HORTICULTURE

POST HARVEST TECHNOLOGY

Principles of Food Processing

Dr Shruti Sethi
Scientist
Division of Post Harvest Technology
Indian Agriculture Research Institute
New Delhi-110012

(09-10-2007)

CONTENTS

Keywords

Fruit, vegetable, spices, flower, thermal processing, drying, dehydration, water activity, freezing, irradiation, fermentation, chemical additives, microbial stability, intermediate moisture foods, packaging, marketing, distribution, food quality, food laws, R&D Institutes

History of Food Processing

Food processing dates back to the prehistoric age when crude processing including various types of cooking, such as over fire, smoking, steaming, fermenting, sun drying and preserving with salt were in practice. Foods preserved this way were a common part of warriors' and sailors' diets. These crude processing techniques remained essentially the same until the advent of the Industrial Revolution. Nicolas Appert developed a vacuum bottling process to supply food to troops in the French army, which eventually led to canning in tins by Peter Durand in 1810. Modern food processing technologies, in the 19th century were also largely developed to serve military needs. In the early 20th century, the space race, change in food habits and the quality conciousness of the consumers in the developed world furthered the development of food processing with advancements such as spray drying, juice concentrates, freeze drying and the introduction of artificial sweetners, colourants, and preservatives. In the late 20th century products including dried instant soups, reconstituted fruit juices, and self cooking meals such as ready-to-eat food rations etc., were developed.

Importance, Scope and Benefits of Processing of Horticultural Crops

Horticulture is a crucial component of agriculture, which is the mainstay of Indian economy. Horticulture sector includes fruits, vegetables, root and tuber crops, spices, mushrooms, honey, floriculture, medicinal and aromatic plants and nuts. These crops though account for only 6-7 per cent of the total area (176.4 mha) under cultivation, provide more than 25 per cent of total agricultural GDP and the total agricultural exports. Inspite of having varied agro-climatic conditions, abundance of natural resources like sunlight and water, sufficient labour availability and abundant produce, our country is trailing behind in productivity, export and processing of horticultural produce as compared with other horticulturally advanced countries. Further, due to lack of adequate post harvest handling, processing and infrastructure facilities, post harvest losses caused by spoilage are very high. It is estimated that post harvest losses of horticultural produce range between 8-37 per cent. Generally losses occur during pre-harvesting, harvesting, transportation, storage, processing, packing, marketing and distribution stages. Even if 10 per cent of these losses could be saved by converting the surplus into processed products, there will be considerable saving to the horticultural wealth in the country. The international trade in preserved horticultural crops consists largely of fruit juices, nectars, juice concentrates, canned pineapple, canned pulps, canned and dehydrated vegetables, instant chutneys and ready-to-use products. Tropical vegetables, fruits, spices and aromatic plants grown in India having nutritional and appetizing appeal have great export potential to the rest of the world because of their medicinal, therapeutic and antioxidant properties as health foods. There is further scope for augmenting exports with respect to tropical fruit juices, pulps and concentrates. Products obtained from fruits like mango, guava, papaya, pineapple and large number of other highly nutritive indigenous fruits, vegetables as well as from floral and medicinal crops have great demand for domestic and export market.

Benefits of Processing

- Converts raw food and other farm produce into edible, usable and palatable form
- Helps to store perishable and semi-perishable agricultural commodities, avoid glut in the market, check post harvest losses and make the produce available during off-season
- Generates employment
- Development of ready-to-consume products, hence saves time for cooking

- Helps in preservation
- Helps in improving palatability and organoleptic quality of the produce by value addition
- Helps in easing marketing and distribution tasks
- Increases seasonal availability of many foods
- Enables transportation of delicate perishable foods across long distances
- Makes foods safe for consumption by checking of pathogenic microorganisms
- Modern food processing also improves the quality of living by way of healthy foods developed for allergics, diabetics, and other people who cannot consume some common food elements
- Food processing can also bring nutritional and food security
- Provides potential for export to fetch foreign exchange

Aim of Preservation/ Processing

Based on the perishability and the extent of preservation required, foods may be classified as:

1. ***Perishable foods*:** Those that deteriorate readily (fruits and vegetables) unless special methods of preservation are employed.
2. ***Semi-perishable foods***: Those that contain natural inhibitors of spoilage (root vegetables) or those that have received some type of mild treatment which creates greater tolerance to the environmental conditions and abuses during distribution and handling (such as pickled vegetables).
3. ***Non-perishable foods*** *(shelf-stable)*: Those that are non-perishable at room temperature (cereal grains, sugar, nuts). Some have been made shelf stable by suitable means (canning) or processed to reduce their moisture content (raisins). Food preservation in the broad sense, refers to all the measures taken against any kind of spoilage in food.

The main causes of spoilage of horticultural produce are microbiological (bacteria, yeasts, moulds), chemical (enzymatic discolouration, rancidity, oxidation) and physical (bruising) factors. There are many reasons for processing foods besides the development of a business with a good return on investment for the owners such as to prevent post harvest losses, to eliminate waste, to preserve quality, to preserve the nutritive value of the raw materials, to make seasonal horticultural produce available throughout the year, to put them in convenient form for the user, to safely put the food away for emergencies and to develop new products and to increase the value of the product. Food preservation, in the broad sense, refers to all the measures taken against any kind of spoilage in food. It is the process of treating and handling food in such a way so as to stop or greatly slow down spoilage to prevent foodborne diseases while maintaining nutritional value, texture and organoleptic quality as well as increasing shelf life. Proper packaging and storage of processed/preserved products are also important aspects of agro-processing to retain quality of fresh horticultural produce which could be adversely affected by physical damage, chemical reactions, microbiological changes and attack by insects and rodents.

Principles and Methods of Value Addition

Principles of Preservation: In accomplishing the preservation of foods by various methods, the following principles are involved:

1. Prevention or delay of microbial decomposition
    - By keeping out microorganisms (asepsis)

- By removal of microorganisms e.g. filteration
- By hindering the growth and activity of microorganisms e.g. by low temperature, drying, anaerobic conditions or use of chemicals
- By killing the microorganisms e.g use of heat or radiation

2. Prevention or delay of self-decomposition of the food
    - By destruction or inactivation of food enzymes e.g. blanching
    - By prevention or delay of purely chemical reactions e.g. prevention of oxidation by means of an antioxidant
3. Prevention of damage caused by insects, rodents, mechanical damage etc.

Methods of Value Addition: Food preservation methods can be broadly divided into two categories i.e.: (i) Bacteriostatic methods in which microorganisms are unable to grow in the food because of the alteration of environmental conditions, e.g. in dehydration, pickling, salting, smoking, freezing etc. and (ii) Bactericidal methods in which most of the microorganisms present in the food are killed, e.g. in canning, cooking, irradiation etc. The preservation of food can be accomplished by physical, chemical and biological means.

(I) Physical Approaches to Food Preservation

- Removal of microorganisms e.g. asepsis and filtration
- Raising the temperature of food e.g. heating (blanching, pasteurization/ sterilization, flash pasteurization/HTST processing)
- Controlled reduction of product temperature e.g. chilling and freezing
- Controlled reduction in the water content of food products e.g. dehydration, freeze drying, osmotic dehydration
- Use of protective packaging such as prepackaging and use of modified atmosphere packaging
- Use of radiations such as ionizing radiations
-

a) **Asepsis and filtration**: Asepsis means preventing the entry of microorganisms. Maintaining of general cleanliness while harvesting, grading, packing and transportation of horticultural produce increases their keeping quality. Washing and wiping of the fruits and vegetables before processing should be strictly followed to reduce the soil particles, pesticide residues and initial contamination by microorganisms. Filtration of liquid foods through 0.45micron seitz filters helps to remove microorganisms and thus minimizes the chances of spoilage.

b) Thermal Processing: Since many of the processes utilized to preserve food products depend on the addition of thermal energy, it is important to understand its underlying principles. The design of a thermal process to achieve food preservation involves two principles: (a) the use of elevated temperatures to increase the rate of reduction in the microbial population present in the raw food material (Microbial population may refer to the number of vegetative cells existing in food product or to the number of microbial spores in a given mass of food) and (b) the transfer of thermal energy into the food products as required for achieving the desired elevated temperatures.

Principles of Thermal Processing

- **Influence of elevated temperatures on microbial populations:** The reduction in microbial population occurs in a logarithmic manner with increasing time at a given constant elevated temperature. The time required for one log cycle reduction in microbial

population is the decimal reduction time (D). The decimal reduction time, or D-value also represents the time required for 90 per cent reduction in the microbial population. The D-value is presented on the logarithmic scale, while temperature is presented on the standard scale, and the decrease in D-value becomes linear as the temperature increases. This linear relationship is referred to as the *thermal resistance curve* for a given microbial population. The thermal resistance curve leads to the definition of a second parameter utilized to characterize thermal resistance of microbial populations i.e., Z-value. The temperature increase required to cause a one log cycle reduction in the decimal reduction time is defined as the thermal resistance constant (Z-value). The third quantitative parameter related to thermal processing is thermal death time (F), or F-value. Thermal death time is defined as the *time required for achieving a stated reduction in the microbial population at a given temperature*. The larger the F-value at a given temperature, the more resistant the microbial population is to that particular elevated temperature.

- **Establishment of product shelf life and/or safety:** The purpose of thermal process is to ensure product safety or the desired shelf life. The thermal resistance parameters for the microbial population must be used to establish the time/temperature relationship needed to provide the desired shelf life and/or product safety. The factors responsible for the thermal resistance of the microorganisms are the species in the microbial population, food composition, pH, oxygen and water activity of the product.
- **Influence of the thermal process on product quality:** Exposure to temperatures above ambient conditions causes detectable changes such as reduction in organoleptic quality as well as reduction in heat-sensitive nutrients. In general, these types of product quality changes demand that thermal processes must be carefully designed to avoid over processing and unnecessary reductions in product quality. The highest temperature and shortest time process can achieve the desired results in terms of product shelf life or product safety while retaining the maximum possible product quality.

Thermal Processing Methods: The severity of the heat treatment and the resulting extension of the shelf life are determined mostly by the pH of the food. In low acid foods (pH>4.5), the main purpose is destruction of pathogenic bacteria whereas, in case of pH below 4.5, destruction of spoilage microorganisms or inactivation of enzyme is usually more important. Heat processing requirements of some of the fruits and vegetables based on different acidity and pH values are given in Table 1.

