors to be determined.
2) In case of non-official method, validation of the methods as per set norms is a must and their range of detection/quantification, L.O.D./L.O.Q. limitations etc. must be established.
3) Selection of method is very important depending upon the requirement of the test and customer requirement.
4) Estimation of uncertainty of measurement should be available for each method in context of the food commodity and test to be done.
5) External calibration of the equipment is a must annually or depending upon its use. However, in case of any equipment being used very frequently, internal calibration facility should be available and done regularly with a record thereof.
6) Glass apparatus should be calibrated.
7) In case of standard chemicals required in testing, whose purity can alter the result should be certified reference material with proper traceability.
8) In case of recovery and PPM level extraction from a food commodity, percentage recovery must be established for each food and the contaminant/constituent which have to be determined and the calculation should take care of such recovery.
9) Sometimes official methods do not prescribe the interfering material in the test method, limitations, its sensitivity, range of detection and qualification, capability of the equipments being used, due to change of the sophisticated equipment as prescribed in the method for a particular model/ technology. Hence it is necessary to establish the suitability of such methods for their particular test and equipment, etc before giving the

results. Obviously the method needs to be validated internally for its particular use using particular equipment.

10) Standard solution/CRM Solution should be stored at required temperature and condition and its strength should be checked regularly and record thereof should be maintained.
11) Calculation should be done and rounded off while reporting the results to the required level of standard.
12) SOP as far as possible should be available for test method along with the protocol.
13) Method should be available while performing any test to follow exactly the test method prescribed. No short cuts should be followed and tests should not be done on a memory basis alone.
14) Purity of the solvents, water being used and other chemicals should be checked regularly and a record thereof should be maintained.
15) In case of any controversy or marginal results, only reference methods should be used.
16) In case of micro biological analysis standard culture must be available to establish the confirmation of the microbes. SWAB testing must be done for inoculation room and media preparation room regularly to ensure that it is not contaminated.
17) The results should be recorded commensurating with the calibration of the glass apparatus etc e.g. in case of a burette, the result should be reported only to the displayed capabilities of the burette.
18) Special precaution should be taken for pipetting and ejecting the solution from the pipette. The solution should not be blown by air through mouth.
19) All the apparatuses specially glass should be contamination free and should be cleaned and rinsed thoroughly before use. No chemicals should be used after its expiry or otherwise if it looks like deteriorated or decomposed.

Equipments:

1) All the equipments being used should be under permanent control of the laboratory and should be capable of in context of the test method.
2) The equipment must be calibrated depending upon the requirements by an outside accredited lab and/or internally as the case maybe.
3) In case the sophisticated instruments are shifted from one place to another the same should be re-calibrated.
4) Depending upon the uses, the equipments should be internally calibrated either daily or at a periodically interval as the case maybe.
5) Instruction manual, operation manual and other details of the equipments like calibration, due date of calibration, safety precaution, etc must be available at the side of the equipment.

6) Each equipment should be uniquely identifiable.
7) The equipment should be placed and test must be performed under a proper environmental condition as prescribed. Normally the room should be dust-free, air conditioned with controlled humidity. Special condition needs to be followed in case of equipment being used in case of micro biological analysis like Air handling unit, etc.
8) Each sophisticated equipment should have IQ, OQ and PQ Certificate from the manufacturer.
9) LOD/LOQ/ Range of detection/ range of quantification must be established for each equipment in context of the test method, nature of the food commodity, constituent to be determined. The reason being that normally in official methods, the model of the equipment being used along with its accessories becomes old whereas due to technological advancement a model of the equipments are upgraded along with accessories and software, hence the LOD, LOQ, etc must be established and should be checked as claimed by the manufacturer which may not commensurate with the limits given in the official methods. SOP must be available for operation.
10) Equipments not working should be placed under a tag “out of order”
11) Software being used in the equipment must be validated and a record thereof should be available.
12) Maintenance plan of the equipment should be available and should be done under annual maintenance contract.
    i. Equipments should not be subjected to overloading or mishandling which could give erroneous results.
    ii. In case the equipment is sent outside the laboratory for repair, etc. proper procedure of packing and transportation as prescribed by the manufacturer should be followed.
    iii. Intermediate checks of the equipments must be done through known and certified standards regularly. The equipment should be handled by technically competent and trained personnel only. Such personnel should be trained on routine maintenance and minor repair of the equipments.
    iv. Proper procedure as prescribed by the manufacturer should be followed for cleaning of the equipments and its accessories before and after use.
    v. The SOP for safe handling, transportation, storage, use and plant maintenance of the equipments must be available to ensure proper functioning and to prevent deterioration/contamination.
    vi. Do and don’ts regarding important instruction should be available along with side of the equipments and should be visible all the time.
    vii. Due care should be taken to ensure constant voltage supply of electricity as required for the equipment to avoid fluctuation and thus variation in results.

viii. After return of the equipment from repair, the same procedure should be followed as that for new equipment to ensure that the results rendered by the equipments are as per capability of the equipment. In such cases the instruments need to be recalibrated before put to use.
ix. Equipments where gases are being used, the purity of the gas should be as per requirement of the equipment/test method.
x. Gas cylinders should be put outside the laboratory room at a well secured and approachable place.
xi. Temperature and humidity of the room where the equipments are placed must be recorded daily. In case of micro biological laboratory, special precaution should be taken as per requirement of the test method for environmental conditions especially in case of isolation and determination of pathogens.
xii. In case of a mobile food testing laboratory a separate SOP should be available andtheequipmentsusedinsuchlaboratoryshouldbetechnologicallysturdyto
xiii. Avoid variation in results. Calibration of such equipments needs to be done very frequently preferable daily before being put to use.
xiv. Software being used in the equipment should be capable of achieving the accuracy required and should be complied with the specification related to the test method.
xv. Software should be upgraded and validated from time to time.
xvi. Obsolete equipments giving erroneous results in context of the requirement of the test method should not be put touse.
xvii. The equipment should be placed on a vibration free platform.
xviii. Daily cleaning of the equipment should be done by trained personnel as per SOP
xix. Proper safety precautions should be taken for equipments running round the clock in the absence of the personnel.

Certified reference materials/ standards and reference cultures:

Testing, validation/calibration, standardization & reference materials are inter-related due to dependent on each other. Without proper reference materials, it is not possible to make up any idealized and reliable measurement system. As per the lab quality assurance procedure reference materials are required for all types of testing and validation/calibration. These are widely used for validation/calibration of an apparatus and testing procedure, assessing the true value.

The reference materials are generally used for, to develop and validate accurate method of analysis ensuring traceable measurement results at the working level, to calibrate measurement system and to demonstrate the accuracy of results, assure the long term

adequacy and integrity of measurement quality assurance programme and monitor the lab performance, use in inter laboratory comparison and proficiency testing programme.

The laboratory shall ensure to maintain the reference standards, which are certified by the competent body having traceability to a national/international system like NIST etc. The certificate provided by the supplier/manufacturer shall be maintained in the laboratory for records.

The reference standards having high purity, critical characteristics and require to store in special condition and hence its, to be stored in appropriate special condition as per the requirements. The substances are to be kept in sealed vial and shall be stored in dry place, away from heat, sunlight & moisture.

The reference material of various parameters such as metals, pesticides, antibiotics, volumetric standards etc. may be received from standard brand like Sigma, Aldrich, Fluka, Riedel-de-Haen, Dr. EhrenstroferGmbh, Merck, Supelco etc. in regular intervals accompanying with certificates with proper label. The certificates shall include the name of the standard, the purity, uncertainty at a stated level of confidence, expiry/ validity/ shelf life, QC release, chemical formula / structure, assay/potency level of confidence / chromatogram, storage condition etc. The same shall be verified for the label, certificate & condition during receiving of thestandards.

The reference standard solutions are required for sample analysis, quantification and QC checks. The laboratory shall be prepared the standard solution as needed like stock / primary, intermediate & working solution and wherever applicable the purity shall be considered during preparation. The standard solutions shall be kept in screw capped glass vials, standard volumetric flasks/stoppered conical flask (transparent/amber coloured) in air-conditioned room / refrigerate /deep freezer depending upon storage condition & requirements.

The standards shall be prepared from bulk reference standard materials received from the market as A grade material. The selection criteria for the bulk material intended to accept as working standard in assay and purity of substances. For accepting the material to be taken as working standard the molecule must be subjected to chemical characterization. First the standard stock solution to be prepared from which different working standard is made. The preparation of standards is generally carried out in regular interval as per the requirement /

laboratory protocol and the records of those are to be maintained and labelled with concentration & date of preparation.

The preparation of working standard is generally carried out during analysis/ whenever necessary and records of these are to be maintained.

The intermediate checks of the standards shall be checked in regular interval to ensure the performance, stability & integrity of the standards and records of those are maintained with Quality Control Chart / Levey-Jennings Chart etc.

The shelf life / expiration date declared by the reference standards providing organization is generally applied to unopened condition that have to store at recommended temperature. Hence it is the responsibility of the laboratory to maintain the critical characterization, performance, stability & integrity of the standards through proper handling, storage etc. & same shall be ensured by the intermediate checks in regular interval / as per the laboratory protocol.

For some reference standards the shelf life / expiration date may not declared by the reference standards providing organization, in those cases the following shelf life may be considered when the standards are stored un opened at recommended temperature

1. Room temperature items, which are not temperature sensitive and usually are stabled for five years from the date of receipt.
2. Refrigerated items usually are stabled for two years from the date of receipt.
3. Freezer items usually are stabled for one year from the date of receipt

However it is the primary responsibilities of the laboratory to ensure the performance, stability & integrity of the standards through intermediate checks in regular interval / as per the laboratory protocol.

Reagent solution/standard solutions shall be prepared in established manner, for preparation of reagents the testing personnel refers to be relevant reference. After their preparation, those are to be stored in appropriate storage condition i.e. protected from light, tightly stoppered, refrigerated etc. Wherever, it is recommended reagents are to be prepared freshly. All the reagents/solutions bottles shall be properly labelled with name, date of preparation, concentration etc.

All reference standards shall be kept under responsible person to maintain proper storage, transport, security, integrity, mishandling etc and the relevant records are also to be maintained. The utmost care & protection shall be taken during handling & preparation of standards to avoid cross contamination & health hazard.

The reference culture/microbial pure cultures are used establishing acceptable performance of media, performance of the kits, validation of methods and assessing/evaluating the laboratory performance. The reference microbial strains are directly collected by laboratory from recognized national or international collection (ATCC, MTCC, NCIM etc) with traceability. Generally the reference strains are received in lyophilized stage or deep-frozen stage. If the reference strain has been thawed they shall not berefrozen.

The reference microbial stains are used for Quality control; internal quality control and performance of culture media in terms of productivity, selectivity, performance evaluation and interpretation of result. The reference cultures are received either on slant form or in lyophilized forms in vials.

On receipt the reference cultures, requires to revive in the laboratory. The active cultures shall be sub-cultured on to recommended medium and incubated at temperature specified. For lyophilized culture the outer surface of the vials is disinfected, wrapped with thick cotton wool and neck of the culture vials is broken. The contents transfer into 3 to 5 ml of recommended broth medium and mixed properly. The suspension is to streak on the recommended agar plate and incubates at specified temperature. Reference cultures to be checked for its purity, homogeneity, and typical morphology. Subsequently they have to check for characteristic reaction in selective medium and biochemical reactions. Whenever necessary, serological test as per analytical procedure is also to be carried out to check the pure culture.

Sub-culturing from original stock in regular intervals as working culture for routine use and records to be maintained. The intermediate checks on the purity and biochemical characterization also to be checked. All the working cultures are properly locate with name, date etc. & to be kept under proper storage condition.

All reference standards / pure culture stains are to be kept under responsible person to maintain proper storage, transport, security, integrity, mishandling etc and the relevant records are also to be maintained. The utmost care & protection shall be taken during

handling of microbial pure cultures for to avoid cross contamination & health hazard. The laboratory has to maintain procedures / instruction for all.

Calibration and performance assessment related requirements:

For accurate test results, lab shall be ensured that the equipments which are suitable for intended purpose and capable of providing valid results, such instruments would be regularly inspected, checked & calibrated accordingly. So laboratory should establish a schedule for the calibration and performance verification of equipments/instruments, which will be direct influence on the test results.

The calibrations to be done by in-house (internal)/external agencies/competent body having traceability to a national / international standard (NABL accredited lab) depending upon the type of equipment / instruments.

Purchase of consumables/ equipments:

The laboratory should maintain a proper system for purchase service & supplies of all media, chemical, reagents & other requirements/appliance, consumables to avoid undesirable, unconfirmed supplies of them and also ensure there should not be any effect on the of test analysis /result. Requirements like name of the chemicals, appliances, glassware's, consumables, brand name, quantity, Management, rate contract/ comparative quotation, quantity available in stock shall be well documented by the laboratory.