Table 1: Heat processing requirements for different products based on different acidity and pH

Acidity class of food	pH	Food item	Processing requirements
Low acid	5.0 – 7.0	Peas, carrots, beets, potatoes, asparagus, tomato soup	High temperature processing 116-121°C (240-250°F)
Medium acid	3.7 - 4.5	Tomatoes, pears, apricots, peaches	-do-
Acid	3.0 - 3.7	Sauerkraut, pineapple, apple	Boiling water processing 100°C (212°F)
High acid	3.0 – 2.3	Pickles, lime juice	-do-

In general, higher temperatures and longer period of heating produce greater destruction of microorganisms and enzymes. High temperature short time process achieves the same extension of shelf life as the treatment at lower temperatures and longer times but permit greater retention of sensory and nutritive properties of foods. At higher temperatures, overcooking may lead to textural disintegration and undesired cooked flavour and nutritional deterioration.

Thermal processing used for preservation is usually classified as follows:
i) Blanching: Blanching is used to destroy enzyme activity in fruits and vegetables, prior to processing. As such, it is not a sole method of preservation but is applied as a pretreatment, which is normally carried out between the preparation of raw material and later operations. The factors that influence blanching time include type of fruit or vegetable, the size of the cut pieces, temperature and the medium of heating such as boiling water, steam, microwaves etc. Blanching helps in several ways as it inactivate enzymes, which prevents undesirable changes in sensory characteristics and nutritional properties that take place during storage, reduces the number of contaminating microorganisms on the surface of foods, leads to softening of vegetable tissues thus facilitating can filling and helps in removal of air from intercellular spaces.

ii) Pasteurization: Pasteurization is a process of heat treatment used to inactivate enzymes and to kill relatively heat sensitive pathogenic microorganisms that cause spoilage, with minimal changes in food properties (e.g. sensory and nutritional). It is a relatively mild heat treatment, usually performed below 100°C. Pasteurization does not aim at killing spore forming microorganisms. It is convenient to separate pasteurization practices into two broad categories: one involving heating of foods in their final containers, the other applying heat prior to packaging. The latter category includes methods that are inherently less damaging to food quality, where the food can be readily subdivided (such as liquids) for rapid heat exchange. However, these methods then require packaging under aseptic or nearly aseptic conditions to prevent or at least minimize recontamination. On the other hand, heating within the package frequently is less costly and produces quite acceptable quality with the majority of foods. In practice, therefore, most of the canned foods produced locally in developing countries such as canned peas and tomatoes, canned pineapple slices etc. are heated within the package.
There are two categories of pasteurization process:

a) Low temperature long time (LTLT): 62.7°C for 30 minutes
b) High temperature short time (HTST): 71.7°C for 15 seconds

iii) Sterilization: In this process foods are heated at a sufficiently high temperature (121°C) and for a sufficiently long time (10-15 minutes) to destroy microbial and enzyme activity. As a result, sterilized foods have a shelf life of more than six months. Higher temperature for a short time (140°C/3-4 seconds) is possible if the product is sterilized before it is filled into pre-sterilized containers in a sterile atmosphere. This forms the basis of Ultra High Temperature (UHT) processing (also termed **aseptic processing**). It is used to sterilize a wide range of liquid foods (fruit juices and concentrates, wine, etc.) and foods which contain small discrete particles (tomato products, fruit and vegetable soups).

iv) Commercial Sterilization: The term describes the condition that exists in most of canned or bottled products manufactured under Good Manufacturing Practices (GMP) procedures and methods. It is the degree of sterilization at which all pathogenic and toxin forming organisms have been destroyed along with other spoilage causing organisms, which if present, could grow

in the product and produce spoilage under normal handling and storage conditions. Commercially sterile foods may contain a small number of heat resistant spores but these will not normally multiply in the foods. These products generally have a shelf life of two years or more. Canning also termed as 'Appertization' is defined as the preservation of foods in hermetically sealed containers and usually implies the heat treatment as the principle factor in prevention of spoilage.

Advantages of thermal processing

- Food becomes more tender and pliable with the desired cooked flavour and taste
- Preservative effect on foods owing to destruction of microorganisms, enzymes, insects and parasites
- Destruction of antinutritional components in food
- Improvement in bioavailability of some nutrients (for example improved digestibility of proteins and gelatinization of starches etc.)
- Relatively simple control of processing conditions

c) Drying/Dehydration: Preservation of foods by drying is perhaps the oldest method known. Drying is a thermo-physical action and its dynamic principles are governed by heat and mass transfer laws inside and outside the product. The weight of the product is reduced to the extent of $1/4^{th}$ to $1/9^{th}$ of its original fresh weight. Drying of foods and biological products is a widely applied process for different purposes such as increasing shelf life, reducing packaging costs, lowering shipping wastes, encapsulating flavours, making food available during off-season, adding value by changing the phase structure of the native material and maintaining nutritional value. Drying or dehydration of fruits and vegetables can be accomplished with little capital while maintaining high quality and obtaining less perishable food products.

Principle of preservation: Microorganisms in a healthy growing state may contain in excess of 80 per cent water. They get this water from the food in which they grow. Horticultural crops contain enough water to permit their spoilage by the activity of microorganisms and enzymes. To be a suitable substrate to support the growth of microorganisms, a food must have sufficient free water. By reducing the free water content (lowering of water activity below 0.7), thereby increasing osmotic pressures (simultaneous concentration of total solids, viz., sugars, salt, organic acids), microbial growth can be controlled. This reduction in water content controls the biological and chemical forces that act upon fruits and vegetables, facilitating preservation of these perishables. Drying or dehydration reduces the amount of available moisture i.e. the water activity (a_w) and hence, product becomes shelf-stable and is preserved for quite a long period. Water activity is a property of solutions or food and is the ratio of vapour pressure of the solution or food over the vapour pressure of pure water at the same temperature. Qualitatively, water activity is a measure of unbound, free water in a system available to support biological and chemical reactions. Two foods with the same water content can have very different a_w values depending upon the degree to which water is free or otherwise bound to food constituents. When a food is in moisture equilibrium with its environment, then the a_w of the food will be quantitatively equal to the equilibrium relative humidity (ERH) divided by 100.The low water content slows the rate of respiration, enzymatic action and overall deterioration rate that makes products less susceptible to decay and much easier and less expensive to store and transport. While all horticultural produce can be dried, not all commodities are converted into high quality, good tasting dried products. Bacteria and yeasts generally require more moisture than moulds, and so moulds often will be found growing on semi-dry foods where bacteria and yeasts find conditions unfavourable such as moulds growing on partially dried fruits. Slight variations in

relative humidity of the environment in which the food is kept or in the food package, can make great difference in the rate of microorganism multiplication. Drying of horticultural produce can be done naturally in sun (direct solar drying), via solar assissted methods (indirect solar drying), or in machines with added ventilation and heat to speed the process (electric, gas or diesel powered dryers). Pretreatments such as blanching and ascorbic acid dips used before drying can assist to reduce losses of flavour, colour and nutritional quality. Value can be added to dried products by enhancing flavour during drying (by adding spices to vegetables, or sweetening fruits with sugar or honey dips).

Mechanism of drying/dehydration: Aim of dehydration is to lower the water activity to a level at which deterioration of food quality takes place at a rate slow enough to allow long term storage. The process involves the application of heat to vapourize water and some means of removing water vapour after its separation from the fruit/vegetable tissues. Hence, it is a combined/simultaneous heat and mass transfer operation for which energy must be supplied. A current of air is the most common medium for transferring heat to a drying tissue and convection is mainly involved. In order to assure products of high quality at a reasonable cost, dehydration must occur fairly rapidly. Four main factors affect the rate and total drying time, namely the properties of the products (especially particle size and geometry), the geometrical arrangement of the products in relation to heat transfer medium (drying air), the physical properties of drying medium/ environment and the characteristics of the drying equipment. It is generally observed with many products that the initial rate of drying is constant and then decreases, sometimes at two different rates. Factors influencing drying rate include surface area, temperature, air velocity and dryness of air, atmospheric pressure and time.

During dehydration process itself, some deterioration of quality occurs. Most common changes associated with dehydration process are textural changes in the food due to removal of water and subsequent cross linking of polymeric constituents, flavour and nutrient losses apart from quality changes due to chemical reactions occuring during the process of dehydration, in particular those due to non enzymatic browning.

Drying Techniques: Several types of dryers and drying methods, each better suited for a particular situation are commercially used to remove moisture from a wide variety of food products including fruits and vegetables. There are different types of drying processes are as follows:

- Solar drying
- Atmospheric drying including batch (mechanical/cabinet drying) and continuous (fluidized bed, spray and drum drying)
- Osmotic dehydration
- Sub-atmospheric dehydration (freeze drying)

i)Solar drying: Drying in the sun is the least expensive method, and quite viable if the climate is hot and dry during harvest time and also the slowest method often resulting in products of lower quality. The fresh crop should be of good quality and as ripe (mature) as it would need to be if it was going to be used fresh. Poor quality produce cannot be used for natural drying. Different lots at various stages of maturity (ripeness) must not be mixed together; which would otherwise result in a poor dried product. Some varieties of fruits and vegetables are better for natural drying than others because they are able to withstand natural drying without their texture becoming tough and thus reconstitute better. Some varieties are unsuitable because they have irregular shape and there is lot of wastage in trimming and cutting. After trimming, the greater part of the

fruits and vegetables are cut into even slices of about 3 to 7 mm thick or in halves/quarters, etc. It is very important to have all slices/quarters/ pieces in one drying lot of the same thickness/size. Uneven slices or pieces of different sizes dry at different rates and this results in a poor quality end product. As a general rule fruits like plums, grapes, figs, dates are dried as whole fruits without cutting/slicing. Some fruits and vegetables, in particular bananas, apples and potatoes, go brown very quickly when left in the air after peeling or slicing, which is due to an active enzyme called polyphenoloxidase. To prevent the slices from going brown they must be kept submerged under water until drying or blanching can be started.

ii)Mechanical (cabinet) dehydration: It is done in mechanical dehydrators such as cabinet dryers where there is control of drying conditions such as temperature, humidity and air flow. Mechanical dehydration offers a number of advantages over solar drying, namely,

- It is faster as compared to solar drying
- It requires less floor space
- It is done under hygienic conditions
- Unlike solar drying, mechanical dehydration is not dependent on weather
- The colour of mechanically dehydrated food products remains uniform due to uniformity in temperature during drying process
- Higher yield of dried product is obtained compared to sun drying and in addition rehydration properties are better
- In all cases the dehydrated fruits and vegetables are superior in quality and appearance to the sun dried counterparts

iii)Osmotic dehydration: Osmotic dehydration helps in the removal of water from fresh commodity by placing the solid food, whole or in pieces, in sugar or salt aqueous solutions of high osmotic pressures to reduce water activity for checking microbial growth. Two major simultaneous countercurrent flows occur during osmotic drying i.e., water flows out of the food into the solution and solutes from the solution into the food. The various process variables which influence the mass transfer rate and quality of the product are pretreatments, temperature, nature and concentration of dehydrating solution, agitation, additives etc. It is usually not worthwhile using osmotic dehydration for more than a 50 per cent weight reduction because of the gradual decrease in the osmosis rate. Water loss mainly occurs during the first two hours and the maximum solid gain takes place within 30 min. The effect of osmotic dehydration as a pretreatment is mainly related to the improvement of some nutritional, organoleptic and functional properties of the product. As osmotic dehydration is effective at ambient temperature, heat damage to colour and flavour is minimized. Also, the high concentration of the solute surrounding the fruits and vegetables prevents discoluration and leads to better nutrient retention in the product.

Intermediate Moisture Foods (IMF): IMF contain moderate levels of moisture (20-50%) by weight, which is less than what is normally present in natural fruits and vegetables, but more than what is left in dehydrated products. As a consequence, IMF do not require refrigeration to prevent microbial deterioration. Intermediate moisture foods include honey, jellies, jams and bakery items such as fruit cakes etc. In all these products, preservation is partially from osmotic pressure associated with the high concentration of solutes, in some, additional preservative effect is contributed by sugar, salt, acid, preservative and other additives.

Fluidized bed drying: In this process, heated air is blown up through the food particles to just suspend them in a gentle boiling motion. The moist air is then exhausted out from the top. It is used to dry grains, peas and other particulates.

Spray drying: This technique is used for drying of liquid foods to convert them to powder. The liquid food is passed through an atomizer (at a temperature of 200°C), which breaks the food into minute droplets, resulting in drying of material in seconds. This method of dehydration can produce exceptionally high quality dried products.

Drum drying: In drum or roller drying, liquid foods, purees, pastes are applied in a thin film onto the surface of steam heated, revolving drums. The thin layer of food loses moisture and dries up. This layer is scraped off with the help of a blade attached to the drum. With a food layer of thickness less than two mm, drying can be achieved in one min or less, depending upon the food material. Drum dried foods generally, have a more cooked flavour than the spray dried counterparts.

iv) Freeze drying: Freeze-drying utilizes the principle that under high vacuum (27-133Pa pressure), frozen water can be removed from a food and collected without going through a liquid phase. Because the material remains frozen, no damage because of heat occurs. In addition, there is little or no loss in sensory qualities of the product. Further, because the removal of ice crystals leaves a porous honeycomb structure, the products tend to rehydrate rapidly. However, freeze drying is slow and expensive. The long processing time requires additional energy to run the compressor and refrigeration unit, which makes the process very expensive for commercial use. Therefore, freeze drying is most often used for products that can either be sold at a premium prize or which can withstand only a small amount of sensory deterioration. In this method, the material such as fruit juice concentrates is first poured on trays in the lower chamber of a freeze drier, frozen and then dried in the upper chamber under high vacuum. The material is directly dried by sublimation of ice without passing through intermediate liquid stage. The dried product is highly hygroscopic. It reconstitutes easily. Mango pulp, orange juice concentrate, passion fruit juice and guava pulp have been prepared to give freeze-dried powders of excellent quality for taste, flavour and reconstitution property.

Dehydro-freezing: In this method, the product is first dried partially and then frozen, and is thus slightly different from the usual freeze drying technique. More energy is required in order to freeze the large quantity of water present in the fresh produce. A reduction in moisture content of the material reduces refrigeration load during freezing. Other advantages of partially concentrating fruits and vegetables prior to freezing include saving in packaging and distribution costs and achieving higher product quality because of the marked reduction of structural collapse and dripping during thawing. The products obtained are termed “dehydro-frozen” and the dehydration step is generally carried out through conventional air-drying, the additional cost of which has to be taken into account. Osmotic dehydration could be used instead of air-drying to save energy or for quality improvement especially for fruits and vegetables sensitive to air-drying.

Osmoappertisation: In order to obtain an alternative to the canned fruit preserves and to maintain a high quality of the fruits, a research has been carried out on the osmoappertisation of apricots, a combined technique that consists appertization (canning) of the osmodehydrated apricots. This technique could contribute to the reduction in energy consumption; limit the cost of production and combine convenience (ready-to-eat, medium shelf life) with many market outlets (retail, catering, bakery, confectionery, semi-finished products). Osmoappertisation combines two unit operations, namely, dehydration by osmosis and appertisation.

d) **Low Temperature/Freezing:**Low temperature can be obtained by (i) cellar storage (about 15°C) in underground rooms, (ii) refrigeration or chilling (0 to 5°C) and (iii) freezing (-18 to –40°C). Temperatures in cellars (underground rooms) where surplus food is stored in many villages are usually not much below that of the outside air and is seldom lower than 15°C. The temperature is not low enough to prevent the action of many spoilage organisms or of the plant enzymes. Decomposition, is however, slowed down considerably. Root crops, potatoes, apples can be stored in cellars for limited periods during the winter months. Chilling temperatures can be obtained and maintained by means of ice or mechanical refrigeration. The fruits and vegetables can be stored safely upto a period of a few days to many weeks when kept at this temperature. Commercial cold storages with proper ventilation and automatic control of temperatures are now used throughout the country for the storage of semi-perishbale products such as potatoes and apples.

Principle of freezing: Freezing is the most harmless method of preservation and is an excellent way to preserve fresh fruits and vegetables at commercial and domestic level. It is the speedy removal of heat from horticultural crops. Freezing does not sterilize food. The extreme cold simply retards growth of microorganisms and slows down changes that affect quality or cause spoilage in food. Most foods retain their natural colour, flavour and texture better than when other methods of food preservation are used. Freezing may preserve foods for long periods of time provided the quality of the food is good to begin with and the temperature of storage is far below the actual freezing temperature of food.

The rate of freezing of foods depends upon temperature (gradient between food and refrigerating medium), circulation of air/refrigerant (air velocity), size and shape of package (product thickness), kind of food (composition and distribution) and packaging material properties. Freezing is achieved by cold air blast, direct immersion of produce in a cooling medium, contact with refrigerated plates in a freezing chamber and with liquid air, nitrogen or carbondioxide (cryofreezing).

Methods of freezing

i)Slow freezing process: It is also known as sharp freezing. In this method, the foods are placed in refrigerated rooms at temperatures ranging from -4°C to -29°C. Freezing may require from 3 to 72 hours under such conditions. Freezing at domestic level is done by this method.

ii)Quick freezing process: In case of quick freezing process the temperature is kept between -32°C to -40°C. It freezes fruits and vegetables so rapidly (in less than 30 minutes) that fine crystals of ice are formed and the time of freezing is greatly reduced over that required in sharp freezing. In quick freezing, large amount of food can be frozen in a short period of time having better quality than slow freezing. Quick frozen foods maintain their identity and freshness when they are thawed (brought to room temperature).

iii)Freezing in air: There are two types of air systems for freezing of horticultural produce i.e., still air and forced air. Still air freezing is accomplished by placing packaged or loose produce in suitable freezing rooms. The length of time required to freeze the food is dependent upon the temperature of the freezing chamber. Forced air freezing involves the use of cold air blasts to freeze the products. It is a faster process as compared to still air freezing.

iv)Freezing by indirect contact with refrigerants: Fruits and vegetables may be frozen by placing these in contact with a metal surface, which is cooled by a refrigerant. The method has a limitation of freezing regular sized square or rectangular packs only.

v) Direct immersion freezing: In this method, the prepared commodity is directly immersed in a liquid refrigerant such as sugar solution or salt solution. Liquids are good heat conductors, as compared to air or gases. The produce can be frozen quickly and the contact is intimate between the food and the refrigerant. High heat exchange rates can be obatined by using turbulent flow techniques.

vi) Cryogenic freezing: In this process, cryogenic fluids (liquefied gases of extremely low boiling point) such as liquid nitrogen (BP -196ºC) and liquid carbon dioxide (BP -79ºC) are used. The freezing is achieved by immersion in the liquid, spraying of liquid or circulation of the vapours over the product. It is done in case of mushrooms, sliced tomatoes, whole strawberries and raspberries. Liquid nitrogen is nontoxic and inert to food constituents. Product undergoes slow boiling at -196ºC, which provides a great driving force for heat transfer. Intimate contact with all portions of irregularly shaped foods minimizes resistance to heat transfer. Since the cold temperature results from evaporation of liquid nitrogen, there is no need for a primary refrigerant to cool this medium. This technology is highly expensive.

Changes during freezing: Freezing process actually consists of freezing the water contained in the food. When the water freezes, it expands and the ice crystals formed can cause the cell walls of the food to rupture. Consequently the texture of the product will be much softer when the product thaws. These textural changes are most noticeable in fruits and vegetables that have a high water content. For example, when frozen lettuce thaws, it turns limp and wilted. This is the reason vegetables with a high water content, such as celery and salad greens, are not usually frozen. Getting a food to a frozen state quickly helps keep the size of the ice crystals small. Less damage to cell walls of foods will occur and the final texture will be better. Keeping food frozen at -18ºC (0°F) or lower will also minimize ice crystal growth that results when food temperatures fluctuate (i.e., warm up and re-freeze) too much while in the freezer. Textural changes due to freezing are not as apparent in products that are cooked before eating because cooking also softens cell walls.

Chemical changes also affect quality or can cause spoilage in frozen foods. One major chemical reaction is oxidation. If air is left in contact with the frozen food, oxidation will occur even in the freezer. An example is the oxidation of fats, also called rancidity. Deterioration of food quality can also be affected by enzyme activity. Freezing only slows the enzyme activity that takes place in foods. It does not halt the reactions, which continue after harvesting. Enzyme activity causes browning which can occur in fruits while they are being frozen or thawed. Methods used to stop enzyme activity include blanching and addition of ascorbic acid.

Advantages of freezing

- Frozen fruits and vegetables closely resemble fresh counterparts since all enzymes are inactivated and microorganisms are under control
- Taste, flavour and colour of horticultural commodities are preserved to a maximum
- Better retention of nutrients
- Greater convenience in handling and preparation
- Less time in cooking
- Pigment retention is maximum due to less thermal treatment
- More hygienic

The limitation of freezing includes the high initial investment to purchase and maintain the freezing equipment. In addition, the size of the freezer limits the amount of storage space and the undesirable texture in some foods. Chilling injury may be caused by very low storage temperature leading to symptoms such as skin and pulp browning, pitting of skin, increased susceptibility to disease, loss of flavour, sunken fruit surface and incomplete ripening/yellowing. It causes release of metabolites, such as amino acids and sugars, which together with degradation of cell structure provide an excellent substrate for the growth of pathogenic organisms. Also, for marketing of frozen products, cold chain is a prerequisite. All frozen foods must be packaged to protect them from dehydration by sublimation during freezing (freezer burn). It irreversibly alters the colour, texture, flavour and nutritive value of frozen foods.

e) Ionizing Radiations: The utilization of ionizing radiations for stabilization of foods offers a method of cold sterilization, wherein foods are preserved without marked change in their natural characters. Food irradiation consists of exposing the food to ionizing radiations, emanating either from radioactive isotopes Co^{60} and Cs^{137} or from electrical machines generating electrons or X-rays so as to destroy the microorganisms and inactivate the enzymes. Foods can be subjected to a maximum dosage of 10 kGy to maintain the wholesomeness. The limitations of the applicability of this technique are on grounds of microbial safety, wholesomeness of the product, and deterioration in physical properties and economy.