Sampling & sample handling:

Sampling for testing or analysis is a process of taking a representative portion from a material or product to test (e.g. by physical measurements, chemical analysis, microbiological examination), typically for the purposes of identification, quality control, or regulatory assessment. The sampling is a significant role in testing activities as it reflects the ultimate test results.

It is not mandatory that all the laboratories shall be involved in sampling activities. However, the laboratory involves in sampling shall maintain at least the following

The laboratory policy & declaration on sampling.

The laboratory should have authorized personnel / sampler with adequate knowledge, training etc on sampling. The laboratory shall maintain the sampling plan & procedure in respects of the products / materials that shall include selection, withdrawn & preparation of samples during sampling. The same shall be based on appropriate statistical method /

regulatory guidelines / references. Work instruction shall be maintained for the personnel involve in sampling activities.

The laboratory should have all facilities like tools, equipments / instruments etc requires for various sampling. The laboratory shall maintain the relevant data & operation related to sampling, procedure use, location, date / time of sampling, identification of sampler, other specific requirements like environmental conditions, transportation, statistics the sampling procedures are based upon etc and documents shall be maintained.

All incoming samples shall receive through the receiving section maintained and supervised by laboratory responsible person. The laboratory shall maintain a system on traceability of all accepted samples and the same shall be maintained throughout the retention of the sample in the laboratory without any confusion.

The laboratory should ensure to maintain a proper documented system procedure for handling of test items including sample receiving, storage, transportation, retention / disposal, integrity, avoid and prevent loss/damage of the test samples.

General Principles:

The identity, homogeneity and integrity of the materials being handled by the laboratory must be ensured throughout the time they are under the control of the laboratory e.g. from sample receipt to data report and authorized disposal of the surplus material. The analytical data report must reflect the composition of the received material as a whole.

The sampling procedure should describe the selection, sampling plan, withdrawal or preparation of sample from a substance, material or product to yield the required information. If the customer requires deviations, additions or exclusions from the documented sampling procedure, these shall be recorded in detail with appropriate sampling data and shall be included in all documents containing test and /or calibration results.

The laboratory shall have the procedure for recording relevant data and operations relating to sampling that forms part of the testing and calibrations that is undertaken. These records shall include the sampling procedure used, the Identification of the sampler, environmental conditions (if relevant) and diagrams and other equivalent means to identify the sampling location as necessary.

Samples may be conveniently classified under two broad divisions:

a) Formal samples – These are samples taken to determine if the food complies with national or local laws or regulations and

b) Informal Samples – These are samples taken for the purpose of monitoring or as part of survey work.

Formal follow-up samples can be taken if informal samples receive adverse laboratory reports. Formal or informal sample are also taken under others such as follow-up to a consumer complaint.

Control and Storage:

The storage of test materials is of major importance if the analytical data produced is to reflect and be traceable to the original sample. Deterioration of test materials invalidates any results. Therefore; test materials must be stored so as to ensure their integrity, safety, legality and stability. The laboratory must guard against deterioration, contamination and loss of identity. Special care will be needed where trace analysis is involved in order to ensure that extraneous materials do not contaminate the test materials and equipment.

There are three basic forms of storage - room temperature (dry room), refrigeration and freezing. The QA programme should specify the conditions to be used. There are also problems associated with the type of container in which food can be stored. Foods that contain fats and oils should not be stored in copper or metallic vessels and foods that easily desiccate such as fruits need to be stored in ways, which avoid loss of water.

The Analytical Sample (Test Portion):

Before removing the test portion (s) for analysis, the analyst must be certain that all records are in order, integrity has been maintained containers are intact and sealed (if any), unbroken.

Any ambiguity in the analytical requirement must be resolved, e.g. with canned pickle in oil, is the analysis to be done on the pickle, oil or the whole contents of the can.

For analysis, the analyst first removes a test portion. If the test material comprises more than one item (fruit, vegetable etc.) the test portion should contain material from each item – usually achieved by comminuting a number of items and removing a portion. After the test portion has been removed, the remaining test material is returned to the storage.

Referral of the Test Material:

On occasions it may be necessary to pass a test material to another laboratory for some specialized analysis or because of some analytical facility not being available with the laboratory or because of overload of work. Unless the other laboratory is a part of the same QA programme or the two laboratories are accredited by the same (or equivalent schemes), this referral would mean that the test portion sent for that analysis ceases to be quality assured by the parent laboratory. This should be made clear in the analysis report to the customer.

Test Material Disposal:

Sample disposal is relatively a simple matter. The only problem arrives when there is a hazard involved in the destruction or the sample remains must have specific treatment e.g. a sample of groundnut heavily contaminated with alfatoxin. Any residual material if valuable such as flavouring concentrate maybe required to be returned to the originator. The register should therefore have a column in it for details of when, how and where the test material was disposed.

Documentation for QA Programme:

- Register for sample receipt: Test materialidentification
- Flow chart of the sample submitted for laboratory examination
- Storage conditions for food testmaterials

4.9. HACCP implementation program

During implementation of HACCP, it is imperative to set controls at each point of the production line at which safety problems (physical, chemical and microbiological) are likely to occur. A HACCP plan is required to be in place before initiating the HACCP system. HACCP is a system which identifies specific hazard(s) (i.e. any biological, chemical, or physical property that adversely affects the safety of the food) and specifies measures for their control. A HACCP Plan consists of 5 initial steps and 7major HACCP principles.

Risk Assessment

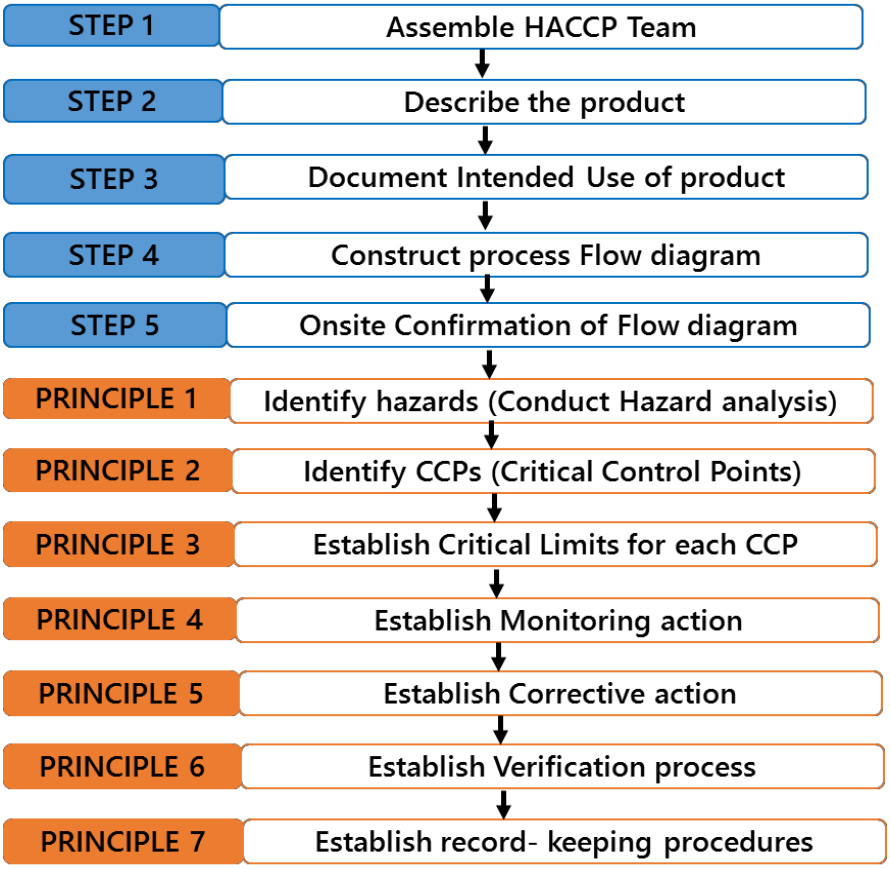
Risk assessment is a critical step in a HACCP plan. Risk is the combination of the likelihood (probability) of Occurrence & Consequence(s) (sometimes referred as severity) of a specified hazardous event occurring.

So the risk is defined as:

RISK = OCCURRENCE * CONSEQUENCE

The following scales can be used for the measurement of the likelihood of Occurrence & the consequences; hence the risk as well.

Criteria for Likelihood of Occurrence				
Likelihood of Occurrence	**Criteria**			**Rating**
	Frequency of occurring at least once in		**Description**	
	Routine job	*Irregular job*		
Very High	Daily	5 batches	Persistent, will occur if not attended to	**5**
High	Fortnightly	50 batches	Frequent chance of occurrence	**4**
Moderate	Monthly	100 batches	Occasionally could occur	**3**
Low	Yearly	1000 batches	Relatively some chance of occurrence	**2**
Remote	In 5 years	5000 batches	Unlikely to occur	**1**



Consequence (Severity)		
Rating	**Severity**	**Effect**
5	Very High (Catastrophic)	Death
4	High (Critical)	Serious Illness
3	Moderate	Illness/Injuries
2	Low	Un-comfort
1	Remote	No injuries

Nature of Control over Risk

Rank of Risk	Risk Index Value	Level of Control	Significant
R1	16-25	Avoidance/Special Process	Significant Hazard
R2	9-15	Physical Control/Monitoring	Significant Hazard
R3	5-8	Formal Control	Non-Significant Hazard
R4	0-4	Informal Control / Training	Non-Significant Hazard

The level of risk could help to identify the level of control as per the following:

R1: Avoidance:	Precluding the possibility of a given hazard, it may be the modification of the process if necessary.
R2: Physical Control:	Continuous control & monitoring of the actual physical process.
R3: Formal Control:	It is the management of the conditions of an operation to maintain compliance with documented criteria.
R4: Informal Control and Training:	It is the monitoring/check of the process without formal recording.
	It is the teaching of the staff responsible for the process about what is to be done in order to prevent the hazard.

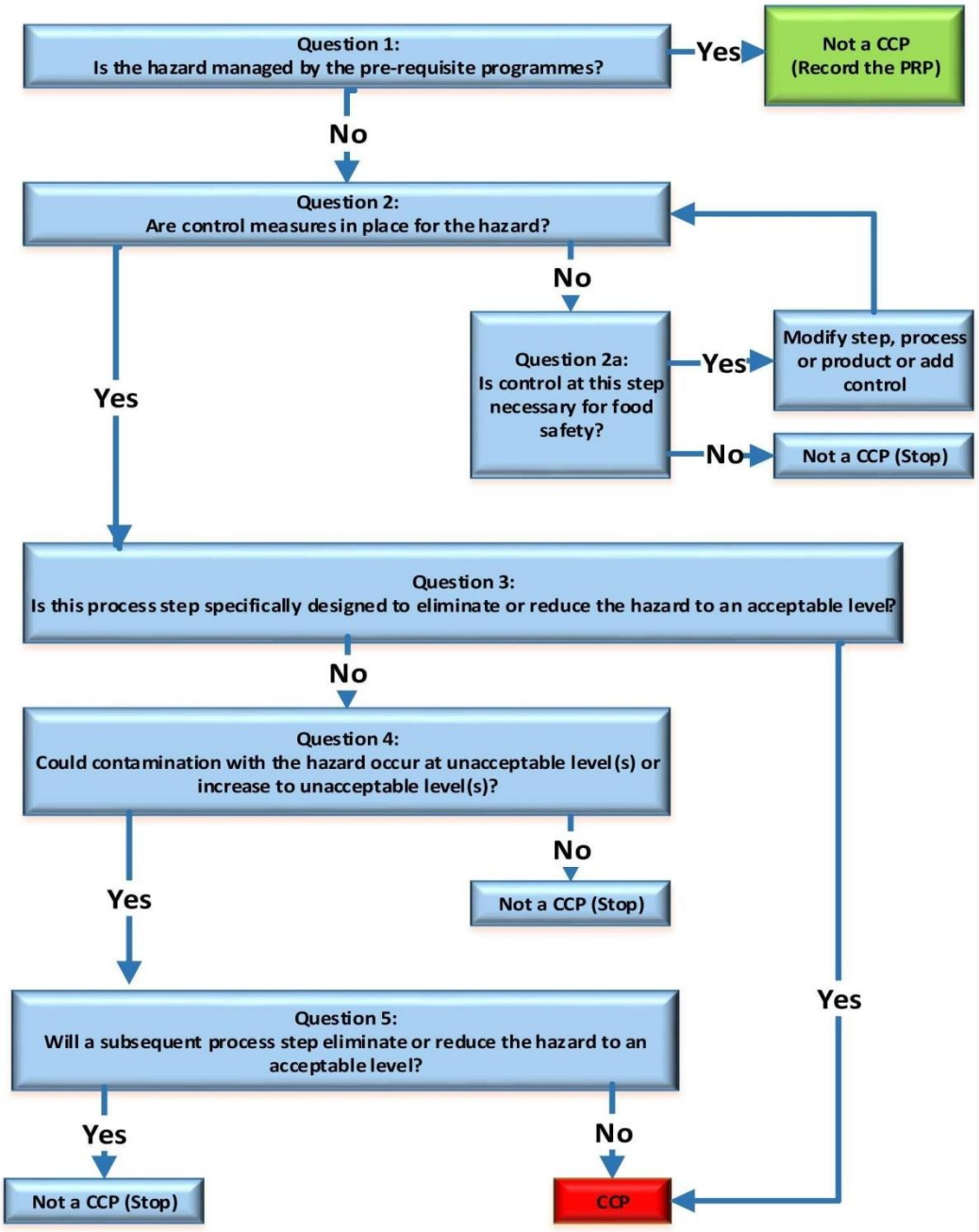
Below is a template to determine what severity and probability a processing step is involved with and therefore what level of criticality is holds in the processing line.