II) Chemical Preservation

- Use of chemical additives such as sugars, salt, acids, spices etc.

a) High sugar preservation: In the food preservation with sugar, the water activity cannot be reduced below 0.70. This value is sufficient for bacteria, yeasts and molds inhibition but does not prevent osmophilic yeasts and xerophillic molds attack. For this reason, various means are used to avoid mould development such as finished product pasteurization (jams, jellies, etc.) and use of chemical preservatives alongwith low pH in order to obtain the antiseptisation of the product surface.

Principle of preservation: The principle of this technology is to add sugar in a quantity that is necessary to augment the osmotic pressure of the product's liquid phase at a level, which will prevent microorganism development. From a practical point of view, however, it is usual to partially remove water (by boiling) from the product to be preserved, with the objective of obtaining a higher sugar concentration. In concentrations of 68 to 70 per cent sugar in the finished products the sugar generally assures food preservation. Addition of acid to bring the pH down to 4.0 and addition of small amount of preservative has synergistic effect on preservation.

b) Use of salt/acid/spices (Pickling): Pickle is an edible product preserved and flavoured in a solution of common salt and/or vinegar. The preservation of fruits and vegetables in common salt and/or in vinegar is called pickling. Spices and edible oils may be added to the product. Raw mango, lime, turnip, cabbage, cauliflower etc. are preserved in the form of pickles, which have become popular in several countries. Apart from having nutritional and therapeutic value, they have appetizing appeal.

Principle of preservation: Underlying principle for preservation is the fermentation process i.e., the conversion of fermentable carbohydrates to organic acids during bulk storage and/or addition of sufficient amount of sugar, spices, salt, vinegar and other ingredients to the fully cured and packed products to preclude any microbial growth.

Pickling can be done in three ways:

1. **Curing/fermentation by dry salting:** In this technique, alternate layers of vegetable and salt are filled inside the barrels till 3/4th of the container is filled. A layer of muslin cloth and wooden board are placed on top. In order to press the vegetables, a clean stone is also placed on the wooden board. The salt extracts juice from the vegetables so as to form brine. Brine is formed in 24 hours. The extracted brine is fermented by naturally occurring lactic acid bacteria. Lactic fermentation is completed in 8-10 days at a temperature of 27-32°C to produce lactic acid that acts as a preservative.
2. **Fermentation in brine:** Vegetables are preserved in a salt solution of suitable concentration (8-10 per cent) for a certain period of time. This process is called brining. The brine and vegetable ratio is kept as 2:1.
3. **Salting without fermentation:** This is carried out by adding salt in washed and prepared vegetables in the ratio of 1:5. Such high concentration of salt inhibits fermentation, acts as preservative and the vegetables get cured. Excess salt is drained by soaking in warm water. Thereafter the vegetables are pickled by storing in sweetened or spiced vinegar of 10 per cent strength for several weeks. The cured vegetables can also be prepared by addition of spices and oil along with salt.

Vegetable such as cucumber (gherkins), which do not contain sufficient juice to form brine with dry salt are fermented in brine (fermented pickles). In unfermented pickles, the raw material is preserved by salt, spices, oil and vinegar.

c) Use of chemical additives: The Food and Drug Administration (FDA) has defined food additive as a substance or a mixture of substances, other than the basic foodstuff, which is present as a result of any aspect of production, processing, storage or packaging. It comprises of preservatives, antioxidants and many others. According to FDA, 'chemical preservative is any substance which is capable of inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food or masking any of the evidence of any such process or of neutralizing the acid generated by any such process but does not include salt, sugars, vinegar, spices or oils extracted from spices'. Chemical food preservatives are added in very small quantities (up to 0.2 per cent) and they do not alter the organoleptic and physico-chemical properties of the foods. Preservation of food products containing chemical food preservatives is usually based on the combined or synergistic activity of several additives, intrinsic product parameters (e.g. composition, acidity, water activity) and extrinsic factors (e.g. processing temperature, storage atmosphere and temperature). This approach minimizes undesirable changes in product properties and reduces concentration of additives and extent of processing treatments. Chemical food preservatives are applied to foods as direct additives during processing, or develop by themselves during processes such as in fermentation. Certain preservatives have been used either intentionally or accidentally for centuries, which include sodium chloride (common salt), sugar, acids, alcohols and components of smoke. In addition to preservation, these compounds contribute to the quality and identity of the products.

Chemical food preservatives can be classified as Class I and Class II preservatives. Class I preservatives include common salt, sugar, dextrose, spices, vinegar and honey. They are mainly natural products, which are used, in comparatively higher concentrations than Class II preservatives. On the other hand, Class II preservatives are synthetic chemicals used in small quantities. Benzoic acid and its salts, sulphur dioxide and salts of sulphurous acid, nitrites and

nitrates, sorbic acid and its salts, propionic acid and its salts, lactic acid and its salts are commonly used. Mode of action of food additives involves alteration of cell wall permeability, alteration of colloidal nature of protoplasm, damage of the cell wall, damage of proteins, inhibition of enzyme activity, disruption of cytoplasmic membrane, bacteriostatic or bactericidal action (toxicity of the antimicrobial agent towards microorganisms) and interference with synthetic processes.

General rules for chemical preservation

- Chemical food preservatives have to be used only at a dosage level that is needed for a normal preservation and not more than that prescribed by FPO.
- Reconditioning of chemical preserved food, e.g. an addition of new preservative in order to stop a microbiological deterioration already occurred is not recommended.
- The use of chemical preservatives must be strictly limited to those substances which are recognized as being without harmful effects on human beings' health and are accepted by national and international standards and legislations.

Factors which determine/ influence the action of chemical food preservatives are chemical composition, pH, concentration, microorganism species and the initial number of microorganisms in the treated product. Sulphur dioxide (as potassium metabisulphite) and its derivatives can be considered as "universal" preservatives. They have an antiseptic action on bacteria as well as on yeasts and moulds. Benzoic acid (as sodium benzoate) and its derivatives have a preservative action which is stronger against bacteria than on yeasts and moulds. Sorbic acid acts on moulds and certain yeast species which in higher dosage levels also acts on bacteria and formic acid is more active against yeasts and moulds and less on bacteria.

III) Biological Preservation (Fermentation)

- Fermentation technology involving alcoholic or acidic fermentations using selected desirable microorganisms

The various preservation methods discussed so far, based on the application of heat, removal of water, freezing etc., have the common objective of decreasing the number of living microorganisms in foods or at least holding them in check against further multiplication. Fermentation processes for preservation purposes, in contrast, encourage the multiplication of lactic acid forming bacteria and their metabolic activities in foods. But the organisms that are encouraged are from a selected group and their metabolic activities and end products are highly desirable. The acidification during fermentation can be obtained by two ways i.e., natural acidification and artificial acidification.

i) Natural acidification is achieved by a predominant lactic fermentation, which assures the preservation based on acido-anabiosys principle. In the production of lactic acid fermented vegetables, the raw material is put into brine without previous heating. Through the effect of salt and oxygen deficiency, the vegetable tissues gradually die. At the same time, the semi-permeability of the cell membranes is lost, whereby soluble cell components diffuse into the brine and serve as food substrate for the microorganisms. Under such specific conditions of the brine, the lactic acid bacteria succeed in overcoming the accompanying undesirable microorganisms and lactic acid as the main metabolic product is formed. Under favourable conditions (for example moderate salt in the brine, use of starter cultures) it takes at least 3 days until the critical pH value of 4.1 or less (desired for microbiological reasons) is reached.

ii) Artificial acidification is carried out by adding acetic acid which is stable in specific working conditions. In this case biological principles of the preservation are acido-anabiosys and, to a lesser extent, acido-abiosys.

iii)Combined acidification is a preservation technology, which involves as a preliminary processing step a weak lactic fermentation followed by acidification (vinegar addition). The two main classes of vegetables preserved by acidification are sauerkraut and pickles. Sauerkraut is the product of characteristic acid flavour, obtained by the full fermentation, chiefly lactic, of properly prepared and shredded cabbage in the presence of 2-3 per cent salt. On completion of fermentation, it contains not more than 1.5 per cent of lactic acid. Pickle means the cured product prepared entirely or predominantly from clean, sound fruits and vegetables alongwith other ingredients which may or may not have been previously subjected to fermentation and curing either with salt or in brine (solution of sodium chloride, NaCl). Sauerkraut and pickle products can be preserved under the effect of natural or added acidity, followed by pasteurization when this acidification is not sufficient.

Inspite of the introduction of modern preservation methods, lactic acid fermented vegetables still enjoy a great popularity, mainly because of their nutritional and gastronomic qualities.

IV) Combined Method of Preservation (Hurdle Technology)

- A judicious combination of more than one method mentioned above for synergistic preservation (hurdle technology)

The trend of using a wide range of mild preservation techniques has emerged to be known as combined preservation or barrier (Hurdle) technology. Hurdle in food is defined as the substance or the processing step or various preservation factors, inhibiting the growth of various microorganisms resulting in the death of microorganisms. It advocates the deliberate combination of existing and novel preservation techniques in order to establish a series of preservative factors (hurdles) that any microorganisms present should not be able to overcome. It requires a certain amount of effort from a microorganism to overcome each hurdle. Higher the hurdle, greater the effect. The quantification of various factors in terms of pH, redox-potential, water activity, temperature, preservatives etc. gives the successful level of combination of hurdles, which lead to failure of homeostasis. As a result the microorganisms will not multiply i.e. either remain in lag phase or die. Several tropical and semitropical fruits and vegetables like carrot, capsicum and coconut are processed by hurdle technique by slight reduction of water activity (a_w 0.92-0.95), lowering of pH (below 4.5) and mild heat treatment (in-pack pasteurization at 85^0C) or treatment with antimicrobial additives with a view to control microbial growth, packed in flexible polymeric pouches and were evaluated for their shelf stability under ambient conditions.

Potential hurdles for use in preservation of food

a. Physical hurdles: High temperature (sterilization, pasteurization and blanching), low temperature (chilling and freezing), electromagnetic radiation, packaging film, modified atmosphere packaging (gas, vacuum, moderate vacuum and active packaging), aseptic packaging etc.

b. Physico-chemical hurdles: Low water activity (a_w), low pH, low redox-potential (E_h), common salt (NaCl), nitrate, CO_2, O_2, O_3, organic acids, lactic acid, lactate, acetic acid, acetate,

ascorbic acid, sulphite, smoking, phosphates, glucono-o-lactone, phenols, chelators, ethanol, propylene glycol, maillard reaction products, spices, herbs, lactoperoxidase and lysozyme.
c. Microbially derived hurdles: Competitive flora, protective cultures, bacteriocins and antibiotics.