			Consequence/Severity				
			How severe could the outcome be if the risk even to				
			Severe	Major	Significant	Minor	Insignificant
Probability/Likelihood	What's the chance of the risk occurring?	Frequent	Extreme	Extreme	Very High	High	Medium
		Likely	Extreme	Very High	High	Medium	Medium
		Occasional	Very High	High	Medium	Medium	Low
		Seldom	High	Medium	Medium	Low	Very Low
		Unlikely	Medium	Medium	Low	Very Low	Very Low

Decision Tree

Hazard Analysis and Critical Control Point (HACCP) decision trees are tools that can be used to help you decide whether a hazard control point is a critical control point (CCP) or not. A CCP is a step at which control can be applied. However, it is not always possible to eliminate or prevent a food safety hazard, so this allows you to reduce it to an acceptable level.

The purpose of a decision tree is to support the judgment of the team and help you to confirm whether the hazard needs more food safety controls. Decision trees are not mandatory elements of HACCP but they can be useful in helping you determine whether a particular step is a CCP. It is vital that you determine the correct CCPs to ensure that food is managed effectively and safely. The number of CCPs in a process will depend on how complex the process is and how many hazards are present.



Criteria for identifying a Critical Control Point- Decision Tree

Possible Hazards in Fruits and Vegetables Processing

Hazard Types

There are three primary types of hazards to consider when conducting a hazard analysis. They include the following: - Chemical Hazards; Physical Hazards & Biological Hazard.

Chemical Hazards

A wide variety of chemicals are used in food production and processing. Some chemicals, such as pesticides used in growing fruits & vegetables, cannot be removed by a subsequent process thus their control needs to be prior to the intake of the facility. This would normally be through controls in GAP (Good Agricultural Practices) or through product testing / rejection upon arrival.

However, there are chemicals in processing facilities and manufacturing plants that should be rigorously controlled. These include such items as sanitizers, lubricants, pest control chemicals used within a processing facility and water treatment additives, plus chemicals added to the manufacturing process for a specific process.

Types of chemical hazards found:

- Agricultural products, pesticides, fertilizers, antibiotics, other field chemicals
- Toxic elements, lead, mercury, and other heavy metals
- Added Chemicals
- Food additives, such as preservatives, flavor enhancers, color additives.

Physical Hazards

As the fruits and vegetable processing industries deals with field or comparable materials, one of the objectives for it is to remove physical hazards. Types of physical hazards include glass, wood, metal, plastic, soil and stones, personal items like jewellery, hair clips, other like paint flakes, insulation, sticks, staples, weed seed, toxic weeds. Physical hazards usually result in personal injuries, such as a cut from glass or a case of choking from foreign materials. Controlling foreign objects in raw materials can be started by specifications, letters of guarantee and vendor inspection and certifications.

Causes of contamination

Hazards	**Causes of Contamination (examples)**
Foreign objects from the environment – soil, stones, sticks, weed seeds	▪ Harvesting of ground crops during wet weather ▪ Dirty harvesting and packing equipment, picking containers, packaging materials ▪ Stacking of dirty containers on top of produce

Foreign objects from equipment, containers, buildings and structures – glass, wood, metal, plastic, paint flakes	▪ Broken lights above packing equipment and areas where produce is exposed ▪ Damaged picking containers, harvesting and packing equipment, pallets ▪ Inadequate cleaning after repairs and maintenance
Foreign objects from human handling of produce – jewellery, hair clips, personal items, staples used for closing packaging	▪ Untrained staff or Careless ▪ Inappropriate clothing

Biological Hazards

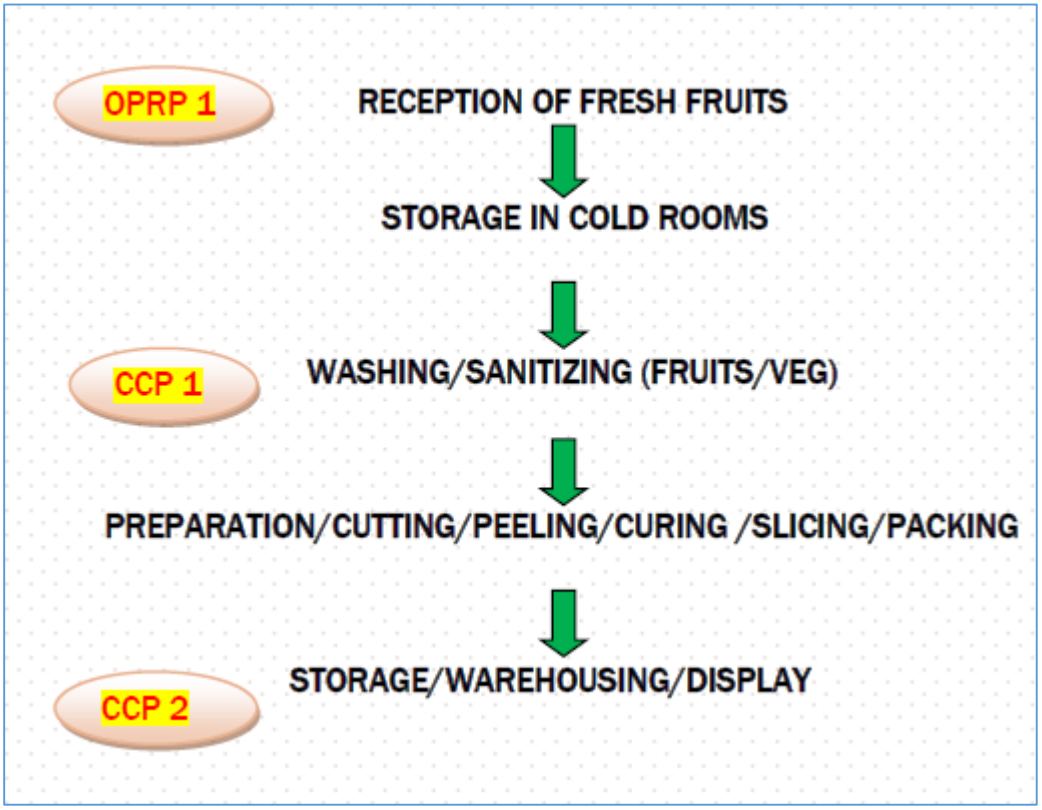
One of the greatest risks for illness or injury from food comes from microbiological hazards. For an illness to occur, the pathogen must be present in the food and must grow to high enough numbers to cause an infection or to produce toxin. The food must be capable of supporting growth of the pathogen and must remain in the growth temperature range long enough for the organism to multiply.

Common pathogenic bacteria that have been linked to contamination of fresh fruits & vegetable are:

Salmonella, Campylobacter species, Listeria monocytogenes, Bacillus cereus, E. coli, Aeromonas species, , Clostridium botulinum , staphylococcus, Coliforms, Yeast, Molds, Aspergillus sp., Thermophiles & Mesophiles, Anaerobic microbes.

Process Flow Charts-Hazard Analysis

A. Process flow chart of Minimally processed/ Fresh Cut Fruits and vegetables



Hazard Analysis and Identification

Table-Hazard Analysis

Process Step	Type of hazard	Description of hazard	Hazard Evaluation/Assessment			Control Measure
			Likelihood	Severity	Significance	
Receiving	P	– External contamination from rain water, Dirt/Dust, bird droppings, vermin/rodents and flying insects during in loading process. – Glass contamination from internal light sources. – Pests/rodents and or Flying insects due to poor hygiene/debris build up. – Contamination due to dirty crates.	3	3	9	Prerequisite programs in place to control all named hazards, include; Daily hygiene schedules and cleaning programs, glass policy and daily audits. – External and internal Pest control programmes. – All light fittings covered. – Supplier Q.A.S systems and verified/audited to eliminate/ reduce potential foreign body or Microbiological contamination. Chemical/ pesticide used at source in conjunction with Local regulations.
	C	– Chemical contamination due to cleaning agents.	2	3	6	As per SOP

		– Chemical adulteration				
	B	– Fungal growth	**4**	**3**	**12**	Incoming checks and compliance to specification.
Storage	P	Physical contamination from operatives. – Glass contamination from internal light sources.	2	4	8	Prerequisite programs in place to control all named hazards, include; Daily hygiene schedules and cleaning programs, glass policy and daily audits, Pest control programs
		Insects/ Pests/rodents and due to poor hygiene/debris build up.				– Staff awareness/training programs in place with records of training.
	C	--	--	--	--	---
	B	Fungal growth	2	4	8	As per SOP & Routine storage checks of controlled temp condition
Washing and Sanitization of Raw Vegetable, Fruits.	p	Nil				
	C	Excessive chlorine	2	3	6	Training. Checking the chlorine dosage through test strips
	B	Survival of bacterial contamination	3	4	12	--Do--

Cutting	P	Physical contamination from operatives. – Glass contamination from internal light sources. – Insects/ Pests/rodents and due to poor hygiene/debris build up. – Fragment of knife/chopping board.	1	4	4	Prerequisite programs in place to control all named hazards, include; Daily hygiene schedules and cleaning programs, glass policy and daily audits, Pest control programs – Staff awareness/training programs in place with records of training.
	C	– residue of cleaning chemicals	1	3	3	Cleaning as per SOP, Training
	B	– Cross contamination from Knife and Chopping boards	3	3	9	Cleaning as per SOP, Training
	P	Contamination by fragments of packaging. Contamination from dirty baskets/trays and hands. Contamination form air-borne contaminants.	3	3	9	Staff hygiene rules. Control of non food item in food area and storage of primary packaging material under controlled condition.
Packing	C	Nil				

	B	Contamination due to dirty hands	3	3	9	Staff hygiene rules, Hand washing, Correct usage of disposal gloves
Storage/ Warehousing/Display	P	Nil				
	C	Nil				
	B	Bacterial Growth	3	4	12	Holding/Storage temp <5˚C

(Note: This is only a reference model for Risk Assessment example. These may vary from plant to plant depending on risk assessment and process controls).

HACCP Plan (for 2 CCP's)

OPRP	Hazard	Control Measures	Critical Limits	Monitoring				Correction	Corrective Action	Verification	Record
				What	How	When	Who				
OPRP 1 Receiving Fresh Fruits and Vegetables	▪ Microbial contamination ▪ Bacterial growth in the food.	Incoming checks	▪ Approved supplier ▪ truck clean ▪ No fungus or rotten F&V	▪ Check for rotten or fungal infested F&V. ▪ Check condition of truck	Visual observation	Each delivery	Receiver	Product: Sorting to be done.	Process: Head Receiving will inform to procurement team ▪ Revisit/inspect supplier ▪ Change supplier	Audit of supplier premises as per risk associated	Receiving/delivery records Form of warranty
CCP 1	Training, Checking the chlorine dosage through test strips	▪ Survival of pathogens due to incorrect sanitizer concentrations or inadequate contact time.	▪ Use correct concentration and contact time F&V products to be washed in 50	Chlorine concentration of 50 ppm and time of 10 min	Use test strips	Each batch	QA	▪ Rewash and test again if concentration is greater than 50ppm ▪ Product: Re-sanitize if	▪ Re-train staff to correct usage of chemicals	Chlorine concentration tests	1)Chlorine tests concentration monitoring

Washing & sanitizing fruits & vegetables		▪ Chemical contamination due to high concentrations of chemical sanitizer.	ppm chlorine and time of 10 min					concentration is less than 50 ppm		Internal audit reports	
CCP 2 Cold holding	Growth of food poisoning bacteria	Holding cut F&V in holding unit maintains temperature 5˚c or below. if Holding at ambient temp, then discard the product after 4 hrs if not consumed Storage & display in a clean chilled cabinet & trays	▪ Use a temperature setting that keeps food 5*C or below. Clean cabinet & trays	Product temperature Product protection and clean, sanitized equipment	Visual inspection Calibrated and sanitized thermometer	Measure product temperature every 4 hours Each batch	QA	▪ Discard food that has been exposed to room temperature for more than 4 hours (Cumulative time).	▪ Process: If temperature of Cold Cabinet cannot maintain 5*C or below, contact maintenance and / Cooling technique and/or the amount of food in the unit. ▪ Inform QA	Internal audits Microbiological sampling of finished products Calibration of thermometers	1) Temperature records 2) Thermometer calibration records 3) Microbiological test records

4.10. FSSAI Regulations and standards for maintaining food safety and quality domestic regulation

FSSAI Establishment & Role:

- FSSAI is an autonomous body established under the Food Safety and Standards Act, 2006, under Ministry of Health & Family Welfare, Government of India.
- FSSAI - responsible for protecting and promoting public health through the regulation and supervision of food safety.
- As per Section 31(1) & 31(2) of FSS Act, 2006 every Food Business Operator in the country is required to be licensed/registered under the FSSAI.

Terminologies:

Adulterant – Any material which is or could be employed for making food unsafe or sub-standard or mis-branded or containing extraneous matter.

- **Penalty** - If any person who whether by himself or by any other person on his behalf, imports or manufactures for sale, or stores, sells or distribute any adulterant shall be liable –
  - ✓ Adulterant is not injurious to health - penalty not exceeding two lakh rupees;
  - ✓ Adulterant is injurious to health, to a penalty not exceeding ten lakh rupees.

Contaminant - any substance, whether or not added to food, but which is present in such food as a result of the production, manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food or as a result of environmental contamination and does not include insect fragments, rodent hairs and other extraneous matter.

Extraneous matter - any matter contained in an article of food which may be carried from the raw materials, packaging materials or process systems used for its manufacture or which is added to it, but such matter does not render such article of food unsafe

- **Penalty -** may extend to one lakh rupees.

Food - Any substance, whether processed, partially processed or unprocessed, which is intended for human consumption.

Food additive - Any substance not normally consumed as a food by itself or used as a typical ingredient of the food, whether or not it has nutritive value or otherwise affecting the characteristics of such food but does not include “contaminants” or substances added to food for maintaining or improving nutritional qualities.

Some examples:

Acidifying Agents	Citric Acid Malic Acid	GMP GMP
Antioxidants	Ascorbic Acid	GMP
Thickening Agents	Arabic Gum	10 g/kg max.

Food business operator - A person by whom the business is carried on or owned and is responsible for ensuring the compliance of this Act, rules and regulations made.

Food safety - Assurance that food is acceptable for human consumption according to its intended use.

Food Safety Management System - The adoption Good Manufacturing Practices, Good Hygienic Practices, Hazard Analysis and Critical Control Point and such other practices as may be specified by regulation, for the food business.

Hazard - A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect.

Ingredient - Any substance, including a food additive used in the manufacture or preparation of food and present in the final product, possibly in a modified form.

Label - Any tag, brand, mark, pictorial or other descriptive matter, written, printed, stencilled, marked, embossed, graphic, perforated, stamped or impressed on or attached to container, cover, lid or crown of any food package and includes a product insert.

Licence - A licence granted under section 31.

- **Punishment for carrying out a business without licence** - Food business operator without licence, shall be punishable with imprisonment for a term which may extend to six months and also with a fine which may extend to five lakh rupees.

Manufacture - A process or adoption or any treatment for conversion of ingredients into an article of food, which includes any sub-process, incidental or ancillary to the manufacture of an article of food.

Manufacturer - A person engaged in the business of manufacturing any article of food for sale and includes any person who obtains such article from another person and packs and labels it for sale or only labels it for such purposes;

Processing aid – Any substance or material, not including apparatus or utensils, and not consumed as a food ingredient by itself.

Misbranded food - An article of food –

- If it is purported, or is represented to be, or is being sold with false labeling / false manufacturing details.
- If the article is sold in packages which have been sealed or prepared by or at the instance of the manufacturer or producer bearing his name and address but is an imitation of, or is a substitute for, or resembles in a manner likely to deceive, another article of food under the name of which it is sold
- if the article contained in the package – contains any artificial flavouring, colouring or chemical preservative and the package is without a declaratory label stating that fact or is not labelled in accordance with the requirements of this Act or regulations made not conspicuously or correctly stated.
- **Punishment for misbranding** - may extend to three lakh rupees.

Package - Means a pre-packed box, bottle, casket, tin, barrel, case, pouch, receptacle, sack, bag, wrapper or such other things in which an article of food is packed.
Standard - Means the standards notified by the Food Authority.
Sub-standard - An article of food shall be deemed to be sub-standard if it does not meet the specified standards but not so as to render the article of food unsafe.
Unsafe food - means an article of food whose nature, substance or quality is so affected as to render it injurious to health.

FSSAI and International standards
List of regulations:

- Food Safety and Standards (Food Products Standards and Food Additives) Regulations, 2011.
- Food Safety and Standards (Contaminants, Toxins and Residues) Regulations, 2011. Food Safety and Standards (Packaging and Labelling) Regulations, 2011.
- Food Safety and Standards (Food or Health Supplements, Nutraceuticals, Foods for Special Dietary Uses, Foods for Special Medical Purpose, Functional Foods and Novel Food) Regulations, 2016.
- Food Safety and Standards (Organic Foods) Regulations, 2017.
- Food Safety and Standards (Alcoholic Beverages) Regulations, 2018.
- Food Safety and Standards (Fortification of Food) Regulation, 2018.

These are the standards are followed for covering quality and safety parameters of various Fruit & Vegetable food products.

Product Standards:

The Authority has notified following Regulations covering quality and safety parameters of various Fruit & Vegetable food products:

Some examples:

(FSS. Act. 2006; sub-2.3.3) Thermally Processed Vegetables:

- Thermally Processed Vegetables (Canned, Bottled/Flexible pack / Aseptically Packed) means the product obtained from fresh, dehydrated or frozen vegetables either singly or in combination with other vegetables, peeled or un-peeled, with or without the addition of water, common salt and nutritive sweeteners, spices and condiments or any other ingredients suitable to the product, packed with any suitable packing medium appropriate to the product processed by heat, in an appropriate manner, before or after being sealed in a container so as to prevent spoilage.
- The packing medium along with its strength shall be declared on the label.
- The name of the vegetables used in the product and prepared in any style shall be declared on the label along with the range of percentage of each vegetable used in the product.
- Drained weight of vegetables shall be not less than the weight given below: —

  i) Liquid Pack

  (a) Mushroom - 50.0 percent of net weight of contents

  (b) Green beans, carrots, peas, sweet corn/ baby corn - 50.0 percent of net weight of contents

  (c) Mushroom Packed in sauce - 25.0 percent of net weight of contents

  (d) Other Vegetables - 50.0 percent of net weight of contents

  (ii) Solid Pack - 70.0 percent of net weight of content

(FSS. Act. 2006; sub-2.3.8) Thermally Processed Tomato Juice:

- Thermally Processed Tomato Juice means the unfermented juice obtained by mechanical process from tomatoes (Lycopersicum esculentus L) of proper maturity and processed by heat, in an appropriate manner, before or after being sealed in a container, so as to prevent spoilage.
- The juice may have been concentrated and reconstituted with water for the purpose of maintaining the essential composition and quality factors of the juice.

- The product may contain salt and other ingredients suitable to the product. The product shall be free from skin, seeds and other coarse parts of tomatoes.
- The product shall have pleasant taste and flavour characteristic of tomatoes free from off flavour and evidence of fermentation.
- Total Soluble Solids m/m free of added salt to be not less than 5.0 percent.

(FSS. Act. 2006; sub-2.3.36) Dehydrated Vegetables:

Name of Vegetables	Moisture not more than (percent)	Sulphur Dioxide not more than (PPM)	Total ash not more than (percent)	Ash insoluble dilute HCl not more than (percent)	Peroxidase Test
Green Leafy Vegetables	7	2000 ppm	-	-	Negative
(a) Tubers like Arvi	7	2000 ppm	-	-	Negative
(b) Lotus Root Tapioca					
(c) Yam					
(d) Carrot					
(e) Potato					
Karela	6	-	-	-	Negative
Cabbage	6	2000 ppm	-	-	Negative
Okra	8	2000 ppm	-	-	Negative
Other Vegetables	8	2000 ppm	5	0.5	Negative
Powders of onion and Garlic	5	-	5	0.5	Negative
Powders of other vegetables including tomatoes	5	2000 ppm	5	0.5	Negative

(FSS. Act. 2006; sub-2.3.43) Pickles:

- Pickles means the preparation made from fruits or vegetables or other edible plant material including mushrooms free from insect damage or fungal infection, singly or in combination preserved in salt, acid, sugar or any combination of the three.
- The pickle may contain onion, vinegar/ acetic acid, citric acid, dry fruits and nuts.
- It shall be free from, garlic, ginger, sugar jaggery, edible vegetable oil, green or red chillies, spices, spice extracts/oil, lime juice, copper, mineral acid, alum, synthetic colours and shall show no sign of fermentation.

(i) Pickles in Citrus juice or Brine conforming to the following requirements:—

(a)	Drained Weight	Not less than 60.0 percent
(b)	Sodium Chloride content when packed in Brine	Not less than 12.0 percent
(c)	Acidity as Citric Acid when packed In Citrus Juice	Not less than 1.2 percent

(ii) Pickles in Oil

(a)	Drained Weight	Not less than 60.0 percent
(b)	Fruit and Vegetable pieces shall be practically remaining submerged in oil	

(iii) Pickles in Vinegar

(a)	Drained Weight	Not less than 60.0 percent
(b)	Acidity of vinegar as acetic acid	Not less than 2.0 percent

(iv) Pickle without medium means the pickles other than enumerated above. This may contain ingredients given in Para 1 of this specification. Such pickles shall be labelled as "(give name of vegetable or fruits) Pickle".

(FSS. Act. 2006; sub-2.3.11) Thermally Processed Mango Pulp / Puree and Sweetened Mango Pulp / Puree:

- (Canned, Bottled, Flexible Pack And/ Or Aseptically Packed) means not fermented but fermentable product intended for direct consumption obtained from edible portion of sound, ripe mangoes (*Mangiferaindica*.L.), by sieving the prepared fruits, whereas, the puree is obtained by finely dividing the pulp by a finisher or other mechanical means and processed by heat in an appropriate manner, before or after being sealed in a container, so as to prevent spoilage.
- It may contain one or more nutritive sweeteners in amounts not exceeding 50 gm/ kg. However, the product shall be described as sweetened Mango pulp/ puree if the amount of nutritive sweeteners is in excess of 15 gm / kg.

Acidity as Citric Acid (For sweetened canned mango pulp)	Not less than Not less than **0.3 %**
Total Soluble Solids (m/m) 1. Sweetened 2. Unsweetened (Natural Mango Pulp)	 1. Not less than 15.0 % 2. Not less than 12.0 %

(FSS. Act. 2006; sub-2.3.27) Tomato Ketchup and Tomato Sauce

- It means the product prepared by blending tomato juice/Puree/Paste of appropriate concentration with nutritive sweeteners, salt, vinegar, spices and condiments and any other ingredients suitable to the product and heating to the required consistency.
- Tomato Paste may be used after dilution with water suitable for the purpose of maintaining the essential composition of the product.