Advantages of Hurdle Technology: The technology leads to the development of high quality food that is shelf stable, with superior quality and with fresh like characters, further more this approach is not single-targeted but multi-targeted. There is every possibility that different hurdles will have an additive or synergistic effect in food. The concept of hurdle technology has proved extensively useful in optimization of traditional foods as well as development of novel products. For securing stable, safe and tasty foods, linkage between hurdle technology (used for food design), the HACCP concept (used for process control) and predictive microbiology (used for process refinement and food safety) is indispensable.

Several methods such as freezing, canning, dehydration, chemical preservation etc. are commonly used for preserving foods. However, all these processes are based on a relatively few parameters or 'hurdles', combination of which decisively govern microbial stability and nutritional quality of almost all foods.

Value Added Products

1. Fruits and Vegetables
i) Jam, Jelly, Marmalade and Preserve: Preparation of jam, jelly and marmalade is based on concentrating fruits to nearly 70 per cent solids (TSS) by addition of sugar and heat treatment. The high osmotic pressure of sugar creates unfavourable conditions for the growth and reproduction of most species of microorganisms i.e. yeasts, molds and bacteria, responsible for the spoilage of food. At this concentration of solids, the water activity is reduced (a_w of 0.60-0.75) which ultimately decreases the chances for microbial spoilage.

Jam is prepared by boiling the fruit pulp with sufficient quantity of sugar to a reasonably thick consistency, firm enough to hold fruit tissues in position. It should contain not less than 68.5 per cent soluble solids as determined by a refractometer. Jam may be made from a single fruit (apple, strawberry, banana, pineapple etc.) or from combination of two or more fruits. The preparation of jam requires several unit operations viz., selection of fruit, preparation of fruit, addition of sugar, addition of acid, mixing, cooking, filling, closing, cooling and storage.

Jelly is a semi-solid product prepared by boiling a clear, strained solution of pectin containing fruit extract with sufficient quantity of sugar and measured quantity of acid. A perfect jelly should be transparent, well set, but not too stiff and should have the original flavour of the fruit. It should be firm enough to retain a sharp edge but should be tender enough to resist the applied pressure. It should not be gummy, sticky or syrupy or have crystallized sugar. Different fruits like guava, plum, papaya, gooseberry etc. are used for jelly preparation. Low pectin fruits such as apricot, pineapple, raspberry etc. can be used only after adding small amount of pectin powder. The essential substances for manufacture of jelly are pectin, water, acid and sugar. Formation of jelly takes place when the concentrations of water-sugar-acid-pectin mixture attain a certain minimum value.

Marmalade is a fruit jelly in which slices of the citrus fruit or its peels are suspended. Marmalades are generally made from citrus fruits like oranges and lemons in which shredded peels are suspended.

Preserves (*Murabbas*) are prepared from whole fruits and vegetables or their segments by addition of sugar followed by evaporation to a point where microbial spoilage cannot occur. The final soluble solids concentration is reached to about 70 per cent. The finished product can be stored without hermetic sealing and refrigeration.

ii) Chutneys and Sauces: Chutney is a mixture of fruit or vegetable with spices, salt and/or sugar, vinegar etc. A good chutney is smooth, palatable and appetizing, and has the true single flavour of the fruit or the vegetable used for its preparation. Most popular chutneys are those from tomato, mango, *aonla* etc. On the other hand, a good **sauce** has a continuous flow with no skin, seeds and stalks of fruits and/or vegetables. It possesses pleasant taste and aroma. Sauces are sieved and as a result, are thinner and have smoother consistency than chutneys. Sauces can be prepared from tomato, papaya etc. Vinegar, salt, sugar and spices are the common preservatives used for the preservation of these products. The chemical preservatives such as sodium benzoate and potassium metabisulphite used for long-term storage help in retarding the growth of microorganisms without interfering with other physico-chemical and sensory characteristics of the product. Some factors taken into consideration for the selection of a chemical to be used as a preservative include type of organism to be controlled, pH of the product, length and conditions of product storage and physical and chemical characteristics of the food.

iii) Fruit Juices/Beverages: Fruit juices **are preserved in different forms such as pure juices and beverages.** Fruit beverages **can be classified into two groups:**
- **Unfermented beverages**: Fruit juices that do not undergo alcoholic fermentation are termed as unfermented beverages. They include natural and sweetened juices, ready-to-serve beverage, nectar, cordial, squash, crush, syrup, fruit juice concentrate and fruit juice powder. These beverages can be distinguished on the basis of the differences in total soluble solids (TSS) content and minimum juice percentage as given in Table2.

Table 2: Fruit Product Order (FPO) specifications for fruit beverages

Product	**Minimum % of total soluble solids (TSS) in final product (w/w)**	**Minimum % of fruit juice in final product (w/w)**
Unsweetened juice	Natural	100
Fruit syrup	65	25
Crush	55	25
Squash	40	25
Fruit nectar (excluding orange and pineapple nectars)	15	20
Orange and pineapple nectars	15	40
Cordial	30	25
Sweetened juice	10	85
Ready-to-serve	10	10
Fruit juice concentrate	32	100
Synthetic syrup/sherbet	65	-

- **Fermented beverages**: Fruit juices, which have undergone alcoholic fermentation by yeasts and lactic fermentation by bacteria. They include wine, champagne, port, sherry, cider and *kanji*.

Methods of preservation of fruit juices/beverages:

A. Pasteurization*:* Preservation by heat is the most common method. It may be done in three ways:

a) Holding pasteurization: After filling of the juice in bottles, the bottles are pasteurized at 85°C for 25-30 min. This is usually done at home scale.
b) Over-flow method: In this case, juice is heated at a temperature of about 2.5°C higher than the pasteurization temperature and filled into hot sterilized bottles upto the brim. The sealed bottles are then pasteurized at a temperature of 2.5°C lower than the filling and sealing temperature. It thus minimizes the adverse effect of air on quality of the juice.
c) Flash pasteurization: In this method, fruit juice is heated for a short time at a temperature higher than the pasteurization temperature and held at that temperature for about a minute and filled into the containers which are sealed airtight.

B. Carbonation*:* It is the process of incorporating carbon dioxide in a beverage to impart a characteristic taste. Apart from the distinctive taste, carbon dioxide also inhibits the growth of certain undesirable microorganisms.

C. Chemical Preservation: For preserving juices chemically, the addition of 700 ppm potassium metabisulphite or 720 ppm of sodium benzoate (for coloured products) is employed. Chemically preserved juices are bottled leaving a head space of 1.5 to 2.5 cm followed by crown corking/sealing.

iv) Fermented products: Fermentation of fruits and vegetables can be classified into three types:

(i) Alcoholic fermentation- which has already been discussed under fermented beverages earlier
(ii) Lactic fermentation – which involves fermentation of carbohydrates into lactic acid to prepare fermented pickles such as sauerkraut, gherkins, fermented olives etc.
(iii) Acetic fermentation – It involves alcoholic fermentation followed by acetic fermentation for the manufacture of vinegar, which is used as a condiment. Vinegar contains about 4 per cent of acetic acid in water and can be prepared from a number of fruits such as grapes, apple, oranges etc.

v) Pickles: The process of preservation of food in common salt or in vinegar is called pickling. Spices and edible oil may also be added to the product. Pickles may be sour, sweet or mixed and can be prepared easily from different fruits and vegetables at home. They can be grouped as unfermented pickles and fermented pickles. Fermented pickles undergo lactic fermentation as discussed earlier. On the other hand in unfermented pickles the raw material is preserved by use of various spices and oil. Most popular unfermented pickles are mango, lime and mixed pickles.

vi) Dried products: Fruits or vegetables may be dried mechanically or under the sun for increasing their shelf life and for further use. Grapes are dried and converted into raisins, which are very popular high-energy foods. Also dehydrated powders of various citrus fruits are available for reconstitution into a refreshing beverage. Onions and ginger are sold in dehydrated form for use in various curried food preparations.

2. Mushrooms

Mushroom, an edible fungus, is the most priced commodity among vegetables, due to its high nutritive value, characteristic aroma and flavour. In our country it is mostly sold afresh and a negligible amount is used for processing. Mushrooms lend themselves to a great variety of culinary treatments. The most common varieties of mushrooms consumed include, *Agaricus bisporus* (European or white button mushroom), *Pleurotus sajor caju* (oyster or *dhingri*) and *Volvariella volvacea* (paddy straw mushroom). They may be baked, fried, boiled, creamed, roasted, pickled and stuffed. They can be processed as canned, dried and frozen mushrooms. Mushroom pickle, ketchup and soup are other important value-added products.

3. Coconut

Coconut provides a diverse range of products. It is a unique crop, where every part is useful in one way or the other. Hence the coconut tree is called the 'Tree of Life'. The main commercial product is copra out of which coconut oil is produced. The other value added coconut products include desiccated coconut, coconut cream, coconut vinegar, tender coconut water, coconut milk based products, coconut jaggery and other industrial non-edible products such as coir.

4. Floricultural Crops

i) Dry flowers and pot pourri: Dry flowers are becoming more popular due to their longer indoor life and non-perishability. The two easiest and least expensive methods to dry flowers are sand drying and air-drying. Another product, pot pourri is a mixture of dried, sweet scented plant parts including flowers, leaves, seeds, stems and roots. These are rich in aromatic oils, which are not confined to the flower only. These are used in naturo-therapy for common ailments (aromatherapy). Fixatives such as salt, gum benzoin etc. are added to make the scent last longer.

ii) Essential oils, flavours and fragrances: Floral extracts like essential oils, alkaloids, pigments, dyes etc., have tremendous demand in both domestic and international markets. In order to produce the highest quality extracts, highly sophisticated extraction methods such as those based on high pressure extraction and super critical fluid extraction are used. Such methods produce very high purity flavour and spice extracts, fragrant chemicals as well as pharmaceutical substances. Compressed gases like CO_2, combine the advantages of both gas and liquid solvents. They have the density of a liquid but diffuse as a gas and therefore, function like a solvent. This enables the extraction of sensitive raw materials at gentle temperatures. The resulting extracts are further purified by fractionation and separation procedures.

iii) **Pharmaceutical and neutraceutical products:** Plants produce pharmacologically valuable compounds, which are used in medicine and as dietary supplements. Such compounds include pigments, oils and alkaloids.

iv) **Pigments and natural dyes:** The anthocyanins, flavanols, carotenoids and xanthophylls are common plant pigments that are responsible for a variety of hues we normally observe. These valuable pigments can be isolated and used for varied applications including pharmaceuticals.

v) **Gulkand, rose water, vanilla products etc.:** *Gulkand* is prepared by mixing rose petals and sugar in the ratio of 1:2 followed by mashing and drying the mixture in sun. It is a laxative and is used for flavouring and sweetening *pan*. It is good for memory, eyesight and blood purification.