Total Soluble solids (m/m) Salt free basis	Not less than 25.0 percent
Acidity as acetic acid	Not less than 1.0 percent

The guideline and standards are given to following fruits and vegetables food products (Chapter 2- the food safety and standard act, 2006 [Act. No 34 of 2006, dt.23-8-2006]

2.3 Fruit & Vegetable Products

2.3.1 Thermally processed Fruits

2.3.2 Thermally processed Fruit salad/Cocktail/Mix

2.3.3 Thermally Processed Vegetables

2.3.3A Canned Tomatoes

2.3.4 Thermally Processed Curried Vegetables/Ready to Eat Vegetables

2.3.5 Thermally Processed Vegetable Soups

2.3.6 Thermally Processed Fruits Juices

2.3.7 Thermally Processed Vegetable Juices

2.3.8 Thermally Processed Tomato Juice

2.3.9 Thermally Processed Fruit Nectars

2.3.10 Thermally Processed Fruit Beverages/Fruit Drink/Ready to serve Fruit Beverages

2.3.11 Thermally Processed Mango Pulp/Puree and Sweetened Mango Pulp/Puree

2.3.12 Thermally Processed Fruit Pulp/Puree and Sweetened Fruit Pulp/Puree other than Mango

2.3.13 Thermally Processed Concentrated Fruit/Vegetable juice Pulp/Puree

2.3.14 Thermally Processed Tomato puree and paste

2.3.15 Soup Powders

2.3.16 Fruit/Vegetable juice/pulp/puree with preservatives for industrial Use Only

2.3.17 Concentrated Fruit Vegetable Juice/Pulp/Puree with Preservatives for Industrial Use Only

2.3.18 Tamarind Pulp/Puree and Concentrate

2.3.19 Fruit Bar/Toffee

2.3.20 Fruit/Vegetable, Cereal Flakes

2.3.21 Squashes, Crushes, Fruit Syrups/Fruit Sharbats and Barley Water

2.3.22 Ginger Cocktail

2.3.23 Synthetic Syrup for use in Dispensers for carbonated water

2.3.24 Synthetic syrup or sharbat

2.3.25 Murabba

2.3.26 Candied, Crystallized And Glazed Fruit/Vegetable/Rhizome/Fruit Peel

2.3.27 Tomato Ketchup and Tomato Sauce

2.3.28 Culinary pastes/Fruits and vegetables sauces Other Than Tomato sauce and Soya sauce

2.3.29 Soyabean sauce

2.3.30 Carbonated Fruit Beverages or Fruit Drinks

2.3.31 Jams, Fruit jellies and marmalades

2.3.33 Fruit Cheese
2.3.34 (Omitted)
2.3.35 Dehydrated Fruits
2.3.36 Dehydrated Vegetables
2.3.37 Frozen Fruits/Fruit Products
2.3.38 Frozen Vegetables
2.3.39 Frozen Curried Vegetables/ Ready- To- Eat Vegetables
2.3.40 Fruit Based Beverages Mix/Powdered Fruit Based Beverage
2.3.41 Fruits and Vegetable Chutney
2.3.42 Mango Chutney
2.3.43 Pickles
2.3.44 Table Olives
2.3.45 Grated Desiccated Coconut
2.3.46 Vinegar
2.3.47 Nuts and Raisins
2.3.48 Beam
2.3.49 Seedless tamarind
2.3.50 Vanilla
2.3.51 Coconut milk (non-dairy)
2.3.52 Coconut Cream (Non-dairy)
2.3.53 Dried apricots
2.3.54 Cocoa beans
2.3.55 Arecanuts or betelnuts or supari
2.3.56 Date paste
2.3.57 Fermented Soyabean paste
2.3.58 Harrisa (Red Hot pepper paste)
2.3.59 Vegetable Protein Products
2.3.60 Quick Frozen Fried Potatoes
2.3.61 Canned Chestnuts and canned Chestnuts Puree
2.3.62 Edible fungi products

Food Additives

Sl. No	Name of Additives	Jam/Jellies/Fruit Cheese	Fruit Marmalades	Fruit Bar/Toffee	Fruit Cereal Flakes	Thermally processed fruit beverages/ Fruit drinks/ready to serve fruit beverages	Tomato Ketchup	Culinary Paste/Other Sauces	Soyabean Sauce	Soups	Soup powder, Fruit powder, Vegetable powder, Instant Fruit/ Vegetable Chutney Mixed (dry), Culinary Powder, Seasoning Mixed Powder	Nectars	Fruit Juices aspectialy packed	Vegetable Juices	Concentrated Fruit/Veg. Juice / Pulp/Puree
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	ACIDIFYING AGENTS (Singly or in combination)														
1	Acetic Acid	-	-	-	-	-	GMP	GMP	GMP	-	-	-	-	-	-
2	Citric Acid	GMP	GMP	GMP	-	GMP	GMP	GMP	GMP	GMP	GMP	GMP	GMP	GMP	GMP
3	Fumaric Acid	GMP	GMP	GMP	-	GMP	0.3% maximum	0.3% maximum	-	-	-	-	-	-	-
4	Lactic Acid	-	-	-	-	-	GMP	GMP	GMP	GMP	GMP	-	-	GMP	GMP
5	L-Tartaric Acid	GMP	GMP	GMP	-	GMP	GMP	GMP	GMP	GMP	GMP	GMP	GMP	GMP	-
6	Malic Acid	GMP	GMP	GMP	-	GMP	GMP	GMP	GMP	GMP	GMP	GMP	GMP	GMP	GMP
7	Phosphoric Acids	-	-	-	-	-	-	-	-	-	-	-	-	GMP	-
B	ANTICAKING AGENTS (Singly or in combination)														
1	Carbonates of Calcium and Magnesium	-	-	-	-	-	-	-	-	-	2% maximum	-	-	-	-
2	Mono-and diglycerides of fatty Acids of edible oils	GMP	GMP	-	-	-	-	10ppm maximum	-	-	-	-	-	-	10ppm maximum
D	ANTIOXIDANTS														
1	Ascorbic Acid	GMP	GMP	GMP	-	GMP	GMP	GMP	-	GMP	GMP	GMP	GMP	GMP	GMP
2	BHA	-	-	-	-	-	-	200 ppm maximum	-	200 ppm maximum	200 ppm maximum	-	-	-	-
3	TBHQ	-	-	-	-	-	-		-			-	-	-	-
4	Ascrobyl palmitate	-	-	-	-	-	-		-			-	-	-	-
E.	COLOURS (Can be used singly or in combination within the specified limits)														
(a)	Natural:														
1	Chlorophyll	GMP	GMP	GMP	-	GMP	-	GMP for Caramel only-	GMP	GMP	GMP	100 ppm max-	-	-	-
2	Caramel				-		-						-	-	-
3	Curcumin or turmeric				-		-						-	-	-
4	Beta-carotene				-		-						-	-	-
5	Beta apo-8 carotenal				-		-						-	-	-
6	Methylester of Beta-apo-8 carotenic acid				-		-						-	-	-
7	Ethylester of Beta apo-8 carotenic acid				-		-						-	-	-
8	Canthaxanthin				-		-						-	-	-
9	Riboflavin, Lactoflavin					-		-						-	- -
10	Annatto				-		-						-	-	-
11	Saffron				-		-						-	-	-
(b)	Synthetic	200 ppm maximum	200 ppm maximum	100 ppm maximum		100 ppm maximum				100 ppm maximum	100 ppm maximum				
1	Poncea 4R				-		-	-	-			-	-	-	-
2	Carmolsine				-		-	-	-			-	-	-	-
3	Erythrosine				-		-	-	-			-	-	-	-
4	Tartarzine				-		-	-	-			-	-	-	-
5	Sunset Yellow FCF				-		-	-	-			-	-	-	-

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
6	Indigo Carmine				-		-	-	-			-	-	-	-
7	Brilliant Blue FCF				-		-	-	-			-	-	-	-
8	Fast green FCF				-		-	-	-			-	-	-	-
F	FIRMING AGENTS (Singly or in Combination)														
1	Calcium Chloride	200 ppm maximum for use only on the fruit pieces	-	-	-	-	-	-	-	350 ppm maximum	-	-	-	-	-
2	Calcium Lectate		-	-	-	-	-	-	-		-	-	-	-	-
3	Calcium Gluconate		-	-	-	-	-	-	-		-	-	-	-	-
4	Calcium Carbonate		-	-	-	-	-	-	-		-	-	-	-	-
5	Calcium Bisulphite		-	-	-	-	-	-	-		-	-	-	-	-
G	FLAVOURS														
1	Natural Flavouring and Natural Flavouring substances / Nature identical flavouring substances / artificial flavouring substances	GMP	GMP	GMP	-	GMP	-	GMP	-	-	GMP	Natural Flavouring and Natural Flavouring Substances only	GMP natural flavours only	GMP natural flavours only	-
H	FLAVOUR ENHANCER														
1	MSG (Enhancer)	-	-	-	-	-	-	GMP	-	GMP	GMP	-	-	-	-
I	PRESERVATIVES (Singly or in combination) & its Salt														
1	Benzoic Acid & its Sodium & Potassium Salt or both (Calculated as Benzoic Acid)	200 ppm maximum	200 ppm maximum	200 ppm maximum	-	120 ppm maximum	750 ppm maximum	750 ppm maximum	750 ppm maximum	-	-	-120 ppm max	-	-	-
2	Sulphur di-oxide (Carry over from fruit products)	40 ppm maximum	40 ppm maximum	100 ppm maximum	-	70 ppm maximum	-	-	-	-	1500 ppm maximum	-70 ppm max	-	-	-
3	Sorbic Acid and its Cal., Sod., Pot. Salt (calculated as Sorbic Acid)	500 ppm maximum	500 ppm maximum	500 ppm maximum	-	300 ppm maximum	1000 ppm maximum	1000 ppm maximum	1000 ppm maximum	-	-	300 ppm max	-	-	-

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
J	PROCESSING AIDS														
1	Nitrogen and Carbondioxide	-	-	-	-	-	-	-	-	-	-	-	GMP	GMP	GMP
K	THICKENING AGENTS (Singly or in combination)														
1	Modified Starches	-	-	-	-	-	0.5% maximum with declaration on label	0.5% maximum with declaration on label	-	0.5% maximum	0.5% maximum of final food for consumption after dilution	-	-	-	-
2	Vegetable Gums (Singly or in combination)	-	-	-	-	-	-	-	-			-	-	-	-
(i)	Arabic Gum	-	-	-	-	-	GMP (for RTS fruit beverages only)	-	GMP	-		-	-	-	-
(ii)	Carrageenan	-	-	-	-	-	-	GMP	-			-	-	-	-
(iii)	Guar Gum	-	-	-	-	-	-	GMP	-			-	-	-	-
(iv)	Carobbean Gum	-	-	-	-	-	-	GMP	-			-	-	-	-
(v)	Xanthan Gum	-	-	-	-	-	0.5% maximum	0.5% maximum	-			-	-	-	-
3	Alginates (Singly or in combination)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(i)	Calcium Alginates	GMP	GMP	GMP	GMP	-	GMP	GMP	GMP	GMP	GMP				
(ii)	Potassium Alginates					GMP (for RTS fruit beverages only)	-					-	-	-	-
(iii)	Sodium Alginates					-						-	-	-	-
(iv)	Propyl glycol Alginate					-						-	-	-	-
(v)	Alginic acid					GMP						GMP	GMP	GMP	GMP
4	Pectines					GMP (for RTS fruit beverages						GMP	-GMP	-	-

5	Ester Gum	-	-	-	-	100 ppm max	-	-	-	-	-	-	-	-	-
6	Gellan Gum	-	-	-	-	GMP	-	-	-	-	-	-	-	-	-
L	Artificial sweeteners and Polyols														
1	Aspertame	1000ppm maximum	1000ppm maximum	-	-	-	-	-	-	-	-	-	-	-	-
2	Sorbitol	30% maximum	30% maximum	-	-	-	-	-	-	-	-	-	-	-	-
M	SOFTENING AGENTS (Singly or in combination)														
1	Sodium Bi-Carbonate	-	-	-	-	-	-	-	-	GMP	GMP	-	-	-	-
2	Sodium Citrate	-	-	-	-	-	-	-	-	GMP	GMP	-	-	-	-
N	SEQUESTERANT														
1	Sodium hexameta phosphate	-	-	-	-	1000 ppm max	-	-	-	-	-	1000 ppm max	-	-	-

Microbiological requirements of food products (FSS. Act. No 34 of 2006, dt. 23-8-2006)

Sl No	Products	Parameters	Limits
1	Thermally processed fruits and vegetable products	a) Total plate count	a) Not more than 50 / ml
		b) Incubation at 37°C for 10 days and 55°C for 7 days	b) No changes in pH
2	a) Dehydrated fruits and vegetable products b) Soup powders c) Desiccated coconut powder d) Table olives e) Raisins f) Pistachio nuts g) Dates h) Dry fruits and nuts	Total plate count	Not more than 40,000 / gm
3	Carbonated beverages, ready - to - serve beverages including fruit beverages	a) Total plate count b) Yeast and mould count c) Coli form count	Not more than 50 cfu / ml Not more than 2.0 cfu / ml Absent in 100 ml
4	Tomato products		
	a. Tomato juices and soups	(a) Mould count	Positive in not more than 40.0 percent of the field examined
	b. Tomato puree and paste	(b) Yeast and spores	Not more than 125 per 1 / 60 c.m.m
	c. Tomato ketchup and Tomato Sauce	(a) Mould count	Positive in not more than 60.00 percent of the field examined
		(a) Mould count	Positive in not more than 40.00 percent of the field examined
		(b) Yeast and spores	Not more than 125 per 1 / 60 c.m.m
		(c) Total plate Count	Not more than 10000 / ml
5	Jam / Marmalade / Fruit jelly / Fruit Chutney and Sauces	Mould Count	Positive in not more than 40.00 percent of the field examined
		Yeast and spores	Not more than 125 per 1 / 60 c.m.m