Rose water is prepared by boiling the rose flowers in water and condensing the steam. It is used as *sherbet*, eye lotion and eye drops.

vi) **Insecticidal and nematicidal compounds** : Natural plant products (secondary metabolites) are insecticides and nematicides. They act as fly and mosquito repellents, kill insects and may be toxic to bees, aphids, caterpillars etc.

5. Spices

Since time immemorial, spices have played a vital role in world food trade, due to their varied properties and applications. We primarily depend on spices for flavour and fragrance as well as colour, preservative, inherent therapeutic, medicinal and appetizing properties. The spices that India can offer in abundant quantities are pepper, ginger, turmeric, chili, cardamom, celery, fenugreek, fennel, cumin, dill, coriander, cinnamon, *ajowan*, cloves, nutmeg and mace. The food industry across the globe is turning more and more to spice oils and oleoresins to create newer varieties of food. New flavour systems are being developed to introduce new products in the market and create competitive advantages.

The essential constituents of spices, which provide the aroma, flavour, pungency and colour, together make up a very small part, often less than 10 per cent, by weight of the whole. The essential constituents may be obtained by super critical fluid extraction (SCFE) technology, which is a two-step process using carbon dioxide as the solvent above its critical pressure and temperature for extraction of various spice constituents. The resultant in an extract called the **spice oleoresins**, which consists of a complex mixture closely resembling the characteristics of the spice as a whole. The actual composition of the oleoresin depends on the spice selected for extraction, its maturity, post harvest treatment and, importantly, the solvent and conditions selected for extraction. The volatile constituents of spices, known as the **essential oil**, which also form part of the oleoresin, are obtained directly from the raw material by steam distillation. The composition of the essential oils depends on the selection of the spice, its quality and the distillation technique applied. The consistent high quality of spice oils and oleoresins required by the user depends very much on the experience, skill, and expertise, provided by the manufacturer in the selection of raw material, its handling, processing and finally blending of extracts. Natural **colouring compounds** are also isolated from certain spices. In particular saffron and curcumin (which is the yellow colouring matter of turmeric), and the red colour of chillies free of pungency, are available. These natural colours or mixtures of them have wide applications in dairy and fat compositions, as well as in sauces, curries, pickles, etc.

6. Horticultural waste utilization

During processing of fruits and vegetables lot of waste gets accumulated that must be utilized in some manner for manufacture of by-products, as feed for livestock or disposed of as garbage. Waste from fruit industry includes peels, cores, trimmings, overripe and blemished fruits, cull fruits, stems, mango kernels, pomace etc. Vegetable waste constitutes tomato seeds, skins, trimmings, vines and pods from pea canning etc. Hulls from almonds can be fermented and converted to ensilage to be fed to sheep and cattle. All fermented beverages such as brandy and alcohol can also be manufactured. Culled fruits can be utilized in preparing fruit jams, dried products, juices, wine etc. Citrus by-products include citrus oil, citric acid, calcium citrate, pectin, candied peel etc. Wastes from the papaya and pineapple industry are used for manufacture of the enzymes papain and bromelin, respectively.

Packaging and Storage

Food packaging serves needs of marketing and also helps preservation of foodstuffs especially processed ones. It is one of the most important unit operations in the agro-processing industry. Packaging can be defined as a tool that protects and contains the goods with the aim of minimizing the environmental impact on the consumption. Ideal packaging can be compared with that of a banana, orange peel and coconut shell – the packaging provided by Mother Nature. In modern times, packaging has been identified as an integral part of processing in the food industry as it protects products from the adverse effects of the environment. Packaging is helpful for the safe delivery of the contents from the centers of production to the points of consumption. Packaging serves as a vital link in the long line of production, storage, transport, distribution and marketing. The primary objectives of food packaging are to provide protection from spoilage, ease in distribution, display and handling, communication between the manufacturer and customer, convenience, avoidance of loss, brand confidence, printing and machine suitability. The packaging materials vary for different products depending upon the product and its storage requirements. Food packaging employs a variety of materials. They are (i) rigid metal containers such as cans and drums, (ii) flexible metals as in aluminum and tin foils, (iii) glass as in jars and bottles, (iv) rigid and semi-rigid plastics as squeeze bottles, (v) flexible plastics as in pouches and wrappers, (vi) rigid card-board, paper and wood as in boxes, (vii) flexible papers as in boxes, bags and laminates and (viii) multiplier laminates which may combine paper, plastic and foil. Packaging of foods has become very complex, and considerable research and development efforts have been made to provide better and cheaper packaging material and packaging methods.

The food packaging containers should satisfy a number of requirements. The more important requirements and functions are (i) non-toxic, (ii) sanitary protection, (iii) moisture and fat protection, (iv) gas and odour protection, (v) light protection, (vi) resistance to impact, (vii) transparency, (viii) tamper proof, (ix) ease of opening, (x) pouring features, (xi) reseal feature, (xii) ease of disposal, (xiii) size, shape and weight limitations, (xiv) appearance and printability, (xv) low cost and (xvi) special requirement if any.

Controlled/Modified Atmosphere (CA/MA) Packaging and Storage: Modified atmosphere (MA) essentially means any deviation from the normal atmospheric gas composition of a regular atmosphere which is having 78.08 percent N_2, 20.95 percent O_2 and 0.03 per cent CO_2. If the deviation is strictly controlled with certain specific gaseous concentrations of N_2, CO_2 and O_2, then it is termed as “Controlled Atmosphere” (CA). Therefore, MA or CA essentially means removal or addition of gases surrounding the commodity either from inside of a package or the storage chamber resulting in an altered atmospheric composition as compared to regular atmosphere. Usually modification of atmosphere for packaging of fresh horticultural commodities involves reduction of O_2 and elevation of CO_2 concentrations. CA/MA storage helps in retardation of ripening, senescence and physiological as well as microbial changes. It thus helps in reduction of quantitative and qualitative reduction in post harvest losses of horticultural commodities.

i)Packaging and storage of frozen foods: Proper packaging material protects the flavour, colour, moisture content and nutritive value of frozen foods from the dry climate of the freezer. Selection of containers depends on the type of food to be frozen, personal preference and types that are readily available. Foods in larger containers freeze too slowly to result in a satisfactory product. In general, packaging materials for the frozen products must be moisture and vapour-

proof, odourless, tasteless and grease-proof, food grade, durable, leak-proof and should not become brittle and crack at freezer temperatures. Package should protect foods from absorption of odours, should be easy to use, seal and label, designed for compact stacking for economical use of freezer space and should be of reasonable cost.

Thawing: Frozen foods have to be thawed before consumption. Thawing refers to bringing the frozen food to ambient temperature. Food must be kept at a safe temperature during defrosting. Foods are safe indefinitely *while frozen*, however, as soon as food begins to defrost and become warmer than 4.4°C (40°F), the bacteria that may have been present before freezing can begin to multiply. Never thaw food at room temperature or in warm water. Even though the centre of a package may still be frozen as it thaws, the outer layer of the food is in the "Danger Zone," between 4.4°C (40°F) and 60°C (140°F). These are the temperatures where bacteria multiply rapidly. Thawing should be done in the refrigerator at 4.4°C (40°F) or less, or in cold running water at less than 23.3°C (70°F), or in the microwave if food has to be cooked or served immediately.

ii)Packaging and storage of dried products: Suitable packages for dried products include air tight jars, plastic or glass bottles or plastic bags. The containers should be filled as much as possible to remove air before sealing. Metal containers should be avoided and packaged products should be kept in a cool, dark place during storage. Shelf life is around one year when products are properly dried (moisture content less than 10 per cent) and sealed in air tight packages.

Quality Standards and Laws

Quality is how well a product or service satisfies the needs of the customer. This includes all aspects related to the needs of the customer such as quality specifications, safety, delivery method or date, price etc. Quality can be interpreted in several ways as conformance to the standards, meeting customers' preference/ satisfaction for desired quality attributes, degree of excellence and zero defect products etc. Because of education and consequent greater understanding of implications of poor quality commodities in recent years, consumers have become quality conscious and this fact is also applicable to food and food products. In order to strengthen competitiveness, quality must be incorporated throughout the value added chains right from the harvesting, handling, manufacturing, processing, packaging, storage, marketing and distribution stages, especially in the case of food and food products.

Elements of Food Quality and Safety: The basic functions of a quality control programme are:

- Physical and chemical evaluation of raw materials and processed products
- In-process control of :
    - Raw materials, ingredients and packaging supplies
    - Processing parameters
    - Finished products
- Microbiological analysis and their control in raw materials and finished products
- Control of storage and handling conditions
- Sanitation and waste products control
- Assurance that final products are within the legal and established marketing standards
-

Steps for ensuring food quality: Quality Control and Quality Assurance are the two steps for ensuring quality. Quality Control is the evaluation of a final product prior to its marketing i.e., it is based on quality checks at the end of production. Quality Assurance is similar to quality

control, but has more to do with the process than the product. It is the implementation of quality checks and procedures to immediately correct any failure and mistake that is able to reduce the quality of the interim products at every production step.

The desired high quality of the final product is planned and obtained by conducting Standard Operating Procedures (SOP) that guarantee the desired quality of the interim products at every production step meeting the demands for **Good Manufacturing Practices (GMPs)**. The management approach to long-term success through customer satisfaction is based on the participation of all members of an organization in improving processes, products, services and the working culture and is known as **Total Quality Management (TQM)**. These are the systems that can demonstrate that the organization can meet the specifications and requirements of the customers. They also allow the management of the organization to know that the customer's requirements are being met. Food quality profile for any product is depicted in Fig 1.

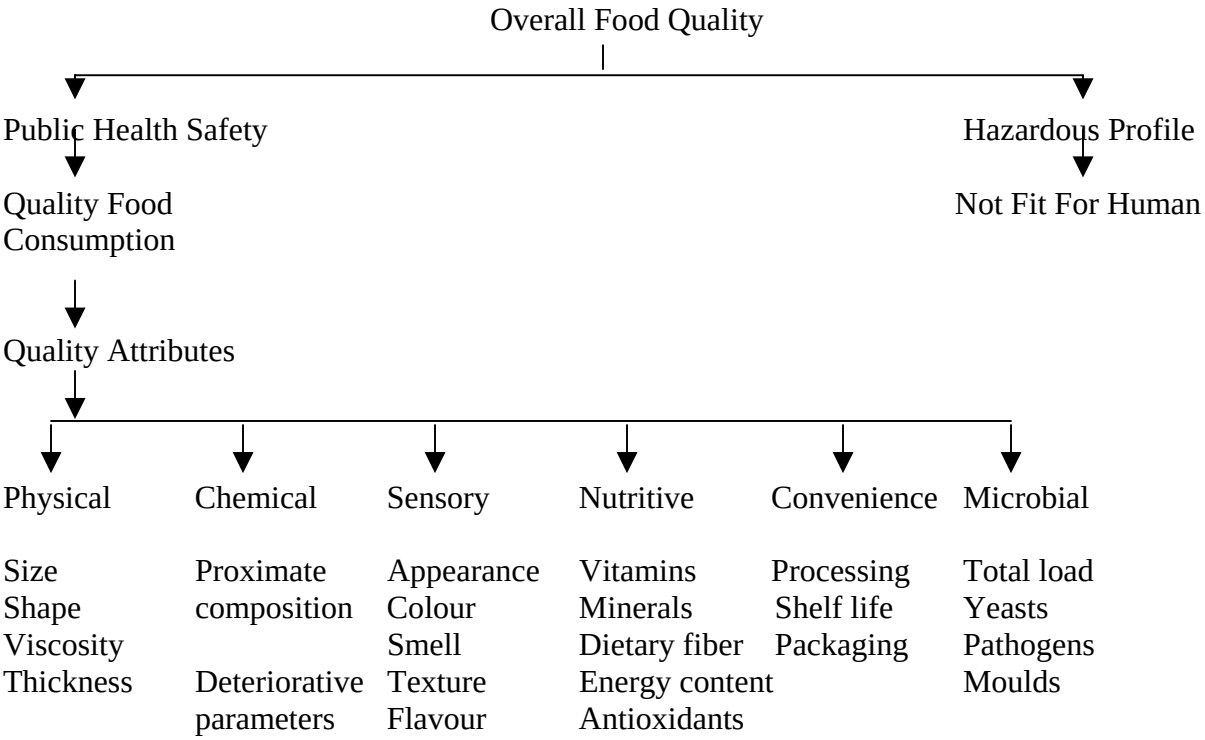

Fig 1: Food quality profile

Good Manufacturing Practices (GMPs) are guidelines to assure that food for human consumption is safe and has been prepared, packed and held under sanitary conditions. These guidelines deal with personnel involved in food processing, building, premises as well as construction and design.

General do's and dont's to assure food safety during processing

- Follow state regulations regarding the type of licensed facility you may use for food processing (for example: no home or farm kitchens)
- Educate and train employees in proper food handling practices and personnel hygiene
- Strictly adhere to Good Manufacturing Practices (GMPs)

- Design food processing and storage areas to allow for easy cleaning and sanitation
- Monitor good quality raw materials for adherence to Good Agricultural Practices and Processing
- Keep processing facility grounds clean and free from litter
- Processing facilities should be completely enclosed from the outside environment by walls
- Windows or other glass panes should not be present in the food processing area
- Processing facility, floors, walls and ceilings must be clean and in good repair
- Adequate lighting should be present and protected in case of breakage
- Pipes, ducts and fixtures should not be suspended over processing areas
- Use only potable water
- Monitor water quality regularly
- Toilet facilities should be clean and segregated from the processing area and food rooms
- Written sanitation schedules and procedures should be established and monitored on a regular basis with proper documentation
- Effective rodent and insect control programme should be taken up at regular intervals

- Regular health check ups should be made for workers for any contagious diseases

Description of Quality Systems

Food Laws: There are a number of food laws being implemented by various Ministries/Departments. These are primarily meant for two purposes namely, (1) Regulation of Specifications of Food and (2) Regulation of Hygienic Condition of Processing/Manufacturing. Some of these food laws are mandatory and some are voluntary. Food laws are set up and established by authorities as a rule for the measure of quantity, weight, value or quality. Food laws are essential to provide uniform units for weights and measures. The purpose/ benefits of food laws are helpful for farmers and other people engaged in harvesting and food production, those who are engaged in processing and marketing of food, for consumers and government agencies.

Legislations Governing Food Industry in India: With trade liberalization and globalization in the food industry after WTO we have to amend / make changes in our legislations to meet international requirements. In our country, standardization systems fall into two categories. Compulsory legislations are formulated by various Ministries whereas voluntary standards are framed by the organizations with the motto of serving the country. The details of Acts/Orders, their mode of operation, regulations with special features are described in Table 3. Different voluntary legislations are made for the purpose to guarantee stated quality and sales promotion. A number of control orders have been formulated under the provisions of the Essential Commodities Act, which operate on the main objectives of regulating the manufacture, commerce and distribution of essential commodities. There are various commodity boards such as Spices Board, Tea Board, Coffee Board, National Horticulture Board operating in India which undertake research and development work for their respective fields.

Table 3: Standardization systems for quality control of foods

S.N	Act / Order	Mode of Operation	Regulations	Special Features
I. Compulsory legislations				
1.	Prevention of Food Adulteration (PFA) Act, 1954	i)Ministry of Health & Family Welfare ii)Directorate General of Health Services iii)Central Committee for Food Standards	Makes provisions for prevention of adulteration of food. Adulterated, misbranded, not in accordance with the conditions of license shall be prohibited for selling. No such food shall be imported. Standards for the commodities have been specified in the rules. Proprietary foods shall specify the ingredients in the product in the descending order of their composition of the label.	Minimum quality standards. Ensure safety against harmful impurities, adulteration. Mandatory law Non-following of PFA Act leads to fine and imprisonment.
2.	Atomic Energy Rules, 1991 (Control of irradiation of food)	Department of Atomic Energy	Regulates the irradiation application in foods. Certificate with the dose and purpose is insisted upon.	Certificate of irradiation indicating the dose and the purpose shall be provided by the competent authority.
3.	Essential Commodity Act, 1954	Ministry of Food	Regulates the manufacture of commodities, commerce and distribution.	Formations of other suborders for easy implementation.
3.1	Fruit Products Order (FPO), 1955	Ministry of Food Processing Industry Central Food Products Advisory Committee	Regulates the manufacture and distribution of all fruit and vegetable products. Exempted from the provisions of the order to products prepared by Drug Control Act and Educational Institutions for training purposes. Quantity shall not exceed 10 kg. License shall be issued after the satisfaction of	Licensing authority 'FPO' standard mark shall be imprinted on the products

			quality of product, sanitation, personnel hygiene, machinery, equipment and work area requirements as per the schedule specified.	
3.2	Vegetable Oil Products (Regulation) Order, 1998	Ministry of Food and Consumer Affairs	Regulates the production and distribution of all the edible oils. Specifications of the products provided.	Supersedes the Vegetable Oil Products (Control) Order, 1947 and Vegetable Oil Products (Standards of Quality) Order, 1975. BIS Certification for the tin plates used for *vanaspati* packing is deleted.
3.3	Sugar (Control) Order, 1966	Ministry of Agriculture and Irrigation Department of Sugar	Regulates the manufacture, quality and sale of sugar.	
4.	Export (Quality Control & Inspection) Act, 1963	Ministry of Commerce Export Inspection Council 5 Regional Export Inspection Agencies Network of 50 Offices	Regulates compulsory, pre-shipment inspection. Exportable commodities list has been notified for pre-shipment inspection. Quality control of various export products is monitored.	AGMARK has been recognized as an agent for inspection and quality control of certain items. Voluntary inspection at the request of foreign buyers and advice of Export Inspection Council is also carried out.
5.	Standards on Weights and Measures Act, 1976	Ministry of Food and Civil Supplies Directorate of Weights and Measures	Prescribed the conditions for packed products with respect to quantity declaration, manufacturing date and sale price.	Providing relief to the weaker sections of society and protecting the consumer in general by guaranteeing the quantity for the amount paid.
6.	The Consumer Protection Act, 1986	Ministry of Food and Civil Supplies	Provision made for the establishment of consumer councils and other authorities for the settlement of consumer disputes.	Protection of the interest of Consumers.

7.	Environ-ment Protection Act, 1986	Ministry of Environment and Forestry	Regulates the manufacture, use and storage of hazardous microorganisms /substances/cells used as foodstuff.	Compulsory for every food plant discharging waste into mainstream to obtain a No Objection Certificate (NOC) from respective State Pollution Board.
8.	The Insecticide Act, 1968	Directorate of Plant Protection, Quarantine and Storage, Ministry of Agriculture	Describes the safe use of insecticides to ensure that residual level doesn't pose any health hazard.	
II. Voluntary Standards				
1.	Agricultural Produce (Grading & Marketing) Act, 1937	Directorate of Marketing and Inspection	Grade Standards are prescribed for Agricultural and Allied Commodities Grading, sorting as per quality attributes and inspection are included.	Activity is based on marketing and grading at producers' level. Non-following of rules leads to fine and imprisonment. AGMARK Certificate System available.
2.	Bureau of Indian Standards (BIS)	Indian Standards Institution	Prescribing of grade standards, formulation of standards, specification for foods, prescribing standards for limits of toxic compounds as applicable. Implementation of regulation by promotion through its voluntary and third party certification system, specifying of packaging and labeling requirements.	General cover on hygienic conditions of manufacture, raw material quality and safety are given. Quality and Safety oriented standards. Enforces certification system.
2.1	Certification Marks Scheme, BIS Act, 1986 (Rules and Regulations)	Bureau of Indian Standards	Regulates the certification scheme for various processed food products, ingredients and packaging containers.	Ensure the quality to the consumer by certification.

Some of the Indian Standards Related to Horticultural Industry

IS 04627: 1968 Dehydrated cabbage (with Amendment No.1)
IS 06542: 1972 Code for hygienic conditions for fruit and vegetable canning units (with Amendment No.1)
IS 03633: 1972 Tea
IS 07732: 1975 Apple juice (with Amendment No.1)
IS 09822: 1981 Canned *Parwal* (with Amendment No.1)
IS 03881: 1983 Tomato juice (first version)
IS 04450: 1988 Brandies
IS 04448: 1994 Benzoic acid, food grade

International Organizations Governing Food Safety

- World Health Organization (WHO)
- World Trade Organization (WTO)
- Food and Agriculture Organization (FAO)
- Codex Alimentarius Commission (CAC) (Under FAO/ WHO)
- International Organization for Standardization (ISO)
- International Association of Milk, Food and Environmental Sanitarians (IAMFES)
- International Commission for Microbiological Specifications for Foods (ICMSF)
- National Advisory Committee for Microbiological Criteria for Foods (NACMCF)
- International Dairy Federation (IDF)
- Her Majesty's Stationary Office (HMSO)

International Organization for Standardization (ISO): International Organization for Standardization (ISO) is based in Geneva, Switzerland. Founded in 1947 for the purpose of advancing standardization around the world, this non-government organization is now comprised of over 130 member countries. The ISO 9000 series of quality management standards were developed by the ISO/TC 176 (ISO Technical Committee 176) convened in 1979. It sets out to create a series of internationally recognized quality management standards that represent the essential requirements that every enterprise needs to address to ensure the consistent production and timely delivery of its goods and services to the marketplace. These requirements make up the standards that comprise the quality management system. The ISO 9000 series is able to provide these quality management benefits to any organization of any size, public or private, without dictating how the organization is to be run. The series contains four system standards of varying complexity and completeness which are: ISO 9001, ISO 9002, ISO 9003 and ISO 9004.
The ISO/TC 207 convened in 1993, developed the ISO 14000 series of environmental management standards. The ISO 14000 series of standards represent the essential requirements that every enterprise needs to address in order to control and minimize the impact that its operation, and resulting goods and services, has on the environment.