6	Other fruits and vegetables products covered under Regulation 2.3	Yeast and mould count	Positive in not more than 100 count/gm
7	Frozen fruits and vegetables products	Total plate count	Not more than 40,000 / gm
8	Preserves	Mould count	Absent in 25 gm / ml
9	Pickles	Mould count	Absent in 25 gm / ml
10	Fruits Cereal Flakes	Mould count	Absent in 25 gm / ml
11	Candied and Crystalised or Glazed Fruit and Peel	Mould count	Absent in 25 gm / ml
12	a) All Fruits and Vegetable products and ready - to - serve Beverages including Fruit Beverages and Synthetic products covered under Regulation 2.3	a. Flat Sour Organisms	(i) Not more than 10,000 cfu / gm for those products which have pH less than 5.2 (ii) Nil for those products which have pH more than 5.2
	b) Table olives	b. Staphylococcus aureus	Absent in 25 gm / ml
	c) Raisins	c. Salmonella	Absent in 25 gm / ml
	d) Pistachio nuts	d. Shigella	Absent in 25 gm / ml
	e) Dates	e. Clostridium botulinum	Absent in 25 gm / ml
	f) Dry fruits and nuts	f. E. Coli	Absent in 1 gm / ml
	g) Vinegars	g. Vibrio Cholera	Absent in 25 gm/ ml

4.11. FSSAI packaging and labelling requirements:

Packaging requirements for Fruits and Vegetables Products:

i. Every container in which any fruit product is packed shall be so sealed that it cannot be opened without destroying the licensing number and the special identification mark of the manufacture to be displayed on the top or neck of the bottle.

ii. For Canned fruits, juices and vegetables, sanitary top cans made up of suitable kind of tin plates shall be used.

iii. For Bottled fruits, juices and vegetables, only bottles/ jars capable of giving hermetic seal shall be used.

iv. Juices, squashes, crush, cordials, syrups, barley waters and other beverages shall be packed in clean bottles securely sealed. These products when frozen and sold in the form of ice shall be packed in suitable cartons. Juices and Pulps may be packed in wooden barrels when sulphited.

v. For packing Preserves, Jams, Jellies, and Marmalades, new cans, clean jars, new canisters, bottles, chinaware jars, aluminium containers may be used and it shall be securely sealed.

vi. For Pickles, clean bottles, jars, wooden casks, tin containers covered from inside with polythene lining of 250 gauge or suitable lacquered cans shall be used.

vii. For Tomato Ketchups and Sauces, clean bottles shall be used. If acidity does not exceed 0.5% as acetic acid, open top sanitary cans may also be used.

viii. Candied fruits and peels and dried fruits and vegetables can be packed in paper bags, cardboard or wooden boxes, new tins, bottles, jars, aluminium and other suitable approved containers.

ix. Fruits and Vegetable products can also be packed in aseptic and flexible packaging material having good grade quality conforming to the standards laid down by BIS.

Labelling:

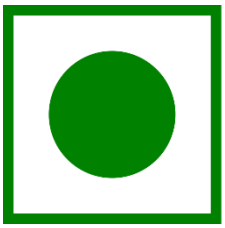
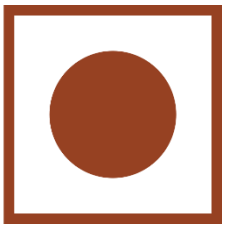
1. ***General Requirements*** - Every prepackaged food shall carry a label containing information as required here under unless otherwise provided, namely,—
   - The particulars of declaration required under these Regulations to be specified on the label shall be in English or Hindi in Devnagri script:
   - Provided that nothing herein contained shall prevent the use of any other language in addition to the language required under this regulation.
   - Pre-packaged food shall not be described or presented on any label or in any labelling manner that is false, misleading or deceptive or is likely to create an erroneous impression regarding its character in any respect;
   - Label in pre-packaged foods shall be applied in such a manner that they will not become separated from the container;
   - Contents on the label shall be clear, prominent, indelible and readily legible by the consumer under normal conditions of purchase and use;
   - Where the container is covered by a wrapper, the wrapper shall carry the necessary information or the label on the container shall be readily legible through the outer wrapper and not obscured by it;

2. ***Labelling of Pre-packaged Foods*** - In addition to the General Labelling requirements specified in 2.2.1 above every package of food shall carry the following information on the label, namely,—
   i. The Name of Food: The name of the food shall include trade name or description of food contained in the package.
   ii. List of Ingredients: Except for single ingredient foods, a list of ingredients shall be declared on the label in the following manner:—
      - The list of ingredients shall contain an appropriate title, such as the term “Ingredients”;
      - The name of Ingredients used in the product shall be listed in descending order of their composition by weight or volume, as the case may be, at the time of its manufacture;
      - A specific name shall be used for ingredients in the list of Ingredients;

3. ***Nutritional information*** – Nutritional Information or nutritional facts per 100 gm or 100ml or per serving of the product shall be given on the label containing the following:—
   - energy value in kcal;
   - the amounts of protein, carbohydrate (specify quantity of sugar) and fat in gram (g) or ml;
   - the amount of any other nutrient for which a nutrition or health claim is made:
   - Provided that where a claim is made regarding the amount or type of fatty acids or the amount of cholesterol, the amount of saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids in gram (g) and cholesterol in milligram (mg) shall be declared, and the amount of trans fatty acid in gram (g) shall be declared in addition to the other requirement stipulated above;
   - Wherever, numerical information on vitamins and minerals is declared, it shall be expressed in metric units;
   - Where the nutrition declaration is made per serving, the amount in gram (g) or milliliter (ml) shall be included for reference beside the serving measure.

4. ***Declaration regarding Veg or Non veg –***
   - Every package of “Non Vegetarian” food shall bear a declaration to this effect made by a symbol and colour code as stipulated below to indicate that the product is Non-Vegetarian Food. The symbol shall consist of a brown colour filled circle having a diameter not less than the minimum size specified inside a square with brown outline having sides double the diameter of the circle.
   - Where any article of food contains egg only as Non-Vegetarian ingredient, the manufacturer, or packer or seller may give declaration to this effect in addition to the said symbol.
   - Every package of Vegetarian Food shall bear a declaration to this effect by a symbol and colour code as stipulated below for this purpose to indicate that the product is Vegetarian Food. The symbol shall consist of a green colour filled circle, having a diameter not less than the minimum inside the square with green outline having size double the diameter of the circle
   - Size of the logo
     1. Upto 100 cms. Square. 3
     2. Above 100 cms. square upto 500 cms square. 4
     3. Above 500 cms square upto 2500 cms square. 6
     4. Above 2500 cms. Square.

- The symbol shall be prominently displayed
  - on the package having contrast background on principal display panel;
  - just close in proximity to the name or brand name of the product;
  - on the labels, containers, pamphlets, leaflets, advertisements in any media;

5. ***Declaration regarding Food Additives-***

- For food additives falling in the respective classes and appearing in lists of food additive permitted for use in foods generally, the following class titles shall be used together with the specific names or recognized international numerical identifications:
- Acidity Regulator, Acids, Anticaking Agent, Antifoaming Agent, Antioxidant, Bulking Agent Colour, Colour Retention Agent, Emulsifier, Emulsifying Salt, Firming Agent, Flour Treatment Agent, Flavour Enhancer, Foaming Agent, Gelling Agent, Glazing Agent, Humectant, Preservative, Propellant, Raising Agent, Stabilizer, Sweetener, Thickener:
- Addition of colours and/or Flavours:-
  - Extraneous addition of colouring matter to be mentioned on the label – Where an extraneous colouring matter has been added to any article of food, there shall be displayed one of the following statements in capital letters, just beneath the list of the ingredients on the label attached to any package of food so coloured, namely:

CONTAINS PERMITTED NATURAL COLOUR(S)

OR

CONTAINS PERMITTED SYNTHETIC FOOD COLOUR(S)

OR

CONTAINS PERMITTED NATURAL AND SYNTHETIC FOOD COLOUR(S)

Provided that where such a statement is displayed along with the name or INS no of the food colour, the colour used in the product need not be mentioned in the list of ingredients.

- Extraneous addition of flavouring agents to be mentioned on the label. Where an extraneous flavouring agent has been added to any article of food, there shall be

written just beneath the list of ingredients on the label attached to any package of food so flavoured, a statement in capital letters as below:

- CONTAINS ADDED FLAVOUR
- In case both colour and flavour are used in the product, one of the following combined statements in capital letters shall be displayed, just beneath the list of ingredients on the label attached to any package of food so coloured and flavoured, namely:-

CONTAINS PERMITTED NATURAL C0LOUR(S) AND ADDED FLAVOUR(S)

OR

CONTAINS PERMITTED SYNTHETIC FOOD COLOUR(S) AND ADDED FLAVOUR(S)

OR

CONTAINS PERMITTED NATURAL AND SYNTHETIC FOOD COLOUR(S) AND ADDED FLAVOUR(S)

6. ***Name and complete address of the manufacturer***

The name and complete address of the manufacturer and the manufacturing unit if these are located at different places and in case the manufacturer is not the packer or bottler, the name and complete address of the packing or bottling unit as the case may be shall be declared on every package of food; Where an article of food is manufactured or packed or bottled by a person or a company under the written authority of some other manufacturer or company, under his or its brand name, the label shall carry the name and complete address of the manufacturing or packing or bottling unit as the case may be, and also the name and complete address of the manufacturer or the company, for and on whose behalf it is manufactured or packed or bottled;

7. ***Net quantity***

(*i*) Net quantity by weight or volume or number, as the case may be, shall be declared on every package of food; and

(*ii*) In addition to the declaration of net quantity, a food packed in a liquid medium shall carry a declaration of the drained weight of the food.

Explanation 1.— For the purposes of this requirement the expression “liquid medium” include water, aqueous solutions of sugar and salt, fruit and vegetable juices or vinegar, either singly or in combination.

Explanation 2.— In declaring the net quantity of the commodity contained in the package, the weight of the wrappers and packaging materials shall be excluded:

(*iii*) Where a package contains a large number of small items of confectionery, each of which is separately wrapped and it is not reasonably practicable to exclude from the net weight of the commodity, the weight of such immediate wrappers of all the items of the confectionery contained in the package, the net weight declared on the package containing such confectionary or on the label thereof may include the weight of such immediate wrapper if the total weight of such immediate wrapper does not exceed –

(*a*) eight per cent, Where such immediate wrapper is a waxed paper or other paper with wax or aluminium foil under strip; or

(*b*) six per cent. In case of other paper of the total net weight of all the items of confectionery contained in the package minus the weight of immediate wrapper.

8***. Lot/Code/Batch identification***

- A batch number or code number or lot number which is a mark of identification by which the food can be traced in the manufacture and identified in the distribution, shall be given on the label.

- Provided that in case of packages containing bread and milk including sterilised milk, particulars under this clause shall not be required to be given on the label.

9. ***Date of manufacture or packing***.— The date, month and year in which the commodity is manufactured, packed or pre-packed, shall be given on the label:

10. ***Best Before and Use by Date***

(*i*) the month and year in capital letters upto which the product is best for consumption, in the following manner, namely:-

“BEST BEFORE ..... MONTHS AND YEAR

OR

“BEST BEFORE ..... MONTHS FROM PACKAGING

OR

“BEST BEFORE .....MONTHS FROM MANUFACTURE

(*ii*) In case of package or bottle containing sterilised or Ultra High Temperature treated milk, soya milk,

flavoured milk, any package containing bread, dhokla, bhelpuri, pizza, doughnuts, khoa, paneer, or any uncanned package of fruits, vegetable, meat, fish or any other like commodity, the declaration be made as follows:—

"BEST BEFORE ……. DATE/MONTH/YEAR"

OR

"BEST BEFORE ..... DAYS FROM PACKAGING"

OR

"BEST BEFORE …….. DAYS FROM MANUFACTURE"

(*iii*) On packages of Aspartame, instead of Best Before date, Use by date/recommended last consumption

date/expiry date shall be given, which shall not be more than three years from the date of packing;

(*iv*) In case of infant milk substitute and infant foods instead of Best Before date, Use by date/

recommended last consumption date/expiry date shall be given,

Provided further that the declaration of best before date for consumption shall not be applicable to

(*i*) wines and liquors

(*ii*) alcoholic beverages containing 10 percent or more by volume of alcohol.

Provided further that above provisions except net weight/net content, nutritional information, manufacturer's name and address, date of manufacture and "best before" shall not apply in respect of carbonated water (plain soda and potable water impregnated with carbon dioxide under pressure) packed in returnable glass bottles.

11. ***Country of origin for imported food:***

(*i*) The country of origin of the food shall be declared on the label of food imported into India.

(*ii*) When a food undergoes processing in a second country which changes its nature, the country in which the processing is performed shall be considered to be the country of origin for the purposes of labelling.

12. ***Instructions for use:***

Instructions for use, including reconstitution, where applicable, shall be included on the label, if necessary, to ensure correct utilization of the food.

Penalties & Punishment:

- Selling food not of the nature or substance or quality demanded - may extend to five lakh rupees.
- Misleading advertisement - may extend to ten lakh rupees.
- Unhygienic or unsanitary processing or manufacturing of food - may extend to one lakh rupees.
- False Information - Punishable with imprisonment for a term which may extend to three months and also with fine which may extend to two lakh rupees.
- Unsafe food –
  - Does not result in injury, with imprisonment for a term which may extend to six months and also with fine which may extend to one lakh rupees;
  - Results in a non-grievous injury, with imprisonment for a term which may extend to one year and also with fine which may extend to three lakh rupees;
  - Results in a grievous injury, with imprisonment for a term which may extend to six years and also with fine which may extend to five lakh rupees;
  - Results in death, with imprisonment for a term which shall not be less than seven years but which may extend to imprisonment for life and also with fine which shall not be less than ten lakh rupees.

4.12. FSSAI registration and licensing procedure:

The licensing and registration procedure and requirements are regulated by Food Safety & Standards (Licensing and Registration of Food Business) Regulations, 2011.

Registration is meant for petty food manufacturers that includes petty retailer, hawker, itinerant vendor or a temporary stall holder or small or cottage scale industry having annual turnover up to 12 lacs.

All food businesses having income more than this limit are required to take a license.

FSSAI issues two types of license based on the nature of food business and turnover:

1. State License: For Turnover between 12 Lakh to 20 Crore
2. Central License: For Turnover above 20 Crore

Other criteria like the location of the business, number of retail stores etc. is needed while evaluating the nature of license applicable.

Food Licensing and Registration System (FLRS):

- It is an online Registration/Licensing System. http://foodlicensing.fssai.gov.in
- It also provides an option to track the status of application online through an Application Reference No. provided by the system during the submission of application.

- The FBOs should take a print out of the Online Application Form generated through the system and submit the application to Regional Authority/State Authority with all supportive documents within fifteen days from the date of online submission of application for State License and Registration Certificate.
- FBO can register themselves online for the username and password.
- Registration - Form A; License – Form B

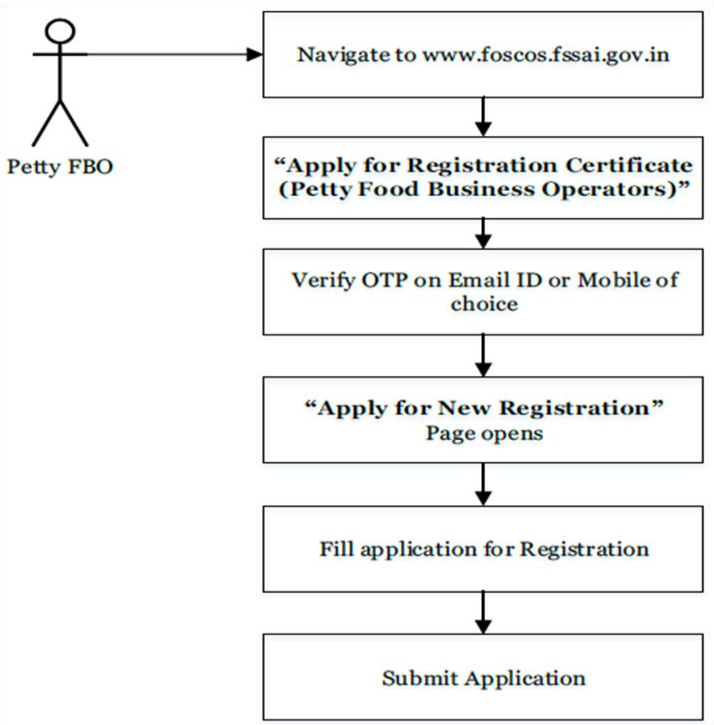
FLRS to FoSCoS

- FSSAI has launched Food Safety Compliance System in the States/UTs of Tamil Nadu, Puducherry, Gujarat, Goa, Odisha, Manipur, Delhi, Chandigarh and Ladakh with effect from 1st June 2020.
- This system replaces the existing online Food Licensing and Registration System
- Users of these States/UTs are required to visit https://foscos.fssai.gov.in and login through same user ids and passwords.

Documents required for Petty FBO Registration Certificate

- Photo
- Government issued Photo ID such as AADHAAR, PAN, Voter ID etc.
- Proof of Address of Businesses activity (if address is other than as mentioned in Photo ID Card)

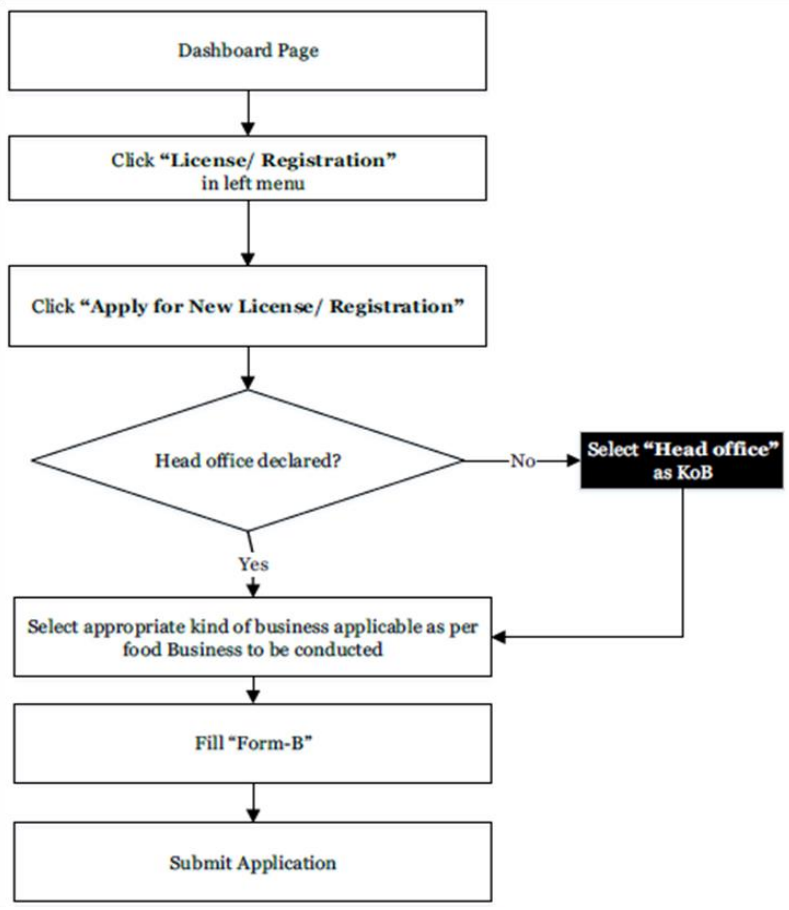
Guideline for online registration:

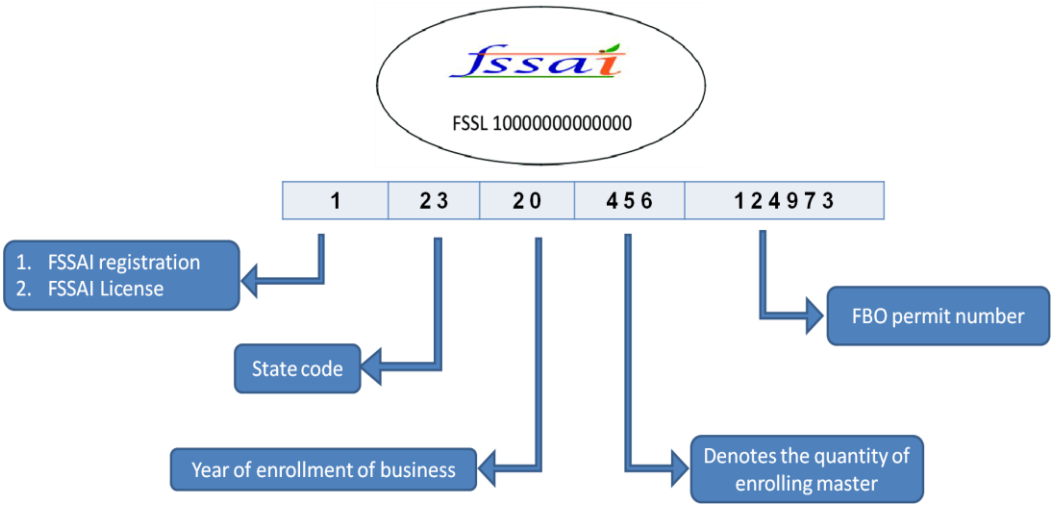


Documents required for License

- Blueprint/layout plan of the processing unit showing the dimensions in metres/square metres and operation-wise area allocation (mandatory for manufacturing and processing units only)
- List of Directors with full address and contact details (mandatory for companies only)
- Name and List of Equipments and Machinery along with the number, installed capacity and horse power used
- Analysis report (Chemical & Bacteriological) of water to be used as ingredient in food from a recognized/ public health laboratory to confirm the potable
- Upload Production unit photograph
- Photo I.D and address proof issued by Government authority of Proprietor/ Partner/Director(s)/Authorised Signatory. .
- Proof of possession of premises. (Sale deed/ Rent agreement/ Electricity bill, etc.).
- Partnership Deed/Self Declaration for Proprietorship/Memorandum & Articles of Association towards the constitution of the firm
- Form IX: Nomination of Persons by a Company along with the Board Resolution.

Guideline for online registration:





Flow of registration and licensing

Suggested literature:

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- Gordon L Robertson. Food Packaging Principles and Practice. 2nd edition, CRC Press, 2006.
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- Halder, P., & Pati, S. (2011). A Need for Paradigm Shift to Improve Supply Chain Management of Fruits & Vegetables in India. Asian Journal of Agriculture and Rural Development, 1 (1), 1-20.
- Saurav Negi and Neeraj Anand (2015) ISSUES AND CHALLENGES IN THE SUPPLY CHAIN OF FRUITS & VEGETABLES SECTOR IN INDIA: A REVIEW. International Journal of Managing Value and Supply Chains (IJMVSC) 6(2). DOI: 10.5121/ijmvsc.2015.6205 47
- **IIFT, GoI:** Fruits and vegetables Supply Chain in India
- http://agritrade.iift.ac.in/html/Training/ASEAN%20%E2%80%93%20India%20FTA%20%20Emerging%20Issues%20for%20Trade%20in%20Agriculture/Fruits%20and%20vegetables%20Supply%20Chain%20in%20India.pdf
- APEDA: https://apeda.gov.in/apedawebsite/Announcements/Note_on_Pack_House.pdf
- FAO (2012). Good practice in the design, management and operation of a fresh produce packing-house. RAP Publication. Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific Bangkok.
- FSSAI (2019). FSMS guidance document-fruits and vegetables.
- FSSAI (2018). Guidance Document Food Laboratory.

ANNEXURE

PM Formalisation of Micro Food Processing Enterprises Scheme (PM FME Scheme)

1. Background

1.1 The unorganized food processing sector comprising nearly 25 lakh units contributes to 74% of employment in food processing sector. Nearly 66% of these units are located in rural areas and about 80% of them are family-based enterprises supporting livelihood in rural household and minimizing their migration to urban areas. These units largely fall with in the category of micro enterprises.

1.2 These units face a number of challenges which limit their performance and growth. These challenges include lack of access to modern technology & equipment, training, access to institutional credit, lack of basic awareness on quality control of products, and lack of branding & marketing skills, etc. Therefore, the unorganised food processing sector contributes much less in terms of value addition and output despite its huge potential.

25 Lakh unorganised food processing units contribute to **74%** of employment in food processing sector

2. Objectives

2.1 Taking cognizance of the contribution of the unorganized micro food processing enterprises and the challenges that impede their performance, Ministry of Food Processing Industries (MoFPI) has launched "PM Formalisation of Micro Food Processing Enterprises Scheme (PM FME Scheme)" through a package support and services. The objectives under the scheme, inter alia, include:

(i) Capacity building of entrepreneurs through technical knowledge, skill training and hand holding support services;

(ii) Increased access to credit to existing micro food processing entrepreneurs for technology upgradation;

(iii) Support to Farmer Producer Organizations (FPOs), Self Help Groups (SHGs), Producers Cooperatives & Cooperative Societies along their entire value chain to enable microenterprises to avail common services.