Codex Alimentarius Commission (CAC): The Codex Alimentarius Commission (CAC) was created in 1963 by FAO and WHO to develop food standards, guidelines and related texts such as codes of practice under the Joint FAO/WHO Food Standards Programme. The main purpose of this programme is protecting health of the consumers, ensuring fair trade practices in the food trade and promoting coordination of all food standards work undertaken by international government and non-government organizations.

Hazard Analysis and Critical Control Point (HACCP): Hazard Analysis and Critical Control Point (pronounced "hassip") is a food safety programme that was developed nearly 30 years ago for NASA to ensure the safety of food products that were to be used by the astronauts in the space programme. HACCP involves a systems approach for identification of hazards, assessment of chances of occurrence of hazards during each phase, raw material procurement, manufacturing, distribution, usage of food products and in defining the measures for hazard control.

HACCP is comprised of seven principles:

- Analyze hazards – Potential hazards associated with a food and the measures required to control those hazards are identified that include biological, chemical and physical contaminants.
- Identify critical control points (CCP). These are points in a food's production at which potential hazards can be controlled or eliminated.
- Establish preventative measures with critical limits for each control point. These are minimum standards required for the safe preparation of food.
- Establish procedures to monitor the critical control points. Such procedures include determining how and by whom processing standards are to be monitored.
- Establish corrective actions to be taken when monitoring has shown that a critical limit has not been met. Therefore, either reprocess or dispose off foods if minimum processing standards have not been met.
- Establish procedures to verify that the system is working properly for testing and calibrating equipment to ensure their proper functioning which is one typical requirement.
- Establish effective record keeping in order to document the HACCP system. This would include records of hazards and their control methods, monitoring of safety requirements and corrective actions taken to either prevent problems or how non-conformances are to be prevented from reoccurring.

All seven principles are to be based on proven scientific research in the appropriate field in which the food processing operation is involved.

HACCP enables the producers, processors, distributors, exporters etc., of food products to utilize technical resources efficiently and in a cost effective manner for ensuring food safety. For food industry in India, adoption of HACCP is becoming imperative to reach global standards, demonstrate compliance to regulations/ customer requirements besides providing safer food at all times. HACCP helps in the reduction of contamination, reduction recalling/ product destruction, providing market protection, providing preferred supplier status, demonstrating conformance to international standards, transforming commodities into branded products and facilitating international acceptance.

Marketing and Distribution Systems

Food products often involve general marketing approaches and techniques that apply to the marketing of other kinds of products and services. In food marketing, test marketing, segmentation, positioning, branding, targeting, consumer research and market entry strategy are highly relevant. In addition, food marketing involves other kinds of challenges such as dealing

with perishable products whose quality and availability vary as a function of current harvest conditions. The **value chain**—the extent to which sequential parties in the marketing channel add value to the product is particularly important. Today, processing and new distribution options provide increasing opportunities available to food marketers to provide good quality products to the consumer with convenience. Marketing services and processing added do, however, result in significantly higher costs but help in sales promotion strategy.

Once the target market has been defined, the channels of distribution and the physical distribution system has to be finalized based on which one of the following is suitable:

- Producer-Consumer
- Producer-Retailer-Consumer
- Producer-Agent-Retailer-Consumer
- Producer-Agent-Wholesaler-Retailer-Consumer

The decision depends on the number of consumers and the geographic concentration of the market. Considering the high perishability and limited shelf life of horticultural produce, it is essential to move them from the processing centre to the consumer in the shortest possible time. Selecting the target market near to the processing centre helps to minimize the transportation cost and spoilage in transit.

Establishment of Processing Units

Location: The following are some of the basic factors that must be considered in the establishment of a food processing business:

- Available raw materials - Primary food processing plants are generally located in areas of the production of the individual fruit or vegetable crop. Production applies sufficient yields to attract growers to want to produce a crop that meets specific quality standards. Adequate quantities of right type of horticultural produce from contract farming should be readily available in the locality, as horticultural crops are highly perishable and deteriorate in long distance transport
- Handling, storage and transportation facilities - There should exist proper handling, storage and transport facilities for the safe and easy movement of raw material and finished product
- Adequate water supply - There should be continuous potable water and electricity supply. The water must be potable and low in mineral salts such as calcium, magnesium, sulphur and iron.
- Clean environment - The environment should be clean and free from debris, dust and disagreeable odours
- Sewage disposal facility- Wastes from fruit and vegetable processing facilities are high in organic matter, consequently the BOD is high and this must be lowered before discharging into the municipal systems. Proper waste disposal mechanism should be there to prevent environmental pollution
- For frozen products, cold chain facility should be available.
- Adequate labour supply – Ample labour should be available at all times for efficient working of the plant
- Adequate markets - The processing industry should look beyond the borders of its own local area and think globally and it may require good transportation facilities. There should be scope for future orderly expansion of the factory.

Machinery and equipments: Diverse types of equipments are used in the food industry for various unit operations. All equipments should be arranged in a proper order so that minimum time and effort are needed in handling the products at all stages of manufacturing. In short, the raw product should more practically in a straight line till it emerges as finished product, ready for labeling and packaging. Some basic requirements of food processing equipments include:

- All food contact surfaces of equipments and utensils shall be constructed of stainless steel or other materials which are smooth, impervious, non toxic, non corrosive, non absorbent and durable under normal circumstances.
- Food contact surfaces must be easily cleanable and shall be free of breaks, open seams, cracks or similar defects
- Food contact surfaces shall not impart any odour, colour, taste or adulterating substances to the food.
- Food contact surfaces should be readily accessible for manual cleaning other than food contact surfaces designed for cleaning in place (CIP) cleaning.
- All joints and fittings shall be of sanitary design and construction
- In addition, there shall be no dead ends and all food contact surfaces must be protected from any lubricant.

The various types of equipments used in the processing industry are as follows:

1. **Raw material preparation (before processing):** Washing machines, peeling machines, cutting machines, preparation tables, pitting knives, coring knives
2. **Preparation of pulp / juice extraction:** Continuous simple crusher, horizontal pulper, turbo refiner, continuous extractor, hydraulic press
3. **Blanching / cooking / concentration / evaporation**: Cooking kettle, steam jacketed pans, continuous water blancher, large stainless steel tank, steam generator, double bottom tank for scalding / blanching
4. **Pasteurization / deaeration:** De-aerator, pasteurizer, horizontal sterilizer, steam heated processing retort, plate heat exchanger
5. **Drying / dehydration:** Cabinet dryers, SO_2 generator / chamber, sulphuring box, solar dryer, tunnel dryer, drum dryer, spray dryer, freeze dryer
6. **Packing machines:** Pouch filler, bottle filling machines, seaming machine, pouch sealing machine, crown corking machine, semi-automatic capping machine
7. **Canned products:** Can reformer, flanger, double seamer, exhausting tunnel, water sprays, brining/syruping tanks, vacuum gauge, retorts, seam testing machines, salometer, hydrometer
8. **Quality control equipments:** Refractometer, retorts (autoclaves), hot oven, pH meter, penetrometer, texture analyzer, microscope, incubation oven, analytical balance, working tables, BOD incubator, refrigerator, spectrophotometer/colorimeter, electronic balance, jars vacuum detector, various thermometers, hand refractometer, vortex shaker, colony counter, gas stoves
9. **Miscellaneous equipments:** Mobile product wagons, storage tank, mixing tank, rotating tank, hot plate, magnetic stirrer, weighing machine, water bath, boilers, exhausts, fans, blowers, illumination and control equipments, waste water treatment equipments, weighing scale, jelmeter, rubber gloves, filter cloth, dusters, aprons, bottles, jars, cans

Equipments used in processing of seasonal products, such as tomatoes, oranges and sugar beets require special maintenance. All equipments remaining idle for a substantial time should be examined thoroughly and repaired, if needed, before starting the new processing period. Equipment failure during the busy processing period can result in significant losses of raw materials, due to spoilage.

R&D Organizations

There are many research organizations, which train the manpower, help in project preparation and consultancy in the area of food processing. Some of the leading organizations are:

1. Central Food Technological Research Institute, Mysore
2. Indian Institute of Technology, Kharagpur
3. Indian Agricultural Research Institute, New Delhi
4. Central Institute of Post Harvest Engineering and Technology, Ludhiana and Abohar
5. Indian Institute of Horticultural Research, Bangalore
6. Indian Institute of Vegetable Research, Varanasi
7. Defence Food Research Laboratory, Mysore
8. Central Institute of Arid Horticulture, Bikaner
9. Central Institute of Subtropical Horticulture, Lucknow
10. Central Plantation Crop Research Institute, Kasargodh
11. Central Tuber Crop Research Institute, Thiruvananthpuram
12. Indian Institute of Technology, Mumbai

Besides these, National Research Centres on Cashew, Citrus, Banana, Mushroom, Oil Palm, Grapes, Medicinal and Aromatic Plants, Onion and Garlic, *Litchi* and *Makhana* etc. are also helping in promoting food processing industries in their respective fields.

Suggested Readings:

1. Girdhari Lal, Sidappa G S and Tandon G L (1986). Preservation of Fruits and Vegetables, ICAR, New Delhi
2. Desrosier N W and Desrosier J N (1987). The Technology of Food Preservation, CBS Publishers, Delhi
3. Verma L R and Joshi V K (2000). Post Harvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management (Vol I and II), Indus Publication Co. Pvt. Ltd., New Delhi
4. Sethi V, Sethi S, Deka, B C and Meena Y R (2005). Processing of Fruits and Vegetables for Value Addition, Indus Publication Co. Pvt. Ltd., New Delhi
5. Srivastava R P and Kumar S (2002). Fruits and Vegetables Preservation: Principles and Practices, International Book Distributing Co., Lucknow
6. Frazier W C (1988). Food Microbiology, Tata Mc Graw Hill Pub Co. Pvt Ltd., New Delhi