(iv) Support for transition of existing enterprises into formal framework for registration under regulatory framework and compliance;

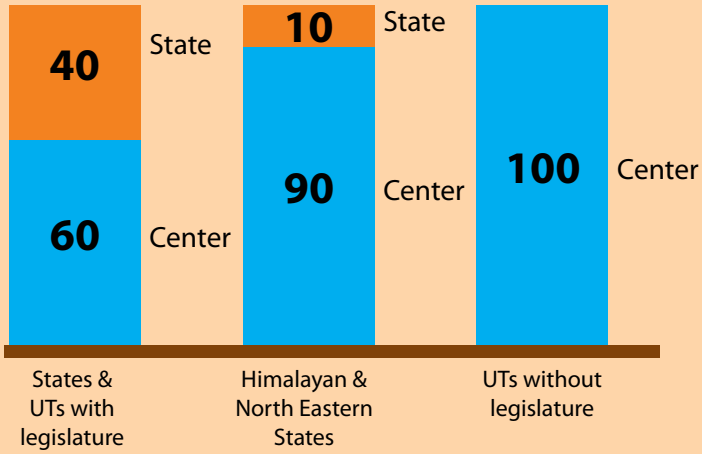
(v) Integration with organized supply chain by strengthening branding & marketing;

3. Coverage of States/ UTs and Funding Pattern

3.1 It is an All India Centrally Sponsored Scheme with an outlay of Rs. 10,000 crore for coverage of 2,00,000 enterprises over 5 years from 2020-21 to 2024-25. The expenditure under the scheme would be shared in 60:40 ratio between Central and State Governments, in 90:10 ratio with North Eastern and Himalayan States, 60:40 ratio with UTs with legislature and 100% by Center for other UTs.

3.2 Expenditure in the first year 2020-21, whether incurred by the Centre or the States would be borne 100% by the Central Government. The expenditure made for the first year would be adjusted in ratio given above in the funds being transferred to the States equally in the next four years.

Fund Sharing Pattern Between Center & State



3.3 Funds under the Scheme would be provided to the States based on the approved Project Implementation Plan (PIP).

4. One District-One Product Approach

4.1 The Scheme will adopt a One District One Product (ODOP) approach to reap benefit of scale in terms of procurement of inputs, availing common services and marketing of products. One District One Product approach would provide framework for value chain development and alignment of support infrastructure. There may be more than one cluster for one product in one district. A cluster may also extend beyond one district. The States would identify food product for a district, keeping in perspective the focus of the scheme on perishables. The ODOP could be a perishable agri-produce, cereal based product or a food product widely produced in a district and their allied sectors. Illustrative list of such products includes mango, potato, litchi, tomato, tapioca, kinnu, bhujia, petha, papad, pickle, millet based products, fisheries, poultry, meat as well as animal feed among others. With respect to support to existing individual micro units, preference would be given to those producing under ODOP approach. However, units producing other products would also be supported. In case of groups, predominately, those involved in products under ODOP approach would be supported. Support to groups processing other products in such districts would only be for those already processing those products and with adequate technical, financial and entrepreneurial strength. Support for common infrastructure and marketing & branding would only be for products under ODOP approach. In case of support for marketing & branding at State or regional level, same product of districts not having that product as ODOP could also be included.

4.2 The scheme would also support strengthening of backward and forward linkages, provision of common facilities, incubation centres, training, R&D, marketing & branding, provision of which would primarily be for ODOP products. Further, this approach would also complement and benefit from the existing promotional efforts of the Government such as development of Agriculture Crop Clusters under the Agriculture Export Policy, the cluster approaches of the Ministry of Agriculture and the Ministry of Rural Development through the National Rurban Mission.

5. Support to Food Processing Units

Support to food processing units would be provided for the following:

(i) Credit linked grant at 35% of the project cost with maximum grant up to Rs 10.0 lakh to existing unorganised food processing units for upgradation;

(ii) Credit linked grant at 35% of the project cost to SHGs/FPOs/cooperatives for capital expenditure with maximum limit as prescribed;

(iii) Seed capital @ Rs. 40,000/- per member to those engaged in food processing as a working capital;

(iv) Credit linked grant at 35% of the project cost for common infrastructure with maximum limit as prescribed;

(v) Support for marketing & branding up to 50% of the expenditure with maximum limit as prescribed.

6. Upgradation of Processing Units

6.1 Individual Category: Individual micro food processing units would be extended credit-linked capital subsidy @35% of the eligible project cost for expansion/ technology upgradation with a maximum ceiling of Rs.10 lakh per unit. The beneficiary contribution should be minimum 10% and the balance should be loan from a Bank.

6.1.1 Eligibility criteria:

(i) Individual / Partnership Firm with ownership right of the enterprise;

(ii) Existing micro food processing units in the survey or verified by the Resource Person;

(iii) The applicant should be above 18 years of age and should possess at least VIII standard pass educational qualification;

(iv) Only one person from one family is eligible for obtaining financial assistance. The "family" for this purpose would include self, spouse and children.

6.1.2 Procedure for applying for upgradation:

6.1.2.1 Applications would be invited at the district level on an ongoing basis for units interested in availing the benefits under the Scheme. Existing food processing units desiring to seek assistance under the scheme should apply on the FME portal. Loan proposals would be recommended to the Banks after scrutiny. States would decide the appropriate level for short listing of the applications to be recommended to the Banks.

6.1.3 Procedure with Banks for Grant:

6.1.3.1 At the national level, a Nodal bank would be appointed for disbursement of subsidy to the banks and liaison with the banks extending loan to the beneficiaries. The bank sanctioning the loan would open a mirror account in the name of the beneficiary. Grant by the Central and State Government in 60:40 ratio would be deposited in this account of beneficiary in the lending bank branch by the State and Central Government. If after a period of three years from the disbursement

of last tranche of the loan, the beneficiary account is still standard and the unit is operational, this amount would be adjusted in the bank account of beneficiary. Release of grant for groups and common infrastructure would also be done in their bank account following the same principle.

6.2 Group Category: The Scheme would provide support in clusters to groups such as FPOs/ SHGs/ producer cooperatives along their entire value chain. SHGs / FPOs / Producer Cooperatives would be provided the following support:-

(i) Grant @35% with credit linkage for capital investment with maximum limit as prescribed;

(ii) Training support;

(iii) Support for marketing and branding for products under ODOP for developing common brand.

6.2.1 Eligibility Criteria:

(i) It should be engaged in processing of ODOP produce for at least three years;

(ii) In case of FPOs / cooperatives, they should have minimum turnover of Rs.1 crore and the cost of the project proposed should not be larger than the present turnover;

(iii) The SHG / cooperative / FPO should have sufficient internal resources to meet 10% of the project cost and margin money for working capital.

6.3. Seed Capital to SHG:

The scheme envisages provision of Seed Capital @ Rs. 40,000/- per member of SHG engaged in food processing for working capital and purchase of small tools. Seed capital as grant would be provided at the federation level of SHGs which, in turn, will be extended to members as loan through SHG.

6.3.2 Eligibility criteria:

6.3.2.1 For Seed Capital, only SHG members who are presently engaged in food processing would be eligible. The SHG member has to commit to utilize this amount for working capital as well as purchase of small tools and give a commitment in this regard to the SHG and SHG federation.

7. Creation of Common Infrastructure

7.1 FPOs/ SHGs/ Producer Cooperatives /State agencies or private enterprises would be supported for creation of common infrastructure including for common processing facility, incubation center, laboratory, warehouse, cold storage, etc. Eligibility of a project under this category would be decided based on benefit to farmers and industry at large, viability gap, absence of private investment, criticality to value chain, etc. Credit linked grant would be available @ 35% with maximum limit as prescribed.

8. Branding and Marketing Support

8.1 Marketing and branding support will be provided to FPOs/SHGs/Cooperatives or an SPV of micro food processing enterprises under the scheme following the cluster approach for developing common packaging & branding with provision for quality control, standardization and adhering to food safety parameters for consumer retail sale.

8.2 Support for Marketing and Branding requires a minimum volume which can be generated through active involvement of FPO/ SHG/ Cooperatives to bring large number of producers together. These organisations would be supported based on DPR prepared by them indicating essential details of the project. Support up to Rs.5 lakh would be available from State Nodal Agency for preparing DPR for proposals for branding & marketing.

8.3 Support for branding and marketing would be limited to 50% of the total expenditure with maximum limit as prescribed. Proposal from states or national level institutions or organizations or partner institutions for branding & marketing will be supported for vertical products at the national level. No support would be provided for opening retail outlets under the scheme.

8.4 Procedure for Applying for Support:

8.4.1 In case of SHGs/FPOs/cooperatives or SPV interested in applying for support for branding and marketing under the Scheme, DPR should be prepared and submitted to State Nodal Agency (SNA). SNA would appraise the proposal and with recommendation from the State Level Approval Committee (SLAC) seek approval from MOFPI. Thereafter, the proposal would be recommended to a Bank for sanction of loan. Same procedure should be followed for applying for support for creation of common infrastructure as well.

9. Capacity Building & Research

9.1 Training is a critical component in technical upgradation and formalization of micro food processing enterprises. All individuals & institutions members receiving grant would undergo training for upgradation of their skills. In addition, training support would also be provided to other existing individual units and groups producing ODOP product in the district, even if they are not being supported through

credit linked grant. Training support would also be provided for units that are part of support for Marketing & Branding or have potential to join such network.

9.2 National Institute for Food Technology Entrepreneurship and Management (NIFTEM) and Indian Institute of Food Processing Technology (IIFPT), two national level food processing technology institutions under MOFPI are given responsibility to spearhead capacity building and research. At the State level, they would partner with a State Level Technology Institution in food processing technology selected by the State Government for conducting capacity building and training.

9.3 Training to individual and group beneficiaries will focus on entrepreneurship development, essential functions of enterprise operations, book keeping, registration, FSSAI standards, Udyog Aadhar, GST Registration, general hygiene, packaging, marketing etc. Specific training designed on the model of ODOP and the vertical focus products will be undertaken nearer to the work place of the entrepreneurs. Existing infrastructure of Rural Self Employment Training Institutes (RSETI) and other institutions at the district level will be utilized for imparting training.

10. Partner Institutions

10.1 The scheme lays special focus on SCs/STs, women and aspirational districts and FPOs, SHGs and producer cooperatives. TRIFED, National SC Development Finance Corporation, NCDC, Small Farmer Agri-Business Consortium (SFAC) and National Rural Livelihood Mission under Ministry of Rural Development have been working in these areas. The above institutions may converge their activities by facilitating identification of units / clusters of STs, SCs, cooperatives, FPOs and SHGs respectively and feed this into state PIPs.

11. Implementation & Monitoring Mechanism

11.1 The Scheme will have the following management structure at the Central, State and District level for effective implementation and monitoring of the scheme:

11.2 Inter-Ministerial Empowered Committee (IMEC): IMEC at the Central level, will be chaired by Minister for Food Processing Industries (MoFPI) for general superintendence, guidance and overall direction for implementation of the scheme, monitoring of progress and reviewing its performance. IMEC will approve scheme guidelines, Project Implementation Plan (PIP) of the State/ UTs under the scheme and various projects of capital investment by SHGs/FPOs/ cooperatives, common infrastructure facilities and proposals of marketing & branding for project size above Rs 10 lakh. A Project Executive Committee (PEC) will be constituted in MoFPI for undertaking administrative function and regular monitoring of the scheme at operational level. A National Programme Management Unit (NPMU) will be set up to assist MoFPI to provide secretarial, managerial and implementation support.

11.3 State Level: State Governments would appoint a Nodal Department and a State Nodal officer to oversee the implementation of the Scheme. The Scheme will be implemented by a State Nodal Agency (SNA) assisted by the State PMU. A State Level Approval Committee chaired by the Chief Secretary will oversee the implementation of the Scheme. The Committee will sanction expenditure up to Rs 10 lakh on various activities related to the implementation of the scheme. A District Level Committee (DLC) would be constituted under the Chairmanship of District Collector.

11.5 District Resources Persons (DRPs) would be appointed by SNA for providing handholding support to the beneficiaries. Handholding support would be for preparation of DPR, taking bank loan, support for obtaining necessary registration and licences including food standards of FSSAI, Udyog Aadhar, GST etc.

12. Studies & Reports

12.1 State Governments should undertake the following studies:

(i) Base-Line Assessments: A baseline study should be undertaken to identifying ODOP. This study should get concluded by 31 July, 2020 in each State. For this study, Rs. 2.5 – 10.0 lakh would be provided to the States.

(ii) State Level Upgradation Plan(SLUP): Once decision is taken on the ODOP, detailed studies should be carried out in the States detailing the number of units undertaking processing of that product in the district, farm level of operations, total volume and value of produce, technology, farm gate level processing, storage, warehousing, etc. This study should be concluded by 31 December, 2020. The amount provided for the above study would be Rs. 25.0 – 75.0 lakh to States.

13. Detailed Guidelines

Detailed guidelines of the scheme may be view at Ministry's website mofpi.nic.in

IIFPT

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